FOOL'S GOLD:
A Critical Look at Computers in Childhood

Edited by
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Alliance for Childhood

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Introduction

THIS REPORT GREW OUT OF A FEBRUARY 1999 gathering in Spring Valley, New York — the founding of the U.S. branch of the Alliance for Childhood. The Alliance is an international effort of educators, physicians, and others who are deeply concerned about the plight of children today, and who believe that only by working together in a broad-based partnership of individuals and organizations can they make a significant difference in the lives of children.

These are our fundamental beliefs and concerns:

- Childhood is a critical phase of life and must be protected to be fully experienced. It should not be hurried.
- Each child deserves deep respect as an individual. Each needs help in developing his or her own unique capacities and in finding ways to weave them into a healthy social fabric.
- Children today are under tremendous stress and suffer increasingly from illnesses such as allergies and asthma, hyperactive disorders, depression, and autism. This stress must be alleviated.

A follow-up meeting of the Alliance's partners and friends with expertise in the field of children and computers raised further, more specific concerns. They suspected that the benefits of computers for preschool and elementary school children were being vastly overstated. They felt also that the costs — in terms of money spent, loss of creative, hands-on educational opportunities, and damage to children's physical and emotional health — were not being accurately reported. They decided to research and document the facts and to publish the results. This report is the fruit of that effort.

During the past year a number of individuals have worked hard to prepare this report, in particular Colleen Cordes, former reporter on science and technology policy for the *Chronicle of Higher Education*, and Edward Miller, former editor of the *Harvard Education Letter*. We are extremely grateful to them and those who contributed to the report for the excellent work they have done.

In this report we focus on children in early childhood and elementary education, for the data seem clear that computers offer few advantages in these years. There is still much work to be done on the question of how to introduce computers safely and effectively for older students. We welcome an opportunity to work with other concerned groups and individuals on these questions.

This report will be distributed widely in the hope that an open and spirited conversation will result. Democracies thrive when social change is accompanied by public debate in which all points of view are explored. In this case, it has been so widely assumed that computers are essential in childhood that there has been almost no public debate. We hope this report will stimulate conversation and lead to healthier and more considered policies on computer use in childhood.

Joan Almon, U.S. Coordinator
Alliance for Childhood

Executive Summary

COMPUTERS ARE RESHAPING CHILDREN'S LIVES, at home and at school, in profound and unexpected ways. Common sense suggests that we consider the potential harm, as well as the promised benefits, of this change.

Computers pose serious health hazards to children. The risks include repetitive stress injuries, eyestrain, obesity, social isolation, and, for some, long-term physical, emotional, or intellectual developmental damage. Our children, the Surgeon General warns, are the most sedentary generation ever. Will they thrive spending even more time staring at screens?

Children need stronger personal bonds with caring adults. Yet powerful technologies are distracting children and adults from each other.

Children also need time for active, physical play; hands-on lessons of all kinds, especially in the arts; and direct experience of the natural world. Research shows these are not frills but are essential for healthy child development. Yet many schools have cut already minimal offerings in these areas to shift time and money to expensive, unproven technology.

The emphasis on technology is diverting us from the urgent social and educational needs of low-income children. M.I.T. Professor Sherry Turkle has asked: "Are we using computer technology not because it teaches best but because we have lost the political will to fund education adequately?"

Let's examine the claims about computers and children more closely:

Do computers really motivate children to learn faster and better?

Children must start learning on computers as early as possible, we are told, to get a jump-start on success. But 30 years of research on educational technology has produced just one clear link between computers and children's learning. Drill-and-practice programs appear to improve scores modestly — though not as much or as cheaply as one-on-one tutoring — on some standardized tests in narrow skill areas, notes Larry Cuban of Stanford University. "Other than that," says Cuban, former president of the American Educational Research Association, "there is no clear, commanding body of evidence that students' sustained use of multimedia machines, the Internet, word processing, spreadsheets, and other popular applications has any impact on academic achievement."

What is good for adults and older students is often inappropriate for youngsters. The sheer power of information technologies may actually hamper young children's intellectual growth. Face-to-face conversation with more competent language users, for example, is the one constant factor in studies of how children become expert speakers, readers, and writers. Time for real talk with parents and teachers is critical. Similarly, academic success requires focused attention, listening, and persistence.

The computer — like the TV — can be a mesmerizing babysitter. But many children, overwhelmed by the volume of data and flashy special effects of the World Wide Web and much software, have trouble focusing on any one task. And a new study from the American Association of University Women Educational Foundation casts doubt on the claim that computers automatically motivate learning. Many girls, it found, are bored by computers. And many boys seem more interested in violence and video games than educational software.

Must five-year-olds be trained on computers today to get the high-paying jobs of tomorrow?

For a relatively small number of children with certain disabilities, technology offers benefits. But for the majority, computers pose health hazards and potentially serious developmental problems. Of particular concern is the growing incidence of disabling repetitive stress injuries among students who began using computers in childhood.

The technology in schools today will be obsolete long before five-year-olds graduate. Creativity and imagination are prerequisites for innovative thinking, which will never be obsolete in the workplace. Yet a heavy diet of ready-made computer images and programmed toys appears to stunt imaginative thinking. Teachers report that children in our electronic society are becoming alarmingly deficient in generating their own images and ideas.

Do computers really "connect" children to the world?

Too often, what computers actually connect children to are trivial games, inappropriate adult material, and aggressive advertising. They can also isolate children, emotionally and physically, from direct experience of the natural world. The "distance" education they promote is the opposite of what all children, and especially children at risk, need most — close relationships with caring adults.

Research shows that strengthening bonds between teachers, students, and families is a powerful remedy for troubled students and struggling schools. Overemphasizing technology can weaken those bonds. The National Science Board reported in 1998 that prolonged exposure to computing environments may create "individuals incapable of dealing with the messiness of reality, the needs of community building, and the demands of personal commitments."

In the early grades, children need live lessons that engage their hands, hearts, bodies, and minds — not computer simulations. Even in high school, where the benefits of computers are more clear, too few technology classes emphasize the ethics or dangers of online research and communication. Too few help students develop the critical skills to make independent judgments about the potential for the Internet — or any other technology — to have negative as well as positive social consequences.

Those who place their faith in technology to solve the problems of education should look more deeply into the needs of children. The renewal of education requires personal attention to students from good teachers and active parents, strongly supported by their communities. It requires commitment to developmentally appropriate education and attention to the full range of children's real low-tech needs — physical, emotional, and social, as well as cognitive.

chapter one

Healthy Children:
Lessons from Research on Child Development

"And remember the seed in the little paper cup:
First the roots go down and then the plant grows up."

—From the song *"Kindergarten Wall,"* by John McCutcheon

WHEN IT COMES TO HUMAN CHILDHOOD, nature is in no hurry at all. At birth, human infants are far more dependent on others' care than are the young of any other species. Even our formidable brains are relatively immature at birth, compared to other primates. And the span of childhood is far longer for our species than for any other animal, including other primates.[1]

In fact, recent brain-imaging studies suggest that even adolescents' brains are relatively immature. The biological changes that allow emotions to be harmoniously integrated with abstract thinking and sound judgment do not generally occur until the early twenties.[2] Human beings also do not reach physical maturity, in terms of muscular strength and motor coordination, until their twenties.[3]

The uniquely unhurried pace of human development is a fact of vast significance to educators because it seems so closely related to the broad range of capacities — including an unparalleled potential for lifelong intellectual, social, emotional, and moral growth — that is also uniquely human. Indeed, the length of childhood allows the human brain and nervous system to achieve their full size and remarkable complexity. This long period of complex growth, anthropologists Raymond Scupin and Christopher DeCorse suggest, is "the source of our extraordinary capacity to learn, our imaginative social interactions, and our facility — unique among all life forms — to use and produce symbols, language, and culture."[4]

The Beginnings of Life

Human life begins in the warm, safe, living sphere of the womb. It is the perfect environment for the child-to-be. Here she is bathed in the gentle flow of amniotic waters, calmed by the rhythmic beat of mother's heart, nourished, and protected. Her world is small, but there is enough space to grow, and even, as the months pass, to stretch and kick, and so to begin a lifetime of motion. As the fetus matures, the womb responds, adjusting and expanding again and again to meet her changing needs. The womb thus offers a constantly recalibrated balance of nurture, security, and freedom that is crucial to healthy prenatal development. It's nature's version of "just-in-time" care.

As the young child learns to stand and then walk, he orients himself to a much larger and yet still spherical environment. The earthly world is beneath his feet, the starry world above his head. Life unfolds around the child on every side. Gradually, the child's senses open and help him to engage the world around him.[5]

The womb is a living metaphor for the nurturing, developmentally-responsive environment — at home, at school, and in the community — that best serves the full range of children's needs. Mechanistic models of education, in contrast, are guided by the dead metaphor of computer engineering. They see the child's mind as a machine that can and should be both powered up and programmed into adult levels of operation as quickly as possible. The fallacy of this premature focus on cognitive skills, as if they could and should be singled out for expedited development, is now evident.

Popular attempts to hurry children intellectually — such as the trend toward academic kindergartens — are at odds with the natural pace of cognitive development. They also ignore evidence that the natural patterns of cognitive development are intricately coordinated with other well-established patterns of development, in the emotional, social, sensory, and physiological realms of human experience.[6]

Research in many disciplines supports what attentive parents and teachers have long known from personal experience: healthy development is promoted by a balance of freedom, secure limits, and generous nurturing of the whole child — heart, body, and soul, as well as head.[7] The child grows as an organic whole. Her emotional, physical, and cognitive development are inseparable and interdependent. Brain-imaging studies are instructive on this point. They indicate that experiences of every kind — emotional, social, sensory, physical, and cognitive — all shape the brain, and are shaped by the brain and by each other. Healthy human growth, in other words, is profoundly integrated.[8]

As Bennett L. Laventhal, an expert on child development and psychiatry at the University of Chicago, has explained: "There is no longer a boundary between biology, psychology, culture, and education."[9]

Emotions and the Intellect

Complex intellectual tasks and social behaviors proceed from a successful integration of a wide range of human skills, not just a narrow set of computational and logical operations. A prime example is the adult capacity for reasoning itself. Studies of brain-damaged patients have demonstrated that feelings are an essential factor in making rational decisions. Our feelings guide us in assigning value to different possibilities, and thus provide some basis for deciding between them. Otherwise, no option that life poses could either attract or repel us, and we would be stymied by the neutrality of each. In other words, sheer logic, divorced from human emotion, is insufficient for assessing the value — and, therefore, the meaning — of a choice.[10]

That does not mean, however, that every human capacity develops at the same pace, in a lockstep fashion. Far from it. In fact, childhood patterns of development, including the physical maturation of the brain and nervous system, seem to reflect the evolutionary history of humanity. The brain's lower centers, controlling movement, evolved first, followed by the basic brain structures governing emotion, and finally by the neural regions that enable the most abstract thinking. A rich network of connections between regions of the brain that primarily govern emotion and higher-order thinking allow human feelings to collaborate in even the most intellectual of tasks.[11]

Young children make the most dramatic strides, in terms of nearing their full adult potential, in their sensory and motor skills, and the neural regions most related to them. During the grade school years and beyond, children continue to progress incrementally in motor and perceptual skills. But now the most dramatic gains are in their social and emotional skills. The brain regions most involved in emotion near maturation as children refine their social skills and their capacity to regulate their own moods and behavior. Finally, after puberty, the developmental focus within the brain shifts to the regions of the brain that enable the most advanced thinking, relying upon abstractions and critical judgment. Also, a rich network of neural connections develops between these areas and brain regions most directly involved in emotion and movement.

Becoming an adult in our culture corresponds to the timing of this neural integration of thinking, feeling, and acting. The most precise movements of which humans are capable, such as the hand-eye coordination of a pediatric heart surgeon, the most nuanced feelings about feelings, based on mature self-awareness, and the most creative artistic and scientific achievements all tend to follow this maturation and integration of body, heart, and mind.

The biological patterns of brain development appear to correspond to children's patterns of learning. In early childhood, the child most naturally learns primarily through energetic use of her whole body in a truly "hands-on" approach to exploring the world. The child makes the most dramatic sensorimotor gains of her life, from the relative physical helplessness of the newborn, to the toddler's running, jumping, grasping relationship with the world around her.

The Essential Human Touch

The elementary-age child fine-tunes these motor skills, as his senses, organs, muscles, and bones continue to mature. His thinking skills, of course, are also advancing. But his whole being is naturally tuned to learn through the window of feelings, as he makes correspondingly dramatic gains in emotional and social development. This is a time for storytelling, music, creative movement, song, drama, making things with the hands, practical and fine arts of every kind — in short, every educational technology that touches children's hearts. They capture children's imagination, waken their interest in learning, and serve their ever-expanding sense of the world around them. Only around puberty does the child's dominant mode for learning finally shift toward the conscious intellect, as abstract considerations of logic and cause-and-effect reasoning gradually begin to hold sway in his mind.[12]

At every stage, however, studies indicate that strong emotional rapport with responsible adults — the human touch — provides support that is critical in helping children master the appropriate developmental challenges. Studies indicate that children's earliest emotional experiences actually lay the foundation for later academic achievement,[13] and that children whose emotional needs were not met in early childhood benefit greatly from early school experiences aimed at helping them to develop the emotional skills that are critical to school success.[14] Studies have also shown that teenagers who report strong connections with parents and teachers are less likely to drop out of school, become pregnant, use illegal drugs, or commit other crimes.[15]

What matters most, research shows, is giving the child rich human interactions, at home, at school, and in the community, in which he receives consistent, loving care from adults who understand and honor the general milestones of childhood as well as the unique constellation of gifts — special talents as well as unusual challenges — and the unique variations in developmental pace that each child brings to the world. That happens when adults calibrate their parenting and teaching to the child's developmental needs of the moment, while encouraging the child to grow across the full spectrum of human capacities.[16]

What matters most, research shows, is giving the child rich human interactions, at home, at school, and in the community.

This point is so critical that it bears repeating: love for each child, respect for the general developmental patterns of childhood, and a sensitive honoring of the unique gifts and developmental variations of each child provide the strongest scaffolding for healthy cognitive, emotional, and sensorimotor growth in childhood. Children need adults who care about them and care for them, personally, in ways that are developmentally appropriate.

The educational implications of this truth are profound. At the very heart of any attempt to improve our schools and educate our children should be a recognition of children's prime needs for close, loving relationships with caring, responsible adults, and for developmentally-appropriate care.

The Dangers of Premature "Brain" Work

Unfortunately, attention to these basics is lacking in many current educational policies and practices. Increasingly, schools are pushing young children prematurely into sedentary, abstract academic work — narrowly conceived "brain" work — wired to the most advanced information technologies that the schools can afford. This approach neglects the actual cognitive needs of children, as well as their emotional and sensorimotor needs.

Indeed, it is hard to imagine a less promising educational strategy for young children than emphasizing abstract thinking, fueled by powerful computers. Why? Because research findings across many scientific disciplines strongly suggests that later intellectual development is rooted in rich childhood experiences that combine healthy emotional relationships, physical engagement with the real world, and the exercise of imagination in self-generated play and in the arts. Intense use of computers can distract children and adults from these essential experiences.[17]

Literacy, for example, is inspired and reinforced by a genuine emotional rapport between the growing child and loving caregivers — first at home, later in school. The nonverbal exchanges between infants or young children and adult caretakers are beneficial in laying the emotional foundations for later literacy skills, as are rich verbal exchanges. And the critical milestones that child-development experts cite as evidence of school readiness all stem from healthy emotional and social attachments in early childhood. These include the abilities to focus one's attention, to form close relationships with other human beings, and to communicate with others successfully, both in terms of expressing one's self and in understanding others.[18] In kindergarten, therefore, an emphasis on play and social skills — not premature pressure to master reading and arithmetic — seems most likely to prepare children for later academic success.

Researchers have documented how much young children learn intuitively through their bodies, and how this lays a critical foundation for later conscious comprehension of the world. The child's first experience of geometric relationships and physics, for example, is literally a visceral one. As she moves herself through space, she actually begins to "learn" unconsciously in her body about relationships, shape, size, weight, distance, and movement — the basis for later abstract, conscious comprehension.[19]

Hand-eye coordination seems to be especially important to later academic achievement. Evolutionary biologists and anthropologists posit that the neural pathways of the brain associated with complex language skills co-evolved with the hand. Early hand-eye coordination, they suggest, may actually blaze the neural pathways that the brain later converts to "grasp" individual words and "shape" them into meaningful communication. So the body, too, is profoundly involved in setting the stage for later abstract thinking, just as the heart is.[20]

Parents and teachers need no experts to tell them about the active energy of children. In the natural rhythms of human learning, that energy is not wasted. Young children are prodigious learners, as their brains rapidly grow. But the most impressive feats of learning, including walking and mastering language, are achieved almost entirely through moving, exploring, touching, sensing, and, above all, imitating others — not as a result of direct instruction delivered by adults. Later, children become less imitative. But they still learn about the world through actively engaging with it, in imaginative play, games, climbing trees, and artistic and other hands-on exploration.

Unfortunately, school policies often ignore the educational impact of suppressing this natural, kinesthetic mode of learning in young children. Instead, they impose the adult mode of seated, intellectually oriented approaches, such as Internet research. Some schools are even eliminating recess to provide more time to drill young students for standardized tests.[21]

The imaginative element of children's play generally first appears about the age of two. It is inseparable from the sheer physicality of play and from its emotional and cognitive rewards. Research points to creative play as the "work" that exercises and expands the imagination. The power to generate playfully one's own images and to transform them in the mind's eye, scientists now theorize, later becomes the capacity to play with challenging mathematical, scientific, and cultural concepts in ways that create new insights. The term "intuitive leap" neatly captures the childlike play that real artistic and scientific achievement reflects.[22]

Learning About the Real World

What the child encounters in the classroom, as in the broader world, is not just some narrow band of "information" about reality. It is the full spectrum of reality itself. The very richness of this world — its beauty, its pain, its chaos, its order, its rhythms of change and motion, and its seemingly infinite possibilities — captivates and challenges the child to bring his whole heart, body, mind, and soul to bear to know it, and to serve it. The real world, in other words, motivates the child to learn and to care in ways no software could replicate. Teachers and parents who experience a wonder and a reverence for the world and who model their love for what they seek to teach can indeed inspire children to learn. The ultimate subject, of course, is our real world, especially what's most special about our own planet — life itself.

This encounter between child, teacher, and world is the very stuff of education. The Latin root of the word "educate" is *educare*, which means "to lead out," as to lead out of darkness into light. This meeting between child and world, facilitated by loving parents, teachers, and other mentors, literally calls forth from the child her incredible capacities for lifetime growth.

In this encounter, each child mirrors the history of human evolution, which is increasingly understood as having been profoundly integrated. Physical anthropologists increasingly emphasize that our most human sensorimotor, emotional, and cognitive capacities were fine-tuned in an integrated way, "called forth" as it were, by encounters with environments that posed specific evolutionary challenges.[23]

The growing dexterity of the human hand, for example, is thought to be closely related to the development of language. So too is each child's development integrated. Neural pathways that primarily relate to physical and emotional experiences connect to the pathways that enable abstract thought, which are the last to fully mature. In this way, different regions of the brain cooperate, enriching experience and learning. Children's sensory development, their skill in movement, their capacity to pay attention and to communicate all directly influence and are influenced by their cognitive development. And all of these ways of being human in the world together help to shape the physical development of the child's brain in ways that cannot be neatly dissected from each other.

Children thus need to experience the fullness of the world around them. Computer simulations or "content delivery" are poor substitutes for hands-on lessons — outdoors, if possible — in botany, zoology, chemistry, and physics. What young children learn first in their bodies and later in heartfelt sympathy with nature does, with time and instruction, later mature into conscious understanding. Educational shortcuts that attempt to bypass the physical and emotional stages of learning defy science.

The idea that schools should focus primarily on speeding up the natural trajectory of children's cognitive development is at odds with research findings on human development. When children's emotional or physical development is stunted, their intellects also fail to thrive.[24] Treating young children like small scholars and overwhelming them with electronic stimuli that outstrip their sensory, emotional, and intellectual maturity may actually be a form of deprivation. It is reminiscent of failed experiments of the 1960s in which preschoolers were pushed to learn to read and write. By the middle of grade school, they had fallen behind less rushed children in both academic and social skills.[25]

Attempts to engineer faster learning in childhood grew out of military research in the 1950s and 1960s that had nothing to do with children. The military sought to program computers to perform complex logical operations, in part by analyzing how humans process information. It also sought to apply the lessons learned about how to "train" machines in this narrow realm of abstract operations to the similarly narrow task of training young adult males to operate and maintain computers and weapons systems.

A new discipline, now called cognitive science, sprung from those studies. But its research agenda continued for years to be driven primarily by the military's limited range of interests, in terms of advancing information technology for weapons systems and developing efficient methods for training young adults with as few instructors as possible. In time, its educational focus shifted to cognitive engineering — attempting to improve the efficiency and productivity of human learners. Its emphasis was frequently on developing generic "problem-solving skills,"often divorced from any context of social needs or the personal goals of the learners.

Over time, many educational researchers embraced this information-processing model of human thinking. They were excited by its potential to generate powerful concepts about the mind's architecture. Eventually this model, with its guiding metaphor of the brain as a programmable computer, became broadly applied to the basic issues of educating even very young children. Researchers tried to identify how children's minds process information, and then devise methods to increase the speed and efficiency of those processes. Schools used these mechanistic models to try to devise standard methods to help children construct their own mental scaffolding for academic subjects. But they also either applied a narrow, information-processing approach to every other aspect of child development — social, emotional, physical, and moral — or neglected those aspects of development all together.[26]

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>
> —Robert Coles

A comprehensive look at human development, informed by many scientific disciplines, clearly demonstrates how foolish it is to pressure teachers to focus exclusively on cognitive skills in the classroom. Human development, it turns out, really can't be reduced to information processing.

Even in processing information, children do not behave like machines. That's because children, influenced by the culture of their families, schools, and larger communities, actively bring to their encounters with life a far wider set of capacities than any machine embodies. Each child has a growing body and a rich, unpredictable inner life, a unique imagination, and a growing sense of self-awareness.

Children don't just process data about the world. They actually experience the world. They are constantly creating new meaning for themselves based on those experiences. They are meaning-makers, and the meanings are created by the complex encounters with the world of their whole selves — bodies, minds, hearts, and souls.[27]

Robert Coles of Harvard Medical School has expressed it this way:

> Again and again I have come to realize that even preschool children are constantly trying to comprehend how they should think about this gift of life given them, what they should do with it. People like me, trained in medicine, often emphasize the psychological aspects of such a phenomenon and, not rarely, throw around reductionist labels.... In fact, moral exploration, not to mention wonder about this life's various

> mysteries, its ironies and ambiguities, its complexities and paradoxes — such activity of the mind and heart make for the experience of what a human being is: the creature of awareness who, through language, our distinctive capability, probes for patterns and themes, for the significance of things.[28]

[1] Carol R. Ember and Melvin Ember, *Anthropology: A Brief Introduction,* 3d ed., Upper Saddle River, NJ: Prentice Hall, 1998, pp. 29, 33, 53, 151.

[2] Shannon Brownlee, "Behavior Can Be Baffling When Young Minds Are Taking Shape," *U.S. News and World Report,* Aug. 9, 1999, pp. 44-54.

[3] Fergus P. Hughes and Lloyd D. Noppe, *Human Development: Across the Life Span,* St. Paul, MN: West Publishing Co., 1985), p. 88.

[4] Raymond Scupin and Christopher R. DeCorse, *Anthropology: A Global Perspective*, 3d. ed., Upper Saddle River, NJ: Prentice Hall, 1998, p. 87.

Also, see Ashley Montagu, *Growing Young*, 2d ed., New York: McGraw-Hill Book Co., 1983.

[5] Michaela Glockler and Wolfgang Goebel, *A Guide to Child Health,* Edinburgh: Floris Books, 1990, pp. 170-174.

[6] Dorothy G. Singer and Tracey A. Revenson, *A Piaget Primer: How a Child Thinks*, Rev. Ed., Madison, CT: International Universities Press, 1997. The seminal work in this area is Jean Piaget's theory of the progressive cognitive stages that children grow through, and how they entail different kinds of thinking — not just a question of quantities of information learned. Piaget also stressed how closely tied a young child's first intuitive learning about the world was to the physical development of his or her senses and motor skills. Cross-cultural studies support the idea of basic thinking processes developing in phases. Especially see pp. 108-110 for a description of Piaget's warning against adults trying to arbitrarily speed up children's progress through the natural phases of cognitive development. These patterns reflect a corresponding process of biological maturation, Piaget pointed out, and so their timing is neither arbitrary nor subject to cultural whim.

Also, see Daniel Goleman, *Emotional Intelligence: Why It Can Matter More than I.Q.*, New York: Bantam Books, 1995, throughout and especially p. 274.

Also, see Stanley I. Greenspan with Beryl Lieff Benderly, *The Growth of the Mind: And the Endangered Origins of Intelligence*, Reading, MS: Addison-Wesley Publishing Co., Inc., 1997, throughout, especially pp. 211-230.

Also, see Jane M. Healy, *Your Child's Growing Mind: A Practical Guide to Brain Development and Learning from Birth to Adolescence*, New York: Doubleday, 1994, especially pp. 227-256.

[7] "The healthiest children, psychologists tend to agree, have parents who are warm and accepting rather than cold and rejecting; who set up firm rules and consequences rather than remaining always lenient; and who support a child's individuality and autonomy rather than exerting heavy control." From Marian Diamond and Janet Hopson, *Magic Trees of the Mind: How to Nurture Your Child's Intelligence, Creativity, and Healthy Emotions from Birth Through Adolescence,* New York: Plume, 1999, p. 209. Diamond is a leading brain researcher whose work strongly supports current theories that the brain's physical organization is responsive, throughout life, to environmental influences and that the brain is particularly responsive — and therefore, particularly vulnerable — to experiences in childhood.

[8] Neurologist Frank R. Wilson, medical director of the Peter F. Ostwald Health Program for Performing Artists at the University of California School of Medicine at San Francisco, has summarized the research and theories on the integration of physical experience and brain development in evolution and child development, drawing upon a wide range of scientific disciplines. See Frank R. Wilson, *The Hand: How Its Use Shapes the Brain, Language, and Human Culture,* NewYork: Pantheon Books, 1998. Wilson notes: "No credible theory of human brain evolution can ignore, or isolate from environmental context, the co-evolution of locomotor, manipulative, communicative, and social behaviors of human ancestors." (p. 321).

Wilson also notes the current anthropological theory that early tool use, combined with the evolution of the hemispheric specialization associated with hand use "provide both the behavioral and neurologic context" to account for the evolution of human language itself (p. 354).

He also presents a wide range of research and case studies to argue that the development of physical skills can help foster an intense emotional commitment to learning — again, in an overall context of the dynamic synergy released by the "fusion" of movement, thought, and feeling. Citing the passion with which musicians, sculptors, jugglers, and surgeons practice their skills, he emphasizes the "hidden physical roots of the unique human capacity for passionate and creative work" (p.6).

Also, again in the context of how the holistic nature of human development generates unique capacities, Wilson states: "If it is true that the hand does not merely wave from the end of the wrist, it is equally true that the brain is not a solitary command center, floating free in its cozy cranial cabin. Bodily movement and brain activity are functionally so interdependent, and their synergy is so powerfully formulated that no single science or discipline can independently explain human skill or behavior. . . The hand is so widely represented in the brain, the hand's neurologic and biomechanical elements are so prone to spontaneous interaction and reorganization, and the motivations and efforts which give rise to individual use of the hand are so deeply and widely rooted, that we must admit we are trying to explain a basic imperative of human life" (p.10).

For a presentation of current evidence pointing to the roots of human language resting in human gestures, see the following work by three leading linguists: David F. Armstrong, William C. Stokoe, and Sherman E. Wilcox, *Gesture and the Nature of Language,* Cambridge/New York: Cambridge University Press, 1995.

For an anthropological review of the evidence that early tool use and the evolution of hemispheric specialization in the brain that is related to left- and right-handedness provide the behavioral and neurologic context for the evolution of human language itself, see Gordon W. Hewes, "A History of the Study of Language Origins and the Gestural Primacy Hypothesis," in A. Lock and C. Peters, eds., *Handbook of Human Symbolic Evolution*, Oxford: Clarendon Press, 1996.

For a summary of research and theories on the two-way, dynamic interplay between emotional experiences — especially the frequency of intimate interactions with other human beings — and brain development, see the work of Stanley Greenspan, a child psychiatrist and a leading expert on healthy emotional development across the human lifespan. For example, Greenspan with Benderly, *The Growth of the Mind and the Endangered Origins of Intelligence,* throughout, especially pp. 319-322, for a history of the science in this area.

Greenspan states: "Perhaps the most critical role for emotions is to create, organize, and orchestrate many of the mind's most important functions. In fact, intellect, academic abilities, sense of self, consciousness, and morality have common origins in our earliest and ongoing emotional experiences. Unlikely as the scenario may seem, the emotions are in fact the architects of a vast array of cognitive operations throughout the life span. Indeed, they make possible all creative thought" (p. 7).

9 Robert Lee Hotz, "Deciphering the Miracles of the Mind," *Los Angeles Times*, October 13, 1996, reprinted in *The Brain in the News*, Vol 3, No. 11, The Dana Alliance for Brain Initiatives, Washington, D.C.: November 15, 1996, p. 2.

10 Antonio Damasio, *Descartes' Error: Emotion, Reason, and the Human Brain,* New York: Grosset/Putnam: 1994. Damasio, a neuroscientist, states: "Surprising as it may sound, the mind exists in and for an integrated organism; our minds would not be the way they are if it were not for the interplay of body and brain during evolution, during individual development, and at the current moment" (p. xvi).

11 Goleman, *Emotional Intelligence: Why It Can Matter More Than IQ,* especially pp. 9-12.

12 The editors gratefully acknowledge Story C. Landis, Ph.D., senior investigator in the Neural Development Section of the National Institute of Neurological Disorders and Stroke, for her review of the section above describing patterns of brain development. Dr. Landis is also scientific director for the Division of Intramural Research at NINDS.

Also, for a discussion of how human evolution, human cultural history, and human cognitive development all suggest the wisdom of educators recognizing and taking advantage of children's progression from relying mainly on "somatic" tools for learning in early childhood to their inclusion, much later in school, of much more abstract, "ironic" understanding as an intellectual tool, see Kieran Egan, *The Educated Mind: How Cognitive Tools Shape Our Understanding,* Chicago: University of Chicago Press, 1997.

13 *Heart Start: The Emotional Foundations of School Readiness*. (Arlington, VA: National Center for Clinical Infant Programs, 1992), especially pp. 7, 9, 13.

14 Goleman, pp. 234-260; also, W. T. Grant Consortium on the School-Based Promotion of Social Competence, "Drug and Alcohol Prevention Curricula," in J. David Hawkins, et al., *Communities That Care,* San Francisco: Jossey-Bass, 1992; also, Greenspan, pp. 252-280.

15 A recent major study of risk factors in adolescence, sponsored by the National Institutes of Health, concluded that the most critical factor associated with whether teenagers used drugs or alcohol, attempted suicide, became sexually active at an early age, or committed acts of violence was how closely connected they felt to their parents. The closer the bond, the less likely teenagers were to get into trouble. From "Add Health," *Journal of the American Medical Association*, Sept. 9, 1997.

Ann S. Masten, associate director of the Institute of Child Development at the University of Minnesota, in summarizing the research on factors that foster resiliency in disadvantaged children at high risk for academic failure, juvenile delinquency, and other negative developmental outcomes, states the following: "The most important protective factor in their lives are their connections to competent, caring adults…They have had opportunities to feel effective and valued, opportunities that were afforded by a combination of their own talents and the interests of the adults around them. They have a knack for getting into healthy contexts for development, making choices that connect them with positive people and places that foster achievement and values. In most cases, it takes more than adversity to bring down a child endowed with normal human qualities. It seems to require significant failures in the major protective systems for human development, which includes the nurturing of body and soul by adults, opportunities to learn, to play, to be safe." From "Fostering Resiliency in Kids: Overcoming Adversity," a transcript of proceedings of a Congressional breakfast seminar, Washington, DC: Consortium of Social Science Associations, March 29, 1996.

16 Greenspan with Benderly, throughout, especially pp. 211-230: "An educational system that serves the needs of our society is compelled to recognize children's developmental levels, deal with individual differences, and foster dynamic affective interactions. We do not need to justify such interactions as part of training in social skills or other desirable goals that some would argue should be left within the purview of the family. Rather, their importance is demonstrated by the fact that they are inextricably interwoven with the process of learning" (p. 230).

17 For summaries of research indicating the wisdom of a wide variety of such experiences for children, see Healy, *Your Child's Growing Mind: A Practical Guide to Brain Development and Learning from Birth to Adolescence,* 1994; and Diamond and Hopson, *Magic Trees of the Mind: How to Nurture Your Child's Intelligence, Creativity, and Healthy Emotions from Birth Through Adolescence,* 1999.

For a summary of the research connecting physically active play and pretend play to intellectual development, see Fergus P. Hughes, *Children, Play, and Development*, Allyn and Bacon, 1998.

For a discussion of the research on the positive impact of art and music education on academic performance, see Martin Gardiner, Alan Fox, Faith Knowleds, and Donna Jeffrey, "Learning Improved by Arts Training," *Nature*, May 23, 1996. The authors note that children's performance in mathematics and reading can be improved especially when arts education is based on a sequential, skill-building approach and consciously integrated into the rest of the curriculum.

For more information on the relatively recent field of research indicating that music education, for example, has an impact on neurological development and on spatial-reasoning skills important in mathematics, science, and engineering, see the MuSICA Research Database at the University of California-Irvine@http://www.musica.uci.edu

18 Greenspan, for example, in discussing how to prepare children for academic learning, states: "Now that we have a far more accurate idea of how the human mind develops, we must base our educational methods not on tradition but on the best current insights into how children learn.... We must base it, in short, on a developmental model and on its key tenet: *intellectual learning shares common origins with emotional learning* [italics sic]. Both stem from early affective interactions. Both are influenced by individual differences, and both must proceed in a step-wise fashion, from one developmental level to another.... First, a child must be able to regulate his attention. Whether he learns this easily or with difficulty

depends, of course, on the particular endowment he arrived with as well as the early nurturing he received. Second, he must be able to relate to others with warmth and trust. Those who lack adequate nurturing may not have learned to engage fully with other human beings. No teacher can then marshal this basic sense of connectedness. The child will not be motivated to please her, and ultimately himself, by doing well at schoolwork. Finally, he must be able to communicate through both gestures and symbols, to handle complex ideas, and to make connections among them. Those who have not mastered these early levels obviously cannot succeed at more advanced ones. The real ABCs come down to attention, strong relationships, and communication, all of which children must learn through interaction with adults. Learning will also be smoother if a youngster arrives at school able to reflect on his behavior, so that, for example, he can tell whether he understands a lesson or assignment and if not, know which part he finds confusing." From Greenspan with Benderly, *The Growth of the Mind* (pp. 219-220).

Also, Jane Healy, educational psychologist and former school principal, cites the work of child-development expert David Elkind in suggesting that children, to be ready for academics, need to be able to express themselves, listen, and follow directions; start and complete a task before moving to another activity; and cooperate with others. Healy adds: "All of these qualities may be eroded by the wrong kind of computer exposure." Jane M. Healy, *Failure to Connect: How Computers Affect Our Children's Minds —for Better and Worse,* New York: Simon & Schuster, 1998, p. 242; and David Elkind, conference paper: "Education for the 21st Century: Toward the Renewal of Thinking." (New York: Teachers College, Columbia University, February 10-11, 1994).

19 Hughes, *Children, Play and Development*, 1998.

Some of the most influential theorists of cognitive development, including Maria Montessori, Jean Piaget, and Rudolf Steiner, have also made the same point, based, in part, on their acute observations of young children. Piaget, for example, suggested that children up to about the age of seven — which, in the United States, corresponds to about second grade — are biologically primed to learn intuitively about the world through their senses, movement, and actually handling objects, especially through play and imitation. Then, from the ages of about seven to 11, Piaget asserted, children become more and more proficient in converting their "in-the-body" knowledge to interior, imaginative pictures and in concrete thinking about their experiences. Play is still important, but children become increasingly interested in organizing games with rules. From the ages of about 11 through 16, he suggested, children gradually grow in their capacity for abstract thought and deductive reasoning. He insisted that reading, writing, and arithmetic should not be imposed upon children until their nervous systems were biologically mature enough for such direct instruction — which he suggested was not until the primary grades. Through sensory and motor experiences in the world, he theorized, children take their "first steps in numerical and spatial intuition," which prepares them for later logical and verbal abstractions. See Singer and Revenson, *A Piaget Primer: How a Child Thinks*, 1997, esp. pp.108-109.

20 Wilson, in *The Hand*, 1998, discusses how the evolution of the human brain over millions of years has been inextricably and dynamically linked to the ways in which humans use tools. Changes in the structure of the human hand and arm, related to the need to grasp, throw, and manipulate objects like stones and sticks, led to changes in the structure of the brain and nervous system and the development of new, more complex patterns of thinking. The hand and its control mechanisms, Wilson summarizes, seem to have been "prime movers in the organization of human cognitive architecture and operations" (p. 286). This same process of co-evolution takes place in the development of individuals: children who learn to play the violin or piano, for example, develop neural networks that affect their ways of learning throughout life. And Wilson speculates that the individual infant's potential to develop incredibly refined and related hand and language skills may be a combined "elemental force in the genesis of what we refer to as the 'mind,' activated at the time of birth" (p.34).

21 Research on recess, for example, indicates that children return from recess outdoors with a new surge of energy for paying attention to their studies. From Hughes, *Children, Play, and Development*, 1998. Yet many schools have reduced or eliminated recess, or are considering doing so, in a misguided move to make more time for computer classes and deskwork.

22 Mihaly Csikszentmihalyi, a psychologist at the University of Chicago, has suggested a theory of "flow," as a special state of consciousness that arises when both energy and creative ability are synchronized. He argues that adults' creativity and achievements in the sciences and arts are linked to a sense of play, which he describes as "the spontaneous

joy of a child's natural learning experience." Like the child's play, adult creative achievements are motivated by the emotional rewards of the activity itself. Mihaly Csikszentmihalyi, *Flow: The Psychology of Optimal Experience,* New York: Harper & Row, 1990.

Also, see Desmond Morris, *The Human Animal: A Personal View of the Human Species,* New York: Crown, 1994, pp. 206-214, for a lyrical exposition of how the human adult's retention of some childlike capacities — especially the capacity and enthusiasm for play — is both unique among species and a critical evolutionary edge. "At our best," says Morris, "we remain, all our lives, childlike adults."

23 Scupin and DeCorse, *Anthropology: A Global Perspective*, 1998, especially p. 88.

24 See Wilson, *The Hand*, 1998, p, 289, for this concise summary of the implications, for example, of research to date across the life sciences: "The clear message from biology to educators is this: The most effective techniques for cultivating intelligence aim at uniting (not divorcing) mind and body."

Also, on emotional impacts on learning, research at the University of Michigan, for example, concluded that regardless of parents' education or social class, factors that placed four-year-old children at risk of emotional problems — such as having depressed or addicted parents or suffering abuse or neglect — were related to poor cognitive development. Also, children from families with four or more emotional, social, and economic risk factors were 24 times more likely than those with just one risk factor to score below 85 on I.Q. tests and to suffer more behavioral problems. Higher test scores were also correlated with having parents who were adept at reading and positively responding to their child's particular emotional and social cues in ways that encouraged the child to explore the world, rather than ignoring their cues or responding to them in a negative or overly directive way. Follow-up studies of the same children at the age of 13 confirmed the findings. See A.J. Sameroff, R. Seifer, R. Barocas, M. Zax, and S.I. Greenspan, "IQ Scores of Four-Year-Old Children: Social-Environmental Risk Factors," *Pediatrics* 79, 1986, pp. 343-350.

Brain researcher Marian Diamond presents an accessible review of the research in this area, as well as the scientific references, in *Magic Trees of the Mind.* Diamond also cites psychologist Howard Gardner's theory of multiple intelligences — faculties for language, logic and mathematics, spatial representation, music, movement, understanding others, understanding ourselves, and understanding and appreciating nature — as confirming common-sense observations. (Recently Gardner has also suggested that there may be an "existential intelligence.") Diamond recommends that parents and schools offer children a wide variety of experiences to nurture the full spectrum of human intelligence and adds: "A school program based on many domains of intellect can also help children get practice in their weaker areas, whatever they may be, and develop and discover talents in new realms." Diamond and Hopson, *op. cit.*, 1999, (p. 197).

25 Pediatrician T. Berry Brazelton has cited this research and later evidence that "such precocious early training is costly" and warns against pushing academics on children too early. Brazelton, *Touchpoints: Your Child's Emotional and Behavioral Development,* Boston: Addison-Wesley, 1992, p. 213. He also notes: "Pressure on children to perform early seems to me to be cheating the child of opportunities for self-exploration for play and for the learning that comes from experimentation" (pp. 356-357).

Also, anthropologist Ashley Montagu has warned of "psychosclerosis," or hardening of the mind. It is, he says, a culturally and educationally induced condition that stems from pressures to rush children into adulthood and that stunts our ability to maintain the childlike qualities that allow us to continue maturing over our entire life span. Among the critical human traits he identifies that are in jeopardy in adulthood are the capacities to love, to wonder, to explore, to learn, to be imaginative and creative, to sing and dance, and to play. See Ashley Montagu, *Growing Young*, 2d ed., *op. cit.*

And child-development expert David Elkind, former president of the National Association for the Education of Young Children, has criticized the push to "collapse" the natural phases of childhood in order to "hurry" children into more adult levels of functioning. Elkind suggests that this attempt to rush children through childhood may actually stunt their development, including the healthy development of their brains. See David Elkind, "Education for the 21st Century: Toward the Renewal of Thinking," New York: Teachers College, Columbia University, February 10-11, 1994.

Also, animal studies involving the over-stimulation of more than one sense too early in life have shown negative lifelong impacts for learning and attention. P.L. Radell and G. Gottlieb, "Developmental Intersensory Interference," *Developmental Psychology*, 28(5), 1992, pp. 794-803.

26 For the most thorough exposition of this history, see Douglas D. Noble, *The Classroom Arsenal: Military Research, Information Technology, and Public Education,* London: The Falmer Press, 1991.

Wilson, in *The Hand,* explicitly issues this "admonition" to cognitive science: "Any theory of human intelligence which ignores the interdependence of hand and brain function, the historic origins of that relationship, or the impact of that history on developmental dynamics in modern humans, is grossly misleading and sterile" (p. 7).

27 Jeffrey Kane, "On Education With Meaning," from Jeffrey Kane, ed., *Education, Information, and Transformation: Essays on Learning and Thinking*, Upper Saddle River, NJ: Merrill, 1999.

28 Robert Coles, *The Moral Intelligence of Children: How to Raise a Moral Child*, New York: Penguin Putnam, 1998, pp. 177-178.

chapter two

Developmental Risks:

The Hazards of Computers in Childhood*

"We need to continually examine what succeeds and fails, and why. And we should do so before we deploy any technical approach on a grand scale."

—Michael Dertouzos, director of MIT's Laboratory for Computer Science, writing about educational technology in *What Will Be: How the New World of Information Will Change Our Lives.*

MANY AMERICANS ASSUME THAT EVEN VERY young children must learn to use computers to guarantee their future success in school and work. In fact, 30 years of research on educational technology has produced almost no evidence of a clear link between using computers in the early grades and improved learning. (One notable exception concerns children with certain disabilities, who have made significant gains with the help of assistive technology.) In spite of the lack of evidence of any real need for them, computers are becoming ubiquitous in U.S. primary schools.

The rush to computerize elementary education is at odds with much of what research in human biology and psychology reveals about children's intellectual, emotional, social, physical, and spiritual needs. Nature has choreographed a carefully timed sequence of human development, marked by long periods of gradual progress and occasional spurts of growth. Each child's experiences and particular variations to the common patterns of growth interact to form the child's unique human identity. This duet of experience and biology nurtures and integrates a wide range of capacities into the synergistic whole that makes us human beings, uniquely capable of learning, adapting, and maturing throughout our lifetimes.

To put it simply, childhood is our species' evolutionary edge. Childhood takes time. And many children are simply not being given the time to be children.

Computers are perhaps the most acute symptom of the rush to end childhood. The national drive to computerize schools, from kindergarten on up, emphasizes only one of many human capacities, one that naturally develops quite late — analytic, abstract thinking — and aims to jump start it prematurely.

Seymour Papert, co-founder of the Artificial Intelligence Laboratory at the Massachusetts Institute of Technology, has been particularly influential in promoting the use of computers by young children. But such an emphasis seems designed for training children to think in ways that appear more mechanistic than childlike.

* This chapter draws extensively on two recent books that thoroughly document the hazards that computers pose to the education of young children: *Failure to Connect: How Computers Affect Our Children's Minds — for Better and Worse* by Jane Healy; and *The Child and the Machine: How Computers Put Our Children's Education at Risk* by Alison Armstrong and Charles Casement.

For example, Papert himself, referring to Logo, the programming language for children he created, has said:

> I have invented ways to take educational advantage of the opportunities to master the art of *deliberately* thinking like a computer, according, for example, to the stereotype of a computer program that proceeds in a step-by-step, literal, mechanical fashion . . . By deliberately learning to imitate mechanical thinking the learner becomes able to articulate what mechanical thinking is and what it is not. [1]

But can young children really differentiate between their own human thinking and the powerful operations of a machine? Is it even fair to impose such a task upon them?

Computers are the most sophisticated thinking tools ever designed. They were developed with adult bodies, as well as adult mental capacities, in mind. Even for adults, their intensive use is related to job stress and serious injuries. But emphasizing computers for children, whose growing bodies are generally more vulnerable to stress, presents several challenges to healthy development. The current focus on computers can distract schools and families from attending to children's true needs, and can exacerbate existing problems.

Hazards to Children's Physical Health

Emphasizing the use of computers in childhood can place children at increased risk for repetitive stress injuries, visual strain, obesity, and other unhealthy consequences of a sedentary lifestyle. Some development experts also warn that increasing the time that children spend on computers, given the hours they already sit in front of televisions and video games, may contribute to developmental delays in children's ability to coordinate sensory impressions and movement and to make sense of the results. That could in turn lead to language delays and other learning problems.[2]

There are also potential but unproved health risks of toxic emissions from new computer equipment and exposure to electromagnetic radiation, especially from the old video display monitors that are still in use in many schools.

These health risks to children demand immediate action. But no one pushing the computer agenda — neither high-tech companies, nor the federal government, nor school officials — has yet publicly acknowledged the hazards, let alone taken action to remedy them.

Musculoskeletal injuries

Long hours at a keyboard, constantly repeating a few fine hand movements, may overtax children's hands, wrists, arms, and neck. That, in turn, may stress their developing muscles, bones, tendons, and nerves. For years, health and safety experts in government and industry have been recommending that adults who work at video display terminals take precautions to prevent such injuries: adjustable office furniture; changes in posture and careful attention to the angles of one's legs, arms, and neck while working; warm-up stretches; and frequent breaks from using a keyboard and mouse or staring at a screen. The American Occupational Therapy Association recommends a ten-minute break every hour.[3]

Alison Armstrong and Charles Casement explain why proper ergonomic design and frequent breaks are essential — especially for children:

> However flexible it may be as a means of accessing and manipulating information, for

> the user the computer is a kind of straitjacket into which the body must adapt itself. The eyes stare at an unvarying focal length, drifting back and forth across the screen. Fingers move rapidly across the keyboard or are poised, waiting to strike. The head sits atop the spine balanced, in the words of one physician, like a bowling ball. Built for motion, the human body does not respond well to sitting nearly immobile for hours at a time.[4]

The U.S. National Institute for Occupational Safety and Health, in a major research review in 1997, concluded that awkward postures and highly repetitive motions are strong risk factors for musculoskeletal injuries related to work.[5] Such injuries can be both painful and serious. The median number of lost workdays for employees suffering from carpal tunnel syndrome, for example, is 25 days per year.[6]

> Childhood repetitive strain injuries: "It's probably a time bomb waiting to go off.
>
> —Dr. Margit Bleecker

Only a handful of studies have been conducted on the potential for musculoskeletal injuries for children using computers. But the results have been disturbing. They indicate that most schools are allowing children to use desktop or laptop computers in ways that put them at risk of straining their bodies and eyes.

College health clinics report high numbers of students complaining of computer-related pain. Many, including Harvard University and the Massachusetts Institute of Technology, have special Websites to advise students on prevention and how to seek help if they are injured. At M.I.T. about 175 students a year seek treatment for computer-related injuries, according to Dr. David Diamond of the university's medical center. A few are so injured they have to change their career plans, he adds.[7]

For Brendan Connell and his family in Silver Spring, Maryland, the pain and the life changes that such injuries lead to are all too familiar. Brendan is a 20-year-old Harvard student who started using computers in school at about age six. By high school he was spending hours each day at the computer, and started experiencing pain in his hands. Before the end of senior year, his injury was so severe that he could no longer write or type, and eventually had trouble even opening doors. With treatment, the pain is now less, but he is not completely healed. He says that he has just about given up the idea of becoming a computer programmer because of the keyboard time that would require.[8]

Schools should get serious about ergonomic issues now, says Dr. Margit Bleecker, a neurologist and director of the Center for Occupational and Environmental Neurology in Baltimore, who has treated Brendan Connell. "We know that these things can happen with children," she says, based on the reports of children who injure their hands playing video games. She expects the incidence of repetitive stress injuries in childhood to rise. "It's probably a time bomb waiting to go off."[9]

As younger children begin using computers intensively they may be at even greater risk of injury than older children are, some experts suggest. That's because their bones, tendons, nerves, muscles, joints, and soft tissues are still growing. A few reports of students developing repetitive stress injuries have begun to appear in the news media.[10] But the full scope of this potential problem may not become known for years. Repetitive stress injuries, such as carpal tunnel syndrome, can be caused by the cumulative impact of years of repeated minor trauma.

For the most part, schools are in a state of denial about this issue. A team of researchers at Cornell University studied computer work stations for children in grades three, four, and five at 11 elementary schools. They found “striking misfits” at every school between the work stations and the children using them, resulting in unhealthy typing postures. In every school, the keyboards were set up too high for the children using them, and the computer monitors were also too high in most cases. The researchers concluded that at least 40 percent of the children were at risk of serious injury.[11]

When repetitive injuries do occur, medical experts emphasize that prompt treatment, changes in work habits, and correction of computer-station ergonomics are essential to prevent chronic conditions. The latter may require expensive surgery, or long periods of recovery during which the simplest daily activities, such as buttoning a shirt or twisting a cap off a tube of toothpaste, can be painful or impossible. Left untreated, musculoskeletal injuries can even be permanently disabling.[12]

Alan Hedge, professor of ergonomics at Cornell University, helped supervise the study cited above, whose results were published in 1998. It appears to be one of the first American studies of childhood ergonomic issues related to computers. Hedge notes that recent studies in Australia indicate that children who use laptops instead of desktop computers appear to be at higher risk of musculoskeletal problems.

One 1998 study, for example, with 314 children aged 10 to 17, found that 60 percent of them reported discomfort in using their laptops. (Sixty-one percent also reported discomfort in just carrying their laptops. This calls into further question the wisdom of proposals to give all children laptops to carry with them wherever they go.) The children who had used computers for the most years reported more discomfort than children who had been using laptops for only a few months. On average, the children in the study reported spending a total of more than 3.2 hours a day at their laptop keyboards, and 16.9 hours per week. The researchers concluded that “school children are exposing themselves to prolonged poor postures with laptop use that is leading to discomfort. This is of particular concern as it occurs during critical periods of their skeletal growth.”[13]

Keyboard and monitor are nearly always attached on a laptop. So it’s almost impossible to follow the guidelines for healthy posture when using them. Either the monitor is too low, causing neck strain, or the keyboard too high for healthy arm, wrist, and hand posture.

Hedge recommends that children take a break from computer work every 20 minutes and spend no more than about 45 minutes in any hour at a computer, and avoid spending more than 4 hours a day at computers and video games — including time spent both at home and school.[14] A Roper Starch survey in 1999 estimated that the average American child is now spending about one to three hours every day at a computer. Hedge points to this figure as evidence of “great potential for injury.”[15]

Who will take financial responsibility for the care of children who do suffer injuries? For the millions of poor children whose parents do not have health insurance, this question is particularly salient. Families without health insurance are more likely to delay seeking treatment for health problems that do not seem serious. Headaches and occasional pain in the back, neck, or shoulders, for example, might seem like minor problems, but may actually be an early warning that a child is at risk of more serious injuries ahead.

Vision problems

Computer use places added strain on a child's eyes and developing visual system, and may actually make learning to read more of a challenge for young children.[16] Adult workers who use visual display terminals (VDTs) frequently complain of fatigue, eye strain, burning, tearing, soreness, blurred vision, and headaches.[17] Eye strain experienced by computer operators is related to screen glare and to the screen being either too bright or too dim compared to the ambient light. Maintaining a constant focus on the same distance, at the same angle, inhibits blinking even more than does reading from a book, probably because the monitor presents a vertical reading surface and because our eyes are open wider, making it more of an effort to blink.[18]

> Expecting beginning writers to poke a letter key and then passively watch a letter appear on a screen . . . may actually hamper the process of learning to write and read.

Children, too, are at risk of visual fatigue from long spells at a computer screen, for all of the same reasons. But the immaturity of their visual systems raises some additional concerns. Infants and toddlers develop their visual-spatial awareness first through gross movements in space, such as crawling, and then by gradually fine-tuning their hand-eye coordination, until their eyes become adept not only at following their hands, but at leading their hands in finer and finer motions. Finally, after many integrated experiences of seeing, touching, and moving their hands and the rest of their bodies in three-dimensional space, young children develop an appreciation of visual forms as real objects, and the capacity to visualize objects without actually seeing them. Too much time spent in passively looking at two-dimensional representations of objects on a computer screen — or a television set — may interfere with this developing capacity.[19]

Children's basic visual skills are generally well-established enough by the age of 6 or 7 — that is, by first or second grade for most children — for them to comfortably focus on the kind of large two-dimensional representations of letters that teachers might draw on a classroom blackboard. Behavioral optometrists recommend that children of this age learn about letters first through direct physical engagement with them — perhaps by drawing or painting the letters as big as possible. This takes advantage of the deep perceptual learning that coordinating vision with gross motor skill encourages.

Expecting beginning writers to poke a letter key and then passively watch a letter appear on a screen can be hard on their eyes and an extra perceptual challenge, and thus may actually hamper the process of learning to write and read.

Grade-school children need even more frequent breaks from close computer work than adults do. That's because their muscular and nervous systems are still developing. It's not until about the age of 11 or 12 that their capacity to balance and coordinate the movement and the focusing of both eyes together is fully mature. Dr. Edward C. Godnig, a behavioral optometrist and author of *Computers and Visual Stress: Staying Healthy*, warns that intense computer use without proper breaks may delay the completion of that maturation into adulthood.[20]

Eye experts also note that it can be difficult to achieve the proper lighting and ergonomic conditions in the average classroom to protect children from straining their eyes. To reduce glare, the fluorescent lighting of many classrooms would need to be dimmed by at least half. But to read books or to write on paper in the same room, the lighting ideally would be at the higher level. Closing window blinds is another way to cut down on glare. But one recent study on classroom lighting found a clear correlation between the amount of natural lighting from the sun and student achievement on tests of math and reading. The authors of that study surmise that sunlight may have a positive effect on eyesight, health, or mood for students and teachers.[21]

Eye experts suggest that children maintain a distance of about two feet from the monitor to avoid visual fatigue.[22] But many children tend to lean as close as possible to the screen. This is a common, involuntary reaction that helps the learner literally "screen out" her peripheral vision, so as not to be distracted from the monitor. Also, ideally, children should be looking slightly down at the screen, at an angle of about 20 degrees, which research indicates is the most comfortable alignment of the eyes, the neck, and shoulders.

"Computers are adult-sized tools and children are having to adapt to them," says Dr. Jeffrey Anshel, a behavioral optometrist in Carlsbad, California, and an expert on computer-related vision problems. "So they're looking up at the screen, often at an awkward angle, for too long, and too close to it." Anshel adds that in his own practice he sees children suffering the "same type of near-point stress that adults do," and that they are developing near-sightedness at earlier ages than in the past.[23]

Some optometrists suggest that the rate of myopia, or near-sightedness, in childhood will increase as children are encouraged to use computers for long stretches at home and school.[24] And some say they are already seeing such an increase in their practice. Although myopia is often related to genetic factors, research suggests that it can also be environmentally induced, particularly by chronic conditions of close visual work.[25]

A pair of glasses may correct the immediate problem. But myopia itself may be a risk factor for other visual problems. It can interfere with children's sports activities and enjoyment of nature, and even limit their choice of career. Some studies have suggested that myopia may have a broader psychological impact — that myopic individuals may tend to be more introverted and to pay more attention to detail, instead of taking a more global, long-range point of view.[26]

Finally, some developmental optometrists suggest that Internet research, which involves scanning or reading long documents for meaning, requires the kind of visual skills and perceptual abilities that are generally not well-developed until about the age of 9, which would mean fourth grade, for many children. It also, of course, requires a child to be an accomplished reader.[27]

Eye experts agree that reading a book or printed page is less of a strain on the eyes than reading from a computer screen. Even Bill Gates of Microsoft has admitted as much. "Reading off a screen," said Gates in a speech, "is still vastly inferior to reading off of paper.… When it comes to something over four or five pages, I print it out and I like to have it to carry around with me and annotate."[28]

Chronic eye discomfort related to intense computer work is likely to exact a toll on student achievement. Research shows that some people respond to eye strain by simply avoiding the task causing it.[29]

Lack of exercise and obesity

Even before the recent push to computerize elementary education, obesity and other health problems related to children's increasing physical inactivity were on the rise. By 1994, the most recent year for which the federal government has statistics, nearly 14 percent of children in the U.S. ages 6 through 11 were overweight. In 1965, only 5 percent were. In 1994, an additional 20 percent weighed enough to be considered at risk of becoming obese.[30] Many health professionals believe childhood obesity has increased since 1994, in large part because children spend more time sitting in front of electronic media and less time actively playing, at home and school, and because they consume so many high-fat, high-sugar foods.[31]

> We have the most sedentary generation of young people in American history.
>
> — David Satcher, U.S. Surgeon General

"We have the most sedentary generation of young people in American history," warns U.S. Surgeon General David Satcher.[32]

The rate of Type 2 diabetes, a serious, incurable disease associated with obesity and which in the past was rarely diagnosed in childhood, is also now rapidly increasing among children.[33] Pediatricians report treating extremely obese children for what are normally adult complications of excess weight, such as obstructive sleep apnea and fatty liver, a precursor to cirrhosis.[34] Children who grow up obese also are at higher risk of other chronic health problems as adults, such as high blood pressure and heart disease.[35] Recent studies also suggest that at least some of the alarming rise in childhood asthma may be related to obesity, perhaps because lack of exercise may reduce the efficiency of a child's respiratory system.[36]

Lack of exercise is bad for learning. Child development experts emphasize that moving in three-dimensional space stimulates both sensory and intellectual development. According to educational psychologist Jane Healy, research with physically disabled children suggests that those who are restricted in freely moving around and applying all of their senses to exploring the world are at higher risk of developmental delays in seemingly unrelated mental abilities, such as comprehending abstract verbal concepts. "As a child learns to put movements in order, brain areas are primed to put words and ideas into a logical sequence," Healy writes in *Failure to Connect*.[37]

Increasing numbers of children are also being diagnosed with attention disorders. Some developmental specialists suspect that some of these children may be spending so much time sitting in front of televisions, video games, and other electronic media that their auditory and perceptual-motor skills are not up to the demands of classroom learning.[38]

Other researchers have noted that the demands of moving about in the real world provide a foundation for more advanced intellectual capacities. As a *Scientific American* article put it: "Human intelligence first solves movement problems and only later graduates to pondering more abstract ones."[39] Through time, the developing nervous system seems to transform actual physical experiences into mental adeptness in manipulating, categorizing, and comprehending abstract ideas. The artificial, two-dimensional environment of computer learning is no match for that.

Toxic emissions and electromagnetic radiation

The U.S. Environmental Protection Agency has identified 21 chemicals that are released in the vapors emitted by new computers and VDTs. The agency estimates that it can take from 144 to 360 hours for them to dissipate completely. In a 1995 report, the agency noted that "the implications of these emissions can be particularly significant in an indoor environment containing several new pieces of electronic equipment, e.g., a computer room in a school."[40] Office workers exposed to these emissions have experienced skin problems and ear, nose, and throat irritations.

VDTs also produce electromagnetic fields, or EMFs. Whether this radiation is dangerous, especially at the relatively low levels that computer monitors generally emit, is a controversial subject among scientists. Some early studies suggested a link between childhood leukemia and exposure to electromagnetic fields for families living near high-current electric wires.

An expert panel of the National Research Council concluded that no convincing evidence exists that exposure to electromagnetic fields from power lines, VDTs, or other home appliances was a threat to human health. The committee based its 1996 report on a review of about 500 studies. It did find a weak but statistically significant link between the incidence of childhood leukemia and living close to high-power lines. But it added that the results of research trying to establish whether the magnetic fields from the wires were actually implicated as a cause of the disease have been "inconsistent and contradictory." It could be that the higher rate of childhood leukemia is related to some other factor common to homes near power lines, the group added, such as poor air quality or pollution from heavy traffic.

But the panel called for more research on that question. It also called for more research on the relationship between exposure to electromagnetic fields and breast cancer in animals that have been exposed to carcinogens, and on why EMFs seem to affect the levels of the important hormone melatonin in animals. The same effect has not been observed in human beings.

In 1999, the U.S. National Institute of Environmental Health Sciences recommended, after a lengthy review, that EMF exposure continue to be recognized as a "possible" cancer hazard. But it also stressed the weakness of the evidence and "the low risk that may be involved." [41]

The release of radiation is highest from the backs and sides of terminals, but many schools place them either front to back, or too close, side to side. That may expose children to radiation from the VDT being used by a nearby child.

To be on the safe side, schools should at least be testing their own VDTs regularly and making sure that children sit some distance away from their own and others' monitors, since the radiation dissipates over a short distance. For older monitors, built before the mid-1990s, three feet is generally considered a safe distance.[42]

For years, the federal government has been warning private employers and employees about the physical health hazards of using computers intensively.[43] But it has done little to alert schools, teachers, or parents of the hazards for children, though it encourages the use of computers from kindergarten on up. In fact, the Department of Education has never conducted any studies of whether children using computers are at increased risk of repetitive stress injuries, or how to prevent such injuries, according to Carol Wacey, deputy director of the agency's Office of Educational Technology.[44]

All of these negative physical effects of children spending increasing amounts of time sitting at computers are among the most obvious hazards that computers pose to children's healthy development. Because they are so obvious, so serious, and yet still so widely ignored, they are also the most troubling. Children are captive audiences in the classroom. Unlike responsible businesses, however, few schools now have in place the kinds of health and safety precautions that would at least try to minimize the chances of computer injuries.

The Alliance for Childhood urges every parent, teacher, and policymaker to take immediate action to ensure that no child is subjected to work stations at school that are not ergonomically designed and adjustable for each student's height and size. If schools insist on requiring young children to use computers, they have a responsibility to take such precautions — and to share the legal liability for injuries if they do not. They also should provide the training and supervision that would be required to try to prevent children from straining their eyes or bodies in unhealthy ways at computer stations.

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Ironically, the U.S. National Institutes of Health, in a labor agreement covering all employees who routinely use VDTs, specifically acknowledges the dangers:

> ...there are certain ergonomic and environmental factors that can contribute to the health, safety, and comfort of VDT users. These factors involve the proper design of work stations and the education of managers, supervisors, and employees about the ergonomic, job design, and organizational solutions to VDT problems as recommended in various studies on VDT usage. The Agency agrees that employees should be provided information about ergonomic hazards and how to prevent ergonomically-related injuries... It is also agreed that when equipment is purchased, to the extent possible, training should be provided by the vendor on how to safely and properly operate the equipment.[45]

It's appropriate, of course, for the government to so warn its own employees. But who will take official responsibility for warning teachers and children?

One reason why schools have not confronted this problem is that correcting it may be practically impossible. In any one class, there is a wide range of heights and sizes among students, and individual children grow unpredictably over the year. Purchasing and setting up equipment to accommodate these differences, and trying to train young children to adjust their posture and to continually readjust the chairs and keyboards they share with others would be a massive and perhaps futile effort. In fact, adjustable child-size furniture is not widely available or affordable at this time. Cornell University's Website with recommendations for schools notes that adjustable furniture is often difficult even for adults to operate. It adds that young children may not yet be aware of how their bodies are oriented in space, so expecting them to maintain correct posture without constant reminders might not be reasonable.[46]

Risks to Emotional and Social Development

Child-development experts like Dr. Stanley I. Greenspan, the former director of the Clinical Infant Development Program at the National Institute of Mental Health, warn that an emphasis on computers in childhood exacerbates the tendency for our increasingly rushed and impersonal culture to harm the emotional development of children. And that, they add, will take a toll on their intellectual, social, and moral development as well, because emotions guide human learning and behavior.

"So-called interactive, computer-based instruction that does not provide true interaction but merely a mechanistic response to the student's efforts," says Greenspan, is one more sign of "the increasingly impersonal quality that suffuses the experience of more and more American children." As children at all income levels grow up with less nurturing at home and school, he adds, "we can expect to see increasing levels of violence and extremism and less collaboration and empathy."[47]

The most important gift that parents can give a child to spur their mental development, Greenspan adds, "is not a good education, elaborate educational toys, or summer camp, but time — regular, substantial chunks of it spent together doing things that are naturally appealing to the child." A single parent, for example, "could consider leaving the television or computer off and recruiting a little interactive partner or partners in daily routines of cleaning, cooking, and shopping."[48]

> Children ages 2 to 18 spend on average about 4 hours and 45 minutes a day outside of school plugged into electronic media of all kinds.

'Isolated lives'

But by 1997, parents were already spending about 40 percent less time with their children than they had 30 years before.[49] With the recent surge in the purchase of home computers, laptops, and home connections to the Internet, as well as school connections, children are likely to spend even less time interacting face-to-face with parents, teachers, and friends. A 1999 study by the Kaiser Family Foundation concluded that children ages 2 to 18 spend on average about 4 hours and 45 minutes a day outside of school plugged into electronic media of all kinds. About 65 percent of the older children, ages 8 to 18, had televisions in their bedrooms, and 21 percent had personal computers.[50]

Another recent study estimated that children between the ages of 10 and 17 today will experience nearly one-third fewer face-to-face encounters with other people throughout their lifetimes as a result of their increasingly electronic culture, at home and school.[51]

"Kids are living much more isolated lives than ever before," Kay S. Hymowitz, author of *Ready or Not: Why Treating Children as Small Adults Endangers Their Future — and Ours*, told *U.S. News & World Report*. "They just disappear into their rooms and spend all of their time with [these] media."[52]

Developmental experts say the intense challenges of face-to-face interactions offer children the most emotionally maturing experiences. But even when teachers and students are together in the classroom, they may be distracted from each other by the powerful new information technologies in their midst.

Proponents of computers in schools argue that they shift the classroom focus to the student instead of the teacher, whose traditional role they describe as the ineffective "sage on the stage." In the high-tech classroom, they suggest, the teacher becomes "guide on the side," encouraging students to take charge of constructing their own education. The result is supposed to be "student-centered" education.

The new sage on the stage

But the ubiquitous pictures in the news media of both students and teachers concentrating intently on a computer screen — instead of each other — clearly illustrates a new sage dominating center stage. The actual shift is to computer-centered, not student-centered, education.

"Nearly half of the staff development courses are now basic computer training," observed Lowell Monke in 1997, speaking of the Des Moines (Iowa) Public Schools, where he was then teaching advanced technology classes. "As I listen to teachers and administrators discussing educational issues now, as opposed to three years ago, I hear much less attention directed toward what is going on inside our students, and much more toward what goes on with the tools they use."[53]

The essence of education is neither the teacher, the students, nor the subject of study alone, but rather the liveliness of the relationship among the three. Students are inspired to learn by the enthusiasm of a teacher they respect — the teacher's enthusiasm, that is, for both the students themselves and the world the teacher is introducing to them.[54]

Research by the Israeli psychologist Reuven Feuerstein on Down syndrome, for example, indicates that even children with severe learning problems can make surprising educational progress when they have an attentive teacher who consciously, consistently, and imaginatively finds ways to directly mediate between the child and the world. The teacher serves as the ideal model for the child of an engaged, competent learner. She also helps the child translate the world's meaning — moral and emotional meaning as well as intellectual — into the child's own words, so to speak. Only a human being, not a machine, can model this uniquely human kind of learning.[55]

Grade-school teachers, the majority of whom are women, are the real classroom experts with both the training and the commitment to work personally with children. Today, however, they often face intense pressure from supervisors or technology coordinators, who are frequently men, to incorporate computers into the curriculum. The teachers themselves often judge the technology to be not particularly beneficial for their young students. Little research has been done to uncover the role of gender in the politics of educational technology or the impact of this pressure on schools' ability to retain strong teachers.

There is anecdotal evidence, however, that teachers are being pressured—or even coerced—into implementing high-tech solutions that may run counter to their own professional judgment.

The male technology coordinator at one inner-city school in Washington, D.C., for example, candidly conceded to an outside observer that teachers who were not enthusiastic about his school's new high-tech approach to learning had been encouraged to retire or seek transfers to other schools, and that several had done so. He volunteered that he was considering encouraging the principal to get rid of one remaining kindergarten teacher, solely because he believed the children in her class did not spend enough time on computers.[56]

Given the dazzling graphics and animations of the latest software — which may be highly entertaining without being particularly educational — and the daily challenge of keeping so much sophisticated equipment up and running, and frequently updated, how could attention not shift to the machines in the classroom?

Less self-motivation

Computers are invariably said to be highly motivating to students. But those who make this assertion rarely provide specific evidence for their claim. They rarely attempt to quantify the presumed increase in motivation, or to determine whether girls and boys are equally enthusiastic about the new technical overlay to every subject of study. They rarely offer evidence of how this supposed boost in motivation has led to any deeper or broader learning. Nor do they examine whether any number of other educational techniques—using artistic activities to bring the subject alive, for example—might not have boosted motivation in less expensive and more age-appropriate ways.

A recent study by the American Association of University Women Educational Foundation challenges the notion that computers routinely motivate classroom learning. Many girls, it found, are bored by computers. And many boys seem more interested in violent video games than educational software.[57]

Other researchers have suggested that young students often seem to be mesmerized by, and some even addicted to, the action on their screens, rather than motivated to learn. A fascination with technology, they caution, is not the same thing as a motivation to learn about educational subjects beyond the technology itself. Even some software producers admit that the most mesmerizing educational software may be more entertaining than educational.[58]

On the other hand, some studies have indicated that any initial academic gain generated by bringing computers into the classroom may dissipate as the novelty of the technology wears off for both students and teachers. To some extent, this would seem to be a matter of common sense. Eventually, students tend to become just as jaded about surfing the Internet as anything else, say experienced teachers.[59]

Research indicates that the most troubled schools can improve the educational performance of their students by strengthening teacher-student bonds and making other, people-oriented changes to foster a strong sense of community.[60] But the huge costs of purchasing, maintaining, and constantly updating computers and training teachers and students to use them has made it difficult for schools to hire additional, qualified teachers to reduce class size and to give the most disadvantaged and challenging students the personal attention they need.

Researchers often hypothesize that the shared excitement generated by new technologies in the classroom can itself boost the sense of community at the classroom and school level, and encourage student collaborations and faculty exchanges. The evidence for how lasting or how much related to learning such effects really are, however, is thin. Much of the research is sponsored by high-tech companies, and the reports of results rarely provide objective measures to prove the sweeping conclusions researchers draw about the positive effects of computers on student collaboration and motivation. Yet federal officials and others frequently cite such work as proof of technology's benefits. Meanwhile, educators have noted that computer-aided collaboration may spark classroom conflict as well as cooperation.

Detachment from community

Instead of boosting the sense of community, highly computerized schools may actually weaken it, especially as Internet and e-mail options proliferate. Few researchers have investigated this possibility. But a special report published by the U.S. National Science Board in 1998 included an unusual federal admission that prolonged exposure to a computing environment may harm children's emotional and psychological development in ways that would hardly build strong communities. Citing the work of Sherry Turkle, professor of sociology at M.I.T., the report stated: "Computing and cyberspace may blur children's ability to separate the living from the inanimate, contribute to escapism and emotional detachment, stunt the development of a sense of personal security, and create a hyper-fluid sense of identity."

The Science Board panel added: "Turkle raises the possibility that extensive interaction with cyberspace (especially through multi-user domains) may create individuals incapable of dealing with the messiness of reality, the needs of community building, and the demands of personal commitments."[61]

The commercialization of childhood

The emphasis on connecting every child to the Internet raises a host of issues related to exposing children to a flood of commercial messages promoting everything from candy and electronic toys to pornography, violence, drugs, and race hatred.

As one school librarian in Greenville, South Carolina told her local newspaper, "It doesn't matter if you put 100 software filters on there. You can still get around them if you want to."[62]

She was speaking of pornography. But commercialism is even more difficult to escape. Many companies now intentionally direct a barrage of commercial messages at young children on the Internet. Sites designed to captivate young children often promote early sexual behavior, sugary foods, and a limitless craving for new products.

"Generation X is going to give way to Generation Excess," warns Betsy Taylor, executive director of the nonprofit Center for a New American Dream, which opposes the commercialization of childhood.[63]

The Website of MaMaMedia.com, for example, promotes itself as presenting "playful learning" activities aimed at children 12 and under, based on extensive research at Harvard and M.I.T. The co-founder of M.I.T.'s prestigious Media Lab is listed as chairman of MaMaMedia's advisory board.[64] The site also features the names of its commercial sponsors — which include the producers of high-sugar drinks and foods and video games. The site links children to one advertiser's new release, "X-Men Mutant Academy," which will allow young children to "Brawl your way around the world, one opponent at a time."[65] It also links children to the Websites of a long list of candy companies. On one link children are able to download a screensaver of Hershey's Miniatures "stacking up before your eyes," or "Flying Reese's Peanut Butter Cups," thereby setting up their own background ad for a chocolate break.

The high cost of technology is leading some schools to make deals with companies that provide free or leased computer equipment and telecommunications services in exchange for online advertising opportunities. Even SesameStreet.com, which caters to preschoolers, makes available to advertisers "a variety of ad models from targeted banner campaigns to premium sponsorships."[66]

Marketing consultants like Roper Starch Worldwide now survey children ages 6 to 17 about their "hopes and dreams ... their daily lives, what they love and hate on TV and why, what they buy and why they buy it, what they do online." Why should companies be interested in buying this information? Because this generation is the largest ever, representing "the supreme opportunity to today's marketers of youth products."[67]

Another site, iCanBuy.com, was created to let children of all ages shop directly over the Internet by first setting up accounts that draw on their parents' credit cards, with parents' permission. The site, in a nod to moral rectitude, also includes a page from which children can direct donations to their favorite charities. Here, former Spice Girl Geri Halliwell promises to reward them for such altruistic behavior with a "free gift with every donation you make!" The more children contribute, the more free autographed products they get. And, by the way, children can also point and click on the same page to purchase Geri's new CD. The message to young children could not be clearer — never give anything without first making sure exactly what you will get in return.[68]

Some responsible proponents of Internet learning suggest that "media education" — lessons in how to appraise critically the biases and subtle messages promoted by the media — will protect children from such commercialism. Teen-agers would surely benefit from such a direct appeal to the kind of logical, abstract reasoning that such critiques require. But what of five-year-olds, for whom abstract reasoning is not a realistic expectation? And must we train every young idealist to be a cultural skeptic, or worse, a jaded cynic?

Few adults are capable of resisting, day in and day out, the relentless, sophisticated marketing ploys that some of America's most creative minds have designed, aided by professional psychologists and anthropologists paid to advise corporations on how to manipulate consumer behavior. What then of children, who are now the targets of intense consumer research? To be a child, after all, is to have the right to be immature and to need adult guidance and adult protection.

It is neither fair nor realistic to expect young children to be intellectually, emotionally, and morally mature enough to exercise advanced critical thinking skills in the face of commercials scientifically calibrated to target their most vulnerable emotions.

The American Academy of Pediatrics, in a policy statement on children and advertising, notes that the ancient Code of Hammurabi "made it a crime, punishable by death, to sell anything to a child without first obtaining a power of attorney." It also reports on "numerous studies documenting that young children under 8 years of age developmentally are unable to understand the intent of advertisements and, in fact, accept advertising claims as true." Its conclusion is blunt: "The American Academy of Pediatrics believes advertising directed toward children is inherently deceptive and exploits children under age 8 years of age."[69]

And what of older children? They do not suddenly become fully capable of critical judgment at the age of 9. In fact, the adult content and come-ons so common on the Internet are a powerful illustration of why it is inappropriate for children.

"Having the Internet in the classroom," one commentator has said, "is like equipping each classroom with a television that can be turned on at any time and tuned in to any of 100,000 unrestricted channels, only a tiny fraction of which are dedicated to educational programming (and even those have commercials). The Internet isn't about education. It's about marketing."[70]

Risks to Creativity and Intellectual Development

Computers, which are supposed to accelerate the pace of children's cognitive development, reflect the same mechanistic approach to education as a narrow focus on raising standardized test scores. Because all aspects of children's growth are so well integrated, however, the concentration on cognitive skills, narrowly conceived, actually can backfire. Failing to meet children's emotional and physical needs, as discussed above, can take a toll on academic learning as well.

But even as tools narrowly focused on cognitive development, computers do not appear to be a promising technology for elementary education. Their sheer power seems more likely to repress the development of important intellectual capacities than to enhance it.

Stunted imagination

Creativity and imagination, for example, are critical to intellectual insights and sophisticated problem-solving in just about every academic domain. Creative work draws on a child's own inner resources — including originality, playfulness in generating ideas, and vigor and perseverance in carrying them out. Similarly, imagination involves the capacity to bring to life pictures of one's own in one's own mind.

Teachers find that today's video-immersed children can't form original pictures in their mind or develop an imaginative representation.

—Jane Healy, Educational Psychologist

Children who are exposed to a heavy electronic diet of television, the Internet, video games, and multimedia are bombarded with ready-made images, often cleverly animated and quickly swapped with a point and a click, literally leaving nothing to the imagination. Entertained constantly and effortlessly by so many adult-generated images, children seem to be finding it harder to generate their own images and ideas.

Educational psychologist Jane Healy, a former school principal, notes that creativity involves the ability to generate "personal and original visual, physical, or auditory images – 'mind-images' in the words of one child." But she adds: "Teachers find that today's video-immersed children can't form original pictures in their mind or develop an imaginative representation. Teachers of young children lament the fact that *many now have to be taught* *to play symbolically or pretend* — previously a symptom only of mentally or emotionally disordered youngsters."[71]

Some scientists suggest that popular simulation programs that many schools are using to teach biology and other subjects will dampen the natural, open-ended curiosity and creativity of children. They may lead students to passively accept that the programmed constraints of the simulations neatly capture what is actually a far more complex and less predictable reality. One physicist put it this way: "My concern is that we are tending to expose students to too many contrived, controlled versions of reality rather than nature as its raw, untidy self. If our schools' curricula included an hour of birdwatching or rock collecting, or fossil hunting or astronomical observing for every hour spent in virtual reality, I could be content, but increasingly that seems not to be the case."[72]

Software designers often limit their own attempts to be imaginative to clever animations that draw heavily on fantasy. For grade-school children, however, imagination is a much broader quality, a powerful technique that they naturally tend to use at this age to grasp "from the inside" the real qualities of the world they are exploring. They apprehend the world with their imaginations, which requires that they form their own internal images. By encouraging children in grade school to think in as clear and emotionally compelling pictures as possible, adults help them lay a solid foundation, based in material reality, for later mastery of more advanced forms of thinking. The latter entails logical abstractions, such as conscious considerations of cause and effect.

Douglas Sloan, professor of history and education at Teachers College of Columbia University, has asked: "What is the effect of the flat, two-dimensional, visual, and externally supplied image, and of the lifeless though florid colors of the viewing screen, on the development of the young child's own inner capacity to bring to birth living, mobile images of his own?"[73]

So the issues of creativity and imagination are crucial in elementary education. Unfortunately, like many other questions about the negative impact of computers in childhood, almost no research has been conducted on the potential for computers to stifle children's creativity and imagination. The results of the only well-known study on creativity, however, are not reassuring. It found that preschool children scored significantly lower on measures of creativity after using a popular software package designed to teach reading.[74]

In one sense, at least, teachers themselves are under pressure to be less creative in the classroom. Once they were rewarded for bringing a lesson alive by using, or even recycling, the cheapest materials available in creative ways. Teachers and parents alike encouraged children to be resourceful in using simple materials like crayons, cardboard, and string. Instead, teachers now are often expected to narrow their vision to lesson plans that must incorporate the most expensive equipment available.

Similarly, children's work is now too often judged to be an "authentic product" only if it mimics the slick commercial presentations that adults produce in high-tech offices with computer-generated art, spreadsheets, videos, word-processing, PowerPoint presentations, and other sophisticated software. This devalues children's hand-drawn artwork. Proponents of such narrowly defined "authenticity" even suggest that the technical polish of such "products" makes schoolwork "seem real and important."[75] This emphasis on glossy production values seems calculated to distract both teachers and students from the curricular content and developmental goals that were the point of the project. Instead, the emphasis becomes mastery of technical skills that children don't really need and that will soon be obsolete in the workplace anyway.

Loss of wonder

Computer use may also undermine the sense of wonder and reverence that young children typically bring to their encounters with the real world of rocks, bugs, and stargazing. Such wonder, especially if parents and teachers share in it, can powerfully motivate young learners in the healthiest way possible.

When preserved throughout childhood, this reverence for the beauty and goodness of life can also inspire older students to feel a devotion to truth, one of the most powerful motivations for more mature intellectual work. And young adults, with these healthy capacities intact, are likely to be motivated to transform what they have learned into a resource for their own moral deeds in service to the world.

Without these capacities, it's tempting to treat knowledge as a collection of useful facts and figures that an individual — or even an entire culture — can exploit solely for one's own entertainment or private gain. In short, a child's wonder may later bear fruit in the adult's sense of responsibility for his community and for the larger ecosystems that sustain human life itself.[76]

How does an intense focus on learning about nature and every other aspect of the world through a computer screen affect a child's sense of wonder? It would be difficult to design a study to answer that question. But like other profound questions about how computers are changing children's inner lives, it is too important to ignore.

What happens to the capacity for quiet wonder, for example, when children are regularly bombarded with cartoonish graphics that are far louder and flashier than the real thing, or sanitized, edited versions of reality that don't give them a chance to get their hands dirty? When laptops and other electronic paraphernalia become necessary gear, interfering with a direct experience of nature, on those rare occasions when children are allowed to venture out into the real world? And when children are required to reduce their encounters with nature, often imaginative and emotionally rich experiences in their own right, into data to feed into slick, computer-generated charts and graphs?

Impaired language and literacy

Language and literacy skills are another area of concern when children are on a high daily dose of electronic media. Supportive social interactions with more competent language users is "the one constant factor that emerges" in studies of how children become able speakers, readers, and writers, research psychologists Alison Garton and Chris Pratt concluded after an extensive review of the literature.[77]

But the time spent with computers and other electronic media may distract both children and adults from directly communicating with one another, face to face, weaving together the rich variety of spoken and unspoken cues such interactions encourage. That, literacy experts warn, may place children at risk of language delays. In addition, too few chances for such communication, if extended throughout childhood, may permanently limit children's ability to express themselves in speech or in writing, to comprehend fully what they read, and even to understand themselves and to think logically and analytically.[78]

All of these capacities are rooted in language. Progress in each domain, in turn, enriches a student's language skills. Research charting literacy development has shown that those skills are still very much being developed after children enter school.

"Although we marvel at the magnitude of children's language use at the point of school entry, as clearly as they have learned a great deal about language in a relatively short period of time, they still have a great deal more to learn," Garton and Pratt note. "The years from 5 onwards must be regarded as a time when language skills are consolidated and expanded."[79]

With children spending more time alone with TVs and computers instead of interacting with others, they come to school in need of more, not less, spoken conversation with responsive adults. Is it wise for schools to exchange face-to-face time with teachers for hypertext and hypermedia?

So-called "interactive" software designed to monitor students' performance, correct their errors, modify the pace of lessons accordingly, and even give them programmed encouragement to keep trying obviously can't substitute for the dynamic exchanges, verbal and nonverbal, that a teacher who knows and loves her students can initiate. Literacy is a social enterprise that is threatened when children's social interactions are impoverished.

Barry Sanders, professor of English and the history of ideas at Pitzer College, warns of this in his 1994 book, *A Is for Ox: Violence, Electronic Media, and the Silencing of the Written Word:*

> Every person or group of persons who move into literacy first build a foundation for reading and writing in the world of orality. Orality supports literacy, provides the impetus for shaping it. The skills ones learns in orality are crucial because literacy is more than a series of words on paper. It is a set of relationships and structures, a dynamic system that one internalizes and maps back onto experience. A person's success in orality determines whether he or she will "take" to literacy.… But the way has been blocked. It has been blocked by electronic machinery of every conceivable kind, from TV and movies, through records and CDs, to PCs and video games. Before teachers and parents begin to think about raising literate children, they must first ensure their beings as creatures of orality.[80]

Sanders adds that "good readers grow out of good reciters and good speakers."[81] Then, as a child matures, his success in reading and writing nurtures his "innermost, intimate guide, the self."

So any threat to language and literacy may limit children's "inner voice" — their capacity to tell themselves stories and talk themselves through academic or other problems. "This inner speech," notes Jane Healy, "originates from talking with adult caregivers — and then having enough time and quiet space to practice it alone.… Inner speech is important to academic as well as personal development. From ages six to nine, gains in math achievement as well as in other subjects are related to the use of self-talk. ('How should I do this problem — oh, I think I'll try….') Delays in acquiring and using 'self-talk' may interfere with attention and behavior, as well as effective performance in sports."[82]

Poor concentration

Healy and other experts suggest that many current uses of computers in schools may be encouraging unhealthy habits of mind. Success in school requires children to pay attention in a focused way and to develop their memories and their listening skills. More children than ever before, however, are being diagnosed with attention disorders and placed on powerful drugs to help them concentrate. The multiple options of many software programs and the endless chain of links the Internet presents already make it tough for a child to keep her mind focused on a particular subject or task. And the need for children to take breaks from the computer every 20 minutes to avoid physical stress, as Hedge has recommended, seems likely to make it even harder for children to sustain their concentration.

Marilyn B. Benoit, president-elect of the American Academy of Child and Adolescent Psychiatry, has coined the term "dot.com kids" to describe the negative impact on children of being able to command so many entertaining images and messages with just a click of the mouse. Children's brains, she suggests, are overstimulated by the pace and attention-grabbing nature of multimedia technology. She notes the rise in diagnoses of attention deficit hyperactivity disorder and asks whether it is related to "children's constant exposure to rapid-fire stimuli to the brain."

Little patience for hard work

Instant gratification, Benoit adds, may make it harder for children to tolerate frustration, which, in turn, may lead to episodes of explosive rage when they cannot have what they want, when they want it:

> I am impressed by the apparent link between technology, instant gratification, poor frustration tolerance, lack of empathy, and aggression. While I do not propose that technology is the cause of the episodes of horrific violence we have seen in young people in recent years, I do think that we should be mindful of some of the negative impacts of our technologies... I contend that the combination of decreased parental protection and increased instant gratification changes the psychology and undermines the socialization of the developing child. When frustration tolerance is not acquired, modulation and management of aggression is compromised, and we see children like those who are now labeled "explosive" children. Excluding those children with neurobiological deficits, psychiatry describes such children as "narcissistic" and their explosiveness as "narcissistic rage." They are children who are unable to cope with the slightest of frustrations, and lash out aggressively. They are entitled, demanding, impatient, disrespectful of authority, often contemptuous of their peers, unempathic and easily "wounded." Their numbers are increasing. We must take note of this disturbing trend and intervene with some urgency if we are to raise children who will care about others in society.[83]

Jane Healy suggests that much educational software amounts to "electronically sugar-coated 'learning' that may spoil children's appetite for the main course." She adds:

> Learning is, indeed, fun, but it is also hard work. In fact, working hard, surmounting challenges, and ultimately succeeding is what builds real motivation. Any gadget that turns this exciting and difficult process into an easy game is dishonest and cheats the child out of the joy of personal mastery. Encouraging children to "learn" by flitting about in a colorful multimedia world is a recipe for a disorganized and undisciplined mind....
>
> Accessing or memorizing isolated information, or dabbling at an occasional skill sandwiched amidst an entire loaf of intellectual Wonder Bread, has nothing to do with true learning, which requires making meaningful connections between facts and ideas. Today's children

> are overpowered with data and special effects, but teachers report they have trouble following a logical train of thought or linking ideas together.
>
> Finally, some of the "habits of mind" fostered by this software are dangerous, to wit: impulsivity, trial-and-error guessing over thoughtful problem-solving, disregard of consequences, and expectation of overly easy pleasure.[84]

Plagiarism

Emphasizing Internet research makes plagiarism far more tempting to students. And the subtle shift in focus from their inner intellectual growth to how professionally they present computer-generated projects may make many students wonder what's the difference if they plagiarize or not. As one high-school sophomore remarked after downloading an essay on healthy eating — in Spanish — from the Internet to fulfill a classroom assignment: "I didn't think it was cheating because I didn't even stop to think about it."[85]

And as a high school teacher in Wisconsin noted: "We're somehow not able to convince [students] of the importance of the process. It's the product that counts."[86]

Distraction from meaning

Jeffrey Kane, dean of education at the C. W. Post Campus of Long Island University, argues that teachers, parents, and children may be too dazzled by classroom information technologies to focus much at all on the child's inner experience of meaning. He defines meaning as "a form of inner awakening in response to an encounter," and tells the following story:

> Recently, I visited a sixth-grade classroom where children were studying the Renaissance. They used the Internet to find information about the period. They prepared their reports by using word processing and graphic programs, including video and audio components. The children proudly demonstrated their reports, and the teacher complimented their work by telling me that they knew more about the software used than did she. The reports contained a reasonable amount of information, the kind that would be available in any text, and they showed a great deal of effort in combining the various media.
>
> However, I did not get the sense in talking with them that they internalized much of the drama and cultural richness of the Renaissance. They did not get a vivid picture of the lives of the painters, their motivations, pains, and imaginations. They did not acquire the compelling insights that would come from reading a book such as Giorgio Vasari's *Lives of the Most Eminent Italian Painters, Sculptors, and Architects*, a collection of firsthand biographical sketches written during the Renaissance. The Internet and databases the children used were not conducive to reading such a book. From what I've seen in classrooms, the technologies used have almost no place for books at all. In this case, the children looked for information, got it, and moved on to the presentation. The teacher did not guide them further to experience some of the inner meaning of the period, of the unfolding of new aesthetic and intellectual capacities played out on the scale of individual lives. Rather than pursue the richness of the Renaissance as a foundation for new visions and insights within themselves and in the world, the children learned to use the software programs available. They learned more about how to think like computers than like the people of the Renaissance.
>
> Although one may argue that the Internet and computer searches of various sorts could produce the information I describe, the fact remains that neither the teacher nor the students had any sense that something was

WARNING: Computers May Be Hazardous to A Child's Health

Emphasizing computers in childhood may expose children to the risk of a broad range of developmental setbacks. Potential hazards include the following:

Physical Hazards
- Musculoskeletal injuries
- Visual strain and myopia
- Obesity and other complications of a sedentary lifestyle
- Possible side effects from toxic emissions and electromagnetic radiation

Emotional and Social Hazards
- Social isolation
- Weakened bonds with teachers
- Lack of self-discipline and self-motivation
- Emotional detachment from community
- Commercial exploitation

Intellectual Hazards
- Lack of creativity
- Stunted imaginations
- Impoverished language and literacy skills
- Poor concentration, attention deficits
- Too little patience for the hard work of learning
- Plagiarism
- Distraction from meaning

Moral Hazards
- Exposure to online violence, pornography, bigotry, and other inappropriate material
- Emphasis on information devoid of ethical and moral context
- Lack of purpose and irresponsibility in seeking and applying knowledge

missing. The "lessons" reflected a fascination with technology, rather than with the capacities for human experience and vision identifying the Renaissance.[87]

Risks to Moral Development

If schools treat the child as an object, a kind of "biological computer," then education becomes a matter of calculating how most efficiently to train children to collect, sort, store, analyze, and apply information. The fact that information technologies are dramatically reshaping the economy reinforces the notion that children are "the Nation's intellectual capital," as the influential 1983 report *A Nation at Risk* suggested.

"What is lost in all this," writes Jeffrey Kane, "is that children are human beings whose minds are not a *public or corporate* resource. The source of the error is in assuming that children *have* intelligence, rather than that they *are* the embodiment of intelligence. Children not only process information but also exist as self-conscious human beings who construct meaning in their thinking." And schools, whether they intend to or not, have a profound impact on how children discover or create meaning for themselves. "Every fact imparted, every thinking skill emphasized, however subtle, opens some possibilities for meaning and may close others."

In other words, for children, all education is moral education. From this perspective, a concept like "'Web-based education" is an oxymoron, because moral education requires moral educators. As Kane puts it:

> The educational imperative of our day is not to cultivate intellectual capital for the economy; it is not to teach children to process bits of information in formal ways to solve problems; and it is not to get them to store as much discrete information where "more" and "earlier" are the rule. It is to guide children in their development as whole persons; it is to help them to learn through direct and varied forms of encounter with the world as a foundation for clear, rigorous thinking; it is to bring all the resources of the culture to help them experience meaning, identity, purpose, and responsibility in the whole of life; and it to address the "I am" as being, rather than as abstraction or capital.[88]

A Massive National Experiment

Schools are spending so much money — and so much time — on computers that many are cutting essential programs to try to keep up with the latest technology. Schools pushing intense academics in kindergarten, for example, often now linked to computers, have to sacrifice recess and creative play time — the very activities that researchers have identified as "warm-up" exercises for the young mind that pay off in academic achievement later.

Despite the Pandora's box of hazards outlined in this chapter, corporate, government, and school officials are proceeding at full speed with plans to radically transform kindergarten and grade-school classrooms with high-tech machinery.

A panel of President Clinton's top advisers on science and technology recognized this as the massive national experiment that it is. Our children are the experimental subjects. That presidential commission called for stepping up this massive experiment, with no mention of how children will be protected from the risks to their health and well-being. It pointed to the tremendous amount of money the federal government invests in pharmaceutical research in arguing for large increases in research spending to promote the use of computers in education. But the panel failed to note that the clinical trials required before new drugs can be approved are so expensive precisely because drug companies are required, by federal law, to prove, above all, that new medications are safe, and, after that, that new drugs are effective in treating the conditions for which they are to be prescribed.[89]

There are few examples, in the decades in which federal agencies have been actively promoting computers in elementary education, of federal funding for research designed to examine whether this prescription really is safe for children. The effects on children's health of this massive experiment have simply not been considered.

1 Seymour Papert, *Mindstorms: Children, Computers, and Powerful Ideas,* New York: Basic Books, 1980, p. 27.

2 Esther Thelen, "Motor Development," *American Psychologist*, Vol. 51, No. 11, 1996, pp. 1134-1152; and Phyllis S. Weikart, "Purposeful Movement: Have We Overlooked the Base?" *Early Childhood Connections,* Fall 1995, pp. 6-15.

3 American Occupational Therapy Association, "Repetitive Motion Injury," www.aota.org, as of March 22, 2000.

4 Armstrong and Casement, op. cit., p. 144.

5 Bruce P. Bernard (editor), "Musculoskeletal Disorders (MSDs) and Workplace Factors: A Critical

Review of Epidemiologic Evidence for Work-Related Musculoskeletal Disorders of the Neck, Upper Extremity, and Low Back," DHHS, (NIOSH) Publication No. 97-141, Washington, DC: U.S. Department of Health and Human Services, July 1997.

6 Occupational Safety & Health Administration, "Women and Ergonomics," *Ergonomics Fact Sheet,* Washington, DC: U.S. Department of Labor, March 2000.

7 Dr. David Diamond, Massachusetts Institute of Technology Medical Center, telephone interview, June 30, 2000.

8 Brendan Connell, telephone interview, July 28, 2000.

9 Dr. Margit L. Bleecker, telephone interview, August 1, 2000.

10 Pearl Gaskins, "I Didn't Think Typing Would Hurt Me," *Scholastic Choices*, March 1999; Susan Gregory Thomas, "Kid Wrists at Risk," *U.S. News & World Report,* July 5, 1999; Abby Fung, "RSI Attacks the Next Generation," *Boston Globe,* Sept. 29, 1998.

11 S. Oates, G. Evans, and A. Hedge, "A preliminary ergonomic and postural assessment of computer work settings in American elementary schools," *Computers in the Schools*, 1998: 14, 3/4, 55-63. See also K.L. Laeser, L.E. Maxwell, and A. Hedge, "The effects of computer workstation design on student posture," *Journal of Research on Computing in Education*, 1998: 31(2), 173-188.

12 OSHA, "Women and Ergonomics," U.S. Department of Labor, www.osha-slc.gov/ergonomics-standard/fs-women.html, as of March 2000.

13 Courtenay Harris and Leon Straker, "Survey of physical ergonomics issues associated with school children's use of laptop computers," *International Journal of Industrial Ergonomics,* in press.

14 L. Straker, K. Jones, and J. Miller, "A Comparison of the Postures Assumed when Using Laptop Computers and Desktop Computers," *Applied Ergonomics,* Vol. 28, 1997, pp. 263-268.

15 Alan Hedge (professor of ergonomics and director of the Human Factors and Ergonomics Laboratory, Cornell University), "Risks of Keyboarding," Cornell University Ergonomics Website:http://ergo.human.cornell.edu/Mbergo/schoolguide.html, as of March 2000.

16 Lawrence Calhoun, "VDT's Through Rose-Colored Glasses," *American School and University,* Vol. 56, No. 16: January 1984, p. 16; Armstrong and Casement, pp. 150-153; and Weldon G. Bradtmueller, "Perception of the Use of High Technology in the Teaching of Reading: Microcomputer Use in Teaching Reading," ERIC Database (ED246396), 1983.

17 National Institutes of Health, "Safety Notes Number 11: Safety and Health Program for Video Display Terminal VDT Operators," July 25, 1994.

18 U.S. National Institute for Occupational Safety and Health, "Potential Health Hazards of Video Display Terminals," as referenced in the online Health and Safety Manual of the U.S. National Institute of Environmental Health Sciences (www.niehs.nih.gov/odhsb/manual/man11f.htm, as of March 22, 2000). Also, Dr. Jeffrey Anshel, e-mail communication, July 26, 2000.

19 Shirley Palmer, "Does Computer Use Put Children's Vision at Risk?" *Journal of Research and Development in Education*, 1993: Vol. 26, No. 2, p. 59-65.

20 Edward C. Godnig, telephone interview, August 1, 2000.

21 Kenneth J. Cooper, "Study Says Natural Classroom Lighting Can Aid Achievement," *Washington Post,* Nov. 26, 1999; and Warren E. Hathaway, *The Effects of Types of School Lighting on Physical Development and School Performance of Children*, Edmonton: Alberta Department of Education, March 1994.

22 The American Optometric Association, for example, recommends placing monitor screens about 20 to 26 inches from the eyes and about four to nine inches below eye level. See AOA, "New Release: Computer-Related Vision Woes Can Be Solved," AOA,1997.

23 Dr. Jeffrey Anshel, e-mail communication, July 26, 2000. Anshel is the author of the 1998 book, *Visual Ergonomics in the Workplace.*

24 Shirley Palmer, op. cit. See also W. Jaschinski-Kruza, "Transient Myopia after Visual Work,"

Ergonomics 1984: Vol. 2, no. 11, pp 81-89; and H. Yoshikawa and I. Hara, "A Case of Rapidly Developed Myopia among VDT Workers," *Japanese Journal of Industrial Health* 1989: Vol. 31, No. 1, pp. 24-25.

25 American Optometric Association, "Common Vision Conditions: Myopia," 1997: www.aoanet.org.

26 Edward C. Godnig, telephone interview, August 1, 2000.

27 Ibid.

28 Quoted in Robert Darnton, "The New Age of the Book," *The New York Review,* March 18, 1999, p. 5.

29 Armstrong and Casement, pp. 150, 218; and Bradtmueller, op. cit.

30 Office of Communication, Media Relations, U.S. Centers for Disease Control and Prevention, (Telephone: 770-488-5820), Atlanta, GA, July 2000.

31 Newsweek, "Generation XXL: Childhood Obesity Now Threatens One in Three Kids with Long-Term Health Problems, and the Crisis Is Growing," Newsweek, July 3, 2000.

32 Quoted in "Surgeon General's Warning: Watch Less TV," *The TV-Free American*, Washington, DC: TV-Free America, Summer 1999.

33 American Academy of Pediatrics press release: "Rise in Childhood Obesity Linked to Increase in Type 2 Diabetes," Chicago: American Academy of Pediatrics, Feb. 23, 2000.

34 *Newsweek*, op. cit.

35 David S. Freedman et al., "The Relation of Overweight to Cardiovascular Risk Factors Among Children and Adolescents: The Bogalusa Heart Study," *Pediatrics,* Chicago: American Academy of Pediatrics, June 1999.

36 Carol Krucoff, "The Obesity-Asthma Connection: Inactivity May Contribute to Breathing Problems, While Appropriate Exercise Brings Relief," *Washington Post,* May 25, 1999, Health Section, p. 16.

37 Jane M. Healy, *Failure to Connect: How Computers Affect Our Children's Minds — for Better and Worse,* New York: Simon & Schuster, 1998, pp. 122-123.

38 Healy, op. cit., p. 183; and Armstrong and Casement, op. cit., pp. 56-59.

39 W. H. Calvin, "The Emergence of Intelligence," *Scientific American*: October 1994, pp. 100-107. See also Calvin, "The Emergence of Intelligence," *Scientific American*, Special Issue: Winter 1998, pp. 44-50.

40 U.S. Environmental Protection Agency, "Office Equipment: Design, Indoor Air Emissions, and Pollution Prevention Opportunities," March 1995.

41 Office of News and Public Information, the National Academies, "No Adverse Health Effects Seen from Residential Exposure to Electromagnetic Fields," Washington, DC: the National Academies, Oct. 31, 1996.

NIEHS Press Release No. 9-99,"Environmental Health Institute Report Concludes Evidence Is 'Weak' that Electric and Magnetic Fields Cause Cancer," Research Triangle Park, NC: NIEHS, June 15, 1999.

42 Louis Slesin, editor of *Microwave News* and former editor of *VDT News,* New York, NY, telephone interview, March 31, 2000.

43 See, for example, U.S. Department of Labor, Occupational Safety and Health Administration, "Ergonomics: The Study of Work," Washington, DC: OSHA 3125, 1991.

44 Carol Wacey, U.S. Education Department, Office of Educational Technology, telephone interview, July 11, 2000.

45 Office of the Director, U.S. National Institutes of Health, Article 38: "Video Display Terminals," Nov. 9, 1999.

46 Cornell University Ergonomics Website, No. 9: "Children's Special Concerns," http://ergo.human.cornell.edu/Mbergo/schoolguide.html, as of April 4, 2000.

47 Stanley I. Greenspan, *The Growth of the Mind and the Endangered Origins of Intelligence*, p. 174.

48 Greenspan, op. cit., pp. 311, 313.

49 Marilyn B. Benoit, "Violence Is as American as Apple Pie," *American Academy of Child and Adolescent Psychiatry News,* Washington, DC: AACAP, March-April, 1997, p. 20.

50 Katy Kelly, "Get That TV Out of Your Children's Bedroom," *U.S. News & World Report*, Nov. 29, 1999, p. 79.

51 Sara Hammel, "Generation of Loners? Living Their Lives Online," *U.S. News & World Report*, Nov. 29, 1999, p. 79.

52 Kelly, op. cit.

53 Lowell Monke, "Computers in Schools: Time to Grow Up," paper presented at a conference on computers and education, sponsored by the Center for the Study of the Spiritual Foundations of Education at Teachers College, Columbia University, New York, December 1997.

54 See, for example, Hubert L. Dreyfus, "Education on the Internet: Anonymity Versus Commitment," paper presented at a conference on computers and education, sponsored by the Center for the Study of the Spiritual Foundations of Education at Teachers College, Columbia University, New York, December 1997.

55 Meir Ben-Hur, ed., *On Feuerstein's Instrumental Enrichment: A Collection*, Arlington Heights, IL: SkyLight, 1994.

56 Elementary school observation by Colleen Cordes in northeast Washington, D.C., June 1997. The school's name and the names of the staff members are protected, under a confidentiality agreement.

57 AAUW Educational Foundation Commission on Technology, Gender, and Teacher Education, *Tech-Savvy: Educating Girls in the New Computer Age*, Washington, DC: American Association of University Women Educational Foundation, 2000.

58 For example, Bill Dinsmore of the Learning Company, in a 1993 presentation, noted that it was very difficult to design software that was truly educational, engaging, and capable of generating profits. The more educational software is, the harder it is to make it entertaining, and vice-versa, he suggested. Dinsmore spoke on the panel "Education as a Competitive Marketplace for Industry," at the National Academy of Sciences Convocation, Reinventing Schools: The Technology Is Now, May 12, 1993.

59 See, for example, National Science Board, "Economic and Social Significance of Information Technologies," (Chapter 8) in *Science and Engineering Indicators, 1998*, Washington, DC: 1998, pp. 8-25 and 8-26.

60 For example, Robert J. Rossi and Samuel C. Stringfield conducted a major study for the U.S. Education Department to determine how to help at-risk students succeed in school. They reviewed 30 years of research and conducted extensive school observations. They found that schools with a strong sense of community were particularly effective. The essence of community, they concluded, was in the quality of the human relationships: "Students felt cared about and respected, teachers shared a vision and a sense of purpose, teachers and students maintained free and open communication, and all parties shared a deep sense of trust." See Rossi and Stringfield, "What We Must Do for Students Placed at Risk," *Phi Delta Kappan,* September 1995.

61 National Science Board, "Children, Computers, and Cyberspace," *Science and Engineering Indicators 1998*, Washington, D.C.: 1998, p. 8-23.

62 "State Bills Would Punish Librarians if Kids See Internet Pornography," quoting librarian Pat Scales in the *Greenville News, eSchool News*, Bethesda, MD: IAQ Publications, March 2000, p. 12.

63 Deirdre Donahue, "Ads Put Pressure on Children," *USA Today,* Aug. 3, 1999, p. 3D.

64 See www.mamamedia.com as of July 2000.

65 See www.gameboy.com/wmen/index.html as of July 2000.

66 See www.ctw.org/fyi/mediakit/pages/ rates/ 0,4244,00.html as of July 2000.

67 Roper Starch Worldwide, *The Roper Youth Report*, 1998, www.roper.com/research/syndicat-

ed/youth.htm as of July 2000.

68 See www.icanbuy.com as of July 2000.

69 Committee on Communications, American Academy of Pediatrics, *Policy Statement: Children, Adolescents, and Advertising (RE9504)*, Chicago: American Academy of Pediatrics, 1995.

70 Brian Hecht, "Net Loss," *The New Republic*, Feb. 17, 1997, p. 16.

71 Healy, op. cit., p. 64.

72 Ron Haybron, "Too Much Emphasis on Computers," *Cleveland Plain Dealer*, Aug. 6, 1996, p. 8E.

73 Douglas Sloan, "Introduction: On Raising Critical Questions About the Computer in Education" in Douglas Sloan, ed., *The Computer in Education: A Critical Perspective,* New York: Teachers College Press, 1985.

74 S. W. Haughland, "The Effect of Computer Software on Preschool Children's Developmental Gains," *Journal of Computing in Childhood Education*, Vol. 3, No. 1, 1992, pp. 15-30.

75 Barbara Means and Kerry Olson, "The Link Between Technology and Authentic Learning," *Educational Leadership*: 1994, pp. 15-18.

76 For example, for an explanation of the cultural roots of intelligence, versus a definition of intelligence as the individual's ability to manipulate information, see C.A. Bowers, *Educating for an Ecologically Sustainable Culture: Rethinking Education, Creativity, Intelligence, and Other Modern Orthodoxies*, State University of New York Press, Albany: 1995.

77 Alison Garton and Chris Pratt, *Learning to Be Literate: The Development of Spoken and Written Language*, Malden, MA: Blackwell, 1998, pp. 218-220.

78 Healy, op. cit.

79 Garton and Pratt, op. cit., p. 101.

80 Barry Sanders, *A Is for Ox: Violence, Electronic Media, and the Silencing of the Written Word*, New York: Pantheon, 1994, p. xii.

81 Ibid, p. 243.

82 Healy, op. cit., p. 233.

83 Marilyn B. Benoit, "The Dot.Com Kids and the Demise of Frustration Tolerance," speech given at the Roundtable of the Whole Child Initiative at the State of the World Forum, San Francisco, October 1999.

84 Healy, op. cit.. p. 54.

85 Carolyn Kleiner and Mary Lord, "The Cheating Game: 'Everyone's Doing It,' from Grade School to Graduate School.," *U.S. News & World Report*, Nov. 22, 1999, p. 55.

86 Ibid, p. 57.

87 Jeffrey Kane, "On Education with Meaning," in Jeffrey Kane, ed., *Education, Information, and Transformation: Essays on Learning and Thinking,* Upper Saddle River, NJ: Prentice-Hall, 1999, pp. 12-13.

88 Ibid, pp. 1-21.

89 President's Committee of Advisors on Science and Technology: Panel on Educational Technology, *Report to the President on the Use of Technology to Strengthen K-12 Education in the United States,* Washington, DC: Executive Office of the President of the United States, March 1997.

chapter three

Childhood Essentials:

Fostering the Full Range of Human Capacities

"Interactive multimedia leaves very little to the imagination. Like a Hollywood film, multimedia narrative includes such specific representations that less and less is left to the mind's eye. By contrast, the written word sparks images and evokes metaphors that get much of their meaning from the reader's imagination and experiences. When you read a novel, much of the color, sound, and motion come from you."

—Nicholas Negroponte, founding director of MIT's Media Lab, in *Being Digital.*

WHEN WE CONTEMPLATE A NEWBORN infant, we experience a feeling of reverence for the sacred reality of a new human life — its unique potential and profound mystery. Children who grow in an environment suffused with this sense of reverence, cared for by adults who respect each child's special gifts and special challenges, have the best chance of thriving.

They also experience, in their very bones, the most personal and persuasive lesson we can possibly teach them about reverence for life. Children, after all, learn much about how to treat others by how we treat them.

In that context, the most daunting educational challenge that new technologies pose is really a moral issue. Human beings now wield unprecedented power to wage war on one another and on other species — and unprecedented power to sustain life as well. How can we prepare our children for these unprecedented moral responsibilities? Will proficiency in technical skills alone suffice? Or will a renewed sense of reverence for life be essential for humanity's survival — perhaps for the survival of life itself?

Our task, then, is to educate our children in ways that develop the traits of character and habits of mind that shouldering the moral responsibilities of a high-tech future will demand. We fail in that task if we deny the imperatives of childhood. Children's minds are especially tuned to learning through experiencing the world with their bodies, their hands, and their hearts. Computer technologies have proven useful in many adult realms of activity. But they are advanced intellectual tools that do not engage bodies, hands, or hearts in the experiential ways so essential for children's development. Instead, they can overwhelm young children with abstract information about grown-up realities. Children of elementary-school age and younger are in general neither intellectually nor emotionally mature enough to benefit from using these tools.[1]

The new technologies that are reshaping so much of our culture do present a formidable challenge to education. But the challenge is not to mechanize the education of young children even further. Instead, the most pressing issue is how to enliven and re-humanize education in the face of an increasingly dehumanized culture. Children, in close company with caring adults, should be encouraged to explore and develop their own inner resources as human beings, including the special qualities they share with the rest of the living world. Then, as adults, they will command not just data but also the wisdom, imagination, courage, and moral will — all uniquely human qualities — to consciously shape their own technological future. They will learn to serve life on earth, not destroy it.

Never have such qualities been so crucial for our shared future. Bill Joy, co-founder and chief scientist of Sun Microsystems and the co-chair of President Clinton's 1998 blue-ribbon panel on the future of information-technology research, predicts that our culture is only decades away from designing technologies that could self-replicate beyond our capacity to contain or control them. The survival of humanity and other forms of life, he warns, will literally be at stake.

Joy also notes that we are racing into this frightening scenario with almost no public debate or planning. His warning, echoed by other leading scientists and engineers, is a wake-up call to parents, educators, and policy makers:

> The 21st-century technologies — genetics, nanotechnology, and robotics (GNR) — are so powerful that they can spawn whole new classes of accidents and abuses. Most dangerously, for the first time, these accidents and abuses are widely within the reach of individuals or small groups. They will not require large facilities or rare raw materials. Knowledge alone will enable the use of them.
>
> Thus we have the possibility not just of weapons of mass destruction but of knowledge-enabled mass destruction (KMD), this destructiveness hugely amplified by the power of self-replication... Nothing about the way I got involved with computers suggested to me that I was going to be facing these kinds of issues... As Thoreau said, "We do not ride on the railroad; it rides on us;" and this is what we must fight, in our time. The question is, indeed, Which is to be the master? Will we survive our technologies?[2]

With knowledge now so potent a force for good and for evil, all education becomes moral education. One of the most critical moral questions we will have to help our children answer — by the power of our own example — is this: In a world of incredibly powerful machines, what's so special about imperfect human beings and other vulnerable forms of life?

Unless we actually intend our children to become the appendages — or the victims — of powerful technologies, we must educate them in ways that clearly demonstrate the difference. The popular image of the child's mind as a "biological computer"[3] to be jump-started has spawned an endless stream of new technologies and products. We are being sold on the idea of an upgrade to childhood itself. Children are pushed to master much more, much sooner than ever before.

Pushing children in this way is both inhumane and counterproductive. The unhealthy stresses it has added to children's lives threaten their intellectual, emotional, social, and physical development. Evidence from many sciences indicates the wisdom of protecting childhood as a lengthy and necessary period of vulnerability and immaturity — a time for extended, loving nurture.

A buried acorn sinks a long, sturdy tap root into the earth, to nourish the mighty oak it will become in the far distant future. Children, like acorns and unlike machines, also must sink deep, strong roots for a lifetime of growth and a broad flowering of the unique capacities that mark human nature. Recent research has demonstrated anew just how intricately integrated all of these aspects of being human really are, in terms of both healthy growth and healthy functioning — even at the level of neural connections.

No wonder, then, that human capacities range far beyond the narrow limits of machines' logical and mechanical operations. Even the most sophisticated machines, after all, mimic only a narrow portion of human cognitive and physical capacities. They are incapable, for example, of either intuitive or imaginative thinking. Nor can they physically express love with a look or a touch. In fact, our many nonlogical attributes are what make human thinking so alive. What we refer to as the intellect is abundantly enriched by all other aspects of being human — emotional, social, physical, and spiritual — even as it enriches them.

The current emphasis on early computer use and computer-like thinking leads children to "the rigid, logical, algorithmic thinking, bereft of moral, ethical, or spiritual content, that is characteristic of computer interaction," write Valdemar Setzer and Lowell Monke, themselves computer scientists and educators. Such accelerated but narrow intellectual development, they add, "brings a child's mental abilities to an adult level long before the emotional, psychological, spiritual, and moral sensibilities have grown strong enough to restrain it and give it a humane direction."[4]

We therefore urge families and schools to recommit themselves to providing young children with the essentials of a healthy childhood. In our rushed culture, many children, both rich and poor, were deprived of these, even before the current computer craze. But the time and huge sums of money now being diverted to computers in childhood have further distracted adults from these healthy essentials. All of them — unlike computers — are strongly supported by both research and simple common sense:

1. **Close, loving relationships with responsible adults.**
2. **Outdoor activity, nature exploration, gardening, and other direct encounters with nature.**
3. **Time for unstructured play, especially make-believe play, as part of the core curriculum for young children.**
4. **Music, drama, puppetry, dance, painting, and the other arts, offered both as separate classes and as a kind of yeast to bring the full range of other academic subjects to life.**
5. **Hands-on lessons, handcrafts, and other physically engaging activities, which literally embody the most effective first lessons for young children in the sciences, mathematics, and technology.**
6. **Conversation, poetry, storytelling, and books read aloud with beloved adults.**

Close, Loving Relationships with Responsible Adults

As documented in previous chapters, the quality of children's emotional connections to parents, teachers, and other mentors is critical to every aspect of their development, including intellectual development. For this reason, any proposed educational reform should be scrutinized for its impact on strengthening or weakening the bonds between the teacher, her students, and students' families. The same question can be asked at the level of the whole school, as a community. Is a proposed innovation likely to strengthen or weaken the school's sense of community?

From this perspective, one of the most promising and least expensive school reform strategies is to let teachers to stay with the same group of students for more than one year. Such extended teaching, or "looping," makes it easier for teachers to know students and their families well. Professor David Elkind of Tufts University, former president of the National Association for the Education of Young Children, has pointed out how "ideally suited" such an extended relationship is for many children today, when parents are often pressed for time and children have often experienced frequent turnover in child-care providers:

> Because of the attachment of children to teachers whom they have been with for many years, the teacher becomes a much more powerful role model than when the child only has the teacher for a year. The class also becomes more like a family as the children grow up learning and working together... School-age children need someone who knows them as totalities and who can reflect this wholeness back to them. Having the same teacher for a number of years is one of the best compensations for the often truncated interactions of postmodern, permeable family life.[5]

Research also indicates that smaller classes and smaller schools are effective for all students, especially the most disadvantaged.[6] And fostering a strong sense of community has proven to be one of the most promising remedies for the most troubled schools.[7]

Parents and policymakers often assume that poor children without access to a computer at home will suffer academically. They push for highly computerized classrooms as the best chance to cross the "digital divide" and help poor children compete academically with those who have home computers.

We know that computers pose hazards to children and can distract adults from children's real needs. But the most disadvantaged children may be at particular risk of educational failure if we insist that they interact with computers for much of the school day. Often, what they most desperately need is more personal, caring attention from teachers, school counselors, and other adults who will take the time to work with their strengths and weaknesses and to convey patient confidence in the child's ability. The research evidence for the wisdom of such special attention is overwhelming.[8]

So the real danger for disadvantaged children, as one technology expert has suggested, is just the opposite of what many parents fear: **"In the end, it is the poor who will be chained to the computer; the rich will get teachers."**[9]

Outdoor Activity, Gardening, and Other Direct Encounters with Nature

A second critical test of every proposed educational reform is whether it will strengthen or weaken the bond between children and the natural world. Our ecological crisis amounts to a "planetary emergency," in the words of environmental educator David W. Orr. It is also an educational crisis, Orr points out, because it demands entirely new ways of thinking, and of setting intellectual priorities:

> Those now being educated will have to do what the present generation has been unable or unwilling to do: stabilize world population, reduce the emission of greenhouse gases that

> threaten to change the climate — perhaps disastrously — protect biological diversity, reverse the destruction of forests everywhere, and conserve soils. They must learn how to use energy and materials with great efficiency. They must learn how to run civilization on sunlight. They must rebuild economies in order to eliminate waste and pollution. They must learn how to manage renewable resources for the long term. They must begin the great work of repairing, as much as possible, the damage done to the Earth in the past 150 years of industrialization. And they must do all of this while they reduce worsening social, ethnic, and racial inequities. No generation has ever faced a more daunting agenda.[10]

Many concerned scientists urge schools to create far more regular opportunities for children of all ages to forge deep emotional bonds with the natural world. Otherwise, they warn, our children, as adults, will have trouble summoning the courage and moral will to respond to such grave challenges.

"We cannot win this battle to save species and environments," Stephen Jay Gould has said, "without forging an emotional bond between ourselves and nature as well — for we will not fight to save what we do not love."[11]

A love of nature is natural in childhood, given enough time for outdoor exploration. The Harvard biologist Edward O. Wilson emphasizes the evolutionary significance of "biophilia," or human beings' deep need to connect with the living diversity of nature. We have evolved as part of a rich web of life, according to Wilson, and both biologically and culturally we tend to connect our lives to other species.[12]

Our emotional bonds with the rest of the natural world help us to mature physically, intellectually, and spiritually. Nature's diversity nourishes our material needs, including food, clothing, medicines, even the air we breathe. But it also builds our emotional capacity for kinship, affection, awe, nurturing, and beauty; promotes our intellectual capacity for problem-solving, creativity, discovery, and control; and helps stimulate the recognition of a just and purposeful existence. Living diversity, adds Yale University scientist Stephen Kellert, "offers us inspiration, a source of language, story, and myth, a bedrock of understanding of beauty and significance."[13]

Nature trains all of a child's senses, and encourages reflection and acute observation, which later support scientific insight and precision in thinking. The noise and flash of electronic media demand the child's attention. In contrast, the silence and subtle beauties of the natural world encourage children to focus their attention for themselves. This kind of self-motivated attention is critical for persisting in learning tasks of all kinds.

Traditional cultures have long recognized the subtle qualities of nature as powerful teaching tools. Among the Lakota people of North America, for example, children "were taught to use their sense of smell, to look where there was apparently nothing to see, and to listen intently when all seemingly was quiet."[14]

Today, scientists consider childhood the most critical period for "cultivating an affinity, appreciation, awareness, knowledge, and concern for the natural world."[15]

But biophilia is by no means automatic. To cultivate a relationship with nature, children need much time outdoors, both in active play and in quiet contemplation. Young children's first education in the life and earth sciences comes through their personal, emotionally engaging experiences of nature, as a whole, live world to which the child himself belongs.

Every child has a right to such experiences beginning in early childhood and continuing throughout childhood. They lead both to engaged learning and to the wonder, reverence, and moral commitment that the subject in question — life itself — deserves. But many children today, even in rural areas, are growing up increasingly isolated from the natural world. They have far fewer chances to explore and enjoy the world outdoors on their own than children had in the past.

Computer software that presents sanitized or sensationalized versions of nature are part of the problem. Such intellectual abstractions are out of step with the far more concrete experiences that young children need to relate to the natural world.

Preschool children learn about nature by experiencing the world with their whole bodies, their senses, and their own profound emotional reactions to nature, including wonder, joy, and even fear. Between the ages of six and nine, children also are developing feelings of empathy for the needs and distress of other creatures.

Next, their concrete knowledge and their curiosity about plants and animals increases dramatically. Not until late adolescence, however, do children show more abstract and conceptual consciousness about the natural world. At this later age, they also develop a capacity to make moral judgments about ecological issues and human responsibilities, and a hunger to literally stretch their horizons, enjoying the personal challenge that wilderness experiences provide, for example.[16]

Some schools now purchase software simulations of nature as a substitute for live field trips to local rivers, parks, or campgrounds. But such simulations reduce children's actual connection to the real world rather than increase it — just the opposite of what's intended. As a 1998 report from the U. S. National Science Board noted: "Computing and cyberspace may blur children's ability to separate the living from the inanimate, contribute to escapism and emotional detachment, stunt the development of a sense of personal security, and create a hyper-fluid sense of identity."[17]

The report cited the research of Sherry Turkle, a sociologist at the Massachusetts Institute of Technology who has most closely studied these issues. When her own young daughter saw a live jellyfish for the first time, Turkle reported at a 1998 conference, her daughter exclaimed: "But Mommy, it looks so realistic."[18]

Reconnecting children to the natural environment would be far less expensive — and far more effective — than electronic simulations and all the paraphernalia required to support them. Intense exposure to nature, such as frequent hands-on exploration of fields and woods and participation in gardening through the seasons, can inspire deep connections to the land and the many species that inhabit it. Such experiences also provide a natural opening to a broad study of subjects like botany, biology, zoology, meteorology, geology, geography, and history.

For a child, even an overgrown patch of weeds in an urban neighborhood can foster magical moments with bugs and flowers. But a small patch of ground, at school or near home, can also be turned into a garden — the ideal hands-on science lab for young children living far from wilderness.

David Orr, who chairs the Environmental Studies Program at Oberlin College, also urges parents and schools to create chances for children of all ages to immerse themselves in a particular aspect of their own local ecology — a river, a mountain, a farm, a forest, even a particular animal — before introducing them to more advanced lessons based on information abstracted from nature. Children who live near a river, for example, could learn far more if they are allowed to return to it again and again over a period of time, to canoe in it, to experience its various seasons, to study its flora and fauna, to listen to it, smell it, and touch it, and to talk to those who live or work along it.[19]

> "It's not that children are little scientists, but that scientists are big children."
>
> —Alison Gopnik, *The Scientist in the Crib*

Children from urban neighborhoods with high crime rates, poor housing, and little access to parks are especially in need of such safe, enriching experiences in nature through school and community programs. Again, our most disadvantaged children stand to lose the most when schools divert time and money to flat-screen versions of nature.

Time for Unstructured Play, Especially Make-Believe Play

Some high-tech companies have begun to provide playrooms to try to maximize their employees' creativity.[20] But many preschools and elementary schools are reducing or eliminating play and recess from their schedules.[21] Only adults, it seems, have time to expand their minds through play.

Few parents, policymakers, or school administrators seem aware that a voluminous body of research over the last 30 years has decisively demonstrated that play — especially make-believe play — contributes in unique and critical ways to children's intellectual, social, and emotional development.[22] In contrast, studies over the same time period have failed to demonstrate that computers in elementary education make any critical contribution to children's development. Yet playtime in many classrooms is being sacrificed, as computer time increases. Play also, of course, contributes to children's physical health.

Edgar Klugman and Sara Smilansky, two leading researchers in the field, have argued that the evidence of gains from play is so strong that play should be part of the core curriculum in the education of young children, through the age of eight. "In many crucial ways," they add, "play, an old friend, awakens the potential of each child."[23]

Many studies have demonstrated the relevance of what researchers call "sociodramatic play" — make-believe play involving more than one individual — to scholastic achievement in many subjects, including reading, writing, science, and arithmetic. Studies have shown, for example, that make-believe and other kinds of play help young children learn to classify objects and group concepts in hierarchies, skills that have proven resistant to formal instruction. Children also test and revise their immature ideas about space, time, probability, and cause-and-effect relations during play. They test hypotheses, draw generalizations, and find creative, divergent ways to solve problems. All of these skills are relevant to later achievement in the sciences.[24]

The Smithsonian Institution is planning a major conference for the fall of 2000 to explore the connection between children's play and adults' scientific and artistic innovations. "It's not that children are little scientists, but that scientists are big children," explains Alison Gopnik, co-author of *The Scientist in the Crib.*[25]

From the child's point of view, "pretend" play is worth doing because it's fun. But in the process children sharpen and integrate a wide range of concepts and problem-solving skills. They spontaneously improvise from moment to moment in a hypothetical situation. And they integrate their experiences and construct meaning from them. In other words, make-believe presents complex intellectual challenges for young children that are intrinsically motivating. The more children engage in such play, the more proficient they become at it, especially at symbolically representing actions, objects, and abstract situations with language and gestures.

Research also indicates that parents and teachers can create an environment that encourages — or discourages — such play, and the benefits children derive from it. Smilansky has summarized the benefits that research points to from sociodramatic play as follows:

- **Gains in cognitive and creative skills:** Vocabulary, language comprehension, problem-solving strategies, curiosity, ability to take on the perspective of another, innovation, imaginativeness, attention span, ability to concentrate, overall intellectual competence.

- **Gains in social and emotional skills:** Playing with peers, group collaboration, peer cooperation, reduced aggression, increased empathy, better impulse control, better prediction of others' preferences and desires, overall emotional and social adjustment.

Researchers attribute the loss of play time in preschools and elementary schools to the increasing emphasis on early academics, linear thinking, and standardized testing in the education of young children.[26] The new focus is aggressive and didactic, pushing facts and isolated cognitive skills. Play, on the other hand, seems to have evolved as nature's far more subtle strategy for motivating children to expand all of their capacities — physical, social, emotional, and intellectual — in an integrated way.[27]

"Seen through this lens, play is the best possible preparation for adulthood, especially in our highly technological, competitive society," suggests Arkansas master teacher Sheila G. Flaxman. "Children have never before been exposed to so much, so early. Play not only allows them to practice with all the new concepts — social, emotional, moral, and intellectual — they are learning so rapidly as they develop, but also helps them make sense of, and internalize, all the stimuli to which they are exposed."[28]

Substituting computer time for play time may actually reduce children's ability to play. Teachers report that many children of all income levels who have been exposed to heavy diets of television, computers, and other electronic media now enter kindergarten not knowing how to play.[29] More computer time at school means even more exposure to powerful electronic images generated by others. That seems likely to further depress children's ability to generate their own imaginative dramas.

Studies suggest that children who engage spontaneously and often in make-believe tend to be proficient at solving problems that have no one, simple solution.[30] So schools that reduce free play time may be discouraging the very activity that best fosters innovative thinking.

Research also suggests that, for young

children, "high-tech toys" is an oxymoron. The most brain-stretching materials appear to be the simplest, including water, clay, and blocks. Their very simplicity allows children the most freedom in creating and experimenting with endless versions of their own make-believe realities.[31]

As Nancy Foster, a veteran teacher in a play-oriented kindergarten in Silver Spring, Maryland, explains:

> We wish to provide play materials which support and stimulate the young child's capacity for fantasy play — their ability to use objects in many different ways to meet their needs of the moment. A carved piece of wood may, for example, be used as a bridge, or as a telephone, a boat, a cradle, a delivery truck, a fish, merchandise for a store, a package for the mailman to deliver, etc., etc. Younger children, of course, may see it as just another piece of "firewood" for the "fires" they love to build by piling up every movable object in the room![32]

The sophistication of many electronic toys and video games, on the other hand, limits the range of a child's creative responses. The experience may be entertaining — at least till the novelty wears off. But it is more likely to stunt than to expand imagination. Many teachers, including Foster, have noted that children today often need help breaking out of a disturbing psychological fixation in their play, with scenes from some popular video that they have seen. A recent study reported in Walt Disney Home Video Press confirms that observation.[33]

Poor children may be particularly vulnerable to such shortsighted classroom policies. Numerous studies suggest that children from families of low socioeconomic status do not tend to develop the verbally elaborate imaginative play that children from families of higher socioeconomic status do. But research also suggest that certain sensitive interventions by teachers, parents, and other caregivers can help them become more able make-believers and achieve the developmental gains such play promotes.[34] Schools that offer little or no time to play, however, are cheating the most disadvantaged children of a chance to catch up.

Music, Drama, Puppetry, Dance, Painting, and the Other Arts

Children are born artists. They are naturally creative — eager to sing, dance, pound rhythmically on tabletops, act out great dramas from their own shared imaginations, and design masterpieces with sand, shells, stones, logs, clay, paint, crayons, or any other material that's handy. Even as they enjoy the creative process, they are integrating and expanding a wide range of intellectual, emotional, and social skills.

Because the arts both enliven and illuminate everything they touch, they provide powerful motivation and powerful insights for students and teachers. Studies have found, for example, that children have more positive attitudes about school and do better in subjects such as spelling, writing, mathematics, and social studies when their classes include and incorporate the arts.[35]

The arts are especially appropriate in the education of children of elementary age and younger because they learn most easily when lessons engage their feelings and bodies as well as their minds. Artistic lessons encourage self-discipline, imagination, critical thinking, originality, flexibility and divergent thinking in the face of ambiguity, and facility in using a wide range of symbolic tools, according to researchers and educators. Words and numbers are both sets of symbols, each representing a different way of thinking about the world and its meaning. Every form of art — music, dance, drama, sculpture — provides children with another set of symbols for thinking about and expressing ideas and meaning.[36]

Harvard psychologist Howard Gardner has pointed out that most schools focus on developing children's logical-analytical and linguistic skills. He considers that too limited an approach, given the "multiple intelligences" of human beings. The arts, he emphasizes, help develop the far broader range of intelligences.[37]

> Experts now realize that creating things with your hands helps to develop the brain, music and songs cause the student to focus on sounds within words and tonal (spatial) relationships, while body movement of all kinds helps produce physical, mental, and cognitive benefits.
>
> —Kate Moody, Reading Specialist at the University of Texas

Just as the arts help children develop open minds, they also help open hearts. The arts teach practical emotional skills, including the self-discipline that comes from practice over time, persistence, the ability to delay gratification, healthy ways to reflect upon and express one's own feelings and the feelings of others, and the self-motivation for learning that stems from the active, emotionally engaging challenges that the arts can bring to all other subjects.

And the arts can develop critical social skills. Children who perform together in a choral group or orchestra, for example, sharpen their communication skills and learn powerful lessons about collaboration and the value of each individual's gifts and commitment if any group is to "make music" together.

Physically, too, the arts are enriching. They draw on all of the senses, leading to what Eliot Eisner, professor of education and art at Stanford University, calls "the refinement of visual and tactile sensibilities upon which consciousness itself depends."[38] The arts also challenge teachers to be creative in inviting children to comprehend a wide range of subjects literally "in their bodies." Geometrical relationships and multiplication tables, for example, can be taught through creative motion or rhythmic games, and history comes alive when children act out the great dramas of the past.

Charles Fowler, the late well-known music educator, pointed to how profoundly the arts can enrich children's moral development:

> One of the arts most important contributions to the development of young people is the cultivation of their emotional and spiritual well-being. The human spirit in all its manifestations is central to the arts. Think of the great cathedrals, mosques, and temples, the paintings, sculpture, and music that have been created around the world to put us in touch, and sustain our contact, with the spiritual world. Students can be inspired by the arts to reach deeper within themselves to stand in awe of dimensions of life we cannot fully understand or grasp, of our own fragile and temporal being, and of life itself in the vastness of the cosmos.[39]

The current emphasis on computer tools in elementary schools encourages children to produce "authentic products," such as PowerPoint presentations that mimic the style if not the substance of adults' professional work. The message is clear: the beauty of children's own simple artistic creations is not good enough. They can and must be held to adult standards, whether or not such standardized fare is really the most effective way to develop the individual child's inner capacities for creative thinking.

Just how sophisticated software will help children construct meaning for themselves, compared to less sophisticated learning tools, such as paper and paints, is not clear. Students' choices of expression, for example, are often severely constrained by the software programs they use, whose parameters are controlled by a whole team of software developers and marketing professionals unknown to the students.

Artistic approaches to learning are not only far more age-appropriate but also far cheaper than the more adult-oriented emphasis on high-tech classrooms. Yet budgets for music and other arts, never generous, are now being cut even further or eliminated in some schools to help pay for equipping and maintaining high-tech classrooms.[40]

My observations in schools are that drugs, crime, hostility, indifference, and insensitivity tend to run rampant in schools that deprive students of instruction in the arts.

—Charles Fowler, music educator

Art, music, and physical education are not "frills." Research shows these multisensory experiences to be essential for the developing brain in general, and for reading proficiency in particular. Kate Moody, an expert on reading, dyslexia, and electronic media at the University of Texas at Gainesville, reports that "experts now realize that creating things with your hands helps to develop the brain, music and songs cause the student to focus on sounds within words and tonal (spatial) relationships, while body movement of all kinds helps produce physical, mental, and cognitive benefits."[41]

Recent research further suggests that childhood may be a window of opportunity, a time when the brain is naturally primed to learn music and possibly other arts most easily — and to benefit in a wide range of academic subjects from the incorporation of the arts into the whole curriculum. The biophysicist Martin Gardiner, for example, suggests that "learning arts skills forces mental 'stretching' useful to other areas of learning," including mathematics.[42]

Research also shows that individuals who are not educated in the arts as children are less likely to participate in the arts as adults.[43] In effect, then, sacrificing the arts for computers in school may deprive children of lifelong enjoyment of some of the most emotionally, culturally, and spiritually enriching experiences of being human.

Finally, research suggests that schools rich in the arts can be especially healing for at-risk children in troubled neighborhoods. The arts generate healthy outlets for expressing anger, sadness, and a whole range of other confusing and painful feelings, and may even be useful in preventing violence. An immersion in the arts teaches children to respect the cultures of different peoples, to respect themselves, and to experience more deeply the meaning of their studies and of their own lives, even as they build skills and self-confidence through artistic practice.[44]

As Fowler noted in *Strong Arts, Strong Schools*:

> My observations in schools are that drugs, crime, hostility, indifference, and insensitivity tend to run rampant in schools that deprive students of instruction in the arts. In the process of overselling science, mathematics, and technology as the panaceas of commerce, schools have denied students something pre-

> cious: access to their expressive communicative beings and their participation in creating their own world. In inner-city schools that do not offer instruction in the arts, the students have little pride and less enthusiasm, and such deprivation saps their lives of vitality and potential.[45]

Hands-on Lessons, Handcrafts, and Other Physically Engaging Activities

Research clearly demonstrates that hands-on experiences, at home and in the classroom, are powerfully motivating and particularly effective for learning in many realms, including science, mathematics, reading, and languages.[46] Integrating the arts into these subjects, as described above, is an exceptionally powerful example of hands-on education, because the arts are so emotionally engaging. But children benefit intellectually from a wide array of other concrete encounters with real materials. As with the arts, this includes classes in handcrafts such as knitting and woodworking, and the integration of hands-on activities into academic studies.

A 1990 study showed that children learn spelling more easily when teachers use a multisensory, hands-on approach that includes first saying the spelling of a word, then writing it out by hand, and then seeing it, as they have themselves shaped it by hand. This approach proved more effective than trying to teach children by typing the letters out on a computer screen.[47]

Unfortunately, the solid research evidence of the wisdom of a hands-on curriculum, like the research on play, is rarely applied in classrooms. F. James Rutherford, a leading science educator, noted in 1993:

> Hands-on learning activities used appropriately can transform science learning by engaging the student in the process of science. Unfortunately, these activities are not widely used. It could be because so few teachers have had opportunities to develop skills needed for hands-on instruction. Another factor is that hands-on learning takes time — and the pressure to get on with the overstuffed curriculum discourages many teachers from taking that time.[48]

Teachers are under ever greater pressure today to substitute sedentary work at computer screens for more physically and emotionally engaging activities. Computer proponents argue that computers are just what the latest theory of learning, the "constructivist" model, calls for. According to this theory, students are active learners, constructing their own conceptual framework, constantly "renovating" their mental representations as their understanding of the world grows and changes.

Constructivism is promoted as replacing the old, industrially based model of the school as a factory, in which the teachers were seen as the workers and the students their products — empty containers which teachers filled with knowledge. The new model, however, when applied to computerized learning, often ends up being treated as little more than a dressed-up version of the old one. In the new version, teachers become effective managers, and the students are the workers. The product they are producing is their own learning.

Under this approach, then, schools are still viewed as similar to commercial enterprises, with the emphasis on efficiency, productivity, and the bottom line. This narrow metaphor is hardly appropriate for the care of young children. But it makes the automation of kindergartens and the elimination of such "frills" as creative play, recess, and the arts seem perfectly rational. After all, every other workplace has been automated in the hopes of productivity gains — why not the classroom?

Because children are the "workers," we expect them to sit still, at their electronic workstations, for hours on end, intellectually "constructing" as quickly and efficiently as possible their "product" — knowledge. Because we are narrowly focused on children's cognitive processes, to the exclusion of their emotional and physical experiences, we mistake intellectual abstractions — i.e., data — for the raw material of knowledge construction. In this context, then, the more information children can access, and the faster, the more productive workers they will be.

"The student is still a receptacle for facts — it's just that he must learn to stuff himself, instead of being stuffed by someone else," notes Steve Talbott, editor of the online newsletter *NetFuture*. "I'm not sure there's much difference between the equally constipated outcome of these two approaches."[49]

Hence, the new classroom emphasis on the Internet. And hence our expectations that children prove their progress by producing projects that resemble as closely as possible the standardized reports and presentations that adult workers produce, using the same sophisticated office equipment that adult workers use in real workplaces. But the most effective teaching and learning may not seem — in the short run — very efficient at all, as Rutherford notes above, or even obviously productive. That's because hands-on and other "in-the-body" learning experiences lay a foundation for creative abstract thinking that may not fully bear fruit until years later.

Even the U. S. Department of Education, a major booster of high-tech classrooms, does not emphasize computer technology in its own online summaries of what research suggests actually works in science education. Instead, it strongly emphasizes the wisdom of hands-on activities. The department's 1993 guide, "State of the Art: Transforming Ideas for Teaching and Learning Science," states: "Hands-on, inquiry-based science instruction is well established as an effective teaching strategy."[50] And its 1994 digest, "Doing Science with Your Children," expands on this emphasis:

> To give your children a firm foundation in science, they should be encouraged to think about and interact with the world around them. Concrete experiences that require the use of children's senses, such as planting and watching a seed germinate, provide a strong framework for abstract thinking later in life.
>
> Rich sensory experiences (seeing, hearing, tasting, touching, and smelling) can help children become more observant and curious. Exploring the characteristics of objects and living things can help them learn how to classify or group things based on their characteristics. By playfully interacting with their environment, children understand how they are distinct from the world around them and how they can influence aspects of it. Science begins for children when they discover that they can learn about the world through their own actions, such as blowing soap bubbles, adding a block that causes a structure to collapse, or refracting light through a prism. A child best learns to swim by getting into the water, likewise, a child best learns science by doing science. Hands-on science experiences, together with conversations about what is occurring, are the best method for developing children's science process skills. These experiences go beyond improving science skills to improving reading skills, language skills, creativity, and attitudes toward science. Fortunately, these hands-on sciences experiences are ones that most children enjoy.[51]

Experts on science education add that

even older children, ages 9 to 12, still learn best through hands-on experiences. They note that children do not need expensive equipment to "do science." On the contrary, often everyday life provides the best opportunities, as described in one museum's guide for parents: "Sometimes science opportunities happen when you least expect them. Your child may notice a spider spinning its web on the way to the store, or soil getting washed away on a rainy day, or a full moon shining. It's worth getting a little wet or dirty, or losing a little sleep sometimes."[52]

The Education Department's guide for parents also notes that for children, simple is often best: "Opportunities for positive science experiences can be found in kitchens, yards, parks, science museums, beaches, nature centers, and even toy boxes... It is important to remember that often the simplest experiences may produce the most profound learning."[53]

Neal Lane, the president's top adviser for science and technology policy, made a similar point in offering "holiday toy tips" to parents, while he was still director of the National Science Foundation. Parents, he said, should consider "simple toys that kindle their child's natural curiosity," and that "stimulate creativity and thinking skills." A Slinky, he suggested, teaches fundamentals of wave motion, and a pocket-size illuminated magnifier "can cost less than $10 and provides a wonderland view of nature for children. Simply add insects to create a hands-on science experience."[54]

Computer simulations are becoming popular classroom resources. But some educators and scientists question the impact of exposing young children to them.[55] And scientists are beginning to call for more direct observation in the field and practical experience — even in their own research — to correct an overreliance on computer-generated models.[56]

The current interest in "Web-based education" and ubiquitous Internet access for every student, from the age of five up, assumes that a lack of access to information has been a major problem in elementary schools. Actually, experts on math and science education have argued just the opposite. They have concluded, in part based on analyses of the disappointing performance of American students in international comparisons, that American children have been subjected to far too broad and too shallow a sweep of scientific information.[57] A deeper, less sweeping but more personally engaging approach — exactly what hands-on classes embody — would serve our children better, science educators have argued.

William H. Schmidt, U. S. coordinator for the Third International Math and Science Study, argues that the curriculum in American schools is "a mile wide and an inch deep... Concentrating instruction on fewer key concepts could substantially improve science literacy."[58] Likewise, numerous studies have pointed to the exploration of real phenomena in the physical world is the *a priori* of science literacy. In a special 1999 review of what experts in science education recommend, *Scientific American* reported: "Real-world research that allows kids to test their own theories is best for teaching science."[59]

But the Internet's infinite trail of links discourages concentration on key concepts. Thomas Sherman of the Virginia Polytechnic Institute and State University has pointed out that educators sensitive to young children's developmental needs actually try to "limit children's access to information by simplifying messages and sequencing contents." Their intent is to avoid overwhelming children with information that is so outside their experience they can neither understand nor assimilate it.

Given that many adults experience "information fatigue syndrome," the sheer volume of information from Web surfing could be very confusing to children whose intellects are still maturing, Sherman adds.[60] And flashy software simulations, with all conditions and outcomes predetermined, are the opposite of messy real-world exploration.

On the other hand, when urban schools with high proportions of low-income children use computers in the classroom, they tend to emphasize "drill and kill" remedial software, which almost seems calculated to stamp out a child's curiosity and wonder about the science of the real world.

"There is an implicit racism in the rise of mind-numbing software in inner-city schools," says Judah Schwartz, co-director of Harvard University's Educational Technology Center. "Lock up such software in the closet."[61]

Conversation, Poetry, Storytelling, and Books Read Aloud with Beloved Adults

A rich diet of face-to-face, oral conversations with parents, teachers, and other caring adults provides the basic nourishment children need to succeed in reading, writing, and many other forms of academic learning.

Literacy actually begins with being held and fed, writes Barry Sanders of Pitzer College in *A Is for Ox: Violence, Electronic Media, and the Silencing of the Word*. Nursing, Sanders notes, provides a "fundamental, kinesthetic connection to literacy." Vigorous sucking strengthens the infant's respiratory system, which later contributes to the rhythms and patterns and pitches of speaking and listening. All five senses are involved as the infant, held close, feels and hears the rhythm of the parent's heart and breath, as well as the vibrations of whatever the parent may say or sing. Such warm, close interactions with loving adults — literally, the human touch — have been shown in study after study to promote language and literacy skills in the most powerful and natural way.[62]

Building on such early, emotionally engaging experiences, children learn to listen and to speak as social and cultural acts. Later, they learn to read and to write — that is, to "listen" to the meaning of others' written words, and to express themselves in writing. So orality, as well as touch, is an essential prelude to literacy. According to Sanders:

> Literacy fits over orality like a protective glove, following every contour and outline that orality hands it. Orality provides the rhythms, the intonations, and pitches, the very feelings, that find final expression in writing... Children need to hear language in order to learn language. This may sound like a tautology, but a child must hear language spoken by a live human being. Conversely, a living human being must listen to the child, and suffer through all the millions of questions and complaints. An electronically simulated voice will not work.[63]

Kate Moody, the University of Texas reading expert, stresses the importance of a child being able to count on one or more adults who will "talk them through their world." She writes that "conversational experience, which can be provided by any caring adult, is of immense importance to the child's emerging abilities to listen, pay attention, follow directions, develop vocabulary and interact socially."[64]

Such conversations are by no means simple exchanges of information or one-sided entertainment. Adults who are in close, prolonged contact with a child intuitively adjust the complexity of their communication to the child's growing ability to comprehend verbal and nonverbal cues in conversation, and to express himself within a cultural context.[65] Over time, such conversation helps children develop their own inner voice, which then becomes an invaluable guide, in the classroom and out, in planning and making choices.

Much of a child's learning about language takes place through nonsense rhymes, songs, and other forms of word play — through verbal games with adults and other children. Other children, too, provide the human companionship necessary to practice language skills. One study found that children who talk together while playing tend to become better and earlier readers, especially if their play includes play with language, such as silly rhymes and tongue-twisters.[66]

Narratives, or stories, are essential to both oral and written communication. Storytelling captures the imaginations of children in ways that foster intellectual, emotional, and moral growth. It also provides a literacy booster for children that even parents who cannot read well themselves can provide. Children love stories made up just for them; they love the recounting of family history. Rhymes also naturally captivate children, and prepare them to treat words in reading as individual units that represent individual sounds with meanings attached to them. Research suggests that learning to read rhymes is easier than learning to read straight prose.[67]

The element of rhythm in poetry and in good storytelling also aids school learning, as a basic sense of timing seems to help children learn to read. The imagery and playfulness of stories and poems feed children's inner powers of image-making and wordsmithing.

Finally, literacy thrives in an environment that is rich in books, with ample time for adults to read them to and with children. Reviews of research indicate that reading aloud to children is "the most important activity for building the knowledge and skills eventually required for reading."[68]

Here too, research suggests that direct human contact makes the difference. What seems to make reading aloud so powerful is the conversation that accompanies it, as children and adults actively discuss the story in an emotionally secure environment. It seems that parents, teachers, and other adult readers, through such conversation, can guide children to move from the words and pictures in a text to their own imaginative pictures and to comprehend the stories by relating them to their own experiences.

As Senator James M. Jeffords, chair of the Senate Health, Education, Labor, and Pensions Committee, has noted:

> No matter how much technology we apply in the classroom, no matter how drastically our educational system may change during the 21st century, nothing will ever take the place of a good book and a caring adult to share it. The quiet space of a book sets a child's imagination free. And it is this first introduction to reading that will excite a child about learning for the rest of his or her life.[69]

What about reading books on computer, with exciting graphics added? Isn't that even more effective in promoting literacy? Some teachers report that the animation and other multimedia features of electronic books are so visually diverting that they actually distract children from the story.[70] One survey of computer-based reading programs found that few "have consistently proven to be effective and few have produced substantial achievement gains in students' reading performance."[71] There is some evidence that computer programs can help children who have trouble understanding language with pre-reading skills in phonological awareness — the awareness of individual sounds in words. But it's not clear that this translates into later success in reading.[72]

The late Jeanne Chall, who was a leading expert in reading research, observed in more than 300 schools before concluding that the critical factor in interesting children in reading was not the particular method or technology but the teacher. "It was *what the teacher did* [emphasis from the original] with the method, the materials, and the children rather than the method itself that seemed to make the difference."[73]

Children growing up today will have nearly a third fewer face-to-face interactions over the course of their lifetimes . . . human conversation, so vital to children's emotional, social, and intellectual development, is on the wane.

Nor have computer programs designed to help children learn to write been particularly effective. That may be due to inherent aspects of the technology itself, according to Alison Armstrong and Charles Casement:

> Unlike print, which encourages reflection and a careful consideration of various points of view, computer software urges immediate action. Words and images on-screen invite constant change or substitution — that is, after all, one of the things the computer and the software it runs are designed to do. And the faster you can manipulate what you see on the screen, the more control you appear to have over the technology you are using. Speed and control are emphasized at the expense of thoughtfulness and understanding.[74]

Given what is now known about the importance of sharing conversations and sharing books with adults as the basis for literacy, two recent educational trends are especially troubling.

First, many school libraries, habitually underfunded even before computers, are now letting their book collections dwindle and using the money to buy computer hardware and software instead. In 1999, the average cost of a school library book was $16, but the median expenditure for books in elementary school libraries was just $6.73.[75]

With elementary school populations rapidly increasing, the lack of money for the purchase of books is especially troubling because they are "the very place where a wide variety of interesting books on many reading levels can lead to a lifelong love of reading."[76] A major research review in 1993 found that the amount of time that children spend voluntarily reading material they chose themselves is positively related to reading comprehension, vocabulary growth, spelling ability, grammar, and writing style. It also found that providing students with a large library collection is one effective way to boost reading achievement.[77]

Linda Wood, a Rhode Island librarian representing the National Association of School Librarians, put it simply, in testifying to the U. S. Senate in 1999: "There is no point teaching a child how to read if there is nothing for the child to read! It is not the method of teaching reading that lies at the heart of any reading crisis; it is access to reading material."[78]

The second disturbing trend is the

substitution of time with computers and other electronic media for such live interactions, at home and at school. Children today are already spending far less time with their parents than in the past — according to one estimate, about 40 percent less time than 30 years ago.[79] Now, even when parents are home, children are increasingly spending time alone. A 1999 study by the Fortino Group in Pittsburgh estimated that children growing up today will have nearly a third fewer face-to-face interactions over the course of their lifetimes than the preceding generation. The difference is due to the increasing time that children are spending — at school and at home, where they are often alone in their own rooms — using electronic media of all kinds.[80]

The amount of time that Americans of all ages spend interacting with computers and other electronic media, instead of speaking directly with each other, is now being cited by educators and health-care professionals as a destructive trend for the social coherence of families and communities.[81] Human conversation, so vital to children's emotional, social, and intellectual development, is on the wane.

Emphasizing computers in the education of young children seems likely to exacerbate their deficits in such conversational experiences, not correct it. Instead of rushing into early academics with computer programs, families and schools could renew the far more developmentally appropriate curriculum of spoken, shared language.

"Let us take youngsters out of the linguistic limbo they find themselves in and move them back into the key experience they have missed — orality," writes Barry Sanders. "The teaching of literacy has to be founded on a curriculum of song, dance, play, and joking, coupled with improvisation and recitation. Students need to hear stories, either made up by the teacher or read out loud. They need to make them up themselves or try to retell them in their own words... Good readers grow out of good reciters and good speakers."[82]

This approach is especially well suited to families where adult literacy is an issue. As Stanford University Professor Larry Cuban has argued, spending on adult literacy programs — which will both help prepare parents for the job market and enable them to read with their children — is a wiser expenditure of limited public dollars than school computers.[83]

Poor families rely more on school libraries for books to read at home. Yet spending on unproven technologies is siphoning tax dollars from this proven educational practice.

Parents who may still be learning to master reading themselves could be empowered immediately by the kind of practical parenting education that would encourage them to tell their children their own stories. A focus on technology they can't afford at home may be a further blow to their confidence as parents and to their children's self-confidence in school, as

In summary, the educational essentials we advocate above share five features:

- **Each supports the development of the full range of a child's human gifts, not just the intellect.**
- **Each is strongly supported by research and practical experience.**
- **Each was already endangered in schools before the current enthusiasm for computers.**

• Each is even more threatened by the new emphasis on computers.

• Each is especially critical to the education of our most socially and economically disadvantaged children. Likewise, when computers replace them, the loss most harms our most at-risk children.

they learn to devalue their own handiwork in comparison with others' glitzy printouts.

The pace and the power of high technology cries out for real educational change. But the moral choices our children will confront will be the most demanding aspect of tomorrow's high-tech agenda. Therefore, the single educational reform that is most critical for educators, parents, and policymakers to begin implementing today is to enliven our schools and our homes with these healthy essentials of a human and humane education.

As Valdemar Setzer and Lowell Monke conclude, in arguing that such an agenda for children is truly future-oriented:

> Our hope is that the introduction of computers only after a childhood environment steeped in love, beauty, and respect for children's natural, holistic growth may make it possible for them to put these machines in their proper place... We recognize that it will take courage to withstand the pressures against it. Perhaps the most important thing is to try. Right now, more than anything else, we need more voices challenging the trend toward technological dominance of education.[84]

[1] Thomas M. Sherman, "Another Danger for Children?" *Education Week,* June 3, 1996, pp. 30, 32; and Valdemar W. Setzer and Lowell Monke, "Challenging the Applications: An Alternative View on Why, When, and How Computers Should Be Used in Education," unpublished paper, 1995. (Valdemar Setzer may be reached at the Institute of Mathematics and Statistics at the University of São Paulo, Brazil, and Monke, formerly a teacher of advanced computer technology in the Des Moines Public Schools, is now at Wittenberg University in Ohio.)

[2] Bill Joy, "Why the Future Doesn't Need Us," *Wired Magazine,* April 1999.

[3] See, for example, Herbert A. Simon, "Scientific Opportunities of Learning and Intelligent Systems," *Symposium Proceedings June 1996: Learning and Intelligent Systems,* (National Science Foundation, Arlington, VA: June 1999) p. 32: "…That human computing system called the brain."

[4] Valdemar W. Setzer and Lowell Monke, op. cit., p. 34.

[5] David Elkind, "Waldorf Education in the Postmodern World," *Renewal: A Journal for Waldorf Education,* (Fair Oaks, CA: Association of Waldorf Schools of North America, 1997) Vol. 6, No. 1, p.8.

[6] F. Mosteller, "The Tennessee Study of Class Size in the Early School Grades," *The Future of Children,* (Los Altos, CA: David and Lucille Packard Foundation, 1995) Vol. 5, No. 2, pp. 113-127; U. S. Department of Education, "Reducing Class Size, What Do We Know?" March 1999.

[7] See, for example, Chapter Two, reference 60, of this report.

[8] The Charles A. Dana Center, The University of Texas at Austin, "Hope for Urban Education," Washington, DC: U.S. Department of Education Planning and Evaluation Service, 1999.

[9] Technology editor of *Forbes Magazine*, as quoted by Diane Ravitch, "Technology and the Curriculum: Promise and Peril." In White, M.A. (ed.) *What Curriculum for the Information Age?* (LEA, Hillsdale, NJ: 1987.)

[10] David W. Orr, "Educating for the Environment," *Change* (Washington, DC: Heldref Publications) May/June 1995.

[11] Stephen Jay Gould, "Enchanted Evening," *Natural History,* September 1991.

[12] E. O. Wilson, *Biophilia: The Human Bond With Other Species*, Cambridge: Harvard University Press, 1984.

[13] Stephen R. Kellert, *Kinship to Mastery: Biophilia in Human Evolution and Development*, (Island Press, Washington, DC: 1997) p. 207.

[14] William Crain, "Love of Nature: Lessons from the Lakota," *Holistic Education Review,* No. 8, Holistic Education Press, 1995, pp. 27-35.

[15] As described by Stephen R. Kellert, op. cit., p. 167.

[16] Ibid, p. 166.

[17] National Science Board, "Children, Computers, Cyberspace," *Science and Engineering Indicators 1998,* pp. 8-23.

18 As quoted in Alison Armstrong and Charles Casement, *The Child and the Machine*, Beltsville, MD: Robins Lane Press, 2000, p. 196.

[19] David W. Orr, *Earth in Mind*, Washington, DC: Island Press, 1994, p. 96-97.

[20] Dale Russakoff, "Mind Games for Tech Success: You've Got to Play to Win," *The Washington Post,* May 8, 2000, p. A01.

[21] Anna Murline, "What's Your Favorite Class? Most kids would say recess. Yet many schools are cutting back on unstructured schoolyard play." *U. S. News and World Report,* May 2000, Vol. 128, No. 17, pp. 50-52.

[22] Edgar Klugman and Sara Smilansky, *Children's Play and Learning: Perspectives and Policy Implications*, New York: Teachers College Press, 1990, p. 251.

[23] Ibid, p. 255.

[24] James E. Johnson, "The Role of Play in Cognitive Development," in Klugman and Smilansky, op. cit., pp. 213-234.

[25] Dale Russakoff, op. cit.

[26] Doris Pronin Fromberg, "An Agenda for Research on Play in Early Childhood Education," in Klugman and Smilansky, op. cit., p. 237.

[27] "Review of Research on Achieving the Nation's Readiness Goal: Technical Report," Washington, DC: U. S. Department of Education Office of Educational Research and Improvement, 1993, p. 41.

[28] Sheila G. Flaxman, "What Happened to Play?" *Education Week*, February 16, 2000, pp. 28, 30.

[29] Jane M. Healy, *Failure to Connect,* New York: Simon & Schuster, 1998, pp. 224-225.

[30] Fergus P. Hughes, *Children, Play and Development,* Boston: Allyn & Bacon, 1998; and Dorothy J. Singer and Jerome L. Singer, *Partners in Play*, New York: Harper & Row, 1977.

[31] Fergus P. Hughes, Op. Cit.

[32] Nancy Foster, "How Do You Choose Toys and Play Materials for the Classrooms?" *In a Nutshell,* Silver Spring, MD: Acorn Hill Children's Center, May, 1999.

[33] Walt Disney Home Video Press Release (June 5, 1998) as quoted in *The TV-Free American,* Washington, DC: TV-Free America, 1998, Vol. 4, No. 2, p. 6.

[34] Sara Smilansky, *The Effects of Sociodramatic Play on Disadvantaged Preschool Children*, New York: Wiley & Sons, 1968.
—— "Sociodramatic Play: Its Relevance to Behaviour and Achievement in School," in Klugman and Smilansky (eds), op. cit., pp. 18-42.

[35] Much of this research is summarized by Charles Fowler in *Strong Arts, Strong Schools: The Promising Potential and Shortsighted Disregard of the Arts in American Schooling*, New York: Oxford University Press, 1996.

[36] Eliot W. Eisner, "The Role of Art and Play in Children's Cognitive Development," in E. Klugman

and S. Smilansky, op. cit., pp. 43-56.

37 Howard Gardner, *Frames of Mind: The Theory of Multiple Intelligences*, New York: Basic Books, 1983.

38 Eliot W. Eisner, op. cit., p. 38.

39 Charles Fowler, op. cit., p. 53.

40 Ibid, pp.12-13; and Todd Openheimer, "The Computer Delusion," *Atlantic Monthly,* July 1997.

41 Kate Moody, "Cutting School 'Frills' Puts Our Young Readers at Real Risk," *Houston Chronicle,* Oct. 3, 1999, Section C.

42 Martin Gardiner et al., "Learning Improved by Arts Training," *Nature,* May 23, 1996.

43 Ontario Arts Council, *The Arts and the Quality of Life: The Attitudes of Ontarians*, Ontario Arts Council: Toronto: 1995, p. 28.

44 Charles L. Gray, *Transforming Ideas for Teaching and Learning the Arts,* (U.S. Department of Education, Washington, DC: 1997) p. 6; and Arline Monks, "Waldorf Approach Offers Hope in Schools for Juvenile Offenders," *The Journal of Court, Community and Alternative Schools,* (Juvenile Court, Community, and Alternative Schools Administrators of California: 1997) Vol. 9, pp. 12-15.

45 Charles Fowler, op. cit., pp.12-13.

46 Thomas M. Sherman, "Another Danger for Children?" *Education Week,* June 3, 1996, p. 4D; and Jane Healy, op. cit. Also, see Arthur Harvey, "An Intelligence View of Music Education," *Leka Nu Hou*, the Hawaiian Music Educators Association Bulletin, February 1997.

47 Anne E. Cunningham and Keith E. Stanovich, "Early Spelling Acquisition: Writing Beats the Computer," *Journal of Educational Psychology* (1990) Vol. 82, No. 1, p. 159.

48 F. James Rutherford, "Hands-on: A Means to and End," *Project 2061 Today,* Washington, DC: American Association for the Advancement of Science, March 1993, Vol. 3, No. 1.

49 Steve Talbott, *The Future Does Not Compute,* Sebastopol, CA: O'Reilly & Associates, 1995, p. 371.

50 Mary Lewis Sivertsen, "State of the Art: Transforming Ideas for Teaching and Learning Science. A Guide for Elementary Science Education," Washington, DC: U. S. Department of Education, 1993.

51 Peter Rillero, "Doing Science With Your Children," from the ERIC Clearinghouse for Science Mathematics and Environmental Education, Washington, DC: U.S. Department of Education, 1994.

52 North Carolina Museum of Life and Science, "Sharing Science with Children: A Guide for Parents" North Carolina Museum of Life and Science, Durham, NC: undated.

53 Peter Rillero, op. cit.

54 Neal Lane, "NSF Tipsheet: NSF Director Offers Science Toy Tips," Washington, DC: National Science Foundation, Dec. 19, 1997, p. 1.

55 Larry Miller and John Olson, "How Computers Live in Schools," *Educational Leadership,* Oct. 1995, p. 75.

56 See, for example, Cheryl Lyn Dybas, "Appetite for Slow-Reproducing Fish Breeds Worry Over Stocks," *Washington Post*, Oct. 27, 1997, p. A3, which notes the concerns of some biologists that their colleagues gather more data about the sustainability of fisheries by actually making personal, on-the-scene observations at the fisheries. As one oceanographer said: "There is a paramount need in the future of fisheries science for factual data on the environment of fish and fewer theoretical assumptions derived by scientists working with computers, out of touch with nature."

57 W. Wayt Gibbs and Douglas Fox, "The False Crisis in Science Education," *Scientific American,* October 1999, p. 88.

58 *Scientific American*, "Six Steps Toward Science and Math Literacy, *Scientific American*, October, 1999, p. 92-93.

59 *Scientific American*, op. cit.

60 Sherman, op. cit.

[61] Armstrong and Casement, op.cit., p. 197.

[62] Barry Sanders, *A Is for Ox: Violence, Electronic Media, and the Silencing of the Written Word,* New York: Pantheon, 1994, especially pp. 188-191.

[63] Ibid, p. 35.

[64] Kate Moody, op. cit.

[65] Jerome Bruner, *Child's Talk: Learning to Use Language,* New York: Norton, 1983.

[66] A. D. Pellegrini and L. Galda, "Ten Years After: A Reexamination of Symbolic Play and Literacy Research," *Reading Research Quarterly*, Vol. 28, No. 2, 1993, pp. 163-175.

[67] Marilyn Jager Adams, *Beginning to Read: Thinking and Learning About Print*, Cambridge: MIT Press, 1990, p. 321.

[68] Adams, op. cit., p. 86. See also R. C. Anderson et al., *Becoming a Nation of Readers: The Report of the Commission on Reading*, Pittsburgh: National Academy of Education, 1985, p. 23.

[69] Sen. James M. Jeffords, Official Statement, Hearing on the Reauthorization of the Elementary and Secondary Education Act, the Senate Committee on Health, Education, Labor, and Pensions, U. S. Senate, May 20, 1999.

[70] Armstrong and Casement, op. cit., pp. 85-86.

[71] John Schacter, *Reading Programs that Work: A Review of Programs for Pre-Kindergarten to Fourth Grade*, Santa Monica, CA: Milken Family Foundation, 1999, p. 19.

72 Ibid.

[73] Jeanne Chall, *Learning to Read: The Great Debate*, New York: McGraw-Hill, 1967, p. 270.

[74] Armstrong and Casement, pp. 11-12.

[75] Linda Wood, representing school librarians, Statement at Hearing of the Senate Health, Education, Labor, and Pensions Committee on the Reauthorization of the Elementary and Secondary Education Act, U. S. Senate, May 20, 1999.

76 Ibid.

[77] Stephen Krashen, *The Power of Reading*, Libraries Unlimited, Englewood, CO: 1993.

[78] Wood, op. cit.

[79] Marilyn B. Benoit, "Violence Is as American as Apple Pie," *American Academy of Child and Adolescent Psychiatry News,* Washington, DC: AACAP, March-April, 1997, p. 20.

[80] Sara Hammel, "Generation of Loners? Living Their Lives Online," *U. S. News and World Report*, Nov. 29, 1999, p. 79.

[81] John L. Locke, *The De-Voicing of Society: Why We Don't Talk to Each Other Anymore*, New York: Simon & Schuster, 1998.

82 Sanders, op. cit., p. 243.

[83] Larry Cuban, "Is Spending Money on Technology Worth It?" *Education Week*, Feb. 23, 2000.

[84] Valdemar W. Setzer and Lowell Monke, op. cit., p. 35

chapter four

Technology Literacy:[1]

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.[2]

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.[3] 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.[4]

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.[5] 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?[6]

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?[7]

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.[8]

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."[9]

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."[10] 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 train ing program offered in school.**
3. **For high school students, consider making the study of the fundamen tals 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.[11]

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.[12]

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.

[1] An excellent resource for educators, parents, policymakers, and anyone else interested in technology literacy is *Confronting Technology* (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.

Also, see *NetFuture,* an online newsletter that deals with technology and human responsibility, at 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.

[2] 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.

[3] 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.

[4] 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.

[5] Ibid, p. 102.

[6] Ibid, p. 53.

[7] Todd Oppenheimer, "Schooling the Imagination," *Atlantic Monthly*, September 1999.

[8] 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.

[9] Joseph Weizenbaum, *Computer Power and Human Reason: From Judgment to Calculation,* NewYork: W. H. Freeman, 1976, p.261.

[10] Howard P. Segal, *Future Imperfect: The Mixed Blessings of Technology in America*, Amherst: University of Massachusetts Press, 1994.

[11] 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.)

[12] Howard Rheingold, *The Virtual Community: Homesteading on the Electronic Frontier*, New York: HarperPerennial, 1994, p. 290.

chapter five

Real Costs:

Computers Distract Us From Children's Needs

"I've probably spearheaded giving away more computer equipment to schools than anybody on the planet. But I've come to the conclusion that the problem is not one that technology can hope to solve. What's wrong with education cannot be fixed with technology. No amount of technology will make a dent."

—Steve Jobs, co-founder of Apple Computer, in *Wired Magazine*, Feb., 1996.

OUR NATIONAL INFATUATION WITH COMPUTERS in early childhood and elementary education is diverting scarce resources from children's real unmet needs. To what extent is the push to computerize childhood driven by the profit imperative — and political power — of high-tech industries? How much of it is fueled by adults' fears about their own ability to keep up with the pace of technological and cultural change? Is it reasonable to expect that training young children to operate powerful machines — machines doomed to obsolescence long before they apply for their first job — will somehow inoculate them against tomorrow's economic uncertainties? Can we afford to ignore what we know about the health and welfare of growing children to pursue educational policies that are fear-based and profit-driven?

The Real Costs of Educational Technology

U.S. public schools have spent more than $27 billion on computer technology and related expenses in the last five years, based on one estimate. Yearly spending has more than doubled since the 1994-1995 school year, rising from about $3.6-billion that year to an estimated $7.8-billion for 1999-2000. Those numbers are primarily based on reports by Quality Education Data (QED), a company that conducts a detailed yearly survey.[1] It does not separate out figures for elementary schools. Other companies also collect and sell similar information. But no official government estimate of trends in technology spending exists, let alone specific data on elementary schools, according to the National Center on Education Statistics.[2]

The high costs of computerizing early childhood and elementary education are likely to grow much higher — both in dollars spent and in opportunities lost to meet children's far more pressing needs. The Clinton administration has been urging schools to adopt its goal of one multimedia computer for every five children, Internet access in every classroom from kindergarten on up, and the software, training, and support services necessary to realize its vision of training all teachers to use computers to teach every academic subject.[3]

How close are schools to meeting these federal goals? The Department of Education has estimated that 100 percent of schools are likely to be connected to the Internet by the end of 2000.[4] By the fall of 1999, 94 percent of elementary schools had access to the Internet, according to the Education Department. But only about 62 percent of elementary classrooms did. And the ratio of students to computers with Internet access was 11 to 1 in elementary schools.

The initial costs of computerizing classrooms are just the beginning.

Schools that serve high proportions of low-income students are lagging behind. Those in which at least 71 percent of the students qualified for free or reduced-price lunches had one computer with Internet access for every 16 students in the fall of 1999. Only 39 percent of their classrooms had computers with Internet access. Schools with no more than 11 percent of students qualifying for free or reduced-price lunches had one computer with Internet access computer for every 7 students. And 74 percent of their classrooms had at least one such computer.[5]

Between 1990 and 1998 the ratio of computers in K-12 schools went from one for every 20 students to one for every 6 students.[6] Many classroom computers are older models that can't run the latest multimedia software, however. Multimedia computers represented only about 57 percent of schools' instructional hardware base in 1998-1999.[7]

And schools are still spending far less on teacher training than most experts say is necessary — at least 30 percent of total technology spending — if schools expect the new machines to do more than gather dust.[8] In 1998-1999, for example, they spent less than 8 percent on technology-related training and professional development.[9]

Estimates of the total cost, over time, for schools to fully realize the administration's goals start at about $47 billion.[10] Almost none of these estimates, however, include money to protect children from eye strain and repetitive stress injuries. This health issue — the ergonomic design of computer workstations so that they properly fit the growing children who use them — has been largely ignored by schools, the federal government, and other proponents of school computers. Few data are available on this issue. But it seems likely to add billions or even tens of billions of dollars to school computing costs.[11]

The initial costs of computerizing classrooms are just the beginning. Maintaining the machines and networks is a huge continuing expense: the repair and maintenance of equipment, retraining, and the frequent replacement of hardware and software, given how quickly they become obsolete or simply boring. Schools are training students and teachers to be avid educational "consumers," demanding the excitement of one new product after another. A 1995 report from SRI International refers to this effect as a powerful "technology appetite."

"As soon as more powerful computers are introduced, no one wants to use the older, slower machines," SRI notes. "Even if the school does not get new hardware, teachers' and students' technology activities will lead them to read about newer technologies available elsewhere, with an attendant frustration if they cannot have the same technology in their own school."[12]

A panel of President Clinton's advisers in science and technology policy urged K-12 public schools in 1997 to earmark at least 5 percent of their total budget — roughly $15 billion for the academic year 1999-2000[13] — every year, from now on, for technology-related expenses. That would be nearly twice what schools are now spending.[14]

Flawed Assumptions

A close reading of the president's advisory panel report provides compelling reasons to reject the panel's own advice. The report notes all of the following:

- The quality of research to date on the impact of computers on academic achievement has been low, relying partly on anecdotes. (The report cites approvingly one such anecdote about the Christopher Columbus Middle School in Union City, New Jersey, as "the most widely publicized example of the successful application of educational technology."[15] That particular story, however, has since been discredited. The celebrated rise in test scores at the school happened before the introduction of computers, not because of them.[16])

- No one has established how to use technology in ways that actually improve education — let alone how to do so in a cost-effective way, compared to alternative reforms. For this reason, the report adds, a huge new federal research effort would be critical to try to help schools figure out how to use computers wisely in the classroom.[17]

- Not only is there no consensus on how to use technology to support the best pedagogy, but there is also no agreement on an even more basic question: Which pedagogical approaches actually are best for children?[18]

- Schools will have to make significant cuts in other programs to come up with billions more for technology.[19]

- There is both "a relative dearth" of high-quality software and digital content designed for K-12 schools, and an "absence of a demonstrably effective base of educational software."[20]

- Teachers need three to six years to learn how to fully integrate technology into their teaching. But technology should be updated every three to five years. So "a teacher's learning curve is thus unlikely to ever level off entirely."[21]

Despite these sobering facts, the panel urged the nation to forge ahead and "deploy"[22] as much technology in schools as possible. No money should be "wasted," it added, to research the still unanswered question of "whether computers can be effectively used within schools."[23] After all, the White House report declares, "the probability that elementary and secondary education will prove to be the one *information-based industry* [emphasis added] in which computer technology does not have a natural role" is far too low to spend money on investigating the matter.[24]

In ruling out this critical research question, the panel here disregards its own warning about how dangerous such assumptions can be in educational research:

> It is well to remember that the history of science (and more specifically, of educational research and practice) is replete with examples of compelling application-specific hypotheses that seem to arise 'naturally' from well-founded theory, but which are ultimately refuted by

either rigorous empirical testing or manifest practical failure.[25]

We cite this report at length for three reasons: First, its recommendations have exerted a powerful influence on current educational policies. Second, the report is typical of government documents on the subject, in representing a narrow range of perspectives. The White House panel included two top executives of high-tech companies, including the group's chair, and other strong proponents of educational technology. Missing from the panel were classroom teachers from elementary or secondary schools, child-development experts, or critics of educational technology. Third, the report urges schools to spend much more on educational software — despite the current dearth of high-quality products — to provide software companies with financial incentives to develop better products.[26]

The same flawed thinking can be seen frequently at the state level. In 1996, for example, the California Education Technology Task Force issued an influential report urging the state to spend nearly $11 billion on technology for schools over the next several years as the single most important measure to "right what's wrong with our public schools." Executives from companies like Apple Computer, Hewlett Packard, IBM, and Sun Microsystems dominated the advisory group, according to the *Los Angeles Times*.[27]

The Politics of Technomania

The Clinton administration has taken the lead, but the high-tech-for-tots agenda has been very much bipartisan. Democrats and Republicans alike have enthusiastically campaigned for generous federal, state, and local school technology budgets. The Republican-controlled Congress, for example, has established the bipartisan Web-based Education Commission, which will recommend policy changes to promote the use of the World Wide Web in educating students of all ages.

This 16-member group includes no current elementary-school teachers, no critics of educational technology, no child-development experts, and only one high-school teacher. It does include several members of Congress and three executives from high-tech companies, including the founder of OnlineLearning.net, a company that sells continuing education courses through distance learning, and the senior vice president of bigchalk.com, a new company that provides educational resources via the Internet.

The commission plans to issue final recommendations by November 2000. The group's mission is to "help ensure that all learners have full and equal access to the World Wide Web." And it intends to conduct "a thorough study of the critical pedagogical and policy issues affecting the development and use of Web-based content and learning strategies to improve achievement at the K-12 and post-secondary levels." But its Website shows no sensitivity to the different developmental needs of a child in kindergarten, for example, compared to a college undergraduate. Instead, the assumption seems to be that even five-year-olds need "full and equal access" to the Web.[28]

Of the five public hearings the commission has planned, one was held at the National Education Computing Conference in Atlanta — hardly neutral territory — and a second at the headquarters of Sun Microsystems in Silicon Valley. One or two critics of educational technology have surfaced at the four hearings held so far. At the Sun-hosted hearing, for example, the majority of witnesses represented companies with a financial interest in promoting Web-based education, including Sun's own director for the "global K-12 market" and Sun's vice-president of "global education and research." Kim Jones, the Sun vice-president, urged Congress to spend more money to help schools purchase the products and services of companies like her own.

Jones described Sun's vision of the future of grade-school math. "There may be only a handful of, say, third-grade math courses that are the best in the world," she said. "A robust network that links schools and students to those courses ensures that any third-grader anywhere can benefit from the best course, no matter where it originates. This is why Congress must invest not only in such a network, but also in the best educational content."[29]

The commission's presumption that Web-based instruction will improve education at all levels reflects a long history of wishful thinking. Few leaders from either party have taken note of the 30 years of disappointing research findings about the likelihood that technology will improve academic achievement.

Even fewer seem to have considered whether such an agenda might harm young children. The U.S. Department of Education plans to issue a revised national plan for educational technology in September 2000. Based on preliminary documents the agency posted on its Website in May 2000, it appears that the administration is preparing to adopt an even more aggressive computer agenda, calling for "universal access to effective information technology" at home, school and in the community, for all students and all teachers, and declaring that "all teachers will effectively use technology."[30]

These documents make no mention of how to protect young children from repetitive stress injuries if their lives truly involved "universal" computing at home and school. In fact, the Education Department has never conducted any studies to investigate whether children using computers are at increased risk of repetitive stress injuries, or how to prevent such injuries, according to Carol Wacey, deputy director of the agency's Office of Educational Technology.[31]

Both major presidential candidates, Vice President Al Gore and Texas Governor George W. Bush, have endorsed the continued expenditure of billions of federal dollars every year to computerize schools. Much of this federal money is spent on the products or services of high-tech companies. And both candidates have conspicuously sought political and financial support from high-tech industries. Gore, who has made computerizing schools a key plank in his campaign, helped raise about $2.6 million for the Democratic Party at a Silicon Valley fundraiser in April 2000. And Bush announced his own plan to spend $3.4 billion a year on school technology and research on school technology just hours before attending the first of three Republican fundraisers in Silicon Valley in June 2000. Republicans expected to raise a total of about $5.9 million at those events.[32]

The Commercial Blitz: A Mega-Scam

Hardware, software, networking, and telecommunication companies don't leave the promotion of their sales agenda to politicians alone. Many have gotten directly involved in financing and/or taking leadership roles in groups like the Consortium for School Networking, TECH CORPS, and the CEO

Forum on Education and Technology. The press frequently quotes such organizations without mentioning their close links to companies with a financial interest in high-tech schools.

These groups talk about the complete technological makeover of K-12 education as a kind of national emergency. The CEO Forum, for example, organized a public challenge to every college of education in the country to sign a pledge to President Clinton that they will train all future teachers — presumably including all early childhood teachers — to use and integrate technology effectively in their teaching. The forum, joining with the secretary of education and two national associations related to teacher education, also challenged them to pledge to make technology a priority on their own campuses in every way — including funding. (About 20 percent had done so by the forum's deadline, after having received a letter that was signed by, among others, John S. Hendricks, the chief executive of Discovery Communications, Inc.[33])

In June 2000, the forum released a report declaring that "we need to apply technology's powerful tools to change the way our students, of every age, learn." It urged schools and districts to commit to that vision and to "increase investment in digital content."[34]

Of the CEO Forum's 25 members, 23 are from industry, including high-ranking executives of Apple Computer, BellSouth Business, Compaq Computer, Computer Curriculum Corporation, Discovery Communications, IBM, Lucent Technologies, NetSchools Corporation, Quality Education Data, ZapMe Corporation, America Online, Bell Atlantic, Classroom Connect, Inc., CompassLearning, Dell Computer, and the Washington Post Company. The National Education Association and the National School Board Association are the only two noncorporate members. Nearly all of the 23 corporate members either sell high-tech services and products or represent clients who do.

TECH CORPS is a nonprofit group that encourages volunteers to share their technical skills with schools. Its Website has declared that TECH CORPS is "passionate about giving America's students a chance to have the most technologically advanced education possible."[35] But it's primarily financed by corporate sponsors with profits, as well as passion, at stake in emphasizing that goal. Its four national sponsors are all high-tech powerhouses: Cisco Systems, Compaq Computer, Intel, and the Cellular Telecommunications Industry Association. So are most of its patrons and partners, including America Online, Bell Atlantic, Hewlett-Packard, MCI WorldCom, Microsoft, and the National Cable Television Association. TECH CORPS's Website includes direct links to all of those companies' sites.

TECH CORPS's guide for parents, "Child Safety on the Information Highway," encourages parents to "get online yourself." While noting the dangers to children of adult predators and adult material, the brochure also adds: "To tell children to stop using these services would be like telling them to forego attending college because students are sometimes victimized on campus." Children, it adds, without specifying any age in particular, can learn to be "street smart," to safeguard themselves. The TECH CORPS brochure was sponsored by several Internet-related businesses, including America Online and Prodigy Service.[36]

Other authorities strongly recommend that parents closely monitor who and what their children are exposed to online. The American Academy of Child and Adolescent Psychiatry, for example, advises:

> Most parents teach their children not to talk with strangers, not to open the door if they are home alone, and not to give out information on the telephone to unknown callers. Most parents also monitor where their children go, who they play with, and what TV shows, books, or magazines they are exposed to. However, many parents don't realize that *the same level of guidance and supervision must be provided for a child's online experience.* [emphasis in original][37]

Even the International Society for Technology in Education, in the past an organization for educators, has just created a new corporate program — "ISTE 100" — for "industry leaders in the educational technology field" who are committed to the group's goal of "improving education through the appropriate use of technology." This new corporate arm of the group is interested in promoting technology from preschool through high school. At the request of the founding corporate members, ISTE has invited all of its teacher members interested in "advocating for the effective use of technology in schools" to join its new Advocate Network. The companies will then be able to directly e-mail them to conduct marketing research for the design of new products.[38]

It is surprising how little the private sector is actually donating to cover the high costs of educational technology.

In a draft report on the high-tech future of education, the society proposes an ambitious set of technological goals for the nation's schools. The goals "are designed to support the overall goals of education." They also appear to be closely aligned with the business goals of the man who is funding the report — Bill Gates of Microsoft, author of *The Road Ahead.* The draft is titled: "Foundations for The Road Ahead: An Overview of Information Technologies in Education."[39] (About 76 per cent of all K-12 public schools and about 84 per cent of all the nation's school districts used instructional software produced by Microsoft in 1998-1999, according to one major survey.)[40]

The Consortium for School Networking is another nonprofit group that includes school districts and other institutions. It also includes many companies — each with a "hot link" from the consortium's Web page directly to their own. The companies involved almost without exception are high-tech players in the school market. One of the consortium's major initiatives is "building a grassroots network of advocates for investment in education technology," especially for lobbying the federal government. The New York Times Electronic Media Company is one of these corporate members, which puts *Times* reporters in an awkward position in covering the politics of such spending.[41]

Given the keen interest of so many companies in promoting childhood computing, it is surprising how little the private sector is actually donating to cover the high costs of this agenda. School districts report that donations and fundraising accounted, on average, for only 2.1 percent of the costs of technology in 1998-1999.[42]

The school market is not the only corporate incentive for promoting the use of computers by children. Parents frequently cite their children's education as the reason for buying home computers. The belief that young children's futures hinge on early and ubiquitous access to computers, then, creates an opportunity for companies to sell parents the entire array of high-tech equipment, Internet services, and software. It also benefits major media companies that are increasingly eager to generate more traffic and more revenue through their dot.com sites. In this way, children's "need" for computers opens the spigot for high-tech products and services to flow into households.

The resulting hard sell to parents and schools, says Alex Molnar, professor of education at the University of Wisconsin at Milwaukee, is "a mega-scam."[43]

The Dog That Didn't Bark

It seems likely that the top executives of these high-tech companies sincerely believe that their products really will revolutionize education in positive ways. After all, to paraphrase an old saw, to a man with a hammer to sell, everything looks like a nail.

But why are so many Americans buying the pitch? Parents, policymakers, and educators should take note, as Sherlock Holmes suggested, of "the dog that didn't bark." If it is truly a matter of competitive survival for the United States that young children be trained to operate the most sophisticated tools ever devised, as high-tech companies and politicians keep telling us, why is it almost exclusively the companies with high-tech products or services to sell that are so exercised about this issue? Why is the rest of corporate America not clamoring for such an expensive and unproved educational fix?

The answer is obvious. Wiring and computerizing America's schools is an urgent priority — not for children, but for high-tech companies that need to constantly expand their market. The competitive pressure in these industries is famously intense. Schools and families with children represent a huge market. Many companies aim to establish brand loyalty with children at ever younger ages, at home and school. And others count on "the whine factor" to turn online advertising on children's sites into parents' purchases.

Quality Education Data, which provides research and marketing advice to companies that sell instructional technology, publishes "tipsheets" pointing out that the federal Title I program has become a major source of money for schools' purchases of technology. Companies can "capitalize on this funding source" by "following the money" and targeting schools with higher percentages of Title I students. One tipsheet is actually titled: "Title I Funding: Are You Getting Your Share?"[44]

Title I was designed to improve the academic achievement of disadvantaged children, especially those attending school in high-poverty areas. By 1997-1998, schools were spending nearly $300 million of the program's total cost of about $7.1 billion to purchase computers and other instructional technology.[45] Schools can also use the money to improve curricula, provide professional teacher development, and pay teacher salaries. The last helps schools reduce class sizes — an educational reform, unlike technology, that is strongly backed by research.

It is time for educators, policymakers, parents, and advocates for children to resist these pressures and to refocus on children's needs — not industry's hunger for an ever bigger market.

Children's Real Unmet Needs

The White House panel has urged the nation to spend on the order of about $15-billion a year on educational technology, and all the related services and training, for K-12 schools. Again, that's about twice the level of current spending. (On a pro-rated basis, it would be about $8-billion for students from kindergarten through sixth grade.) Presumably a large portion of this extra money would come from new tax expenditures.

But what makes educational technology such a high priority? What about other, far more significant and underfunded priorities, in terms of children's unmet needs — especially the unmet needs of our most disadvantaged children? How else might we spend the billions now directed to technology, as well as the billions more that proponents are calling for? Perhaps we could focus on some real childhood emergencies:

Eliminating lead poisoning

First, we might finally make a long overdue commitment to eliminate childhood lead poisoning. This serious, preventable injury affects an estimated 4.4 percent of all children between the ages of one and five — or about 890,000 preschoolers.[46] At these ages, children's developing brains and nervous systems are especially vulnerable to damage from lead exposure. Lead-based paint in houses and residential apartments is the major source of lead poisoning in this country. The problem is most severe in deteriorating housing, where children may eat paint chips, breathe lead dust, or ingest the dust by putting their hands in their mouths after touching toys, food, or other items the dust has settled on.

For that reason, the prevalence of lead poisoning among children living in poverty is eight times that of children from the wealthiest families. And children of color, who are more likely to live in crumbling urban neighborhoods, are also disproportionately harmed. African-American children suffer lead poisoning five times as frequently as white children. And Mexican-American children are twice as likely as non-Hispanic white children to show toxic levels of lead in their blood. An estimated 11.2 percent of all African-American children have suffered toxic exposure; 4 percent of all Mexican-American children have, and 2.3 percent of all white children.[47]

This is one of America's most serious educational crises. "Even when exposed to small amounts of lead levels," reports the American Academy of Child and Adolescent Psychiatry, "children may appear inattentive, hyperactive and irritable. Children with greater lead levels may also have problems with learning and reading, delayed growth and hearing loss. At high levels, lead can cause permanent brain damage and even death."[48]

According to the Alliance to End Childhood Lead Poisoning, half of all the preschool children in some of the nation's most blighted neighborhoods are lead-poisoned.[49] Teachers and health care professionals testify that the educational fallout is as tragic as it is preventable.

"Over and over again, we see kids coming out of the same houses lead-poisoned," says Dr. Charles I. Shubin, director of children's health and family care at Mercy Medical Center in Baltimore, which monitors and cares for about 8,000 lead-exposed children. "One generation after another, we see the same addresses, the same blocks, the same neighborhoods, the same landlords. Our kids are being poisoned while we watch."[50]

In Baltimore, according to a recent report by the *Baltimore Sun*, nearly seven out of every ten children tested each year in the slum enclaves of Park Heights, Sandtown, and Middle East show elevated lead levels in their blood. These same neighborhoods, the *Sun* added, "are home to some of the city's poorest performing schools, its highest violent crime rates and its largest blocs of substandard rental housing." Dr. Herbert L. Needleman of the University of Pittsburgh Medical School, perhaps the nation's top expert on the effects of lead on children, doesn't think that convergence of social problems is coincidental.

Why pour billions into computers — at best an unproven intervention and at worst actually harmful — before first eliminating this toxic barrrier to the academic success of so many poor children?

"In some populations," says Needleman, "[lead exposure] may be the most important factor in determining a broad range of neuromotor, psychosocial and behavioral pathologies — poor cognitive performance, hyperactivity and aggression being particularly well-established traits… It's a very potent metabolic poison."

The classroom impact alone is dramatic. Danette Murrill, instruction coordinator for an elementary school in one of Baltimore's most severely affected communities, estimated that one in five of the students at her school had suffered lead poisoning.

"They don't stay on task, they're very fidgety, they're uncooperative in class and they have great difficulty retaining information," Murrill told the *Sun*. "As a teacher, it's very frustrating because you always have at least 5 or 6 of them in a class — but you don't always know who they are."

Poor children, the *Sun* noted, are also more likely to be poisoned repeatedly and less likely to have access to good health care and a healthy diet, both of which can counter the harmful effects of high lead levels.

> Lead poisoning, Needleman added, "can put [children in troubled neighborhoods] so far behind at the beginning of the race of life that they never make up the lost ground, particularly as they deal with all the other pathologies in their environment — crime, drugs, malnutrition, neglect, alcoholism — and particularly if the exposure is persistent. Lead sets them up to fail across the board."[51]

Here is an educational emergency that could truly benefit from the political clout of high-tech industries. Between 5 million and 15 million residential properties pose lead hazards because of deteriorating paint, and the cost per unit of lead abatement averages about $5,000, according to the Alliance to End Childhood Lead Poisoning. That means the total cost to erase the major cause of this problem would be between $25 billion — less than the amount schools have spent on computer technology in the last five years — and $75 billion.

The Clinton administration has proposed a ten-year plan to address the problem. The federal government would provide an average $230 million a year over current federal spending, now about $60 million a year. The administration has suggested that other non-federal sources of funding that are already in place will take care of the rest of the problem. Child advocates, however, are not hopeful that Congress will adopt even this modest proposal.[52]

Why wait ten years? Why pour billions into computers — at best an unproven intervention and at worst actually harmful — before first eliminating this toxic barrier to the academic success of so many poor children?

Other Pressing Needs of Our Most At-Risk Children

There are many other challenges to the academic success of our children — especially poor children — that we can and should take up with the same sense of mission now lavished on computers. We could, for example, invest much more in nutrition programs, health care, high-quality child care, and early-childhood education for low-income families. Lack of access to such services can pose a real threat to a small child's healthy development, cognitive and otherwise.

In contrast, there is absolutely no evidence that the lack of computer technology in elementary school poses any threat at all to a child's development.

Nearly one in five children in America lives in poverty, with all the pressures on parents that implies — and the extra obstacles to school success. The Children's Defense Fund has calculated how much we would need to spend "to give large numbers of children a fairer start in life."[53] That also means a fairer start in school. Another 1.7 million of our poorest citizens, for example, could be served if we spent an additional $800 million a year on the federal food program designed to make sure that young children and their mothers at least have enough to eat.

Millions of children still lack health insurance. For an additional $2.3 billion a year, according to the Children's Defense Fund, all uninsured children from low-income families could have access to health care.

As a nation we spend so little on Head Start — the preschool program proven to give poor children and their families a boost into the school years — that only about half of the children who are eligible for it are enrolled. Fully funding this program would cost $6.23 billion more a year.

And finding safe, affordable, high-quality child care can be a nightmare for the working poor. Providing child care assistance for another 2.5 million children would cost $5.6 billion a year.

Critical Needs of Our Public Schools

All of these initiatives are far more pressing examples of children's unmet needs. Other critical needs within public schools themselves are also inadequately funded and must now compete with the siphon of technology spending. Teachers, for example, continue to call for smaller class sizes so they can give their most challenging and disadvantaged students the personal attention they deserve. They ask for more human resources of all kinds — more aides and volunteer mentors, more tutors in reading and other subjects, more social workers and counselors, to help meet children's emotional and remedial needs. To its credit, the Clinton administration proposed and secured funding from Congress for a major federal initiative for smaller classes in kindergarten and the early grades. But more money is, and will continue to be needed.

Schools also need large sums of additional money to give teachers the salary increases they deserve, as well as to be able to attract and retain additional qualified individuals to our nation's classrooms. The latter is a particular challenge today, as schools brace themselves for a major wave of retirement among the current pool of elementary-school teachers.

Because school districts are investing so much in technology, they are less able to repair and renovate aging school buildings. They also find it harder to build the 2,400 new schools that will be needed by the year 2003 to ease overcrowding and make room for growing enrollments.[54]

About 50 percent of all public schools reported in 1999 that they needed to fix basic building problems, such as leaky roofs or plumbing, according to the U.S. Department of Education. And 43 percent reported at least one environmental problem, such as poor ventilation, inadequate heating, or poor indoor air quality.[55] Two-thirds needed renovations to correct health, safety, or accessibility problems, such as removing asbestos, lead in water or paint, or problem materials in underground storage tanks, according to a 1995 report.[56] Studies suggest that schools need to spend more than $100 billion to provide all students with adequate buildings.[57]

Research indicates that deteriorating and overcrowded schools have negative effects on student achievement and behavior.[58] Yet most schools that reported building inadequacies of all kinds in a survey in 2000 by the National Center for Education Statistics "had no plans for major repair, renovation, or replacement in the next two years."[59] Again, compared to this undeniably real and costly challenge, the false sense of urgency around computer investments seems ludicrous.

Finally, the high-tech approach to early childhood and elementary education is shrinking the time and money available for the simple technologies that are far more developmentally appropriate. Real technology enrichment for children would mean increased public support for school gardens, camping and other field trips, music and other artistic experiences, time for creative play and physical education, hands-on science labs, handcrafts such as woodworking, library books, smaller classes and smaller schools, and mentors at school and in the community. These are developmentally appropriate precisely because they are the opposite of "distance learning."

Once we recover from the illusion that technical innovations will revive education, the really critical conversation can begin: How can we tackle the social obstacles to children's healthy development with renewed social commitment?

A New Conversation

The above list of children's priorities that computers distract us from is not intended to be exhaustive. It is an attempt to begin a conversation about the many ways the billions we now spend on computers for children of elementary age and younger could be better invested if our intention is to offer every child a chance to succeed in school.

Nor do we mean to suggest that simply expanding current public programs in the high-priority areas above would resolve all of these stubborn social problems. In fact, once we recover from the illusion that technical innovations will revive education, then the really critical conversation can begin — the one we have been avoiding for far too long: How can we tackle the social obstacles to children's healthy development with renewed commitment? And with social, as opposed to

Eight Billion Dollars:
For High-Tech Companies or Children's Needs?

An influential presidential commission has recommended that the nation spend on the order of $15-billion a year for educational technology in public schools, K-12. Proportionately, that would be about $8-billion at the elementary-school level. How might those billions in public dollars be better spent? Consider the much higher educational priorities below — especially those aimed at providing low-income children with a fairer start in life:

Critical Needs of the Nation's Public Schools:

- Reducing classroom size.
- Raising teachers' salaries to attract and retain good teachers.
- Funding the aides, counselors, and other adult mentors children need — especially children most at risk of failure.
- Repairing and renovating dilapidated school buildings.
- Building the 2,400 new schools needed by 2003.
- Reviving essential school programs such as music and the other arts, gardening, physical education, outdoor experiences, hands-on education of all kinds, and libraries.

Critical Needs of Our Most Disadvantaged Children:

- Eliminating childhood lead poisoning now.
- Providing quality child care for children of the working poor.
- Insuring access to health care for all children and their parents.
- Meeting the nutritional needs of families in poverty.
- Making quality pre-school programs such as Head Start available to all children.

mere technical, creativity? For example, what kind of assistance do troubled neighborhoods need to capitalize on their own assets? Too often, outside aid concentrates almost exclusively on these neighborhoods' deficits. How can low-income parents be empowered to identify for themselves their families' and their neighborhoods' most pressing needs — and empowered to work creatively to meet them?

Such a conversation might draw on Making Connections, a model of community participation being tested in 22 cities by the Annie E. Casey Foundation. Its aim is to spark and help sustain local movements that engage everyone involved — residents, civic groups, politicians, grassroots groups, school leaders, public agencies, private organizations, and faith-based groups — "to help transform tough neighborhoods into family supportive environments." The initiative focuses on strengthening families in troubled neighborhoods by helping them to connect to economic opportunities, positive social relationships that boost neighbor-to-neighbor support, and the full range of social services and supports that can help struggling families grow stronger. It also emphasizes the full participation of neighborhood residents in designing their own futures.

This democratic approach seems a far more promising strategy for helping our most disadvantaged children thrive, at home and school, than forcing computers on every teacher as a kind of silver bullet for school reform.

"Making Connections should not be thought of as a housing initiative, neighborhood revitalization project, community safety program, or a school reform movement," the foundation advises. "Rather, this effort seeks to draw from, build on, and weave together what our work, the work of others, and the experience of communities show to be the most effective practices and strategies in community building, system reform, family support, and economic development."[60]

Unfortunately, no powerful coalitions of hardware, software, and telecommunications giants are leading the charge for the empowerment of distressed communities, for safe school buildings and lead-free housing, for proper nutrition, or for health insurance for children whose families, working or not, still struggle to make ends meet — or for the kind of low-tech, hands-on school agenda on which children thrive. Instead, many of these powerful corporations are demanding that parents, teachers, and schools adopt their own agenda for education, which just happens to be based on the products they sell.

1 "Technology Purchasing Forecast 1999-2000," 5th ed., Denver: Quality Education Data, 2000, p. 5. Figures cited here are based on annual surveys by QED of spending on instructional technology by K-12 public schools. The five years extend from the 1995-1996 school year through 1999-2000. QED estimated spending for 1999-2000 at $6.2-billion, which did not include the total subsidies that schools would be receiving for their purchase of telecommunications services — the so-called "e-rate" discounts. QED said it was not able to include how much schools would be receiving in e-rate discounts in that estimate, because schools at the time of the survey did not have that information. The Schools and Libraries Division of the Universal Service Administrative Company, however, more recently estimated the total e-rate discount provided to public schools and school districts for 1999-2000 as $1.6-billion. (Telephone interview with Mel Blackwell of the Schools and Libraries Division, August 17, 2000.) The $7.8-billion estimate for 1999-2000, then, is derived by adding those two estimates.

2 "Answers to Frequently Asked Questions: Educational Technology Spending," U.S. National

Center for Education Statistics, published on the official web site of the U.S. Department of Education, at http://nces.ed.gov/edfin/faqs/technlgy.asp as of June 21, 2000. The statistics center poses the question: "How much is spent on educational technology in the US?" Its answer: "Unfortunately there are no figures on this. No reports have been done or studies made."

3 "Getting America's Students Ready for the 21st Century: Meeting the Technology Literacy Challenge," Washington, DC: U.S. Department of Education, June 1996.

4 *Digest of Education Statistics, 1999*, Washington, DC: U.S. Department of Education, 1999, from Chapter Seven: "Learning Resources and Technology"; and *Challenging the Status Quo: The Education Record 1993-2000*, Washington, DC: U.S. Department of Education, May 2000, from Chapter Five: "Using Technology to Enhance Teaching and Learning."

5 National Center for Education Statistics, "Survey on Internet Access in U.S. Public Schools, Fall 1999," in *Quick Tables and Figures: Elementary and Secondary Education: Fast Response Survey System*, (FRSS 75), Washington, DC: U.S. Department of Education, 1999.

6 U.S. Department of Education, "Challenging the Status Quo: The Education Record 1993-2000."

7 QED, op cit., derived from statistics on p. 7.

8 President's Committee of Advisors on Science and Technology: Panel on Educational Technology, "Report to the President on the Use of Technology to Strengthen K-12 Education in the United States," Washington, DC: Executive Office of the President of the United States, March 1997, p. 48.

9 QED, op. cit., based on its estimates of the average spending by school districts on both training and professional development related to instructional computing, as a percent of total average spending on instructional technology for 1998-1999. That was $10.81 per student. Total average spending by district per student for instructional technology was $140.66.

10 The $47 billion figure is quoted by the President's Committee of Advisors on Science and Technology: Panel on Educational Technology, op. cit., p. 59.

11 The cost could range from about $400 to $3,000 per computer, based on a preliminary estimate in 1999 by an ergonomics consultant at Professional Ergonomic Solutions. The company provides training and products for ergonomic workstations, keyboards, and accessories. Because of the low level of public awareness about this issue, we include their toll-free number here for parents and others interested in more information: 888-744-ERGO.

12 Barbara Means and Kerry Olson, "Restructuring Schools with Technology: Challenges and Strategies," SRI International, November 1995, p. 32.

13 Based on the total day-to-day expenditures for public elementary and secondary schools in school year 1997-1998, as reported by National Center for Education Statistics, *Statistics in Brief: Revenues and Expenditures for Public Elementary and Secondary Education: School Year 1997-98*, Department of Education, May, 2000. The total that year was $285-billion. By 1999-2000, estimating conservatively that total spending would increase by 3 per cent a year, that total would have grown to about $302-billion.

14 President's Committee of Advisors on Science and Technology: Panel on Educational Technology, op. cit., p. 8.

15 Ibid, pp. 18-19.

16 *ABC News Nightline:* "The $50 Billion Gamble: Will Computers Improve Public School Education?" Transcript for September 30, 1998.

17 President's Committee of Advisors on Science and Technology: Panel on Educational Technology, op. cit., especially pp.17, 107, 122, 130.

18 Ibid, especially pp. 34-35, 107, 123, 128.

19 Ibid, especially p. 8.

20 Ibid, especially pp. 44, 116.

21 Ibid, especially p. 118.

22 Ibid, p. 131.

23 Ibid, especially p. 124.
24 Ibid, especially pp. 93-94.

25 Ibid, p. 88.

26 Ibid, pp. 42-43.

27 Leslie Helm, "High Tech Sales Goals Fuel Reach into Schools," *Los Angeles Times*, June 9, 1997, Home Edition, p. A1.

28 Congressional Web-Based Education Commission, www.hpc.net.org/webcommission, as of June 23, 2000.

29 Press release: Sun Microsystems VP Calls on Congress to Invest in Network Infrastructure, Education Content, Palo Alto, CA: Congressional Web-based Education Commission, April 7, 2000.

30 U.S. Department of Education, "Revising the National Educational Technology Plan: Emerging Priorities," www.ed.gov/Technology, and www.air.org/forum/ as of July 12, 2000.

31 Phone interview, July 11, 2000.

32 Terry M. Neal, "Bush Hits Democrats on Tech Education," *Washington Post,* June 20, 2000, p. A6.

33 "Business and Education Leaders Push Teacher Prep Component of President's Digital Divide Initiative," news release, Chicago: CEO Forum on Education and Technology, April 18, 2000; and "Dear Colleague" letter, www.ceoforum.org/scde-colleague.cfm, March 2000.

34 The Power of Digital Learning: Integrating Digital Content, CEO Forum, June 26, 2000.

35 TECH CORPS, www.ustc.org/index.html, February 3, 1999.

36 TECH CORPS, "Child Safety on the Information Highway," TECH CORPS, www.ustc.org/index.html, as of June, 2000.

37 "Facts for Families: Children Online," Washington, DC: American Academy of Child and Adolescent Psychiatry, 1997.

38 International Society for Technology in Education, "ISTE 100: Partners in Educational Technology Leadership," Eugene, OR: ISTE, www.iste.org/Members/index.html, as of July 12, 2000.

39 David Moursund et al., "Foundations for The Road Ahead: An Overview of Information Technologies in Education," International Society for Technology in Education, www.iste.org/Research/index.html, as of July 12, 2000. (The draft includes the disclaimer that it does not represent the views of ISTE, Bill Gates, or anyone but the authors, who are staff of the ISTE.)

40 Quality Education Data, op. cit., pp. 121, 123.

41 Information about the consortium is from the Consortium for School Networking's Website, www.cosn.org, as of July 31, 2000.

42 Ibid, p. 38.

43 Leslie Helm, *Los Angeles Times*, op. cit.

44 Tipsheet #15: "Title I Funding: Are You Getting Your Share?" and Tipsheet #19: "10 Trends to Watch in Instructional Technology," Denver: Quality Education Data, undated.

45 Jay Chambers, Joanne Lieberman, Tom Parrish, Daniel Kaleba, James Van Campen, and Stephanie Stullich, "Study of Education Resources and Federal Funding: Final Report," Washington, DC: U. S. Department of Education, Planning and Evaluation Service, 2000.

46 "Our Children at Risk: The Five Worst Environmental Threats to Their Health," Washington, DC: Natural Resources Defense Council, 1997, posted at http://nrdc.org/health/kids/ocar/zchapter3.asp. (Report based, in part, on data from the U.S. Centers for Disease Control and Prevention and the U.S. Environmental Protection Agency.)

47 Ibid, based on data from the National Research Council.

48 American Academy of Child and Adolescent Psychiatry, "Facts for Families: Lead Exposure in Children Affects Brain and Behavior," Washington, DC: AACAP, undated.

49 Phone interview with Don Ryan, executive director, the Alliance to End Childhood Lead Poisoning, Washington, D.C., June 26, 2000.

50 Jim Haner, "Lead's Lethal Legacy Engulfs Young Lives," *Baltimore Sun*, Jan. 20, 2000.

51 Ibid, for all of the above quotes from the *Baltimore Sun.*

52 Phone interview with Don Ryan, executive director, the Alliance to End Childhood Lead Poisoning, Washington, D.C., June 26, 2000.

53 Estimates of spending for nutrition, health insurance, child care, and early-childhood education to serve more poor children and their families are from "Children Deserve a Fair Share of the Federal Budget Surplus," Washington, DC: Children's Defense Fund, February 2000.

54 "A Back-to-School Special Report on the Baby Boom Echo," Washington, DC: U.S. Department of Education, Aug. 19, 1999.

55 National Center for Education Statistics, "Condition of America's Public School Facilities: 1999," Washington, DC: U.S. Department of Education, 2000.

56 U.S. General Accounting Office, "School Facilities: The Condition of America's Schools," GAO Report HEHS-95-61, Washington, DC: U.S. GAO, February 1995.

57 See, for example, U.S. General Accounting Office, op. cit.

58 For a summary and bibliography of this research, see U.S. Department of Education, "Impact of Inadequate School Facilities on Student Learning," www.ed.gov/inits/construction/impact2.html, as of July 10, 2000.

59 National Center for Education Statistics, "Condition of America's Public School Facilities: 1999."

60 "Contributing Ideas, Support, and Resources to Build on Neighborhood Strengths," Annie E. Casey Foundation, www.aecf.org/initiative /ntfd/making.htm, as of June 22, 2000.

chapter six

Conclusions and Recommendations

"The fundamental dilemma of computer-based instruction and other IT-based educational technologies is that their cost effectiveness compared to other forms of instruction — for example, smaller class sizes, self-paced learning, peer teaching, small group learning, innovative curricula, and in-class tutors — has never been proven."

—U.S. National Science Board,
Science & Engineering Indicators — 1998.

WHY ARE WE, AS A NATION, SO ENAMORED of computers in childhood? This one-size-fits-all fix for elementary schools does seem to meet a lot of adult needs. It makes politicians and school administrators appear decisive and progressive. It tempts overworked parents and teachers with a convenient, mesmerizing electronic babysitter. And it is irresistible to high-tech companies that hope to boost sales in the educational market.

But a machine-centered approach does not meet the developmental needs of grade-school children. Nor will it prepare them to muster the human imagination, courage, and will power they will as adults need to tackle the huge social and environmental problems looming before us.

Young children are not emotionally, socially, morally, or intellectually prepared to be pinned down to the constraining logical abstractions that computers require. This sedentary approach to learning is also unhealthy for their developing senses and growing bodies.

What's good for business is not necessarily good for children. We cannot afford educational policies that will expand the market for Microsoft, Compaq, IBM, Apple, and other companies at children's expense.

Nor can we afford the delusion that pushing young children to operate the very latest technological gadgets will somehow inoculate them from economic and cultural uncertainties in the future. Nothing can do that — certainly not soon-to-be obsolete skills in operating machines.

In the long term, what will serve them far better is a firm commitment from parents, educators, policymakers, and communities to the remarkably low-tech imperatives of childhood. Those include good nutrition, safe housing, and high-quality health care for every child — especially the one in five now growing up in poverty. They also include consistent love and nurturing for every child; active, imaginative play; a close relationship to the rest of the living world; the arts; handcrafts and hands-on lessons of every kind; and lastly time — plenty of time for children to be children.

A new respect for childhood itself, in other words, is the gift that will best prepare our children for the future's unknowns. Empowered by this gift, our children can grow into strong, resilient, creative human beings, facing tomorrow's uncertainties with competence and courage.

Some may fear that our prowess in science and technology will suffer if children are allowed to be children. The opposite is true. Consider the recent Microsoft ad, "Chasing the Future." As companies rapidly turn out one high-tech product after another, it stresses, companies and nations must "constantly replenish their long-term reserves of intellectual capital." Research, Microsoft declares, is the engine driving technical advances. So research, it adds, "has never been more important."[1]

To the extent that's true, then so, too, has childhood never been more important — or more endangered by the current push to transform children into technicians. For childhood is the one period in the human lifespan naturally designed for pursuing the most basic science of all. That's why pushing children instead to produce PowerPoint presentations that mimic the work of adults is shortsighted. It's as shortsighted as Microsoft argues it would be for the United States to pull the plug on basic research and finance only short-term product development.

By supporting basic research, we give our most creative scientists the time they need to play with the fundamental qualities and questions of nature. In periods of great productivity, scientists say, this open-ended creative process can totally dominate their lives — whether they are working, eating, sleeping, or socializing. In short, they live their science. Granted that freedom, they generate the insights that lead to fruitful discoveries, sometimes even paradigm-shifting breakthroughs at the very edges of knowledge.

Childhood, rightly protected, is the same kind of creative process — the same kind of basic science. Children, too, need time to play with the most fundamental qualities and questions of nature — to "live" them with their whole beings: body, heart, mind, and soul. How closely related this wonder-full quest of childhood is to the expansive spirit of basic science is neatly captured in *The Scientist in the Crib: Minds, Brains, and How Children Learn:* "Our otherwise mysterious adult ability to do science may be a kind of holdover from our infant learning abilities," suggest the authors. "Adult scientists take advantage of the natural human capacities that let children learn so much so quickly. It's not that children are little scientists but that scientists are big children."[2]

Imagination and the spirit of play are crucial to both child and adult forms of "basic science." As the anthropologist Ashley Montague noted, the most creative scientists excel in playing "let's pretend":

> The scientist says to himself, "Let me treat this 'as if' it worked that way, and we'll see what happens." He may do this entirely in his head or try it mathematically on paper or physically in the laboratory. What he is doing is using his imagination in much the same way the child does. The truth is that the highest praise one can bestow on a scientist is not to say of him that he is a fact-grubber but that he is a man of imagination. And what is imagination really? It is play — playing with ideas.[3]

The high-tech agenda pushes children to hurry up and become skilled little technicians, experts in "accessing" other people's answers to narrow, technical questions and manipulating machine-generated images. It interrupts the creative process, the basic science, of childhood itself — the playful generation of images from one's own imagination. We do not know what the consequences of such a machine-driven education in adulthood will be. But we suspect that they will include a narrower and more shallow range of intellectual insights, a stunting of both social and technical imagination, and a drag on the productivity that stems from imaginative leaps. In short, a high-tech agenda for children seems likely to erode our most precious long-term intellectual reserves — our children's minds.

School reform is a social challenge, not a technological problem.

School reform is a social challenge, not a technological problem. The Education Department's own 1999 study, "Hope in Urban Education," offers powerful proof. It tells the story of nine troubled schools in high-poverty areas, all places resigned to low expectations, low achievement, and high conflict — where even the adults bickered and blamed each other. But all transformed themselves into high-achieving, cohesive communities. In the process, everyone involved — principals, teachers, other staff members, parents, and students — developed high expectations of themselves, and of each other.

The strategies that worked in these schools, the study emphasizes, were persistence, creativity in devising new ways of collaborating, maximizing the attention focused on each child, and a shared commitment to meeting the full range of children's needs.

That intensely human approach — not large expenditures on technology — is what seems to have moved all nine communities from despair to hope. Educational technology plays only a relatively minor role in the report. The words "computer" and "technology" do not even appear in the executive summary.

Instead, much credit goes to a new quality in human relationships. "Visitors to these schools," the report notes, "quickly sense that teachers and other staff members genuinely love and care for the students.… The improvements in student behavior were also influenced by the changes in the extent to which children came to understand that they were valued and respected." In all nine schools, the principals "knew all of the students by name and knew many of the families. The personal relationships among students and school staff created a powerful context for good behavior." At all nine schools, parents too became active, engaged, creative partners. This happened because the schools clearly expressed their need and respect for the parents — and because the parents saw "tangible evidence of the school's concern for their children."[4]

Larry Cuban, professor of education at Stanford University, has documented how U.S. education policymakers have careened from one new technology to the next — lantern slides, tape recorders, movies, radios, overhead projectors, reading kits, language laboratories, televisions, computers, multimedia, and now the Internet — sure each time that they have discovered educational gold.[5] Eventually, the glimmer always fades, and we find ourselves holding a lump of pyrite — fool's gold.

Perhaps what we're looking for is not a technology, not a product to be bought and sold at all. Perhaps the gold is something to be mined and refined within ourselves.

Could it be that simple, and that hard?

Some of the world's most thoughtful teachers have suggested as much. John Dewey spoke of the eight loves that mark great teachers — love of others, love of being with children, love of knowledge, of communicating knowledge, of a particular subject that one has an aptitude for, and love of arousing in others similar intellectual interests, a love of thinking, and the ability to inspire in others one's own love for learning itself.[6]

And Rudolf Steiner, the Austrian innovator, advised, "Accept the children with reverence. Educate them with love. Send them forth in freedom."[7]

Those who place their faith in technology to solve the problems of education should look more deeply into the needs of children. The renewal of education requires personal attention to students from good teachers and active parents, strongly supported by their communities. It requires commitment to developmentally appropriate education and to the full range of children's real low-tech needs — physical, emotional, and social, as well as cognitive.

M.I.T. Professor Sherry Turkle has asked: "Are we using computer technology not because it teaches best but because we have lost the political will to fund education adequately?"[8] Her question deserves an answer.

In view of the overwhelming evidence summarized here and the urgent needs of our children and schools, the Alliance for Childhood calls for the following actions:

Recommendations

1. A refocusing in education, at home and school, on the essentials of a healthy childhood: strong bonds with caring adults; time for spontaneous, creative play; a curriculum rich in music and the other arts; reading books aloud; storytelling and poetry; rhythm and movement; cooking, building things, and other handcrafts; and gardening and other hands-on experiences of nature and the physical world.

2. A broad public dialogue on how emphasizing computers is affecting the real needs of children, especially children in low-income families.

3. A comprehensive report by the U.S. Surgeon General on the full extent of physical, emotional, and other developmental hazards computers pose to children.

4. Full disclosure by information-technology companies about the physical hazards to children of using their products.

5. A halt to the commercial hyping of harmful or useless technology for children.

6. A new emphasis on ethics, responsibility, and critical thinking in teaching older students about the personal and social effects of technology.

7. An immediate moratorium on the further introduction of computers in early childhood and elementary education, except for special cases of students with disabilities. Such a time-out is necessary to create the climate for the above recommendations to take place.

1 Microsoft Corporation, "Chasing the Future," advertisement in the *Washington Post*, July 10, 2000, p. A17.

2 Alison Gopnik, Andrew N. Meltzoff, and Patricia K. Kuhl, *The Scientist in the Crib: Minds, Brains, and How Children Learn*, New York: William Morrow, 1999, p. 9.

3 Ashley Montague, *Growing Young*, NewYork: McGraw-Hill, 1983, pp. 156-157.

4 The Charles A. Dana Center, University of Texas at Austin, "Hope for Urban Education," Washington, DCZ: U.S. Department of Education Planning and Evaluation Service, 1999.

5 Larry Cuban, *Teachers and Machines: The Classroom Use of Technology Since 1920*, New York: Teachers College Press, 1986.

6 Douglas J. Simpson and Michael J. B. Jackson, "The Multiple Loves of the Successful Teacher: A Deweyan Perspective," *Educational Foundations*, vol. 12, no. 1, Winter 1998, pp.75-82.

7 As quoted by Stephen L. Talbott in *The Future Does Not Compute: Transcending the Machines in Our Midst*, Sebastopol, CA: O'Reilly & Associates, 1995, p. 425.

8 Sherry Turkle, "Seeing Through Computers: Education in a Culture of Simulation," *The American Prospect*, Issue 31, March-April 1997.