Education and Technology: Future Visions

BACKGROUND FOR THIS STUDY

Several times over the last decade, Congress has asked the Office of Technology Assessment (OTA) to examine the status of technology in American education from various perspectives. In the 1988 study *Power On! New Tools for Teaching and Learning*,[1] OTA looked at the use of computers and other technologies in K-12 schools. In the 1989 study *Linking for Learning*,[2] OTA focused on distance learning technologies, including improvements in their affordability, flexibility, and educational applications. In the 1993 study *Adult Literacy and New Technologies*,[3] OTA looked at technologies for providing literacy instruction to adult learners. And in the 1995 study *Teachers and Technology: Making the Connection*,[4] OTA examined how teachers learn about and use technologies and how various technologies can help teachers improve their teaching and grow professionally.

Although each of these studies gave some attention to new or emerging technologies and factors affecting their adoption, the

[1] U.S. Congress, Office of Technology Assessment, *Power On! New Tools for Teaching and Learning*, OTA-SET-379 (Washington, DC: U.S. Government Printing Office, September 1988).

[2] U.S. Congress, Office of Technology Assessment, *Linking for Learning: A New Course for Education*, OTA-SET-430 (Washington, DC: U.S. Government Printing Office, November 1989).

[3] U.S. Congress, Office of Technology Assessment, *Adult Literacy and New Technologies: Tools for a Lifetime*, OTA-SET-550 (Washington, DC: U.S. Government Printing Office, July 1993).

[4] U.S. Congress, Office of Technology Assessment, *Teachers and Technology: Making the Connection*, OTA-EHR-616 (Washington, DC: U.S. Government Printing Office, April 1995).

studies focused primarily on the present, not the future. But as technology advances more and more rapidly, the future seems to arrive ever more quickly. Decisions currently facing Congress about telecommunications policies, funding for education, and education program continuations and consolidations will have impacts on schooling that could last several years, or even decades. To make wise decisions, it is important that Congress consider the long-range potential and impacts of technologies for education. Where is the nation's educational system headed, how will we know when we get there, and what opportunities or difficulties may lie along the road?

In keeping with its role as an "early warning system" for Congress, OTA commissioned several papers on the topic "Technology Trends and Their Impacts on Teaching in the Future." OTA asked the authors of the commissioned papers to consider future visions of schooling over the next five to 10 years, taking into account recent trends in technology, school reform, student demographics, and telecommunications regulation. What might schools of the near future look like? Which factors or incentives will influence the direction of change? What might be the positive and negative implications of different future scenarios? What are the roles of the various players in the educational system? How can schools help shape technology decisions to acquire the resources they need? How might the federal government help achieve the most promising of these visions?

In response to OTA's request, five contractors prepared papers in the fall of 1994. Each took a slightly different approach to envisioning the future of education:

- James Bosco's paper, "Schooling and Learning in an Information Society," reviews the historical impact that various developments in communications have had on learning. Bosco also examines past changes in the institution of the school and, rather than sketching a scenario, discusses the effects of technology on learning inside and outside of school, today and in the future.
- "Learning and Teaching in 2004: The Big Dig," by Beverly Hunter and Bruce Goldberg, lays out a scenario in which students, teachers, and the entire Boston community develop an extensive body of learning experiences based on an actual, major urban construction project, the Central Artery Tunnel Project, currently slated for completion in 2004. Hunter and Goldberg envision fundamental changes in the nature of schooling and lifelong learning and describe how technological applications can bring together school, work, family, and neighborhood in new learning environments.
- Margaret Riel's paper, "The Future of Teaching," is told through the voices of educators in 2005 as they explain their school's philosophy and program to the district's quality review team. The paper describes a new school organizational and physical structure, explains how technologies support this system, and addresses staffing, educational, and community concerns.
- "Year 2005: Using Technology to Build Communities of Understanding," by Robert Kozma and Wayne Grant, uses scenarios to tell the story of a "community of learners" from three perspectives—connections from school to the outside world, to the workplace, and to the home—and analyzes the social, pedagogical, and technological implications for each perspective as demonstrated by the scenarios.
- Larry Cuban's paper, "Public School Teachers Using Machines in the Next Decade," discusses three possible outcomes of technological integration in schools: that of the technophile, the preservationist, and the cautious optimist. Cuban assesses the likelihood of each occurring and discusses the basis for his prediction.

To supplement the information and ideas in these papers, OTA convened a workshop on June

9, 1995, on the topic "Education and Technology: Future Visions."[5] At this workshop 17 educators and researchers, including the authors of the contractor papers, met with OTA staff to explore in more detail the issues raised in the five papers and to discuss other future scenarios and their policy implications. Also discussed at the workshop was a sixth paper, by Chris Dede and Matt Lewis, entitled "Assessment of Emerging Educational Technologies That Might Assist and Enhance the School-to-Work Transition."[6] Although this paper was written for OTA's assessment *Learning to Work: Making the Transition from School to Work*,[7] it is also relevant.

This OTA background paper synthesizes the major themes and ideas from these futures papers and the workshop discussion. It summarizes the views of the contractors and workshop participants about possible future visions of schooling over the next decade. The paper considers technology and school reform in the context of the demands of the information age, changing views of learning, and conflicting roles of schools. It considers some key issues for these future visions, including changing curriculum and assessment, changing roles for teachers and staff, an expanded view of community, and considerations associated with the potential negative impacts of technology.

This background paper does not endorse any particular vision. Instead it analyzes various factors likely to influence the different future scenarios and lays out possible courses of federal action and potential state and private roles as discussed in the papers and workshop.

SUMMARY OF KEY POINTS AND WORKSHOP DISCUSSION

- Many factors are pressuring schools to make substantive reforms in curriculum, organization, and teacher roles. Employers are calling for individuals who can manage large amounts of information, solve complex problems, adapt to changing requirements with flexibility and creativity, and work in teams.[8] New research on learning supports school environments in which students can acquire advanced skills and knowledge by working on meaningful problems.[9] And parents, business, and students—the "consumers" of education—are asking schools to fill many roles, yet expressing dissatisfaction with how schools are carrying them out.
- Technology can be an impetus for major school reform or an instrument for making the current school system more efficient and productive. Many educational futurists advocate seizing

---

[5] See page v for the roster of workshop participants.

[6] Chris Dede and Matthew Lewis, "Assessment of Emerging Educational Technologies That Might Assist and Enhance the School-to-Work Transition," OTA contractor report, May 1995.

[7] U.S. Congress, Office of Technology Assessment, *Learning to Work: Making the Transition from School to Work*, OTA-EHR-637 (Washington, DC: U.S. Government Printing Office, September 1995).

[8] See, for example, *What Work Requires of Schools: A SCANS Report for America 2000*, Secretary's Commission on Achieving Necessary Skills (Washington, DC: U.S. Department of Labor, June 1991); William B. Johnston and Arnold H. Packer, *Workforce 2000: Work and Workers for the 21st Century* (Indianapolis, IN: Hudson Institute, 1987); Anthony Patrick Carnevale, *America and the New Economy* (Washington, DC: The Program and Freedom Foundation, 1994); Committee for Economic Development, *Connecting Students to a Changing World: A Technology Strategy for Improving Mathematics and Science Education* (Washington, DC: Committee for Economic Development, September 1995); Lawrence Mishel and Jared Bernstein, *The State of Working America* (Armonk, NY: M.E. Sharpe, 1994).

[9] See, for example, Ronald D. Anderson et. al., *Issues of Curriculum Reform in Science, Mathematics and Higher Order Thinking Across the Disciplines* (Washington, DC: U.S. Government Printing Office, January 1994); Barbara Means (ed.), "Using Technology to Advance Education Goals," *Technology and Education Reform* (San Francisco, CA: Jossey-Bass Publishers, 1994); and Joan Bissell et. al., "National Geographic Kids Network and Language Minority Students (Irvine, CA: University of California, Department of Education, July 1994).

the former opportunity, suggesting that major reform is required and that technology offers a unique and powerful resource to bring about such change.

- One of the most promising aspects of technology for education is how it can link schools, homes, workplaces, and neighborhoods into innovative communities that value learning and offer rich learning experiences. This enhanced network of human resources that can participate in educating students may be the most significant technological offshoot. As the institutional framework shifts from an emphasis on "schools" to one on "learning communities," and as learning is distributed across multiple locations, questions about education governance and the traditional school structure will need to be addressed.
- Technology teaching and learning tools allow students and their teachers to contribute to the information base with their own research and products. If teachers and students are considered not just consumers of information but also creators of information, new opportunities could be made available for funding educational activities through the products and services they provide to the broader community.
- Schools and communities will have to confront concerns about the "down side" of technology, including possible reductions and changes in teaching staff, disparities in technology access, potential exposure of students to harmful material, and a de-emphasis of traditional instructional methods that work well for some children.
- The federal government's role could be most important in articulating a vision of how technologies can support improved communities of learning. Federal support could take the form of seeding innovation, showcasing the most promising local initiatives, and helping to cross-pollinate the best practices. Telecommunications and other technologies can themselves be resources for showing, sharing, and discussing innovation. Support from all segments of society, public and private, will be required if these resources are to be made available to all learners regardless of location or economic situation.

TECHNOLOGY AND SCHOOL REFORM: SETTING THE CONTEXT

The future visions discussed in most of the papers and at the workshop assume a strong and symbiotic relationship between educational technology and educational reform. The contractors and workshop participants view technology not so much as a means for making the existing education system more productive or efficient than as a means for encouraging and facilitating broader reforms in school structure, curriculum, teaching, and learning. Schools grappling with how to incorporate technology and how to encourage teachers to use it effectively can treat these primarily as engineering challenges—which can be remedied with more equipment and training—or, as the OTA commissioned papers suggest, as school design and organization challenges to be remedied with substantive reforms. They maintain that technology creates an impetus for major transformation in the institution of schooling, and it also offers new tools for carrying out this transformation in ways not possible before.

Several forces are converging to encourage school reform though technology. These include: demands and tools of the information age, changing views of learning, and the conflicting roles of schools.

Demands of the Information Age

A major driving force in school reform is the transformation of the American economy from one based on industrial production to one based on information creation and exchange. In their paper, Dede and Lewis describe this change:[10]

[10] Chris Dede and Matt Lewis, op. cit., footnote 6.

> In the past, preparing learners to compete effectively with other Americans in our domestic economy was sufficient to ensure their prosperity. However, the evolution of world-wide markets means that U.S. employers and employees must be more adept than their global competitors at meeting the needs of a very diverse range of customers. In this new economic "ecology," each nation is seeking a range of specialized niches based on its financial, human, and natural resources. Developed countries, which no longer have easily available natural resources and cheap labor, have difficulty competing with rising-star developing nations in manufacturing standardized industrial commodities. However, America is utilizing her strengths (technological expertise, an advanced industrial base, and educated citizenry) to develop an economy that uses sophisticated people and information tools to produce customized, value-added products.

In the popular book *Future Shock*[11] and subsequent works,[12] futurists Alvin and Heidi Toffler use the metaphor of waves to describe the historical transformation of American society from an agricultural society (the First Wave), to an industrial one (the Second Wave), and most recently, to an information society (the Third Wave)—each a revolution of major proportions. Many, including some of the OTA authors and workshop participants, would agree with the Tofflers' view that the current school system, with its factory-like organization and inflexible boxes of space and time,[13] is a vestige of the Second Wave industrial society and is quickly becoming outdated by the Third Wave technological world. Without major reforms in school organization and missions, they maintain, schools will continue to prepare students for a world that no longer exists, developing in students yesterday's skills for tomorrow's world.

A shift to Third Wave schooling is reflected in the kinds of institutions described in most of the contractors' scenarios. These new kinds of schools have a "flat" organizational structure, whereby clusters of teachers and students work in groups on substantive group projects, bringing in information and expertise from resources outside the organization, with more shared responsibility for decisionmaking and initiative—a stark contrast to the closed, bureaucratic, hierarchical structure found in many of today's school districts, buildings, and individual classrooms with their production line approaches to education.

Developing Views of Learning

Other influences on school reform and the adoption of new technologies are emerging views from research about how children learn. Increasingly, attention is being paid to one strain of cognitive theory known as *constructivism*, a view that:

> . . . advanced skills of comprehension, reading, composition, and experimentation are acquired not through the transmission of facts but through the learner's interacting with content. This *constructivist* view of learning is the wellspring of ideas for many of the current curriculum and instruction reform efforts, calling upon schools to teach basic skills within *authentic* and, hence, more complex contexts in order to model expert thought processes and encourage the use of collaboration and external supports so that students thus can achieve intellectual accomplishments they could not attain on their own.[14]

Authentic learning is emphasized in the scenarios presented in several of the commissioned papers. Hunter and Goldberg describe what they mean by *authentic instruction*:[15]

---

[11] Alvin Toffler, *Future Shoc*k (New York, NY: Random House, 1970).

[12] Alvin Toffler, *The Third Wave* (New York, NY: Morrow, 1980); Alvin and Heidi Toffler, op. cit., footnote 8.

[13] See, U.S. Congress, Office of Technology Assessment, *Teachers and Technology*, op. cit., footnote 4.

[14] Barbara Means (ed.), op. cit., footnote 11, p. 5.

[15] Beverly Hunter and Bruce Goldberg, "Learning and Teaching in 2004: The Big Dig," OTA contractor report, November 1994.

- Working on projects and problems of intrinsic interest to the learner or a group of learners, rather than learning what everyone else of the same age is expected to learn at the time.
- Working in a hands-on mode with the physical and social world, in addition to and in interaction with abstract symbols and words and electronic representations.
- Learning something at the time a learner is ready and motivated to learn it—perhaps because it is needed to solve a problem or complete a project, or perhaps just from developmental readiness, or curiosity, or social pressure—rather than in a preset curriculum sequence.
- Continual learning.
- Learning in an interdisciplinary context, rather than in separate subjects and isolated topics; working on a project in depth, rather than covering many topics superficially.
- Working directly with people from other places and cultures, rather than only indirectly through books.
- Learning through teamwork.
- Producing something of real value to someone.
- Using the real tools for intellectual work that are used in the workplace, rather than oversimplified textbook techniques.
- Basing assessment of student progress on performance of real tasks, rather than artificial tests.

Contructivism also takes advantage of the student's natural inclination to learn through experience and to "create mental structures. . .which organize and synthesize the information and experience which the individual encounters in the world."[16] Workshop participants discussed whether constructivism might just be another educational fad, but most agreed that the abilities to construct knowledge, value complexity, and solve complex problems are skills that all students will need to succeed in an information-based society. It was suggested that constructivism is flexible enough to co-exist with other instructional philosophies. As Nancy Hechinger said, "It's not either direct instruction or contructivism or collaborative [work] . . . we know a lot about learning and sometimes one is appropriate and sometimes another is appropriate."[17]

The importance of nurturing in children the kind of learning that they undertake naturally outside of school is not a new idea. Eighty years ago John Dewey said:

> What is learned in school is at best only a small part of education, a relatively superficial part of education; and yet what is learned in school makes artificial distinctions in society and marks persons off from one another. Consequently we exaggerate school learning compared to what is gained in the ordinary course of living. Rousseau was almost the first to see that learning is a matter of necessity; it is a part of the process of self-preservation and of growth. If we want, then, to find out how education takes place most successfully, let us go to the experiences of children where learning is a necessity, and not to the practices of schools where it is largely an adornment, a superfluity, and even an unwelcome imposition.[18]

Futurist George Leonard described learning as an "ecstatic" process that changes the learner.[19] Believing that this kind of learning occurs naturally, Leonard saw no reason why schools cannot produce "ecstatic education," a view shared by several OTA workshop participants who noted that their views of education had been strongly influenced by Leonard's work. These beliefs are central to several scenarios presented in the OTA commissioned papers.

Some reformers have taken these ideas to the extreme of suggesting that education can and

---

[16] James Bosco, "Schooling and Learning in an Information Society," OTA contractor report, November 1994, NTIS No. 95-172227.

[17] Transcript of OTA workshop, June 9, 1995, p. 173.

[18] John Dewey, *School of Tomorrow* (New York, NY: E.P. Dutton & Co., 1915), cited in Bosco.

[19] George Leonard, *Education and Ecstasy* (New York, NY: Delacorte Press, 1968).

should occur independently of schools. Lewis Perelman, for example, suggests, "If learning is everything, everywhere, how do we confine it to the box of a classroom? We can't. Then what's the point of having schools at all? There isn't any."[20]

The commissioned papers and workshop participants rejected this concept, primarily because it ignores the teacher's role in guiding learning and helping students put their understanding in context. Furthermore, to say that schools are extraneous ignores other inherently valuable features of the institution of school and neglects the opportunities that schools provide for students to learn and work together as a community. Workshop participant Bruce Goldberg said, "We forget that schooling is a whole lot more about working with people than it is about working with ideas. . .the only value of an idea is in a community."[21]

Conflicting Roles of School

Throughout history, public schools have been asked to assume many social and cultural roles in addition to their academic functions. As one educator has stated, schools are "the mainstay of our publicly determined means of rearing our children . . . our all-purpose institution for children."[22] Over the years, schools have struggled to assimilate a large immigrant population into the American culture, prepare all students for the roles that they will play in society, and provide a level playing field for economic attainment through equal access to education. American schools have been remarkably successful in meeting these goals, considering the vast challenges involved.

Today, schools are being asked to assume still more responsibilities and are blamed unfairly when they cannot solve all social problems. Workshop participants identified the following important, but often conflicting, roles of schools:

- Custodianship—giving parents a safe place to send their children, a nurturing home away from home.
- Credentialing and work preparation—preparing graduates to meet the requirements of higher education and employment.
- Cultural conservation—transmitting the values and shared traditions of the society.
- Intellectual nourishment—producing people with well-rounded minds, a love of learning, and a sense of themselves as creative, lifelong learners.

These multiple and sometimes conflicting roles create tensions among educators who are having trouble satisfying any of them fully. Many suggest that schools are not fulfilling these roles when:

- children bring weapons to school and are shot on playgrounds;[23]
- American students no longer score at the top of international academic comparisons;
- high school and even college graduates find it difficult to find jobs using the education and skills they learned in school;
- individuals and communities cannot agree on a common set of values; and
- many children are no longer being challenged in school.

---

[20] Lewis J. Perelman, *School's Out: Hyperlearning, the New Technology, and the End of Education* (New York, NY: William Morrow and Co., 1992), p. 55.

[21] Workshop transcript, p. 78.

[22] Patricia Graham, "Assimilation, Adjustment, and Access: An Antiquarian View of American Education," *Learning from the Past*, Diane Ravitch and Maris A. Vinovskis (eds.) (Baltimore, MD: The Johns Hopkins University Press, 1995), p. 4.

[23] See, for example, Office of Technology Assessment, *Adolescent Health*, OTA-H-467 (Washington, DC: U.S. Government Printing Office, June 1991); and U.S. Congress, Office of Technology Assessment, *Risks to Students in Schools* OTA-ENV-632 (Washington, DC: U.S. Government Printing Office, September 1995).

These perceptions exist in public discourse and the popular press and are causing many people to question the mission of schools today.

Workshop participants agreed that the protective, custodial function is often the most central of the various demands placed on schools. Today, with most parents holding jobs outside the home, schools are the places children go while their parents work. But as crime and violence have increased, infiltrating the schools in many communities, confidence in the schools' ability to provide quality care has dropped. As one workshop participant said, "They're not safe enough, and if you put in more metal detectors, that's not going to help it. And if [students] get to school and there is no social fabric within the school itself, the parents aren't going to believe in the inherent conserving guardianship, custodial nature of schools."[24]

Schools are also charged with providing students with the knowledge and skills they need to succeed after graduation. Education has long been the key to the American dream, and a high school degree a passport to a decent job. Increasingly, this is not the case, as even college graduates struggle to find jobs commensurate with their credentials. As the value of the educational credential becomes less clear or less potent, the educational system as a whole is called into question. James Bosco explained this dynamic as follows:[25]

> If they are there [at a university] because they believe that if they do it right and follow the rules, that somehow or other, good things happen as a result of this, then many of them are in for a very, very disconcerting realization. What happens when there is a growing realization that the currency that we issue in schools no longer has value?

This issue of diminishing value is even more a problem for the high school graduates who do not go on to college. There is widespread concern that many high school graduates do not possess the academic and entry-level occupational skills necessary to succeed in the changing U.S. workplace.[26]

Schools are also responsible for transmitting the social and cultural values of society, the customs and "rational myths" that define the community.[27] Today this is increasingly difficult, with so many different views of what our culture is, has been, or should be. As Robert Kozma observed, "The culture is becoming fractionated and so schools are going to be fractionated. There's less consensus and there's less impetus to move forward in some kind of systemic way."[28]

Finally, as discussed above, schools have a mission to help children learn, in the purest sense of the word—to acquire knowledge for its own sake, build good habits of mind, develop a passion for learning. This function of schooling has sometimes taken a back seat to others.

Questions of educational reform are compounded not just by the multiple roles of schools, but also by the multiple "customers" for schooling, as workshop participant Stephen Marcus explained:[29]

> To the extent that we talk in terms of the schools providing a custodial function, it seems that the customer for the school is the parent somehow, whereas if we talk about schools building community, then the customer for the school is the student somehow. . . . To theextent that we talk about preparing students for the work force, sometimes it seems as if we're talking about the good of the employer a little

---

[24] Workshop transcript, p. 77.

[25] Workshop transcript, p. 101.

[26] See, for example, U.S. Congress, Office of Technology Assessment, *Learning to Work*, op. cit., footnote 7.

[27] James Bosco, op. cit., footnote 16.

[28] Workshop transcript, p. 54.

[29] Workshop transcript, p. 109.

more. . . . Who's the key customer in the school? Whom is the school there to serve?

KEY ISSUES FOR FUTURE VISIONS OF EDUCATIONAL TECHNOLOGY

The scenarios in the commissioned papers and the workshop discussion suggest that technological advances could ease the transition toward a form of teaching and learning more appropriate for the information age. The technologies that can facilitate this change are available today; however, the future scenarios assume a much more seamless infrastructure of computer, telecommunications, and connecting technologies that allows students and teachers decentralized control over their educational environment. The commissioned papers and workshop discussion focused on ways in which technology could affect such key reform issues as: changing curriculum and assessment, new teacher roles and staffing patterns, and expanded views of the learning community. They noted, however, the importance of paying careful attention to the potential "dark side of technology."

Technological Advances and Their Potential for Education

In their paper, Christopher Dede and Matt Lewis defined several categories of technologies (basic as well as more advanced) that can help with the school-to-work transition process; these are equally applicable to the general teaching and learning process:[30]

- *Presentational computer-based training and computer-assisted instruction*. These programs are predominantly tutorial or drill-and-practice and use the computer to display information and monitor student reaction.
- *Intelligent tutoring and coaching systems.* These mimic some of a teacher's cognitive abilities. These systems rely on artificial intelligence, which appears to "understand" who, what, and how it is teaching.
- *Multimedia and hypermedia program*s. Multimedia programs are designed to present information in the way that the mind assimilates it, then allow the student to interact with the material. In addition, hypermedia programs interrelate data through concept maps based on related ideas and material.
- *Computer-supported collaborative learning technologie*s. Although these technologies are "not as effective as face-to-face group learning," according to Dede and Lewis, they "provide a strong surrogate for actual cooperative learning."
- *Modeling and experiential simulations.* These range from "models that mirror the simplified essence of reality to elaborate synthetic environments that place students inside alternate virtual worlds."
- *Computer-based tools as learning enabler*s. According to Dede and Lewis, these tools seek to develop "distributed intelligence, in which the learner is free to focus on the concepts and skills to be acquired" because the technology assumes part of the cognitive load.
- Central to all the visions of expanded technology use for education are affordable, user-friendly, *telecommunications networks* to which all students and teachers have easy access.

The visions discussed in the futures papers depend on technologies that, by and large, are already available today (e.g., personal digital assistants, small cellular phones and integrated personal communications systems, simulation and modeling systems, collaborative computing environments, high performance work stations, and extensive use of networks) or are under development and likely to be affordable for schools in the not-too-distant future (e.g., interactive digital video and large flat-screen display technologies). However, a major difference between the present

[30] Chris Dede and Matt Lewis op. cit., footnote 6.

state of technology and the future visions is the extent and fluency of integration among various kinds of technologies. For example, in "The Big Dig" vignette, Hunter and Goldberg use a variety of technological tools that are present today; what distinguishes their vignette from the present reality is the "seamless environment of technology and information infrastructure and the fluency with which these tools are used to design and enhance learning experiences."[31] In "The Big Dig" scenario administrative and instructional technologies are integrated in ways that enable decentralized learning communities to access information (be it student health records or electronic student portfolios) where and when they need it.

Students in the Kozma and Grant scenario use a combination of technological and social supports to "scaffold" their efforts to solve new kinds of problems or address new content domains. Much like the *learning enablers* in the Dede and Lewis typography, the computer-based project tool in the Kozma and Grant paper "steps students through the planning process, asking them to define their goals, prompting them to select activities to accomplish these [goals], guiding them to resources, and structuring their assessment."[32] The tool also gives guidance and feedback on the design, development, and execution of their projects. This tool uses embedded coaching and intelligent critic capabilities that are currently being developed for advanced technologies. The tools keep plans and goals visible so students do not lose track. As students learn the process, they are expected to internalize the necessary skills. The teacher is the important social "scaffold," prompting, encouraging, and guiding the students through the process, and helping them put the learning in context.

Integrated digital and wireless telecommunication technologies are also key in the Kozma and Grant model, as their first scenario shows:[33]

> As he does every morning, Steve Early eats breakfast in front of the teleputer. While he watches a program in one window, his personal communication service relays a video message from his South African friend, Nelson, in another window. . . . This software agent presents the story as it originated in Nelson's community and then goes off to search for additional information about the train accident on GlobalNet. After Steve checks out the Net pointers, he constructs his own agent to search the local and national video news service to find video clips that run less than three minutes, sort them chronologically, and store them on the school server so he can access them later.

Access to technology in school is particularly important in light of increasing disparities in technology access outside of school. Families that can afford to purchase computers are giving their children an educational advantage, through supplementary learning activities and additional opportunities to do school work at home. Today about half of college graduates and two-thirds of those with incomes higher than $50,000 report that their children use a computer at home, compared with 17 percent of parents with a high school education or less.[34] The papers commissioned by OTA deal with this challenge by advocating increased support for technologies for all students and teachers that facilitate better links between school and home and increased parental involvement. These could include take-home computers for students, voice mail in schools and homes, dedicated school video channels and interactive video links between school and home, per-

---

[31] Beverly Hunter and Bruce Goldberg, op. cit., footnote 15.

[32] Robert Kozma and Wayne Grant, "Year 2005: Using Technology to Build Communities of Understanding," OTA contractor report, November 1994, NTIS No. 95-172235.

[33] Ibid.

[34] Times Mirror Center for the People and the Press, "Technology in the American Household," Washington, DC, May 24, 1994.

sonal digital assistants, and wireless modems. To be fully integrated now would require each student or family and classroom to have these technologies. Further developments of integrated computing and communication systems may obviate the need for this variety of separate components.

Changing Curriculum and Assessment

Just as the future visions are based on information technologies that already exist (even if they are not widely available in schools and homes), most are also based on changes already underway in the areas of curriculum and assessment that are tied to developing views of learning. Many states and professional organizations have developed curriculum standards in many subjects that incorporate the skills of gathering, assessing, and handling complex information and that call for instruction based on challenging tasks and complex problems grounded in the real world. These approaches often require students to work in teams on projects that cross traditional curriculum lines and to develop collaborative problem-solving approaches. As schools are attempting to provide more "authentic" instruction, many states and school districts are also developing new methods of "authentic" assessment designed to provide more in-depth demonstrations of what students know and can do than traditional standardized tests. These performance-based assessments often require the use of technological tools from simple wordprocessing to advanced multimedia.[35]

The scenario in "Year 2005: Using Technology to Build Communities of Understanding" by Kozma and Grant is based on authentic, or "project-based," learning, in which teams of students with different strengths work together on real-life issues of their choosing. By collaborating with people in the working world on specific issues, students expand their pool of resources and information. In this scenario, information technology also opens communication between schools and parents and provides new forms of documentation and products that can be used to assess student progress.

In Riel's scenario, the traditional classroom would be replaced by learning centers, which take advantage of what Riel calls the most significant technological off-shoot: a rich network of human resources. Multi-aged groups of students would work in these centers, each of which would have a specific theme, and would learn to draw on their varying strengths for success. Assessment is based on a final exhibition of student works that is attended by the school and community. Riel's fictional narrator explains the process:[36]

> We find that creating a museum exhibit that is enjoyed by the community provides more intrinsic motivation to learn. At the end of every session, the students spend time reflecting on their work as they get ready for the exhibition. They select their best work to display in the exhibition. But they also have to see how they measured up to the goals they set for themselves. The exhibition provides a time for parents and community members to see what students have accomplished. Parents can see how their child's work compares with that of children of different ages and abilities. The exhibition provides students an opportunity to teach their parents.

In "The Big Dig," Hunter and Goldberg propose another kind of model built around project-based learning, interdisciplinary studies, and group activities, many of which use technological tools. Students, educators, parents, the community, and the workforce collaborate to complete a real project and prepare exhibits about particular aspects of the project. Students in this vignette are assessed on the basis of their performance of real tasks and the students' contributions to the team. Teachers also develop assessment plans that are evaluated

---

[35] See, for example, U.S. Congress, Office of Technology Assessment, *Testing in American Schools: Asking the Right Questions,* OTA-SET-519 (Washington, DC: U.S. Government Printing Office, February 1991).

[36] Margaret Riel, "The Future of Teaching," OTA contractor report, November 1994, NTIS No. 95-172219.

by the outside experts who work with the students.[37]

> One of the teachers, the student assessment specialist, and one of the children form a group to review and formalize the evaluation plans. They begin by locating the assessment archives from last year's Tunnel Team exhibition. They see there were some complaints from parents last year that the evaluators had too narrow a focus and missed some important evidence of the team's creativity and communication skills. They decide to avoid that problem by having two levels of evaluation of the exhibition. They call the two levels "Quick" and "Deep." The "Quick" evaluations will be made by interviewing visitors to the exhibition who would have unpredictable kinds of backgrounds, skills, and interests but who would represent a wide range of viewpoints. The "Deep" evaluations will be made by a panel of ten people chosen from the school communities' database of teachers and expert reviewers. In creating the evaluation plan, the group makes links in the database to the individual Tunnel Team students' personal development plans, the Tunnel Team's educational goals, and the emerging exhibit component plans. From these sources, they create packets of background information and draft assessment assignments tailored for each of the ten panelists—depending on their specialty areas—learning, basic competence, communications and collaboration, personal management, information management, mathematics, engineering, inquiry methods, etc.

The students then evaluate the plan and make suggestions to ensure that it reflects all of their work. Without the technology, it would be much more difficult to collect, manipulate, and draw upon these databases of information and personal development plans.

Despite their emphasis on authentic, project-based learning experiences, Hunter and Goldberg recognize the need for other kinds of instructional experiences:[38]

> Learning is not always fun, engaging, or relentlessly faithful to the real world. It can on occasion require the repetitive performance of tasks or intellectual battle with concepts and theories that are unfamiliar, removed from "reality," even somewhat contrived. That is one reason we believe that paying attention to standards, to what students are expected to know and be able to do, is critical. Unlike past attempts at making education "relevant," contemporary preoccupation with authentic learning is grounded in the belief that there should be explicit habits of mind, competencies and core knowledge that all student are expected to master.

New Roles for Teachers and Other Staff

Extensive use of technology in the classroom typically changes teachers' roles.[39] Some futurists have even maintained that technology, by allowing students to interact directly and individually with content, makes it possible to eliminate the teacher.[40] Some teachers themselves fear that limited educational resources may be used to purchase technologies in the expectation that fewer human resources will be required. However, the OTA commissioned papers and workshop participants suggest that technology will always be just one part of the learning equation. While technological advances may make it possible for students to progress at their own pace with materials geared to their individual learning style, interests, understanding, and needs, teachers are the crucial link between students and technology.[41] Without the teacher's guidance and enthusiasm for tech-

---

[37] Beverly Hunter and Bruce Goldberg, op. cit., footnote 15.

[38] Ibid.

[39] U.S. Congress, Office of Technology Assessment, *Teachers and Technology,* op. cit., footnote 4.

[40] See, for example, Lewis Perelman, op. cit., footnote 20.

[41] U.S. Congress, Office of Technology Assessment, *Teachers and Technology,* op. cit., footnote 4.

nology in the classroom, technology in schools is little used and poorly used.[42] If education is to be reformed with support from technology, and if investments in technology are to pay off, OTA finds that more, rather than less, attention should be paid to teachers and their roles.

This is not to say that teachers' roles should not change. Margaret Riel gave one major reason why changes in this area are needed: "Teachers right now do about six different jobs, and there's no reason why one person has to do all six of those jobs."[43] Carrying out custodial and disciplinary tasks, collecting milk money, completing reports and paperwork often take more time than the more intellectually challenging functions that attracted people to teaching in the first place—inspiring, guiding, advising, and coaching students and imparting expertise.

Most of the experts consulted by OTA recommend significant changes in teacher roles and school staffing patterns. Some commissioned papers envision a transformation in the relationships between teacher and student, and some call for a complete reconfiguring of instructional and administrative personnel. Several commissioned papers also propose that people in the school's local community (or networked community) play a much larger role in teaching and learning by contributing their talents, knowledge, and energies to working with students and teachers. All the commissioned papers demonstrate how technology can bring local or distant experts, advisors, parents, colleagues, or friends into the school setting to provide additional teaching and learning resources.

Student-Teacher Interactions

The Kozma and Grant paper describes a new kind of interaction between teachers and students:[44]

> To fulfill our vision, teachers would need to learn not only to use the various technologies described in our scenarios, but also to design, structure, guide and assess progress in learning centered around student projects. This kind of teaching, which most teachers have rarely experienced in their own education, requires wide-ranging subject matter expertise, creativity and intellectual confidence. Teachers need to be comfortable letting their students move into domains of knowledge where the teachers themselves lack expertise; teachers need to have the intellectual confidence to be willing to model their own reasoning process when they encounter phenomena they do not understand or questions they cannot answer. Teachers must be able to roam from group to group physically and electronically, providing stimulation and coaching without dominating the group process.

Workshop participant Stephen Marcus remarked that we all have mental images of the "bad" teacher (the school marm or pedagogue) but questioned why there are no "indelible iconic images for the best kinds of education."[45] In response, Bruce Goldberg related a story about changes in student perceptions of teacher roles. In a collaborative project with Boston College, researchers at Bolt Beranek and Newman worked with a classroom over the course of a year, integrating a range of technology-based innovations. At the beginning of the year, the students had drawn pictures of their classroom that featured the teacher as the dominant figure. By the end of the project, the students drew themselves—working in groups and helping each other—as the dominant figures, although in discussion with the researchers, the students also identified the teacher as exceedingly important. "The visual image of what their life was like was not dominated by the teacher, and that's the distinction," Goldberg ex-

---

[42] Ibid.

[43] Workshop transcript, p. 247.

[44] Robert Kozma and Wayne Grant, op. cit., footnote 32.

[45] Workshop transcript, p. 257.

plained. "The world that they inhabited was not teacher directed, but the world that they inhabited was impossible to conceive of without the facilitating work and nurturing care of that teacher."[46]

School Staffing Structures for Instruction

Margaret Riel's model calls for major changes in school staffing structures for instructional positions. She sets forth four new levels: learning guides (para-professionals), entry-level teachers, mentor teachers, and master teachers.[47]

> Learning guides don't require a great deal of academic preparation, but they need to have good skills in working with and motivating students. . . . We wanted to arrive at a system that included those who wanted a fast entry into working with kids, but also provided a system of rewards, a career ladder that would attract talented men and women into the challenge of continually assessing and evolving the best possible educational system. . . .
>
> Entry teachers are beginning teachers. In practice, most have full credentials, but they can be hired with a provisional credential and finish their credential work while they teach. . . . The difference between a learning guide and an entry teacher is time rather than money. Entry teachers have much more time for planning and for developing ties in the professional community of educators. It is these ties that will lead to professional work and pay.
>
> The transition to *mentor teacher* will be based on the productive use of this time. . . . Mentor teacher positions are very different than traditional teaching positions—one-third of their time is free for them to take on other tasks that are related to their developing area of expertise. These might be consulting contracts, district resource positions, foundations and government grants, or work at the university in either research or education. . . .
>
> After five years of teaching as a mentor teacher, a teacher can request or be recommended for a peer review for the position of *master teacher*. . . . There is no pressure for all mentor teachers to be master teachers. . . . You have to be at the rank of master teacher to be a member of the principal or superintendent teams. But master teachers don't have to be administrators.

Riel's approach is designed to allow instructors with different motives and capabilities to work at the level of their interest and to create opportunities for teachers to advance without giving up classroom instruction.

Community Involvement

Beverly Hunter and Bruce Goldberg predict a very high degree of involvement by community members in learning and teaching. In their scenario, the concept of lifelong learning is valued by all members of the community and almost every job involves a great deal of teaching and learning. In this setting, teachers are responsible for coordinating learning both inside and outside the traditional school environment and gain greater respect from the community. Hunter and Goldberg note additional benefits that occur when teachers work with teacher colleagues and other community members:[48]

> In all these instances teaching roles are richer and more vibrant than teachers now occupy. Teachers are guides and mentors and learners, rather than mere dispensers of knowledge. Information resource facilitator, assessment specialist, technology expert, team manager and facilitator, child development expert, subject matter specialist—all these multiple roles teachers are now beginning to assume must be understood as unfolding within a team environment. Not every teacher need be an expert in each role. What is necessary, however, are changed expectations for, and conditions within, the profession of teaching.

---

[46] Workshop transcript, p. 259.

[47] Margaret Riel, op. cit., footnote 36

[48] Beverly Hunter and Bruce Goldberg, op. cit., footnote 15.

How Technology Helps

While these changes in teacher roles, staffing, and pedagogy can occur without technology, they are all easier to accomplish with technology. On the most basic level, technology can help with paperwork management, thereby freeing up valuable time for teachers to work more directly with students. Technology can also facilitate other more profound transformations by opening the teacher's world to new experts and resources through telecommunications networks, by creating new opportunities for collaborative teaching, learning, and curriculum design, and by offering creative learning environments, simulations, and experiences, as shown in the scenarios.

The new roles, techniques, and teaching styles proposed in the scenarios would require that teachers receive significant training and continuing support in such areas as project-based learning, authentic assessment, community outreach, and technology integration. As OTA found in *Teachers and Technology: Making the Connection*, this kind of preparation is far from the norm in most teacher education programs and is seldom provided as a part of continuing professional development for those already in the classroom.[49]

An Expanded View of the Learning Community

An expanded concept of a learning community, with stronger links among school, home, workplace, and neighborhood, is central to several of the future visions discussed in the papers and the workshop. In these future visions, technology provides schools with access to many more resources beyond the constraints of the traditional "closed" classroom, to the point that, as workshop participant Ted Kahn suggested, "the notion of school as a *building* drops away. . .the school becomes a consortium of available resources, people, teachers, and kids who can provide value to others."[50]

In their paper, Kozma and Grant suggest this definition of community:[51]

> A community is a collection of individuals who are bonded together either by geography or by common purpose, shared values and expectations, and a web of meaningful relationships. In the communities that we envision in this paper—what we call "communities of understanding"—education is the common purpose, learning is highly valued, and a high level of academic achievement is expected of students and their schools. . . . Today, schools, homes, and workplaces function separately—connected by geography and circumstances but infrequently by common purpose and collaborative action. But in our vision of communities of understanding, digital technologies are used to interweave schools, homes, workplaces, libraries, museums, and social services to re-integrate education into the fabric of the community.

Margaret Riel, on the other hand, reinforced the importance of both local and virtual communities: "I see community in two ways, both the geographic community and the virtual communities that we can create on-line. In the virtual communities, we need to bring together the educational community, find ways for them to talk more with one another and share what they're doing."[52] In Riel's scenario, the local community plays a significant role in education, connecting the school to the working world and supporting the teachers through a school-community council. The global community offers additional resources, accessible through electronic and telecommunications technology.

---

[49] U.S. Congress, Office of Technology Assessment, *Teachers and Technology*, op. cit., footnote 4, pp. 165-206.

[50] Workshop transcript, p. 224.

[51] Robert Kozma and Wayne Grant, op. cit., footnote 32.

[52] Workshop transcript, p. 323.

One of Riel's fictional narrators explains how schools interact with both kinds of communities:[53]

> Many of the ideas for our plan have come from our work on-line with schools around the world. Working with distant teachers has resulted in many new ideas that I don't think we would have had without electronic connections. . . . By making it possible for our teachers to work with the larger educational community, they have developed expertise in national and international arenas which enriches their teaching and brings many rewards to the whole district.
>
> [In the local community] our Community Council is a combination of our former PTA and school site council. One of the things we do as part of the council is to encourage all community members to come to our exhibitions—even if they don't have children. We want them to see the school as *their* school. Everyone needs to be involved, not just parents.

The model presented by Hunter and Goldberg in "The Big Dig" emphasizes how technology can bring together learning, work, family, and neighborhood in ways that are far from typical in schools today:[54]

> Ten years ago [in 1995], teachers and students spent all their time in "school buildings," sealed away from the vital life of learning and information their communities offered. On the other hand, the majority of adults were not a part of the formal educational system and thus had little opportunity to participate in organized learning activities. Advances in communications technology had helped break down some of the walls.
>
> [As an outgrowth of several federal and state initiatives] the Boston Metropolitan Education Region (BMER) was funded by a combination of these federal, state, industry, and local funds. . . . As its first pilot project, BMER issued a Request for Proposal to students, teachers, and community members inviting them to design a nine-week project that would engage all the participants in collaborative projects without regard to the political boundaries of their school districts.

Participants and contractors suggested that technology is the key to making schools more inclusive and more connected with the home, the workplace, and the local or global learning community. Otherwise, the scheduling, security, transportation, and other realities make the concept of an interconnected community of learning seem "totally unworkable."[55] "The Big Dig" continues:[56]

> [After a few years of juggling schedules to continue supporting both individual schools and the new collaborative projects] the very contentious issue of scheduling had come to a head in the BMER. It had been extremely frustrating to try to conduct city-wide learning activities that were constantly competing with the rigid class schedules of the separate schools. The separate schools were also at a point of crisis about scheduling because they were also attempting to conduct interdisciplinary project-based learning activities that could not function in 45-minute class periods. . . . [T]hey realized that the technology they were using could free them from some of the time constraints of their school traditions.

Telecommunications technology makes it possible to "knock down walls" between schools and the community. Group projects can involve people from very different areas, even different countries, and teachers and students can interact on more equal footing with others in the outside

---

[53] Margaret Riel, op. cit., footnote 36.

[54] Beverly Hunter and Wayne Goldberg, op. cit., footnote 15.

[55] Robert Kozma, workshop transcript, p. 82.

[56] Beverly Hunter and Bruce Goldberg, op. cit., footnote 15.

world. In the GLOBE program[57] and similar telecommunications projects, students around the world become researchers, collecting, sharing, and analyzing data on meaningful topics identified by international scientists, who then use the data as part of a growing database on scientific topics such as worldwide ecological change. For example, one group is analyzing the effects of ozone layer depletion on various species of pine trees around the world. When the school and the community beyond its walls, whether local or global, become partners in the advancement of knowledge and understanding of issues of common concern, the work of each of the partners within the learning community is valued by all members.

Similarly, in the vision of Kozma and Grant, technology links students not just to their local community, but to the global community. In their scenario, a hazardous railroad fuel spill in South Africa prompts students in a California school to begin a project about how to make tank cars safer. The project has immediacy for the students because they can communicate with people directly affected by the spill.[58]

> The students decide to make an interactive multimedia report as their final product. "You need to think about your audience for the report," comments Mr. Shepherd, their language arts teacher, "and what they would want to know about your topic."
>
> The students decide they will interview Steve's South African friend Nelson [a "telecommunications-pal"] and ask his schoolmates to collaborate with them by gathering video images and other local information about the train accident that can be integrated with the information they create. They will also talk to community members in the McAuliffe neighborhood and see whether there have been any fuel spills in the area during the past year. Finally, they will come up with some suggestions for how to stop fuel spills. They will store their report on the community video server and make it available throughout the community-access cable channel and send it to Nelson and his South African classmates. The report will conclude by taking viewers to the Environmental Chat Room on the GlobalNet, where they can talk to scientists, environmentalists, and others about the problem and potential solutions.

A sense of community, which is fostered and maintained by technology, drives the interest of the students in this scenario and pushes them to investigate difficult subjects. Technology makes the rest of the world newly accessible and newly relevant to them.

Is There A "Down Side" to Technology?

Not all contractors and workshop participants were fully optimistic about the impact of technological advancements on education. The "dark side of technology" could include several areas:[59]

- Downsizing of the teaching force as staffing patterns are altered. (Many workshop participants felt that major changes in staffing, such as those proposed by Riel in her paper, would be challenged by teachers and administrators who faced possible job loss.)
- Greater inequalities in knowledge and skills among different groups of students due to differential access to technological resources. Will adding more technology to the most technologically advanced schools exacerbate discrepancies between the technology "haves" and "have nots," creating inequalities in access to information between students who attend the "have not" schools and students who attend the "have" schools?
- Concerns about whether learning through technology is always the best way for students

---

[57] Global Learning and Observations to Benefit the Environment (GLOBE), 744 Jackson Place, NW, Washington, DC 20503. For more information contact info@globe.gov.

[58] Robert Kozma and Wayne Grant, op. cit., footnote 32.

[59] Workshop transcript, p. 150.

to learn. Will an over-emphasis on technology mean that students who would benefit from direct, traditional instruction get lost in the shuffle of changing approaches to teaching and learning?

- Potential harmful influences from opening the sheltered class to the outside world. Telecommunications networks could give students easier access to questionable or dangerous elements, such as pornography on the Internet.

Proponents of rapid technology integration counter by saying that the education reformers share this concern to avoid the "down sides" of technology. One participant noted: "It's largely because we understand the dark side of technology that we feel such a responsibility to ensure the beneficial applications and to try to minimize the dark side."[60]

IS THERE A FEDERAL ROLE?

The viability of many of the future scenarios will depend largely on value choices and economic investment decisions made by Congress, state and local policymakers, and the American public. Realizing the most promising of these future visions will entail a greater commitment to education—in both funding and energy—than the United States is making today. However, advancements in educational technology and developments in educational reforms are taking place at the same time the nation is undergoing a very critical debate about government and other institutional responsibilities in education. The next five to 10 years are likely to see major changes in federal, state, and local roles in education. Congress is considering decisions that will greatly affect the amount of federal funding for education, the number and type of federal education programs, and the nature of federal education requirements. Congress is also making decisions in the area of telecommunications infrastructure policy and regulation that will have an enormous impact on whether schools have access to technology and a defined place in the National Information Infrastructure.

The current movement in education appears headed toward decreased federal funding, fewer federal programs and requirements, and shifts of education responsibilities from the federal to the state and local levels. Together these developments suggest the need for policy discussions that examine the federal role in conjunction with state, local, and private sector roles and that look at creative options for providing financing and leadership from a variety of sources, not just the federal level. State and local policies for education, telecommunications regulations, and the policies of local public utilities commissions are also critical.

Workshop participants devoted much discussion to the roles the federal government might play in advancing appropriate uses of technology to support learning. Many of the options mentioned were consistent with the realities of limited federal funding and fewer requirements on local schools. The options suggested include supporting and disseminating models of effective practice, providing research and development activities, assuring equity, and encouraging new funding sources. These federal options are not novel. What was unique was the consideration given to how technology itself might improve traditional federal models of evaluation, dissemination, funding, and equity.

Support for Models of Effective Practice

One clear federal role suggested by workshop participants was that of evaluating, promoting, and disseminating the innovative and promising activities already being undertaken by local centers of technology excellence. The federal government could support and encourage the "scaling up" of these kinds of innovative learning communities. "Innovation is local," said Beverly Hunter. "We have to be locally opportunistic about the nature of innovation. Because each locality has different

[60] Beverly Hunter, workshop transcript, p. 156.

resources and different expertise. . .[consider] the possibilities of getting synergy from sharing across localities both know-how and resources."[61]

Some participants suggested that the federal government establish mechanisms that encourage creation and sharing of local processes in support of education—empowerment zones—that provide incentives for business to develop stronger relationships with schools, hospitals, or others; perhaps relationships in which shared investments in telecommunications networks benefit all users.

Research and Development Activities

Consistent with the old saying about giving a hungry man a rod and teaching him to fish, the federal government might subsidize the educational equivalent of the "better fishing rod" or "special worms"—development support for technological tools that help make localized activities more effective, such as software tools for better network access, curriculum materials using the capabilities of newer technologies, pornography firewalls, or new teaching tools such as those used in science experiments, mathematical reasoning, or design activities.

Promoting Equity

Participants also expressed concern that issues of equity remain central to the federal vision. While most welcomed the developments that are bringing powerful learning technologies into the home, many pointed out the possibility of even greater imbalances in learning opportunities among various groups, including parents who can afford a curriculum-based multimedia learning system for their children and those who cannot. How can imbalances be corrected between the community that commits an $8 million local bond to wiring the schools and the one next door that does not?

Funding Sources

Participants in OTA's workshop debated where funding might come from that could provide all children with equal access to the best available learning and communication tools. One suggestion was that the federal government provide significant start-up support for infrastructure development, as was done with the interstate highway system. Another suggestion was to encourage private sector investment in schools through innovative tax policy. As Nancy Hechinger suggested, "What if you say to corporations that you could [choose to] not pay 10 percent of your corporate tax if it goes to education? Or let every corporation in the community elect, like the federal income tax check off for Presidential elections, to allow a portion of their taxes to go directly to a school?"[62]

Others suggested that schools pay for reform and technology investments the way that businesses have: by reducing labor costs through eliminating teaching or administrative positions, reshuffling staff, or automating certain duties with technology, and investing the savings in technology. This option is similar to the funding mechanisms proposed in Margaret Riel's scenario, which eliminates some administrative positions in favor of collaborative teacher leadership and creates a new salary scale for the four levels of instructional positions. Her scenario projected relatively low yearly costs for reform despite substantial technology investments.

The Hunter and Goldberg scenario also assumes some cuts in personnel costs through workforce restructuring. The main funding for "The Big Dig" project, however, is envisioned to come from a cooperative venture of local, state, and federal governments and private industry, working through a hypothetical "Boston Metropolitan Educational Region." Hunter and Goldberg sug-

[61] Workshop transcript, p. 280.

[62] Workshop transcript, p. 295.

gest that entities such as the BMER could be financed through a combination of such means as:

- money drawn from a "lifelong learning account," created for each citizen at birth and expended throughout an individual's life for a variety of learning activities;
- revenues earned by non-profit educational corporations from the creation and sale of socially useful products or services and from leasing space during off-hours;
- income from "entrepreneurial education zone" activities, in which teachers and students produce knowledge with economic value, such as selling information on Web pages, working with local businesses, or generating ideas, products, and information of value to communities; and
- support from the biotechnology, finance, software, and other industries for learning centers that train people and provide school-to-work transition services.

In addition, the Hunter and Goldberg vignettes presume innovative use of space and facilities, including:

- satellite learning centers, such as the public educational facilities that businesses in Dade County, Florida and elsewhere have built on their premises;
- shared use of public and private facilities, such as municipal buildings, libraries, and corporate job retraining centers;
- neglected buildings that could be renovated for educational use by public-private partnerships, with incentives from federal enterprise zone legislation; and
- new and renovated schools designed with advice on best design practices from community experts, foundations, or federally disseminated research sources.

Hunter and Goldberg also suggest that research and development about technology-based learning and cognition could be supported by requiring a percentage of funding in support of school reform to be devoted to conducting and disseminating research on the learning outcomes of alternative approaches to teaching and curriculum, including the integration of technology into these activities.

WILL PROMISING VISIONS BECOME A REALITY?

Can the technological changes presented in the most promising of these visions become reality? Workshop participants were divided on how much change can be expected in schooling. They concurred that change usually comes slowly to schools but they agreed that when required, schools can and do change.

As one analyst wrote, "Like battleships, the schools are large, powerful, cumbersome institutions, difficult to maneuver" and slow to change direction.[63] Nevertheless, schools have changed when there is strong pressure or good reason; schools today are the result of several generations of reform in such areas as desegregation, curricular emphasis, and special education. Reform based on technology presents many unique challenges, however. Past reforms were not dependent upon instructional technologies, and it was not until the 1980s that school reformers began to seize on electronic technologies as a way of "unfreezing the perceived inefficiencies and rigidities of American schooling."[64]

In his early work, Alvin Toffler believed the educational system would be a leader in embracing technology, incorporating it long before industry and private organizations. He believed that schools by nature were more likely to embrace change, citing a "venturesome spirit which stands

[63] Patricia Graham, op. cit., footnote 22, p. 4.

[64] Larry Cuban, "Public School Teachers Using Machines in the Next Decade," OTA contractor report, November 1994, NTIS No. 95-172243.

in total contrast to the security-minded orthodoxy and conformity associated with the organization."[65] This optimism about school change was misplaced; 25 years after this prediction, business and industry are technologically far ahead of the schools, and schools are struggling to keep up despite the benefits that technology offers them.

Workshop participants and contractors cautioned against easy comparisons with business. "Schools differ substantially from other institutions in their workplace characteristics, in the nature of teaching children, and in public expectations . . . [school structures are] profoundly difficult to change."[66] Others noted the fundamental difference between business, in which the goal is to "do" and the bottom line is profit, and schools, in which the goal is to "be" and the bottom lines are many (e.g., meeting the social mandate). They suggested that schools find their own models for restructuring and not take their guidance from business.

Larry Cuban explains his view of why the integration of technology will not occur at the rapid pace many envision:[67]

> Technophiles . . . often minimize the power of social beliefs that have endured for centuries and perform important functions in society. Beliefs that teaching is telling, learning is listening, knowledge is subject matter taught by teachers and books, and the teacher-student relationship is crucial to any learning dominate much popular and practitioner thinking. Most parents expect their schools to reflect those centuries-old beliefs.

Larry Cuban's paper offers three scenarios of possible educational change involving technology: the technophile's vision in which electronic schools of the future become widespread rather quickly; the preservationist's scenario in which schools maintain their current features but add technology as an important yet peripheral component; and the cautious optimist's scenario, in which schools move slowly toward fundamental changes in teaching and schooling using technologies. He argues that the time and rate of technology-based school reform may vary by grade and kind of school. At the high school level, change may be relatively slow, more in keeping with the preservationist's model, in which "policy makers and administrators put computers and telecommunication technologies into school largely to improve productivity but not to alter substantially existing ways of organizing a school for instruction."[68] At the elementary school level, the cautious optimist's model may be more likely.

Cuban bases these different predictions on what he sees as fundamental differences between elementary schools and secondary schools:[69]

> Public elementary and secondary schools differ markedly in the complexity of content students face in classrooms, teachers' formal training, allocation of time to instruction, and external arrangements imposed upon both levels from other institutions. . . . The point that I wish to make is that how the age-graded school is organized for instruction at the two levels determines to a large degree which scenario will most likely occur. The preservationist's scenario is most likely in high schools where academic subjects reign, teachers' training was in disciplinary content, and the number of classes and students teachers teach remains high. The cautious optimist's scenario is more likely to occur in elementary schools where organizational differences make shifts in practice possible and where hybrids of teacher-centered and student-centered instruction have, indeed, evolved slowly over the last century.

---

[65] Alvin Toffler, *Future Shock,* op. cit., footnote 11, p. 148.

[66] Larry Cuban, op. cit., footnote 64.

[67] Ibid.

[68] Ibid.

[69] Ibid.

The problem, suggested some workshop participants, is not so much in getting schools to adopt something new, but rather in getting them to give up the old, thereby creating time, resources, and enthusiasm for the new. Far too often, technology is an add-on rather than an "instead of." Similarly, in order for teachers to take on new roles, they must be allowed to drop some of the old; otherwise, they end up with an unbearable load of responsibilities on their shoulders.

The papers by Bosco, Riel, Kozma and Grant, and Hunter and Goldberg anticipate faster change and more radical revisions in schooling than does Cuban's. As described (box 1), the future is difficult to predict, and more promising futures do not just happen.

CHOOSING A FUTURE

The American educational system is at a crossroads as regards both technology and broader education reform. More and more people inside and outside the schools are calling for deep and fundamental changes in school organization, instruction, content, and processes. This climate creates an opportunity for innovation that has perhaps not been present for over a century. Technological advances provide additional impetus for reform and also offer new tools for implementing their reform.

Whether the nation will have the vision and commitment needed to make courageous choices about education reform remains to be seen. On one hand, the cumulative evidence over the past 25 years suggests that schools are more resistant to change and have less of the "venturesome spirit" that Alvin Toffler saw in them in 1970.[70] And on a national level, there is no clear agreement about the kinds of reforms needed in education, the level of commitment required to achieve meaningful reform, or the role of technology in education reform. On the one hand, there are those who suggest what is needed are traditional approaches: a return to basics and greater investment in staff and textbooks rather than investments in new information technologies. On the other hand, many communities around the nation are demonstrating how technology and reform can come together and produce effective results.[71] The stated commitment of the Administration to put all the nation's schools on the National Information Infrastructure and the expressed interest of congressional leaders in increasing the use of technologies in education are promising steps, but whether these goals will be fulfilled remains to be seen. There is no guarantee that this vision will not become another casualty of shifting culture and political winds.

Perhaps the real factor that will determine the future of technology in education reform will be the extent of the national commitment to a high level of learning for all students. As one leading educator observed, providing only data, even on an information superhighway, may not be enough. He distinguished among data, information (data with a context), knowledge (information with usefulness), and wisdom (knowledge informed by sensibility and experience).[72] How do we Americans define knowledge, let alone wisdom? How do we recognize it? What kinds of learning do we really want for our children? How do colleges, universities, and employers characterize and reward different levels of learning? In 1948 Vannevar Bush and his contemporaries were concerned with the creation of information, and in that con-

---

[70] Alvin Toffler, *Future Shock,* op. cit., footnote 11.

[71] For a brief review of the state of the art in technology effectiveness research, see U.S. Congress, Office of Technology Assessment, *Teachers and Technology,* op. cit., footnote 4.

[72] Stephen Marcus, panel discussion on, "Hypermedia and Lifelong Learning. . .50 Years After Vannevar Bush. . . And Beyond," National Educational Computing Conference, 1995.

BOX 1: Predicting the Impact of Technology

Technological advances always invite speculation about their impact on the future Often projections about technology are wildly optimistic or utopian, and just as often they vastly underestimate the impact of a technology An example of the tendency toward optimism IS Thomas Edison's claim that the motion picture would result in the elimination of textbooks from schools. ' And a famous example of the tendency toward underplaying IS the reaction of the chief engineer of the British Post Off Ice who, upon hearing news of the invention of the telephone, reportedly told his colleagues, "The Americans have need of the telephone, but we do not We have plenty of messenger boys "2 More recently, even presidents of major computer companies have failed to foresee the huge demand for computers Shortly after World War II, Thomas J Watson, Sr., founder of IBM, "predicted that five machines would make up the world market for computers "[3] And in 1970, Kenneth Olsen, founder of Digital Equipment, stated he saw "no reason for any individual to have a computer in their home "

Other predictions have been close to the mark; in 1945, Vannevar Bush predicted the invention of a device he called the "memex, " in which "an individual stores all his books, records and communications, and which IS mechanized so that it may be consulted with exceeding speed and flexibility"[4]—not far removed from today's computers with CD-ROMs and Internet connections

Similarly, past predictions about the future of education have also tended toward the utopian or the dire, and have generally overestimated how quickly schools would change Futurists such as George Leonard in his 1968 book *Education and Ecstasy*[5] share a view that schools and technologies wiII advance together Many of today's education futurists, including most of the OTA contractors and workshop participants, also suggest that the impact of technology on education could be profound For example, in his paper "Schooling and Learning in an Information Society, " James Bosco describes what he sees as the climate for change set in place by Information technology: [6]

> There is little reason to believe that information technology will bring either heaven or hell to earth, but It IS clear that information technology IS causing profound changes in how we live, work, play, and learn Many will continue to debate whether Information technology IS making our lives better or worse, but there IS little argument that information technology IS making our lives very different than they were before this technology was Invented
>
> The changes caused by Information technology in what and how children, youth, and adults learn are not something we await in the future, we are in the midst of these changes Information technology IS transforming the amount and nature of the Information content of civilization as well as the processes whereby this Information IS acquired The modest changes in the nature and conduct of schooling in recent decades stand amidst monumental changes in how, when, where and what learning occurs in our society As Information technology-based learning opportunities become increasingly ubiquitous and efficacious, schooling, teaching, and learning will take on a new character and a new balance between school and non-school learning will be established

[1] Larry Cuban, *Teachers and Machines The Classroom Use of Technology Since 1920 (New* York, NY: Teachers College Press. 1986), p. 9.

[2] A.C. Clarke, *How the World Was Won* (New York, NY: Bantam Books, 1992), p. 224, as cited in J. Bosco, p. 1.

[3] D. Leebaert, "Later Than We Think: How the Future Has Arrived," *Technology 2001 The Future of Computing and Communications,* D. Leebaert (ed.) (Cambridge, MA: MIT Press, 1991), cited in Bosco, p. 2.

[4] Vannevar Bush, "As We May Think, " *Life,* Sept. 10, 1945.

[5] George Leonard, op. cit., footnote 8.

[6] James Bosco, op. cit., footnote 33, pp. 2-3.

text, machines are capable of success. But the ultimate goal—instilling wisdom—is a much harder one to meet.

These papers and workshop created a basis for discussion. The issues they raise for the future for America's children are too important to ignore.