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Extraordinary changes have taken place since the U.S. Department of Commerce invited applicants for this study in 1992. Unprecedented federal education initiatives in the 103rd Congress have set clear goals for an educated, productive nation and provide the momentum to achieve them. Changes in telecommunications policy and regulation have attempted to address the accelerating potential of information and communication technologies. Private corporations, public organizations, and the communications industry have begun the process of linking homes, schools, and businesses to the developing National Information Infrastructure (NII). Taken together, these developments offer the potential for telecommunications technologies to provide Americans with accessible and affordable lifelong learning.

Many of the policies and priorities we might have recommended at the beginning of this study of education and telecommunications are now in place. For example, while this project was underway, coordination of federal learning-technology programs has begun under the direction of the Committee on Education and Training, with the leadership of the Office of Science and Technology Policy. In the 103rd Congress, bipartisan majorities passed nine education bills, including the Goals 2000: Educate America Act, the School to Work Opportunities Act, and the Improving America's School Act, with new visions for technology. Title III of the Improving America's School Act, the Technology for Education Act of 1994, is the first comprehensive learning-technology act ever passed at the federal level.

President Clinton's Administration initiatives for the NII are providing major policy advances for distance learning and technology applications in education. The Administration's efforts in this area are stimulating commitment of private-sector resources and developing public access through schools, libraries, and hospitals. In addition, these efforts are stimulating review of copyright laws and redefinition of universal access to the nation's telecommunications resources. Federal and state regulatory agencies are considering a wide range of new options that will affect the uses of these resources in schools, homes, and workplaces.

Distance learning is an important component of educational technology use aimed at meeting the National Education Goals. This report addresses the following issues critical to any distance learning planning and implementation:

- Access to Learning Technologies. For the 21st century, distance learning is essential to assure Americans of all ages the opportunity to prepare for their economic well being and civic responsibilities. Personal access to technology and distance learning for all learners must be at the center of any technology plan. This report highlights the ways in which distance-learning resources enhance current education opportunities; provide access to learning not available before; and assure learners access to the NII from their homes, education institutions, libraries, and workplaces.

- Training and Outreach. Effective use of any technology requires training for educators as an integral and continuing part of any technology plan. The report illustrates how training activities have been incorporated into distance-learning programs, and emphasizes the potential for these same technologies to provide educators with the means for their professional development and powerful means of interactive collaboration.
- Partnerships Between the Public and Private Sectors. The provision of distance learning requires joint decisions and actions of private providers and governmental entities. Success depends on the quality of these partnerships. New partnerships are needed, especially to link learning and education institutions and the workplace. The report illustrates how school districts, community colleges, universities, and businesses are working together to share resources, infrastructures, and talents through distance learning.
- Statewide and Multistate Technology Applications. State education and telecommunications laws, programs, and regulations shape the use of distance learning. The report emphasizes effective applications of technologies that provide economies of scale through state, regional, and national actions to work with the telecommunications industry for affordable rates and services.
- Federal Action for Distance Learning. Three types of federal actions are included in this report: first, provision of funds to develop distance-learning facilities and services; second, support for distance learning and technology planning; and, third, the unique importance of federal statute and regulation of telecommunications use and costs and their effects on education.

If our nation is to meet the National Education Goals, we must ably use the potential of distance learning. The challenge is how best to use the resources for specific local and state strategies. This report is designed to inform decisions on these strategies and to help shape use of the NII. Every learner in America—from a classroom in Brooklyn, New York; to an office in Detroit, Michigan; to a community college in Truth or Consequences, New Mexico; or to a ranch in Wyoming—can have access to opportunities to achieve the National Goals through wise use of telecommunications and distance learning.

America's first National Education Goals, backed with standards for high student performance, set the pace and direction for education reform. The developments in distance learning and the promise for its future offer a reality for achieving the Goals. The technology in our homes and workplaces must become a reality in our institutions and services of learning. We offer this study and report as a guide for using the potential for distance learning to help achieve the Goals.

Gordon M. Ambach

THE CONTEXT FOR THIS REPORT

Purpose

This report presents the findings and recommendations of the United States Education and Instruction through Telecommunications (USE IT) project. Begun in January 1993, USE IT assessed the relationship of distance learning to the nation's educational needs, especially its role in achieving the National Education Goals. USE IT examined all levels of education, prekindergarten through adult continuing education and worker training. The working definition of distance learning used in this report is "the delivery of video, voice, or text instruction or information to a learner over distance, from one location to another, using some form of telecommunications technology."

Operating Premises

USE IT has been conducted on the following premises, derived from an extensive analysis and evaluation of the literature on how technology is used in education:

1. The objectives for learners, as included in the National Education Goals, determine how technology is applied to learning and teaching.
2. Distance learning offers great promise in providing educational services, chiefly because information and telecommunications technology provide access to instruction and content that students at all levels could not otherwise have.
3. Distance-learning technologies increase learning effectiveness by offering diverse interactions ranging from "one to many" to "many to many" for learning.
4. Distance learning is a source of cost-effective professional development for teachers and school administrators.
5. Distance learning enables schools to use the most effective teachers available in a given subject area, without geographic limitations.
6. Changes in information technology are having a powerful effect on how those technologies are being designed and used in education.
7. Developments in telecommunications and distance-learning policy and operations for education are closely related to developments in general telecommunications policy.
8. Initiatives, support, and direction for telecommunications policy, operations, and financing will come from both public and private sectors.

DISTANCE LEARNING AND THE NATIONAL EDUCATION GOALS

Two distinct trends form the backdrop of this report: (1) the confluence of three major forces that are shaping our society—information and telecommunications technologies, a globally competitive economy, and the changing needs of the workplace—and (2) an unprecedented, decade-long commitment to education reform that seeks to move America from being "a nation at risk" to being a model of world-class education.

The National Education Goals and the benchmarking legislation designed to help achieve them (e.g., the Goals 2000: Educate America Act, the Improving America's Schools Act, and the School to Work Opportunities Act) will help to orient students to the new world of work and learning. The tools of telecommunication and distance learning, including broadcast, cable, satellite, and telephone networks, have a vital role to play in education reform and in meeting the needs of all learners. New digital interactive systems have emerged that significantly influence learning and teaching. These technologies can serve all learners, regardless of age, disability or language. These tools are already being brought together in a National Information Infrastructure (NII) that provides students with improved access to full voice, video, and data services. According to a recent survey, Americans rank education and instruction as the most important benefits to be gleaned from the NII.

Specifically, distance learning provides the following educational advantages that can contribute to achieving the National Education Goals:

- Distance learning offers a broad range of technologies to serve a variety of educational functions.
- Distance learning continues to serve such tra-

ditional functions as providing instruction to learners at remote sites and instruction in subject matter not readily available. A recent survey of small, rural school districts found that half of them use distance learning.

- Distance learning will be increasingly helpful in improving instructional practices through such offerings as electronic field trips and visits to other resource-rich environments.
- Distance learning is uniquely able to connect school-based learning to its applications in the workplace through electronic linkages.
- Distance learning offers educators staff development and school management capabilities not available through other means.
- Distance learning supports lifelong learning, from adult literacy to higher education. This capability is crucial for workers seeking to update skills and for job training and retraining.

But providing these advantages means that distance learning must meet certain functional requirements to realize its advantages: (1) distance-learning materials must maintain high-quality content and should be continually evaluated; (2) distance learning should itself be supported by training, technical assistance, and professional development, both in school and workplace settings; (3) distance learning should be available in a variety of learning environments; and (4) distance-learning applications should be planned for a multiplicity of uses, including integration with the developing NII.

NAVIGATING THE WORLD OF DISTANCE LEARNING

The USE IT report includes information on distance-learning resources, the integration of technologies, types of service providers, and the use of resources.

Distance-Learning Resources

Distance-learning resources come in a bewildering variety of forms and formats. For the technologically insecure, even the sheer terminology can be overwhelming. The report discusses the following telecommunications technologies, their advantages, and their disadvantages:

Broadcasting. Broadcasting is the earth-based, one-way transmission of video and audio signals, usually within a 35-50-mile range. The nation's extensive broadcasting network(s) are regulated by the Federal Communications Commission. Virtually all distance-learning broadcasting is done from some public broadcasting source, for example, the Public Broadcasting Service (PBS) or some institution of higher learning or public channels. Some 98 percent of all American homes have TV sets that can receive public broadcast signals, and about 94 percent of the country is currently within transmission range of public broadcasting stations. Broadcasting costs are high; costs for seven popular children's series on PBS range from $152,000 to $811,000 per broadcast hour. But on a cost-per-viewer basis, broadcasting's ability to reach huge audiences cuts costs to about a 1-cent per household per program hour.

Satellites. Satellites are basically relay devices for signals; their geosynchronous position above the earth makes it possible to send signals across much greater distances. Reception requires an "uplink" transponder and a "downlink" antenna dish. Approximately 29 commercial satellites are now in orbit, capable of delivering signals to the continental United States and, in some cases, Hawaii and Alaska. Satellite advantages include the ability to transmit anywhere in the United States, resiliency with respect to natural and man-made disasters, and a low cost-to-distance ratio. But satellites are expensive. Apart from launching costs, "uplink" transmission facilities can cost from $80,000 to $300,000 to build, and "downlink" dishes range from $4,000 to $6,000 for standard models. Transponder time costs about $300 per hour for a one-year lease. Currently, only about 70-80 percent of the available satellite transponder capacity is in use. Direct broadcast satellites and Very Small Aperture Terminals (VSAT) technologies show promise for further satellite-based distance-learning applications.

Cable. Cable TV sends a signal over coaxial or fiber-optic cable to specially equipped receivers for

a monthly fee. There are 11,160 individual cable systems operating in the United States, which accounts for one of cable's biggest advantages: penetration. Currently, however, only 10 percent of all cable systems in the United States are equipped to provide the interactive services that number among distance learning's most attractive potentials. About 3 of 5 public and private elementary schools (34.5 million students) were cable equipped in 1993, but 95 percent of all high schools will be cable equipped by 1995; 14 percent of community colleges and 22 percent of four-year institutions use cable TV to deliver distance learning. The trend in the cable industry is to replace copper coaxial cable with fiber-optic cable. Fiber-optic's main advantages are its virtually unlimited bandwidth (it can carry enormous amounts of programming and data), its consequent potential for expanded uses, and its reduced need for signal boosting over long distances. Its main disadvantages are its lack of installed base, high costs, and physical constraints in handling and installing.

Telephone. Combined with modems and computers, telephones provide a powerful learning medium. Despite the fact that 95 percent of all American homes have telephones, this technology is not widely used in education; only about 12 percent of U.S. classrooms are telephone equipped. A significant inhibitory factor affecting telephone usage for education is the current rate structures of state public utility commissions. But possibilities exist for creating an "education rate" to complement existing commercial and residential rates. Through fiber optics and other technologies, it is estimated that by the year 2035, 93 percent of all U.S. schools, offices, and households will be served by broadband phone networks.

Microwave/ITFS. Two types of microwave technologies are now being used: (1) point-to-point, line-of-sight transmission of digital or audio signals on the radio spectrum; and (2) Instructional Television Fixed Services (ITFS). ITFS has a more limited range than broadcast TV and costs between $20,000 and $30,000 per channel, compared to the low-end $80,000 to $100,000 cost of a satellite uplink. Four-channel receiving antennas are relatively cheap, at about $150 each. When the unused, commercial-use portions of the ITFS spectrum were allocated in the 1980s, they were bought up by a flood of commercial entrepreneurs. These companies have developed partnerships with educational institutions in which ITFS hardware is provided free to schools. In return, the companies can lease some portion of the four channels allotted per license.

Wireless. Wireless communications technologies include direct-broadcast satellite, broadband broadcast radio, personal communications services (e.g., hand-held radios and cellular phones), wireless local area networks (LANs), and advanced television. Cellular technology is now being used on a very limited basis to transmit and pick up video signals. It is expected that wireless technologies will greatly facilitate delivering the NII to schools and other learning sites and to rural and inner-city areas lacking wired communications.

Computer Networking. Multiple technologies are often combined with a computer network that delivers data and video signals for distance learning. There are currently about 4.5 million computers in America's schools. Since 1989, the number of schools using both internal and external networks has grown substantially, with the fastest growth reported at the upper secondary level. Because computers can store data for later retrieval, networks make interaction among learners, teachers, and service providers much easier. Networks vary greatly in size, scope, and means of communication. Some 38 states now have either fully or partially operational networks for instructional services. LANs connect any number of individual computers, printers, file servers, CD-ROMs, modems, and fax machines. The Internet is a "network of networks," an electronic pathway for data to travel anywhere in the world. There is no "central control"; that means extensive freedom and creativity in using the Internet, with all the advantages and disadvantages entailed. Teachers complain that using the Internet requires a formidable sophistication with computers.

Nevertheless, about half the institutions of higher education that are network equipped report participating in the Internet.

Integration of Technologies

These several technologies are seldom used alone; instead, multiple technologies are integrated into systems or networks, a trend facilitated by the widespread use of digital information, which can be more easily transmitted than standard analog signals. Currently, the integration of distance-learning technologies is occurring at two main levels: (1) delivery systems, which transport voice, radio, and data signals; and (2) interface units, which allow users to access and transmit signals on their own. Even when the available technology permits only one of these, the trend is still in the direction of integrating as many technologies as are necessary to provide interaction and support to learners. In 1991, for example, community colleges engaged in distance learning reported using an average of 3.7 different technologies for delivering and receiving instruction, with an expected increased to 5.6 technologies by 1994. Four-year institutions expected to move from 3.4 to 6.1 technologies in the same time period.

Providers of Distance-Learning Resources

Distance learning is packaged in two basic ways: as video programming (live and prerecorded instruction) and as information services (data bases). Providers of these packages range from multistate, nonprofit consortia to independent producers of for-profit information services. This report describes the distance-learning services and technologies of many major providers, for example:

- PBS and its 300+ public television stations.
- The National Technological University, a consortium of 45 leading engineering schools, which offers degree and nondegree programs, as well as credit and noncredit courses;
- The Massachusetts Corporation for Educational Telecommunications, which serves learners in 37 states with satellite programming, electronic networks, and conferencing capabilities.
- The Satellite Educational Resources Consortium, which serves 5,000 predominantly rural high school students from 500 schools in 34 states, 71 percent of whom are eligible for Chapter 1 funds.
- The Black College Satellite Network, which provides programming for prekindergarten through higher education in 23 states, with more than 1,000 participating downlink sites.
- Mind Extension University, which provides fully accredited college and graduate-level courses via cable TV to approximately 25 million households;
- The Agricultural Satellite Corporation, a consortium of land-grant institutions, government agencies, business, and industry, which provides distance-learning services for agricultural producers and rural families and businesses.
- KIDLINK, a free, global program that involves children ages 10-15 in an international dialogue. The interactive service focuses on conversations between participants.

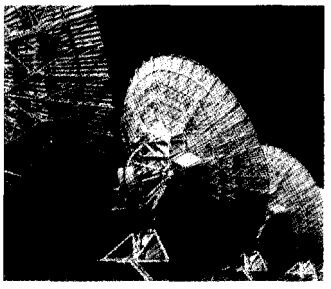
The Use of Distance-Learning Resources

Although comprehensive data concerning the use of distance-learning resources is not available, this report reveals that they are being used at all levels of education, in and out of school. For example, the cable industry reports serving approximately 34.5 million students nationwide. About 4 in 10 of the schools that use distance-learning video programming report receiving it by satellite dish; over a third receive programming by cable television; 9 percent receive programming via ITFS, 5.2 percent via fiber optics; and 4.4 percent via copper-based telephone wiring. Four out of five two-year colleges and 78 percent of all four-year colleges anticipate using distance learning by the end of 1994. Nearly a third of all Fortune 500 companies report using distance learning to train their workers. The report provides a resource-by-resource break-out of how various technologies are typically used. For example:

- Broadcast services are typically used to reach learners both in school and at home; they are seeking to achieve a high degree of interactivity.

HOW TECHNOLOGIES ARE BEING INTEGRATED TO PROVIDE DISTANCE LEARNING

- Fiber optic cable is being used nationwide by all local and long-distance phone companies and many cable companies. A fiber/cable model in Indiana links the Indianapolis Regional Economic/Academic network, Thompson Consumer Electronics, and the Indianapolis schools.
- In Detroit, the Community Telecommunications Network serves approximately half a million schoolchildren by using ITFS as a redistribution system for satellite, cable, and other signals for broadcast microwave reception.
- The San Marcos Telephone Company in Texas has deployed fiber optic cable to connect three education sites: San Marcos High School, the Gary Jobs Corps Training Center, and Southwest Texas State University.
- Maine is currently operating a statewide community college system completely using distance-learning resources, including ITFS, fiber, and an electronic network.



- Satellite use is typically found in school, home, and the workplace.
- Microwave technology is more typically used as a transport link, for example, to link classroom sites participating in live distance-learning sessions.
- ITFS is typically used when a large number of users need to be served in multiple learning sites in a small, defined region of about 30 miles.
- Cable is used in many contexts, from "Cable in the Classroom" documentaries to distributing locally produced courses.
- Telephones are typically used to provide a voice return to a televised instructor, or to connect to online computer services.
- Computer networking is most often used as a secondary form of interaction to support some other distance-learning resource, for example, accessing support materials for a televised class. An emerging use of computer networking is delivering integrated voice, video, and data services directly to a student's electronic desktop.
- Wireless technology is most often used to make the "last link" to the user in unintegrated systems. This is a relatively untested distance-learning option.

CHALLENGES AND BARRIERS TO DISTANCE LEARNING

Despite its growing popularity, distance learning is still a relatively untapped resource with enormous potential to provide improved learning opportunities across the education spectrum. Although many barriers have been overcome, many remain. This report examines the most important of these barriers and offers recommendations, which, taken together, can be instrumental in overcoming them. These recommendations are listed in full at the end of this summary. (The numbered recommendations pertinent to each barrier are provided in parentheses.) Recommendation 1, related to the using distance learning to achieve the National Education Goals, applies across the board.

1. Incompatibility of Technical Systems. Because distance learning incorporates an integration of technologies, compatibility issues are crucial. A typical example is the problems created by the introduction of digital compression technology. Digital compression allows for a much more efficient use of bandwidth and air time, but adopting the technology usually involves new equipment, additional training, and complications in transmissions. Sometimes services have to be offered in both new and old formats to accommodate all users. This particular issue will become more critical as time passes. (Recommendations 3, 10)
2. Insufficient Use of Available Resources. There are many reasons why distance-learning resources are not well used. Not all delivery systems are available everywhere. The haphazard evolution of technologies has created many incompatibilities, inhibiting the integration of distance-learning resources. In many cases, local school systems find it difficult to incorporate distance learning into their existing instructional programs, either because of internal scheduling difficulties or because of scheduling conflicts with cable companies and broadcasters. The rigidity of the school day and year also present conflicts that are difficult to resolve. (Recommendations 3, 4, 6, 9)
3. Costs of Technology. Distance learning involves both significant start-up costs and continuing programming and operational costs. Even audio teleconferencing, a highly accessible and simple technology to use—and low-cost in comparison to using satellite networks—can cost $50 to $400 for each speakerphone and $1,000-$3,000 per port for bridge equipment, plus toll charges. Audiographics equipment can run from $6,000 to $13,000 per school. (Recommendations 6, 9, 10)
4. Regulatory Barriers. All telecommunication systems used to deliver distance learning are regulated by state or federal agencies. Telephone companies and cable companies have made commitments to providing broadband communication networks to schools, but

many issues are yet to be resolved, including to whom access will be required, what fee structures should apply to education and training, and what types of services will be provided. These issues are continuously being discussed, negotiated, and legislated. Copyright and viewing restrictions are also significant concerns for distance learning, and intellectual property rights and "fair use" definitions have not yet been clearly defined for emerging distance-learning technologies. (Recommendation 5)

5 Training People to Use Distance-Learning Technologies. This challenge is particularly acute in the schools, where teachers have been inadequately prepared to use distance-learning technologies. One study conducted by the U.S. Congress's Office of Technology Assessment, for example, reported that 64 percent of the teachers involved in teleteaching had not received any prior training in the distance-learning systems used. The American Association of Colleges of Teacher Education reports that only about 20 percent of teacher training programs offer coursework incorporating current learning technologies. (Recommendations 7, 11)

6 Course Accreditation. In general, course-accreditation issues are most significant at the high school level, where state-regulated graduation requirements must be fulfilled by approved curricula and teaching done by state-certified teachers. (Recommendation 2, 8)

7 Cost and Accounting Systems. Whereas most colleges and universities use cost-accounting systems that relate to specific academic departments, most public schools use the accrual method, which does not distinguish between areas of instruction. In consequence, it is difficult for school-based decision makers to estimate or track the cost-effectiveness of using distance-learning technologies, including space and personnel costs. The business community tends to have a clearer picture of the cost-effectiveness of distance-learning technology with respect to its training mission. (Recommendations 5, 9)

8 Institutional Structures. The overwhelmingly local character of education in the United States greatly complicates the use of distance learning. A critical example is teacher certification. Often, a distance-learning teacher must be certified in every state where the teacher's lessons are used. In addition, the organizational structure of both educational institutions and businesses often prohibits effective planning for nontraditional methods of instruction. But state governments have been taking increasing initiative in planning for distance learning to avoid incompatible and duplicate efforts. State planning for using technology in education increasingly includes partnerships between public and private sectors. (Recommendations 2, 4, 8, 10)

9 Programming Quality. An effective on-screen presence requires different skills than does traditional classroom teaching or training in adult education or the workplace. Traditional distance-learning programming formats also tended toward the "talking head" approach. Formats that are much higher in their production values and appropriate to desired content are needed. (Recommendations 7, 8, 11)

10 Awareness and Acceptance. Distance learning is still plagued by the myth that it offers a second-rate alternative to real instruction in a classroom. Schools have been reluctant to turn to distance learning, except to solve teacher shortages, to meet the challenges of great distance in rural areas, or to provide more cost-effective instruction in certain subject areas. In K-12 schools, particularly, distance-learning resources suffer from the "not invented here" syndrome that prohibits ready acceptance of curriculum developed elsewhere and teachers who are not known. Also, distance learning is often saddled with the image of TV as a time waster and negative influence on students. For this reason, it has been used most often for more self-motivated adult learners. A potential remedy for distance learning's awareness and acceptance problems may lie in its wide array of interactive options and feedback systems, and in

its ability to tailor instruction through different modes of learning. (Recommendations 11, 12)

RECOMMENDATIONS

Significant barriers stand in the way of using distance learning to achieve the National Education Goals. The following 12 recommendations have been developed to address them, within the nation's plans for the NII. These recommendations are nationwide in scope and, therefore, general rather than specific to particular states, localities, institutions, or businesses. They encompass an essential principle for the development of distance learning—namely, that such development requires combined private and public action through federal, state, and local education agencies, private industry, and distance-learning service providers. Recommendations are as follows (the rationale for each is provided in the full report):

Recommendation 1: Education agencies at all levels must support the development and use of distance-learning resources to achieve the National Education Goals.

Recommendation 2: Education agencies at all levels must ensure equitable access to distance-learning resources to increase the opportunity for all citizens to learn.

Recommendation 3: The telecommunications industry, distance-learning service providers, and regulatory agencies must support and develop distance-learning delivery systems and information networks that are compatible, interoperable, and cost effective.

Recommendation 4: Federal and state governments, together with local communities, educational institutions, the telecommunications industry, and business and industry, should promote public/private partnerships for distance learning and support regional and statewide applications of distance learning as part of an integrated national resource.

Recommendation 5: State and federal regulatory agencies must develop policies that ensure affordable rates for the educational uses of telecommunications resources. Regulatory agencies having appropriate responsibility should ensure availability of universal telecommunications services for all levels of lifelong learning and maintain reasonable fair-use copyright guidelines for instructional materials used in distance learning.

Recommendation 6: Federal and state agencies, in cooperation with the private sector, should develop new resources for investment and capital development for distance learning. Support from federal agencies must be coordinated to provide efficient and effective funding uses.

Recommendation 7: Professional development programs for educators and administrators should rely increasingly on distance learning and include technical training for the use of distance learning in formal education programs.

Recommendation 8: State education agencies must improve course accreditation procedures to advance the use of distance learning and other alternative education offerings.

Recommendation 9: Providers of distance learning must develop cost-accounting standards that provide accurate information on unit-of-instruction costs and instructional effectiveness assessments for distance learning.

Recommendation 10: Education institution authorities planning to use or expand distance learning must take special actions to create organizational environments for undertaking the values and limits of the service for the desired effects to be realized.

Recommendation 11: Distance-learning providers and users must join forces to strengthen distance-learning content requirements and instructional formats.

Recommendation 12: Local, state, and national authorities should undertake awareness and outreach activities to inform educators, business and industry, and the public of the value and importance of distance learning to achieve the National Education Goals.

INTRODUCTION

This report is the result of the **United States Education and Instruction through Telecommunications (USE IT)** project, a cooperative agreement between the Council of Chief State School Officers (CCSSO) and the National Telecommunications and Information Administration (NTIA) of the U.S. Department of Commerce, with participation by the Office of Education Research and Improvement (OERI) of the U.S. Department of Education. In January 1993, these groups collaborated to assess current and future educational needs in the United States relating to distance learning and to develop recommendations for using telecommunications and learning technology resources for distance learning to achieve the National Education Goals.

The project was funded by NTIA's Public Telecommunications Facilities Program (PTFP). PTFP assists noncommercial entities to purchase telecommunications equipment that will be used to produce and transmit educational and cultural services. PTFP also supports planning projects pointed toward these ends. Over the years, PTFP has offered financial support to diverse organizations—public broadcast stations and all levels of academic institutions—to help them establish, extend, and plan for distance-learning systems.

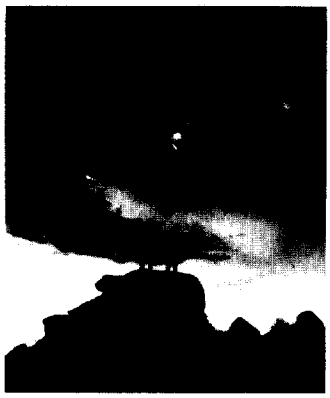
We should note that, since this grant was funded, NTIA has been given an important role in the Administration's wide-ranging National Information Infrastructure (NII) initiative. This initiative will be discussed in greater length elsewhere in this report. As part of its NII-related responsibilities, NTIA has established the Telecommunications and Information Infrastructure Assistance Program (TIIAP). The TIIAP, which distributed its first grants in October 1994, awards monies to such entities as state and local governments, museums, libraries, health care providers, school districts, colleges and universities, public safety services, and nonprofit organizations to help them interconnect with the new telecommunications and information networks.

CCSSO is a nationwide, nonprofit organization composed of the 57 public officials who head the departments of elementary and secondary education and, in some states, other aspects of education in the 50 states, five extra-state jurisdictions, the District of Columbia, and the Department of Defense Dependents Schools (DoDDS).

PREMISES OF USE IT

The USE IT project embraces several basic premises concerning education, technology, and distance learning. These premises emerged from extensive evaluation and analysis of current literature regarding technology and education; consultations with a wide range of government, business, and education representatives; and the clearly defined vision of the Clinton Administration for the capabilities of applying the nation's technological resources and prowess to improving education in this country. The premises are as follows:

1. The objectives for learners, as included in the National Education Goals, determine how technology is applied to learning and teaching.
2. Distance learning offers great promise in providing educational services, chiefly because information and telecommunications technology provide access to instruction and content that students at all levels could not otherwise have.
3. Distance-learning technologies increase learning effectiveness by offering diverse interactions ranging from "one to many" to "many to many" for learning.
4. Distance learning is a source of cost-effective professional development for teachers and school administrators.
5. Distance learning enables schools to use the most effective teachers available in a given subject area, without geographic limitations.
6. Changes in information technology are having a powerful effect on how those technologies are being designed and used in education.
7. Developments in telecommunications and distance-learning policy and operations for education are closely related to developments in general telecommunications policy.
8. Initiatives, support, and direction for telecommunications policy, operations, and financing will come from both public and private sectors.



METHODOLOGY FOR THE PROJECT AND REPORT

The USE IT Project is a collaborative effort by education, business, and government organizations to assess current distance-learning resources and develop strategies and recommendations for using these resources to achieve the National Education Goals. A Governing Board, Steering Committee, and Forum provided input and guidance to the content and structure of the report. The project management team, consisting of representatives from NTIA and CCSSO, commissioned consultants to draft position papers for specific sections of the report. The team held a national teleconference on August 6, 1993, featuring discussion by a distinguished panel of the issues central to the application of telecommunications to education and providing an opportunity for interested people across the nation to participate in the dialogue. Portions of this report reflect this dialogue.

The report examines all levels of education, from prekindergarten through adult continuing education and worker training. This breadth reflects the recognition by the education community of the necessity for lifelong learning and the recent efforts to achieve systemic reform that links all aspects of education. A review of studies and reports by the project management team found that the K-12 uses of distance-learning programs were more heavily documented than were comparable studies for adult learning, higher education, and worker training. Reflecting this limitation, data presented here provide more information about K-12 education than the other levels; but the team's intention is not to emphasize the importance of distance learning to one level of education over another. The report includes discussions of multiple telecommunications and learning technology resources. It reviews policy issues and strategies to better provide education services using telecommunications and learning technologies for distance learning. The report does not advocate one type of technology over another; rather, it indicates the capacities and potentials of different types of technologies. It assumes that learners will use a variety of technologies that best suit their immediate needs.

The Governing Board met in April 1993 to discuss the scope of the project and a means for producing materials for review. Recognizing the broad scope of the project, limited time schedule, and diverse interests of the project participants, the Board formed three working groups to produce three working papers on: functional requirements for achieving the National Education Goals; telecommunications resources; and strategies to maximize use of telecommunications resources to achieve the National Education Goals. The Board designated these three papers as the framework for the final report of the project. The paper on functional requirements would develop a statement of vision about the nature of learning in our society and the expectations for learning in a changed technological context. The paper on telecommunications resources would not take a quantitative approach to inventorying resources; instead, exemplars of systems that successfully integrate telecommunications and education would be identified and presented. Strategies would be developed to maximize use of telecommunications resources to achieve the National Education Goals and would be directly linked with the functional requirements and identification of resources.

The project management expanded on the discussion at the Governing Board meeting and presented preliminary drafts of the three papers at the Steering Committee meeting in June 1993. The Steering Committee divided into three working groups to comment on and further develop the working papers. The project management and an advisory team from the Governing Board selected the Southwest Regional Laboratory (SWRL) to conduct a literature search on the impact of telecommunications on education from 1980 to 1993.

The Governing Board convened a second time in August 1993 and continued to review and revise the working papers and support materials. Three consultants, Susan Fratkin, Richard Hezel, and Saul Rockman, who are leaders in the field of

education and technology, attended the meeting and met with the working groups. Following the meeting, the consultants prepared revised versions of the working papers, which were distributed to Governing Board and Steering Committee members for comment. Four additional consultants, Pam Pease, Ron Anderson, Judy Gray, and John Cradler, were retained to develop papers describing the use of cable television, computers, telephones, and networks in distance learning. These papers were incorporated into Chapter 2, "Distance-Learning Resources."

The Steering Committee met again in December 1993 to review a preliminary draft of the final report, based on the conceptual framework established by the working papers. Following the meeting, the NTIA and CCSSO project management team, under the cooperative agreement, prepared an outline for a new draft of the report, which would incorporate work completed to date, expand on the identification and analysis of distance-learning resources, and refine the content to more specifically guide the role of NTIA in distance learning. NTIA and CCSSO worked closely over the next several months to update the research conducted for the project and draft the report based on the new outline.

After the project management team completed the revisions, copies of the draft were sent to members of the project Forum, representing more than 70 government, business, and education organizations. The team incorporated comments by Forum members into the final report, which was submitted to the Governing Board for approval in December 1994.

Time and resource constraints of this project limited original surveying and data collection by the project management team. The team relied heavily on data already assembled by states, institutions, companies, and associations. The team contacted state education agencies, public service or utility commissions, and land grant colleges by letter requesting information about available telecommunications resources and integration of telecommunications into education. Responses varied in both quality and quantity. To this extent, much of the information collected from these sources has been summarized or used as background material for providing the context of the report. The project management team also conducted phone and personal interviews with service providers, educators, government officials, technicians, engineers, and other leading figures involved in technology and education. The team conducted research on many publications, including reports by government agencies, industry, and public advocacy groups; articles in journals, newspapers, magazines, and trade publications; monographs identified through the ERIC database; speeches; and other relevant print materials. Team members reviewed several dozen videotapes. The team attended several meetings and conferences conducted by government agencies and nonprofit organizations to assess the latest trends in distance learning and education policy.

Because information was collected from so many sources, the level of detail concerning descriptions of technologies, service providers, and users varies accordingly. Extraordinary technical developments and change in pricing and availability; rapid changes in implementation of technologies; unevenness of progress among states, local districts, and institutions; and variations in cost related to isolated applications of technology make aggregate, quantitative findings extremely difficult. They are presented in the report to the greatest extent possible. During extensive contact with experts in the field at all levels and in varied professional positions, the project management team discovered that data collection and assessment in the field of distance learning is limited. The team has used the most reliable and accurate sources of information available, but it should be noted that this is a dynamic and emerging field in education research and application.

This report is considered to be applicable to the continental United States, Alaska, and Hawaii. Although some aspects of distance learning, as discussed here, may also be applicable to the U.S. territories including Puerto Rico, American Samoa, and Guam other aspects may be invalid within the unique circumstances and opportunities in these areas.

DISTANCE LEARNING AND THE NATIONAL EDUCATION GOALS

This report explores the use of distance learning to promote improvements in education aimed at meeting the demands of a modern society. Two distinct trends set the stage for this discussion. The first is our rapidly changing information society, in which telecommunications and information technologies have stimulated a globally competitive economy and a constantly changing workplace. The second is an unprecedented national commitment to education reform, the culmination of decade-long efforts to define improved learning and take this country from being "a nation at risk" to a model of world-class education. Understanding the potential of telecommunications technology is not only essential to functioning in the modern workplace, but is a powerful tool for improving educational opportunities for all citizens. Recognizing this potential, the U.S. Congress enacted the technology component of Goals 2000: Educate America Act in March 1994. The Goals lay out comprehensive national objectives for education in this country, including school readiness, excellence in science and mathematics, adult literacy, professional development, a well-prepared work force, and safe learning environments.

In past decades, distance learning has filled gaps in existing education and stretched instructional resources across geographic boundaries. Now, however, the opportunity exists for distance learning to play a significant role in achieving the nation's education goals. Telecommunications resources—including broadcasting, satellite, cable, telephone, and computer networks—which are already working to deliver distance learning, will soon be integrated into a National Information Infrastructure (NII). Education and learning must be a primary function of the NII if it is to serve Americans, and distance-learning applications already in place must continue to evolve into access ramps for the NII. In this context, distance learning has limitless potential for ensuring opportunities for lifelong learning for all citizens.

THE CHALLENGE OF EDUCATION REFORM

The economy and labor markets in the United States are undergoing dramatic restructuring as a result of advances in technology. Both the nature of work and the bases of productivity are being redefined. The least skilled jobs in the American economy are disappearing. Most new jobs will require more education—particularly higher levels of language, mathematics, and reasoning skills. The rapid technological changes within jobs and the increased mobility among jobs mean that workers need to adapt to new situations and be able to learn new skills throughout their lives. New workers entering the labor force today can no longer count on remaining in the same jobs or working in the same industries until retirement. As old industries decline, new jobs are created that require Americans to be technologically literate, creative problem solvers.

The traditional workplace of the past was characterized by mass production, centralized control, and fragmentation of tasks. The high-performance workplace of tomorrow, in contrast, will be distinguished by flexible production, decentralized control, and teams composed of multiskilled workers (Secretary of Labor's Commission on Achieving Necessary Skills [SCANS], 1991). These changes place enormous demands on both our workers and on the education and training institutions that the nation relies on to prepare young people for productive lives. The challenge for education, therefore, is not to train workers for new technical occupations and careers, but to produce well-educated citizens, prepared for continual change and for the lifelong, independent learning required to accommodate change effectively (National Commission on Excellence in Education, 1983; Resnick, 1987; Resnick & Resnick, 1992; Scribner, 1987).

Research on learning and cognition suggests that traditional approaches to education and training will not produce the kind of adaptive learning or the kind of learners required by changes in technology, work, and society. New learner-centered approaches are needed now. In these environments, students actively construct knowledge for themselves, cooperate in problem solving, and learn skills in the context of meaningful, real-world tasks (SCANS, 1991). The systemic reforms now being contemplated are based on this vision of effective learning in the information age. The Goals 2000: Educate America Act and other initiatives focused on elementary and secondary schools, school-to-work transition, and adult literacy, offer a framework within which systemic education reform can be pursued. At the center of these initiatives are the National Educational Goals, which provide, for the first time, national benchmarks for the kinds of educational opportunities the education system should provide and the levels of accomplishment that all school-aged learners and adults should achieve (U.S. Congress, 1994) (see Figure 1). The Star Schools Programs have already developed a wide range of successful distance-learning services aimed at supporting the National Education Goals, including instruction modules, electronic field trips, otherwise unavailable coursework, access to experts in a variety of fields, and career awareness programs (Far West Educational Laboratory, 1994). The cable industry has also initiated projects aimed specifically at helping communities achieve the National Education Goals (Decker Anstrom, personal communication, January 1995).

The Goals 2000: Educate America Act makes clear the importance of technology in its Leadership in Education Technology initiative. The legislation calls on federal leadership to develop a national vision and strategy for educational technology, including technology planning that is integrated into all state education and training programs, is coordinated among public and private entities, ensures maximum interoperability, and is facilitated by federal policies. Clearly, distance learning has an important role to play in defining this vision and ensuring its objectives.

NATIONAL INFORMATION INFRASTRUCTURE

The tools of telecommunication, including broadcast, satellite, cable, and telephone networks,

New approaches to learning are necessary to prepare all Americans for the 21st century workplace.

are already being used for education and instruction. The NII promises to bundle these powerful tools and deliver them in ways that provide users with improved access to full voice, data, and video services. Recognizing the potential represented by this convergence of technologies, the Clinton Administration has sought explicit linkages between the NII and the National Education Goals, challenging business leaders, the education community, and others to link every classroom to the NII by the year 2000 and to provide access to learning resources through libraries, museums, and other community institutions (State of the Union Address delivered by President Clinton, January 1994; remarks of Vice President Gore to leading executives in the computer and multimedia industries, Los Angeles, February 1994). Increasingly, Americans rank education and instruction as the most important benefit to be received from the NII (Benton Foundation, 1994).

For distance learning, the convergence of technologies represented by the NII offers several important advantages: (1) the potential for individual learners to tap into a broad range of distance-learning programming from any location using any number of interface devices, rather than having to use particular technologies at a particular receiving site; (2) more varied means of interactivity, which will make it more feasible to customize the distance-learning applications to the subject matter taught, the characteristics of learners, and the mix of local resources available; and (3) the possibility of integrating distance-learning programming with other technology-supported learning. Each of these capabilities enhances the utility and attractiveness of distance-learning services for achieving the nation's education goals.

Figure 1
THE NATIONAL EDUCATION GOALS

GOAL 1: By the year 2000, all children in America will start school ready to learn.

GOAL 2: By the year 2000, the high school graduation rate will increase to at least 90 percent.

GOAL 3: By the year 2000, all students will leave grades 4, 8, and 12 having demonstrated competency over challenging subject matter including English, mathematics, science, foreign languages, civics and government, economics, arts, history, and geography, and every school in America will ensure that all students learn to use their minds well, so they may be prepared for responsible citizenship, further learning, and productive employment in our Nation's modern economy.

GOAL 4: By the year 2000, the Nation's teaching force will have access to programs for the continued improvement of their professional skills and the opportunity to acquire the knowledge and skills needed to instruct and prepare all American students for the next century.

ROLE OF DISTANCE LEARNING IN EDUCATIONAL REFORM

Telecommunication and information technologies offer a range of resources that can serve as engines for many of the powerful education and training reforms needed to advance Goals 2000 (see Chapter 2 for a more detailed discussion of these resources). This has been the conclusion of several groups of educators, businesspeople, the policy leaders interested in using technology to improve teaching and learning and to restructure schools. Already, telephones provide connections to distant experts, to remote data bases, and to helpful teachers who answer homework hotlines in many cities. Broadcasting provides education and training courses for distance-learning applications through the Public Broadcasting Service (PBS), public television stations, and public radio. Television provides a variety of educational programs: programs for young learners such as Sesame Street, Reading Rainbow, Square One, and CNN Newsroom; adult education courses and community college offerings; and documentaries and debates on topical issues. Cable networks such as Arts and Entertainment, The Discovery Channel, The Learning Channel, C-Span, and many others all provide educational programs for formal or informal use. Microwave, Instructional Television Fixed System (ITFS), and local area computer networks provide professional development opportunities for teachers and facilitate communication among learners, teachers, and administrators.

Distance learning encompasses a broad range of technologies (see Chapter 2). These resources serve a variety of functions: full-length courses for credit; modules of instructional units that can be integrated into traditional classroom instruction; enrichment experiences that bridge the distance between classrooms and the world beyond; and professional development programs that support teachers and working professionals. Distance-learning programs either offer services to students who would not otherwise have access to them, or enrich the quality of learning services already available.

Traditional distance learning delivered instruction to remote sites or to places where teachers in a particular subject matter were unavailable, and this remains one of its most important functions. Distance learning is helping many institutions to extend otherwise unavailable educational opportunities. The Star Schools program, which delivers distance-learning services nationwide, continues to

find foreign languages, mathematics, and science courses among the most popular programming. A recent survey of small, rural school districts in 32 states found that half of them used distance learning. Satellite and cable are the most commonly used delivery systems in these districts. Again, foreign languages, mathematics, science, and vocational education were noted as the greatest programming needs (Barker & Hall, 1993). In K-12 education, distance learning is most often used for this purpose.

Learning technologies, particularly those telecommunication resources used for distance learning, also have great potential to provide enriched educational experiences. As use of learning technologies becomes more widespread, and resource-rich learning environments become the norm, distance-learning systems will be increasingly helpful for improving current instructional practices. Turner Educational Services' electronic field trips illustrate one of the ways in which distance learning can provide enriching new educational experiences that enhance the existing curriculum. Although the "vicarious" field trip to Gettysburg—complete with a live question-and-answer session with historians—is not part of a structured course, its potential benefit to a text and lecture-based high school history course is evident.

Distance learning can also strengthen mathematics and science instruction throughout the curriculum (Campbell, 1994; Tushnet, Bodinger-deUriarte, Manuel, von Broehuizen, & Millsap, 1993). New curriculum standards call for all students to learn more challenging mathematics and science and to be introduced to advanced concepts in earlier grades. Increasingly, distance-learning programs now provide much-needed support in these areas to classroom teachers, many of whom do not have strong foundations in either of these disciplines. For example, Telecommunications Education for Advances in Mathematics and Science (TEAMS), a collaborative program operating in school districts nationwide, offers participating schools comprehensive courses, lesson plans and other support materials for teachers, and materials to provide hands-on activities for students (Tushnet et al., 1993).

The focus of education reform is improved elementary through adult education, better school-to-work transition, and increased opportunities for worker training. Participatory learning and multidisciplinary, collaborative work that is based on real-world tasks are important components of quality education (U.S. Department of Education, 1993). Leaders of business and industry have also called for a more intelligent work force, better able to analyze situations and solve complex problems (SCANS, 1991). Distance-learning programs are, in fact, uniquely able to achieve some aspects of improved learning, including opportunities to connect school learning to applications in the workplace by electronically linking those communities. Two-way satellite and fiber networks, teleconferencing, and other similar systems can combine collaborative learning and audiographics, for example, in ways not previously possible. Usually video-based, instructional programming can use three-dimensional graphics and other dynamic images in ways that traditional lecture and text-based instruction cannot. Telecommunications is in a unique position to provide educators with staff development resources and management capabilities. Goals for improved education invariably recommend that teachers take a more active role in developing rich learning experiences (e.g., National Council of Teachers of Mathematics [NCTM], 1991). New roles will include responsibility for creating and customizing instruction, conducting authentic student learning assessments, and communicating regularly with parents (U.S. Department of Education, 1993). To effectively take on these roles, educators will need to take part in information-sharing and collaborative processes that professionals in other fields take for granted. Information about the latest research application, technique suggestions, and valuable resource-sharing among colleagues are often inaccessible for most teachers. Coordinated distance-learning systems, particularly those incorporating specialized

GOAL 5: By the year 2000, United States students will be first in the world in mathematics and science achievement.

GOAL 6: By the year 2000, every adult American will be literate and will possess the knowledge and skills necessary to compete in a global economy and exercise the rights and responsibilities of citizenship.

GOAL 7: By the year 2000, every school in the United States will be free of drugs, violence and the unauthorized presence of firearms and alcohol and will offer a disciplined environment conducive to learning.

GOAL 8: By the year 2000, every school will promote partnerships that will increase parental involvement and participation in promoting the social, emotional, and academic growth of children.

provide a powerful opportunity to fulfill these needs (Center for Educational Leadership in Technology [CELT], 1994; Computer Science and Telecommunications Board of the National Research Council, 1994; U.S. Department of Education, 1993).

Distance-learning technologies also support lifelong learning, from adult literacy to higher education and worker training opportunities. Although limited use is made of technology in most adult education programs (U.S. Congress, Office of Technology Assessment [OTA], 1993), that situation is beginning to change as technology becomes more commonplace in public schools and community settings.

As the labor market increasingly requires workers to update their skills, job training and retraining become consistently important factors in achieving high levels of productivity and competitiveness. Distance learning offers opportunities at these levels, as well. Telecommunications and information technologies also are seen as the key to making workplace training accessible and affordable, particularly for small to medium-sized firms (National Institute of Standards and Technology [NIST], 1994). National Technological University (NTU) makes telecourses available to engineers, scientists, and technical managers, most of whom are working professionals sponsored by their companies. NTU, Mind Extension University, PBS Adult Learning Services, and other national distributors present new possibilities for collaborative learning by bringing adult education to a national classroom.

FUNCTIONAL REQUIREMENTS FOR USING DISTANCE LEARNING

For distance learning to realize its potential and promote achievement of the National Education Goals, the best of technology must be integrated with the best of instructional practice for delivery to the widest possible audiences. Viewed in more operational terms, if distance learning is to be appealing and judged effective on a large scale, certain functional requirements related to educational, technical, and access considerations must be satisfied.

Distance-learning materials should maintain high-quality content and should be continuously evaluated.

Materials used through distance learning, whether they are entire courses, a video segment used to demonstrate a concept in a class, or information for a report retrieved from a database, must be of high quality in design, presentation, and content. The materials must facilitate the desired learning outcomes in a way that is compatible with curricular objective, learning styles of students, and the learning environment. Unless learning materials meet these criteria of high quality and functionality—including appropriate levels of interactivity—they are unlikely to be widely implemented. For uses of distance learning meant to enrich existing education, content is particularly important because people are less likely to use any learning technology unless it clearly serves the needs of improved instruction and is compatible with content frameworks (U.S. Department of Education, 1993).

Distance learning is an evolving field, and published literature on the topic is overwhelmingly anecdotal. In addition, because most distance-learning programs are tailored to specific school, business, or industry needs, evaluations are most often informal and conducted by users, not independent sources. When large-scale evaluations have been conducted, they have often been based on strict comparisons with equivalent classroom instruction and tended to focus on issues such as usability, learner preferences, and equipment quality, rather than learner outcomes. Because distance learning is changing constantly, including varieties of media and modes of interactivity, traditional research methods are often insufficient (Schlosser & Anderson, 1994). As methods of teaching and learning change, and more learning technologies are available, the importance of evaluation and studies that take into account the unique characteristics of technology-based education will continue to increase (Block, Guth, & Austin, 1993; Kearsley, Hunter, & Furlong, 1992; Tushnet et al., 1993).

Distance-learning use should be supported by training, technical assistance, and professional development.

One of the most important criteria for effective technology-based instruction is a well-prepared and supported teacher (Pearson, 1989; Schlosser & Anderson, 1994). Preparation and support of teachers in the context of distance-learning technologies involve both learning how to use distance-learning resources in the classroom and having the opportunity to use distance learning as a resource for professional development. Teachers continue to be responsible for managing an expanding array of communication and information tools, acting as resource facilitators who guide learning, rather than distribute information (Withrow, 1994). Preservice and inservice training programs should incorporate technology throughout teachers' education, instructing teachers with the same tools they themselves will be expected to use (Portway & Lane, 1992). Although technical assistance is usually necessary, distance-learning systems should also be reliable and easy to use. Ease of use has proven to be one of the most important factors determining the use of telecommunications technology by teachers (Honey & Henriquez, 1993). Many other studies note the importance of usability to program effectiveness (e.g., Minninger, 1993).

Distance-learning resources should be available in a variety of environments.

Distance learning should be accessible in a variety of learning environments, including schools, workplaces, libraries, and community institutions. Ideally, business and industry can work together with education and community organizations to provide students of all ages and situations an opportunity for lifelong learning. Broadcast, satellite, telephone, cable, fiber optic, ITFS, and microwave systems link communities to create dynamic learning environments. These technologies not only allow communities to share local and national programming, but can provide opportunities for voice, video, and data conferencing. It is clear that shared technology resources are not only cost effective, but provide important links between communities. Proponents of distance-learning applications for vocational education have been particularly interested in the possibility of linking education with real-life experiences (Gooler & Roth, 1990). This type of collaboration is a natural benefit of community-based, learning-technology systems and must be encouraged.

Distance-learning applications should be planned for multiplicity of uses, including integration with the developing National Information Infrastructure.

Distance-learning systems, whenever possible, should support administrative functions, communication needs, information management, and other uses. Being able to use distance-learning technologies as part of a larger telecommunications system improves both cost effectiveness and coordination between instructional and administrative functions. Such networks are intended to provide cost-effective improvements in the areas of communication and administration, as well as instruction. In addition, planners of distance-learning systems should keep in mind potential links with other institutions and organizations. The NII intends to link institutions, businesses, individuals, and resources for many applications. Planners include federal and state agencies, private industry, and telecommunications service providers. Users of distance learning for education and instruction must take an active role in coordinating resources and planning for cooperative community and national networks.

The 1990s represent a time of unprecedented change, challenge, and opportunity for the United States. These changes hold dramatic implications for how we educate today's students for work and for citizenship in the 21st century. Necessary improvements in education, as outlined by the National Education Goals, advances in telecommunications technology, and plans for construction of the NII, are all converging. This is an exciting and important time for distance learning and its potential for providing all citizens with the opportunities for learning necessary for success in today's society.

Distance learning can both enhance existing education and provide learning opportunities where they did not exist.

DISTANCE LEARNING RESOURCES

This chapter reviews resources available to educators for distance-learning services. These resources include the major telecommunications technologies used to deliver these services, the integration of these technologies to provide access, the major providers of distance-learning services, and the users of these services.

Using primary and secondary sources, including reports, journal articles, and personal communications with experts in the field, we provide a general overview of each telecommunications technology. The report discusses in detail only those technologies currently used to provide distance learning and only those aspects of the technology relevant to the delivery of services. Technical descriptions are beyond the scope of this report. We describe each technology in the context that it is used to deliver distance-learning services to elementary and secondary school learners, higher education learners, adult education learners, and worker training learners. Although many of the technologies have specialized applications, such as assistive broadcasts for disabled persons, they are not explored in detail here. We acknowledge that there are many emerging technologies still in development with the potential for distance-learning applications. We discuss some of these, such as the fast-growing cellular technologies; but this chapter should not be considered an all-inclusive listing. The "References and Resources" section of this book provides references to the citations to available literature and lists the people and organizations that we have cited as resources.

The focus of the chapter is on showing the diversity of both the available technologies for delivering distance learning and possible applications of those technologies. In general, we describe how the technologies function; and we provide cost estimates and technical evaluations of capacity, speed, and application where available. Research methodologies for each section in this chapter varied, due primarily to the broad scope of some issues, limited available information for specific areas, and internal research constraints.

To better describe the parameters for our discussion in this report of distance-learning technologies, we offer the following definitions:

- Distance learning is the delivery of video, voice, or text instruction or information to a learner over distance, from one location to another, using some form of telecommunications technology. The distance may be local, from one classroom to another in a remote site only a few miles away; regional, from a computer at office headquarters to a worker's desk in another state; or even international, from a teacher in Germany to a classroom in the United States.
- Telecommunications technologies are tools that transmit an electronic voice, video, or data signal over distance either through a wire or using the electromagnetic spectrum. The major telecommunications technologies addressed in this report as being used for delivering distance learning are broadcasting, satellite, cable, telephone, microwave/ITFS, wireless, and computer networking. Fiber optic technology is addressed in the delivery of both telephone and cable services.
- Integration of technologies occurs when multiple telecommunications technologies are used to deliver distance learning from one location to another. Because these integrations occur in unique ways in each school, community, and workplace application, only some examples of technology integration are illustrated.
- Providers are the organizations that develop, produce, or distribute programming, learning materials, and information for distance learning.

The report provides a description of some major providers of distance-learning services in K-12, higher education, adult education, and workplace training. Many programs and materials are "custom made" by a particular institution, district, or company. This section, therefore, relies primarily on examples of large-scale service providers and significant regional or local programs.

- Users are the learners at the primary, elementary, secondary, higher education, adult education, and workplace training levels who are using distance-learning services as a resource for learning. Many distance-learning activities, both for formal and informal education, are neither documented nor evaluated in central sources, and minimal reliable data on usage exists. This section provides a summary of how some users are incorporating a variety of services to fulfill their particular education needs.

TELECOMMUNICATIONS TECHNOLOGIES FOR DISTANCE LEARNING

Broadcasting

Broadcasting is the terrestrial-based, one-way transmission of video and audio signals from a transmission tower to any point within range of transmission with a receive unit, either a television or radio. Transmission range is usually about 30-35 miles, depending on height and power of the transmission tower and geographical idiosyncrasies. Although reception does not require line-of-sight with the transmitting tower, it can be hampered in mountainous regions and by interference from other electrical signals. Transmission range can be extended by implementing signal repeaters, translators, and microwave towers. Signals are originated at a main station, which usually contains video, editing, and transmitting equipment.

The nation has an extensive system of commercial and public broadcasting networks regulated by the Federal Communications Commission (FCC), which licenses all stations and infrastructure. Practically all bandwidth in the electromagnetic spectrum designated for commercial and public television and radio broadcasting has already been allocated. Therefore, to obtain a broadcasting license, either a current license must be revoked and reallocated, or a spectrum must be repurposed from some other use and designated for broadcasting. Each license allocates use of one channel for broadcasting. A channel can deliver only one program at a time.

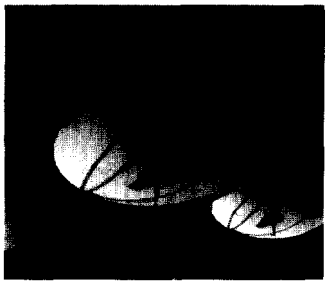
Broadcast television is used regularly for formal and informal distance-learning purposes. Traditionally, it is used to send a live or previously recorded program to a large audience. Educational program content includes documentaries and classroom-style instruction. Since commercial broadcast television does not provide much educational programming on a regular basis, focusing more on the entertainment market, this report will concentrate on public broadcasting. Ninety-four percent of the country currently is within transmission range of public television broadcast stations. Another 4 percent of the nation can receive the broadcast programs through cable or satellite feeds (Somerset-Ward, 1993). Ninety-eight percent of U.S. households, totaling 92 million homes, have televisions capable of receiving the public broadcast signal (Chen, 1994). Although only 25 percent of the nation's K-12 classrooms have televisions (Chen, 1994), most schools have either a television on a media cart, which can be moved from classroom to classroom, or a designated room to which classes can go to use a television.

The significant advantage of using broadcast television to deliver programming is that it is a wireless technology that does not require homes, schools, and other learning sites to invest heavily in new infrastructure. Television is a ubiquitous technology, with retail prices of 20-inch television sets in the $300 range. With almost 100 percent of the country covered by public broadcasting signals, the transmission infrastructure is already in place. Although broadcasting itself is used mostly as a one-way technology, a telephone line can provide audio interaction between the viewer and the

Distance-learning technologies—broadcasting, satellite, cable, telephone, microwave/ITFS, wireless, and computer networking—are being used by schools, regional collaboratives, colleges, and businesses in many applications to meet particular learning needs.

program if it is being viewed live. Using a videocassette recorder (VCR), broadcast programs can be recorded for later viewing.

Access to television broadcast airtime is severely limited due to the scarce spectrum available. Any given community is likely to be served by only one or two public television stations, whose mission extends beyond education to include cultural and news programming. The open signal used by broadcasting prevents monitoring for billing purposes and does not allow for privacy or security of transmitted information.



Producing high-quality video programs and transmitting them are expensive endeavors. For example, production costs for seven popular children's educational series produced for the Public Broadcasting Service (PBS) ranged between $152,000 and $811,000 per hour, averaging $380,000 per hour (Corporation for Public Broadcasting [CPB], 1993). It may be difficult to find the initial capital to finance the high cost of developing this type of programming. However, the ability to reach large audiences makes the user/cost ratio fairly low. The cost of providing a one-hour educational program such as *Sesame Street* to a single household is less than $0.01 per household for each program (Keith Mielke, personal communication, May 20, 1994). Lower production value programming, using lower-grade cameras, sound, and editing equipment, and fewer personnel, costs significantly less than highly produced programming and is used primarily for classroom-style instruction. For example, production costs for a simple studio with two cameras may cost as little as $1,000 per hour, including broadcast air time (Matt Miller, Northern Virginia Public Television, personal communication, June 16, 1994).

In adult education, a number of public television stations provide distance-learning programs, often in the form of telecourses that are offered through one-way video transmission and interaction through telephone lines. The technology resources located at public television stations make them potential "technology centers" for the community, capable of serving as a switch for several telecommunications technologies. For example, the satellite dishes used to receive programming for broadcasting may also be employed for participating in a national teleconference.

Low power television (LPTV) is being used in some areas of the country to broadcast standard television signals over a short distance, a maximum of 20 miles. LPTV allows regions to use more channel capacity without interfering with the transmissions by the higher-powered commercial and public broadcast stations in the area. Because the transmission towers required for LPTV are significantly smaller than for standard broadcasting, the startup costs are far lower.

High-definition television (HDTV) is an emerging broadcast technology that promises almost twice the vertical and horizontal resolution of standard broadcast television and audio of similar quality to compact discs. The broadcast signal requires approximately five times the bandwidth of conventional broadcast television. FCC is in the process of reviewing standards and developing regulatory policy for HDTV. PBS reports that it will be presenting some of its programming in HDTV format, but it is not anticipated at this time that distance-learning programming will be in HDTV format (Carl Girod, Public Broadcasting Service, personal communication, June 10, 1994).

Although distance-learning applications of public broadcast radio are much less extensive than television, some services are available. Most public radio stations, like their television counterparts, tend to provide entertainment and informal educational programming. Some stations, such as Wisconsin Public Radio (WPR), however, have developed more structured learning services. WPR began broadcasting music appreciation, agriculture, and consumer science courses in the 1920s. This service eventually expanded into the "School of the Air" courses that were broadcast via subcarrier to public schools until the 1970s. In the early 1980s, the station began a partnership with the Annenberg/CPB Project to produce a series of audio-print courses, some of which can now be taken for college credit. Ranging in sub-

ject from fundamentals of music for secondary school students to history and psychology, the courses usually consist of taped lectures accompanied by print materials, including study and faculty guides. The courses are primarily distributed to educational institutions and libraries for in-class or distance-learning uses, but are also available to public radio stations for broadcast. WPR plans to expand broadcast applications for their programming, and is working with university public radio licensees to broadcast the audio-print courses to off-campus students who do not have convenient access to libraries or media-centers (Dan Peterson and Sylvia Potempa, WPR, personal communications, June 1994).

Satellites

Satellites serve as relay systems to broadcast video, audio, and data signals over extremely large areas. A satellite, usually in a geosynchronous orbit so that it remains in a constant position above the Earth, receives a signal from an *uplink* transmitter dish, and then transmits the signal back toward the ground. The geographic area covered by the transmission is called the *footprint*. Unlike standard broadcasting, satellite transmissions cannot be directly received using a television, radio, computer, or other user interface device. Reception requires a *downlink* antenna dish aimed at the satellite and within the footprint. The signal, once received by the dish, is then usually transmitted by wire or broadcast to the user, who may have a television, telephone, or computer to interface with the signal.

Approximately 29 domestic commercial satellites in orbit are capable of delivering signals to the continental United State and, in some cases, Hawaii and Alaska. Each satellite carries between 16 and 24 *transponders*, the device that receives and transmits video, audio, and data signals. Although most transponders deliver one or two channels of video programming each, advances in digital compression are increasing the transponder capacity to 6-10 channels. PBS reports that by July 1, 1994, four of its programming signals will be carried on a single transponder using digital compression; and by 1996, all of its signals will be transmitted in a digitally compressed format (Carl Girod, personal communication, June 10, 1994). Most transponders operate on one of two frequencies: *Ku-band* or *C-band*. Ku-band is a high-frequency band that sends a stronger signal to Earth than C-band, therefore requiring smaller and less expensive downlinks. Though C-band better withstands interference from inclement weather than Ku-band, Ku-band does not succumb to interference from terrestrial microwave transmissions as C-band does and can be used with a smaller receive dish. Some downlinks have the capability of receiving both Ku- and C-band signals.

The benefits of satellite communications systems include ubiquity of signal delivery to the entire continental United States, relative cost insensitivity to distance of transmission, and resiliency with respect to natural and man-made disasters. Satellites are currently being used in education at all levels to deliver voice, video, and data signals. For video-based, interactive, distance-learning services, satellite delivery is often used because of the ability of any geographic location in the continental United States to receive the programming if they have a dish. This expands the potential economy of scale of producing and delivering the programming. However, larger audiences also decrease the likelihood that a learner will be able to be interactive with the programming in real time.

Transmission systems using satellites can be relatively expensive to implement and operate, even omitting the cost of building, launching, and operating the satellite itself. Uplink facilities can cost upwards of $300,000 to build, depending on several variables, including model level (commercial vs. professional), mobility (steerable vs. fixed), and options (de-icing mechanisms are required in colder climates). Costs of downlink dishes with receivers (which convert the signal from the dish to the television) range from $4,000 to $6,000 for a standard steerable model about 3 meters in diameter, commonly used by many schools, businesses, and homes (Carl Girod, personal communication, June 10, 1994; Charles Mellone, National

Telecommunications and Information Administration, personal communication, May 23, 1994). Transponder time costs between $300 and $600 per hour, depending on the length of time leased ($600/hour for a one-time use, $400/hour for a weekly lease, and $300/hour for a year lease) (Charles Mellone, personal communication, May 23, 1994). Rates can vary according to the time of day that transmission is occurring.

Currently, it is estimated that only 70-80 percent of C-band and Ku-band transponder capacity is in use (Charles Mellone, personal communication, May 23, 1994). Distance-learning providers have attempted to reduce costs by extending programming to more students. However, this reduces the possibility of synchronous interactivity, a component of distance learning that some deem to be essential. Some distance-learning providers are using alternative technologies, such as "800" hotline telephone numbers, voice mail, and computer networks, to develop asynchronous interactive components that meet learners' needs for interacting with their instructors and peers.

Two promising digital satellite technologies are Very Small Aperture Terminals (VSAT) and Direct Broadcast Satellite (DBS). VSAT systems use dishes that can receive and transmit digitized voice, video (around 15 frames per second, providing limited motion video), and data signals via satellite. VSAT allows multiple channels to be transmitted on a single transponder, in contrast to the single channel of analog transmission. VSAT 56KB dishes, ranging in size from 1.2 to 2.4 meters, with an antenna, outdoor unit, indoor unit, and a cable linking them, cost approximately $12,000 (Carl Girod, personal communication, June 10, 1994). VSAT networks in the United States have grown steadily; the number of terminals has increased from 14,000 in 1987 to 100,000 today (DalBello, 1994). In 1991, 15 percent of community colleges and 33 percent of four-year institutions were using satellites for distance learning, whereas less than 0.5 percent and 1 percent, respectively, were using VSAT (Brey, 1991). Many VSAT data systems are currently used by retail chains to verify credit card information. PBS is in the process of providing each of its 20 licensees with VSAT dishes to be used mostly fo business communications among the stations bu with potential for being used for distance learnin

In one of the few uses of VSAT at the K-1 level, PBS is sponsoring a VSAT project with Washington, D.C., school and a San Rafae California, school. Using segments of MacNei Lehrer programming and additional data tran mitted to the hard disc drives of computers usin VSAT dishes at the two schools, middle schoole compile information and create their own vide programming, using computer-mounted can corders. The student creations are then transm ted between Washington, D.C., and Californ (again using the VSAT dishes) and discussed real time by the students ("PBS's Education Satellite Network," 1993).

The satellite industry expects that high-pov ered DBSs that support high-definition televisio CD-quality radio, and data services, along wit smaller and cheaper receiving antennas, w strengthen the role of satellites in the Nation Information Infrastructure (NII) (DalBello, 1994 The initiation of DBS services in mid-1994 w provide a means of reaching the most rural se tions of the country with multiple channels television service. Two DBS services, DirecT and United States Satellite Broadcasting (USS will use high-powered satellites and digital vide compression to broadcast approximately 20 channels of television programming directly fo home and school reception throughout the co tiguous 48 states. Schools, homes, and other sit will be able to receive DBS television signals wit small satellite receivers that use an 18-inch recei ing dish and cost less than $1,000. The progra offerings for the 200 channels are expected t include many familiar satellite-cable and broa cast television offerings, including public telev sion, as well as customized special programmin services ("The ABC's of DBS," 1993; Stern, 1993 The two-year-old GALAXY Classroom proje provides 37 elementary schools in the Unite States and one in Mexico with original education programming via DirecTv.

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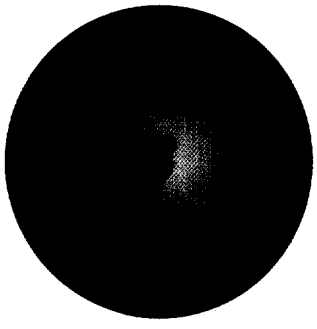
Cable

Cable television systems send a signal over coaxial or fiber optic cable from service providers to subscribers who pay a monthly fee for service (according to the National Cable Television Association [NCTA, 1994], basic service averages $20.75). Coaxial cable, which makes up most of the "last mile" of cable systems, is capable of carrying over 100 video channels transmitted from a local service provider to the subscriber. Compression technologies, which will be implemented by many cable providers in the next year, are expected to increase that capacity by four- or five-fold (Don Dulchinos, Cable Labs, personal communication, June 20, 1994). The signals are decoded and viewed by the user on a television set. Most cable systems are currently operating as one-way video providers, with a minimal capacity for receiving a data stream from subscribers for interactive distance learning or services such as pay-per-view. A return video or audio loop would require reconfiguring the amplifiers and other electronics along the path from the service provider to the user and the use of another channel on the system. Currently, fewer than 10 percent of all cable systems have two-way interactive services—although the coaxial wire in place is capable of carrying the two-way signal, few systems have the electronics in place that are needed (Don Dulchinos, personal communication, June 20, 1994). However, as some systems upgrade their fiber and switching capacity, they are experimenting with offering video-on-demand, Internet, and telephone service. Cable programming comes from a variety of sources, including local commercial and public broadcast stations and regional and national providers. Some localities, when putting the rights to their system out to bid, have required the winning contractor to connect the public schools to the cable system for no added charge.

According to Cable in the Classroom, a public service initiative by the cable television industry, 59 percent of all public and private elementary and secondary schools were receiving cable services in 1993, reaching more than 34 million students. This does not mean cable services in every classroom, but rather, at least one room in the school. Decker Anstrom (personal communication, December 1994), president of the NCTA, projects that by 1995, 95 percent of all high schools will receive cable programming. Analysis of 1993 school statistics by the Nielsen Media Research Group found that 73 percent of all public secondary schools and 66 percent of all public elementary schools have cable television. The percentages for private school are significantly less: 32 percent for secondary and 34 percent for elementary schools. In 1991, 14 percent of community colleges and 22 percent of four-year institutions were using cable television to deliver live distance-learning courses (Brey, 1991).

According to the NCTA (1993b), more than 60 percent of households subscribe to cable programming services; and the services are available for subscription by 96 percent of the homes in the country (this means that a cable service provider has infrastructure within one mile of the home). Over the next 6-10 years, the cable industry estimates it will spend over $14 billion to upgrade 75 percent of its existing systems with state-of-the-art technologies, such as fiber optics (NCTA, 1993a). These changes will enable cable systems to stay at the forefront of increasing channel capacity and using interactive services. Currently, 11,160 individual cable systems serve the country. Of these, 2,280 (20 percent) have less than 30-channel capacity, with approximately 1.9 million subscribers (3.5 percent); 6,364 (57 percent) have greater than 30-channel capacity, with approximately 32 million subscribers (58 percent); and 1,306 (11.7 percent) have greater than 54-channel capacity, with approximately 21 million subscribers (38 percent) (NCTA, 1994, pp. 6-A, 10-A). The lower-capacity systems tend to be located in rural areas with low population density, whereas the higher-capacity systems tend to be located in metropolitan areas. This is likely a function of cost—the fewer channels a system has, the lower its expenditures on licensing fees for programming (Don Dulchinos, CableLabs, personal communication, June 20, 1994).

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