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ABSTRACT

This paper "revisits" distance learning by addressing its past achievements, its present state, and its future in the face of the rapidly converging computer and communications technologies and the goals and potential that underlie the creation of the proposed National Information Infrastructure (NII). The analysis was undertaken recognizing that new demands are being placed on our educational institutions to provide a highly knowledgeable and skilled workforce for the 21st century; that the stakes involved are no less than economic competitiveness, which is now so knowledge dependent; and, that consideration of the present and future of distance learning requires a "paradigm shift" in the role of teachers and educational institutions as the United States enters into a global economy. This inquiry therefore seeks to create a contemporary vision of distance learning based on: (1) its history; (2) the recognition of the importance of life-long learning and the development of new strategies for its realization; (3) the potential of emerging telecommunications technologies; (4) the respective roles of private industry and government in the creation of the NII; and (5) the potential contribution of The High Performance Computing and Communications (HPCC) initiative. Construction of this vision began by the examination of efforts to define distance education and to establish its theoretical base, distance education's major milestones, technology's expanding role and potential, and new opportunities that derive from the NII initiative. The following aspects of distance learning are examined: milestones; technology's influence; distance learning in transition; issues; an interconnected world; non-traditional learning environments; universal availability and access; telecommunications components; evolving physical infrastructure; community service networks; distance learning initiatives; opportunities in the health professions; and final thoughts. (Contains 87 references.) (Author/MAS)

Title:

Distance Learning Revisited: Life-Long Learning and the National Information Infrastructure

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Introduction

Enterprises of all sorts tend to develop modes of operation that, over time, come to be accepted as the "conventional way." Education has always relied heavily on one format: the classroom model. Distance education--which, in its early years, was likely seen as an unconventional way to facilitate learning--developed its own conventional model: the "correspondence course." And despite continuous progress in developing alternative means of communication, these conventional formats have been slow to give way to innovative approaches. Now, in the face of what Lewis Perelman (1992) calls "an implacable technological revolution," that appears to be changing. What this revolution entails and how it may affect education, and distance learning in particular, are critical questions for educators everywhere.

This paper therefore "revisits" distance learning by addressing its past achievements, its present state, and its future in the face of the rapidly converging computer and communications technologies and the goals and potential that underlie the creation of the proposed National Information Infrastructure (NII). The analysis was undertaken recognizing that new demands are being placed on our educational institutions to provide a highly knowledgeable and skilled workforce for the Twenty-First Century; that the stakes involved are no less than our economic competitiveness--which is now so knowledge dependent; and, that consideration of the present and future of distance learning requires a "paradigm shift" in the role of teachers and educational institutions as the United States enters into a global economy.

This inquiry therefore seeks to create a contemporary vision of distance learning based on 1) its history, 2) the recognition of the importance of life-long learning and the development of new strategies for its realization; 3) the potential of emerging telecommunications technologies; 4) the respective roles of private industry and government in the creation of the National Information Infrastructure; and 5) the potential contribution of The High Performance Computing and Communications (HPCC) initiative. We began to construct this vision by examining efforts to define distance education and to establish its theoretical base, distance education's major milestones, technology's expanding role and potential, and new opportunities that derive from the National Information Infrastructure Initiative.

Distance Education Versus Distance Learning

A definition that accurately describes an activity's nature and function is essential for judging its history and creating a vision of its future. Schlosser and Anderson (1994) state that the term "distance education" has been used to describe a great variety of programs employing a wide variety of media. And they cite several scholars who have expanded on distance education's key element--bridging the physical separation that exists between teacher and student via some medium: Rudolf Delling emphasized that distance education is "a planned and systematic activity [that involves] didactic preparation and presentation of teaching materials as well as the supervision and support of student learning...;" Greville Rumble declared that distance education involves a "contract" between the student and the teacher, or teaching institution, that defines respective roles; and Desmond Keegan noted that despite the separation of teacher and student, the influence of an educational institution, the provision of two-way communication and the possibility of occasional meetings all distinguish distance education from private study . Moreover, in distance education, much communication occurs noncontiguously.

These points are well made. But, to simplify, here we use the term "distance education" to indicate the organizational apparatus and process for providing educational experiences to people at a distance, and the term "distance learning" to refer to the process and result of attending to, and responding to, such experiences. As future developments in both communication and knowledge access technologies provide learners with increased capability to learn independently, we expect the distinction between distance education and distance learning to become more meaningful.

Distance Education Milestones

Distance education's history is more than a catalog of program growth and technology evolution, although that is part of it. Schlosser and Anderson (1994) trace distance education's roots in the United States to 1873 when correspondence study "crossed the Atlantic" from Europe and The Society to Encourage

Studies at Home was founded in Boston. Other programs followed as correspondence study continued to expand into the twentieth century.

By the 1920s, electronic technology had become a major factor in distance education with at least 176 radio stations being built at educational institutions. Most, however, did not survive the decade (Schlosser and Anderson, 1994). Some did remain, however, and by the 1950s, a second broadcast medium, television, began to play a growing role in distance education. Western Reserve University and New York University, with its well-known Sunrise Semester courses on CBS, were early users of the medium. Later, as satellite television became cost effective, television's role expanded. The first state educational system, Learn/Alaska, began operations in 1980.

Schlosser and Anderson (1994) mark the 1962 decision by the University of South Africa to become a distance education institution as the beginning of a "fundamental change in the way distance education was practiced in much of the world." The founding of the Open University of the United Kingdom in 1971 was another landmark. As a degree-granting institution dedicated to distance teaching, it extended the university opportunity to many and brought added prestige to distance education as an enterprise. The Open University offered degree programs in many fields and made wide use of communication media. Similar institutions soon followed in Canada, Japan and West Germany, although not all embraced the Open University's liberal enrollment policy.

A good measure of distance education's recent growth is the number and variety of programs presently available. Peterson's Guides 1993 publication The Electronic University is one excellent source of information on "telecourses" and degree programs offered "electronically" to US and Canadian inhabitants. It describes nearly one hundred institutional, network or consortia-based programs. Well known consortia currently offering distance learning programs include the International University Consortium (IUC), Mind Extension University (ME/U), the National Technological University (NTU), and the Electronic University Network (EUN).

Technology's Growing Influence On Education

Technology, as it advances, is playing a larger role in both school-based and distance education. In schools we have seen technology use evolve from "audiovisual aids" used to support classroom lectures to various forms of media-intensive learning centers and, more recently, to modern interactive technology systems. In distance education, educational radio--which expanded greatly after 1925 (Saettler, 1968)--was followed by broadcast television and teleconferencing as major delivery innovations.

An interesting study by Wilkinson and Sherman (1991) provides a useful portrait of distance programs then active. They contacted 276 higher education distance education programs and received 142 "usable" survey responses. With regard to the primary method of delivery for various courses across all institutions, video-based technology was the most frequently used method with about three-fourths of the programs using video in more than half of their courses (p. 56). Print-based instructional delivery was second in frequency of use with both audio- and computer-based technology enjoying lower usage. Print, however, was the primary method of student/faculty interaction in over 75 per cent of courses offered. Clearly, most institutions employ a variety of media to conduct their courses.

The marriage of computers and communication media has led to new forms of in-school learning environments--usually some form of learning station or desktop application--that both supplement and replace standard classroom experiences. In distance learning, use of teleconferencing tools that enable two-way communications is increasing. And networks now enable educators and learners to communicate through e-mail and bulletin boards and to collaborate on problem solving tasks.

Thus, as the power and versatility of computer-mediated communication is amplified by new tools with enormous capacities to store, transmit and control information, technology can offer educators a broad selection of interactive learning systems. These include desktop interactive multimedia, electronic classrooms and other local-area network applications, wide-area network and teleconferencing systems, virtual reality environments and "microworlds." And the proposed National Information Infrastructure (NII)

and "intelligent assistants" (Roesler and Hawkins, 1994) are reportedly just over the horizon. So while the term "information highway" may be a poor technical metaphor, there is an analogy related to its construction with which educators, and the "highway's" builders, can relate. The interstate system was envisioned in the 1950s as a new kind of road (a "superhighway") that would provide greater traffic volume and increased speeds. The NII, when completed, will expand information traffic in much the same way. For distance educators, and the computer, telephone and cable industries, it is the 1950s again; a time to make long-range plans--in terms of both distance and time. Indeed, as distance learning programs are helping to recast the traditional campus, newer technologies are promising to recast distance learning itself. It truly may be, as The Electronic University proclaims, "the hottest education trend of the 90s."

Distance Learning in Transition

Distance education's ongoing efforts to employ new technologies to reach learners, to incorporate new teaching methods and to create new administrative forms has placed distance learning in a definite state of transition.

Distance Learning: The Current Picture

From a near-total reliance on print-based courses, technology use in distance learning expanded to include broadcast radio and television and, later, audio, video and computer teleconferencing. Now computer-based, multimedia teleconferencing systems are the emerging trend (Romiszowski, 1993). Such sophisticated new technologies are presently shifting the emphasis "from single-technology delivery systems to integrated approaches seeking to...combine voice, video, and data technology, often in tandem with print" (Willis, 1993, p. 10).

With respect to methodology, many distance educators seem to describe and gauge the instructional models they employ in relation to conventional classroom practice. Correspondence study suffers in this perspective; it offers no live Communication. Open broadcast radio and television offer the lecture aspect of the classroom, but not the interaction opportunities. The early teleconferencing systems offered limited learner participation, mainly through telephone communication. The new computer-mediated telecommunications systems are being touted highly because they promise, via "real-time" multimedia interactive communication, the "virtual" equivalent of the regular classroom experience.

It would be a mistake, however, to limit the concept and practice of distance learning to the simple notion of delivering conventional classroom instruction at a distance. This would "short circuit" the potential of telecommunications technology to transform education as we know it into a process for enabling children and adults of all ages to empower themselves and to become viable members of the emerging global society and economy. Distance learning must provide opportunities to acquire knowledge and skills both during one's formal education years and on a "just in time" basis throughout life to meet the constantly changing requirements for adult productivity in our society.

The question of what institutional structures are needed to accommodate distance learning activities has become critical. Although university level distance education has grown steadily and upgraded its technology component throughout the twentieth century, from an institutional perspective it remained for a long time what Michael Moore (1993) calls a "first generation" model. That is, distance students received, either by correspondence or by telecommunications, "classroom-like teaching...provided by conventional teachers...." The 1969 opening of Britain's Open University as an institution specifically dedicated to creating and delivering distance education programs--and of similar institutions in other countries--was a major milestone (Willis, 1993). These "second-generation distance education institutions," Moore (1993) observed, "had no classrooms [since] learning occurred in students' own environments." Faculty were chosen specifically for distance teaching and the institutions were given the authority to grant their own degrees. But although the Open University model breaks the tradition that requires teacher and students to meet in a classroom for all educational transactions, it shares with conventional schools one very important feature: courses are developed and taught and achievement is certified by the faculty associated with a particular place. Students therefore are as limited in their selections of courses and teachers as they are at a conventional "brick-and-mortar" campus.

Recent technology developments promise to remove such limitations. We are, Moore (1993) suggests, "rapidly approaching technical readiness for the Virtual University, the third generation of higher distance education." In such universities, courses developed anywhere are made available to students everywhere, as is wide access to libraries and other resources for information and guidance. Moore's prescience was demonstrated in late 1994 with the advent of the Virtual Online University (VOU). It offers, on the Internet, a virtual education environment that combines the academic environment of a physical world university plus the creative dimension of a Multi-User Domain or MUD.

Issues in Distance Learning

There is, however, in the creation of a viable regional, national or global distance learning organization, more to be decided than what technology will be employed and how it will be used. As Rossman (1993) asserts: "The agenda for global education begins with questions about who is to coordinate and regulate electronic courses offered on network or satellite; who is to set standards, especially when nations and universities disagree;...and who is to arbitrate and decide on such matters as degrees and exchange of course credits" (p. 13). And as various state systems and institutions expand distance learning offerings, we can expect numerous policy and administrative issues to come to the fore.

Thus reaching a state of "technical readiness" for what Rossman (1993) calls The Emerging Worldwide Electronic University, may be easier than reaching an equivalent state of readiness in the curricular and administrative areas. Moore (1993) cites the major administrative problem: "In spite of a number of efforts to establish certification of learning by non-traditional methods, there is still no agency in North America that has the power, recognition, or authority to provide a certification of independent, individually constructed learning programs that has credibility in the academic and business environment comparable to the degree awarded by a brick-and-mortar university" (p. 6). And the problems that typically accompany the development and introduction of innovative educational programs are likely to be amplified in the distance learning arena. Jacobson (1994) recently identified several important issues associated with extending the reach of "virtual" classrooms, including: 1) the effect of distance learning on faculty workload/compensation; 2) faculty involvement in course design; 3) faculty job security; 4) certification in-state and across states; and 5) concern that distance learning becomes more than simply transmitting lectures from one place to another.

So as advancing technology affects perceptions of what instructional outcomes can be accomplished at a distance, a number of vital questions follow: Do current definitions of and theories about distance education provide an adequate basis for exploiting the potential of future distributed learning structures? Or do they matter at all? Are the design principles of conventional education adequate for developing distance learning programs? Are institutions up to the task? What are the respective roles of teachers and learners in both short-term and life-long distributed learning applications? How should distance learning designs respond to current trends in American professional and industrial settings that are transforming work and models of learning?

Perhaps more than ever before, distance learning remains an enterprise in transition, a transition driven by advances in technology, recognition of the need to improve the quality of education, a growing demand on the part of various student populations for increased learning opportunities, and the need to make maximum use of available resources. With so many forces affecting distance learning's future, it seems fair to say that we know better where the technology is going than we know where we are going with the technology. Why? Mainly because the "enabling technologies" required to create a national or global information "infrastructure" are known, their past development has been carefully noted, and their projected development in the years immediately ahead is fairly predictable. This applies to computer chips, which provide processing power, to storage devices, which promise massive increases in capacity, to optoelectronics, which is increasing communication speed , to advanced switching devices needed to blend voice, video and data, to digital compression techniques, and to software technology, which is moving steadily toward the goal of providing so-called "intelligent" agents to help users manage the information available to them. .

But how competition in the commercial world of communications companies will play out, what role the government will assume, what initiatives various educational institutions will launch, and what

learning opportunities students at all levels will eventually find on their on-line menus are questions that remain to be answered. Both these issues and the related technologies are explored in what follows.

The National Information Infrastructure and New Opportunities For Distance Learning

Much has happened since Stewart Brand (1989) predicted the inexorable merging of the publishing, broadcasting and computer industries. Private competition among cable, telcos and the computer industry, aided by government legislation and programs, have made Brand's words seem prophetic. A world in which analog information originates from and is controlled by a central source and broadcast at fixed times to many simultaneously is being replaced by digital information originating from a myriad of independent sources and available asynchronously. The capture, manipulation, transmission, and consumption of information in digital form has become a critical function of our economy (Shepard, 1994). Exponential advances in microchip technology and networked computers (Gilder, 1994a) have resulted in wide-spread application of peer to peer computing . Increased "bandwidth" and advances in compression/decompression technology are enablinging the seamless integration of multimedia (voice, data, graphics and video) over local and wide area networks. The multimedia content carried on these networks touches upon all aspects of life: education, entertainment, community, commerce, and health.

An Interconnected World

Today's networks number more than 100,000 and represent a panoply of private, public and government local (LAN), metropolitan (MAN) and wide area networks (WAN). Among them, the Internet, a world-wide "network of networks" (Krol, 1994) that share TCP/IP and similar protocols is the most widely known and used. The Internet has become popularized by the media and is sometimes referred to as "cyberspace," a concept first described in popular Canadian science writer William Gibson's 1984 novel Neuromancer. The Internet has grown exponentially at a rate of ten percent a month and, by 1994, exceeded two million interconnected computers worldwide (Comer, 1995). The approximately thirty million users of the Internet vary from individuals with local area network access to individuals who subscribe to service providers such as America Online, Compuserv or Prodigy for access from computer modems. This trend toward computer-mediated communication (CMC) over long distances is further accelerated by the commercial development and marketing of personal digital assistants (PDAs) and the newly emerging array of personal communications services (PCS) that add digital cellular telephones and wireless digital networks to the mix.

Private and government efforts to design, test and build the electronic infrastructure to succeed the Internet--the "National Information Infrastructure" (NII), or so-called "Information Superhighway"--have taken on a new urgency over the last several years. This urgency is driven both by competition among telcos, cable, and computer companies for a share of the lucrative telecommunications market and by the desire to apply technology in the service of society. While rooted in different motivations and goals, private and government initiatives have complemented each other and have hastened the development of an information-based society and economy. Indeed, Peter Drucker (1994) has noted the emergence of "knowledge workers" as a dominant group in our society and predicts that by the end of the twentieth century they will constitute a third or more of the United States workforce. Knowledge workers require extensive formal education and the ability to acquire and apply theoretical and analytical knowledge. Like others, they will have to acquire the habit of continuous learning to remain productive.

Technology does not develop in a vacuum. Whether it is "pushing" society along or being "pulled" by societal forces, any examination of its effects on learning must first acknowledge the larger changes taking place in society to ensure that technological solutions are applied appropriately. The emerging global economy presents several distinct problems: (1) a mobile, dispersed workforce; (2)

displaced unskilled workers; and (3) an information-based economy requiring highly skilled (knowledge) workers . A highly educated, flexible workforce will be a necessity for the United States to remain competitive in the twenty-first century. It is clear that an educated person will be someone who has "learned how to learn" and who continues to learn throughout his or her lifetime (Drucker, 1994). Varied resources, innovative educational/training strategies and technologies foremost among them, will be required to meet these challenges.

Non-Traditional Learning Environments

The challenges inherent in the global economy affect all stages of education from the formative childhood years through college/university schooling to continuing professional and non-professional education. The notion of education as a formal process occurring at a specified location during a fixed time-frame is not adequate to meet the requirements of the twenty-first century. A paradigm shift in the operational concept of the teaching/learning process is a necessary prerequisite to adequately addressing future challenges. This is not to propose a zero sum game: abandon traditional education and embrace a world of virtual education. Instead, the paradigm suggested is one that integrates a new role for teacher and learner within traditional education and looks to identify transition areas where newer technologies can provide more effective learning environments.

Newly available tools for storing, accessing, creating, delivering, displaying and evaluating information are transforming the learning process. As networked information resources become more widely accessible, learning can occur anytime, anywhere (Twigg, 1994). When access to networked information is available in schools and integrated into curricula, several aspects of the learning environment are transformed. Most notably, students become active participants in learning rather than passive recipients, and teachers embrace a more active role in facilitating learning. Students assume more individual responsibility for achieving learning outcomes and explore alternative sources of information and knowledge. Students develop an understanding of how to use various tools to search and retrieve networked information. Additionally, they learn to manipulate information and to analyze and work with symbols. Teachers collaborate with networked peers and become active mentors, group project leaders and designers of learning experiences. Networked teams of teachers and students collaborate to apply interactive high performance technology to solve real-world problems, to retrieve information from electronic libraries, and perform scientific experiments in simulated environments.

Effectiveness studies of networked technologies in schools have demonstrated increased student-student and student-teacher interaction and increased student-teacher interaction with lower performing students without decreasing the use of more traditional forms of communication (Interactive, 1993; D'Souza, 1993) demonstrated that students who conscientiously use personal electronic mail as an additional means of self-reflection develop greater conceptual understanding of the subject. Additionally, hypermedia environments have been shown to afford students more insight into organizing and synthesizing information (Turner and Dipinto, 1992)

The accessibility of multimedia over networks is expected to extend the range of effectiveness of distance learning applications (Collis, 1991; Steinberg, 1992; Kaye, 1992). Furthermore, networks encourage: (1) cooperative distance learning among peer groups of remotely connected students; (2) an organizational framework for mentoring, apprenticeships, peer collaborations and (3) direct participation in scientific research (Civille, Fidelman, and Altobello, 1993). Ideas such as ubiquitous computing (Weiser, 1991) and the design of computer-supported cooperative work (Ishii, Kobayashi, and Arita, 1994) may provide the necessary ingredients to create a seamless web of media (text, video, audio, graphics, video-on demand and video conferencing) as part of a broadband National Information Infrastructure.

Networked applications reach beyond the schools and extend into the community of work where the integration of hardware and software connect workers with a vast array of information, training and employment services. Much needs to be accomplished to expand these services beyond their nascent stages into a seamless web of educational and training opportunities available during formative schooling and continuing into an adult cycle of productive "life-long learning".

National Information Infrastructure for Life-Long Learning

The creation of the National Information Infrastructure (NII) will effect many aspects of society: electronic commerce, agile manufacturing, government services, civic networking and life-long learning. The intent is to "integrate hardware and software skills to make it easy and affordable to connect people with each other, with computers, and with a vast array of services and information resources" (Civille, Fidelman, Altobello, 1993, p. 1). The remainder of this paper focuses on the availability, access, physical structure and processes of the NII relevant to applying distance learning concepts and technologies. It examines the generic issues of distance learning within the evolving framework of the NII with some specific examples of distance learning in schools, higher education and the health professions.

Universal Availability and Access

Without a public infrastructure that enables both the public and private worlds to expand and grow with the new technology, little real progress can be made in achieving a truly ubiquitous information society (Heldman, 1994). A framework of cooperation between government, academia, industry and key user groups is necessary to meet urgent societal needs, encourage research and innovation, and induce investment from the private sector (Weingarten, 1993).

Mason (1994) describes digital convergence as the most explosive technology confronting our community today. Mason's prescription for universal access to the ubiquitous, networked, multimedia promised by the NII has three basic components. According to Mason every community member should have: (1) a basic "kit" of information equipment for display, input and memory; (2) unrestricted access to the "public" information that is available and (3) basic usability or friendly interfaces to information.

Kapor and Weitzner (Kapor, 1993; Kapor and Weitzner, 1993) present an argument for the re-wiring of America that results in Jeffersonian networks promoting the openness, freedom and diversity that is the true promise of the technology. Their Jeffersonian ideal consist of: (1) increased bandwidth for all information sources; (2) open architecture/open standards; and (3) a model of control patterned on the Internet rather than on the broadcast model. Openness and cooperation between government and private enterprise are the crucial ingredients to ensure universal availability and access to the NII.

The federal government's role is properly perceived as that of: (1) facilitating private sector investment in infrastructure; (2) removing regulatory barriers, establishing standards, supporting research, prototyping and evaluating "benchmark" applications and (3) providing assistance to education and training communities (Gore, 1994). Government also properly communicates a vision for the education and life-long learning applications on the NII. State and local governments would be responsible for a large share of the investment in elementary, secondary and higher education. They are also in a position to remove regulatory and tariff barriers to NII access in local communities.

The private sector on the other hand has responsibility to: (1) build the telecommunications infrastructure and (2) provide the "lion's share of the nation's investment in applications for education and life-long learning. And finally, the private nonprofit groups remain as providers of information and technical assistance in such activities as "Free Nets" (best exemplified by the Cleveland Free Net).

Universal availability and access for all citizens is only ensured through an open platform concept (Electronic Frontier Foundation, gopher.harvard.edu, 1994). The Electronic Frontier Foundation defines an open platform as ranging from narrowband to broadband digitally switched services made available by a variety of providers over interconnected networks using a variety of transmission media: copper wire, coaxial cable, fiber optics and wireless. Criteria for an open platform include: (1) widely available switched digital connections at affordable prices; (2) open access to all without discrimination as to the content of message; (3) sufficient "upstream" capacity to enable users to originate, as well as receive good quality video and multimedia services. This last requirement cannot be overemphasized. As Balabanian (1994) points out in Computer Networks and Equity, the concept of access equity is broader than just equal access and must apply equally to the transmission of information.

Telecommunications

The existing telecommunications infrastructure consists of telephone, broadcast, satellite, cable and electronic networks. Education, training, and life-long learning applications consist mainly of (1) video instruction (one-way video and two-way audio and two-way video/audio); (2) information retrieval from databases/libraries; (3) two-way asynchronous applications such as email, listservs, bulletin boards, newsgroups; (4) electronic transfer of instructional software and simulations and (5) distance learning.

In the aggregate, these applications are representative of what Romiszowski (1993) identifies as the fourth phase in the development of distance education. One that is characterized by the use of advance telecommunications and computer-mediated-communication (CMC). The prior three phases were identified as: (1) a print-based model of correspondence education; (2) radio/television open broadcast with correspondence and print materials and (3) a variety of teleconferencing systems. Taylor (1992) and Miller (1992) identify similar phases in the development of distance education. They describe them as the correspondence model, the multimedia model and the telelearning model. Together these authors foresee a fourth phase of distance education dominated by computer-mediated-communication and advance technologies inexorably tied to the major events that are currently unfolding in the telecommunications marketplace.

The creation of the NII is driven by the convergence of hardware, software, networking technologies and the quest for digital data. The data highway's backbone will use every wide area communication technology known: fiber optics, satellites and microwaves (Reinhart, 1994). On-and off-ramps connecting users to the backbone will consist of fiber, coaxial cable, copper and wireless technologies. Network clients will be served by supercomputers, mainframes, minicomputers, microcomputers and massively parallel machines. Software interfaces to the network will consist of a new generation of "middleware" known as intelligent agents or knowbots (Roesler & Hawkins, 1994). Users will receive and send information on a variety of devices: information appliances, smart phones, personal digital assistants, set-top boxes/TVs and microcomputers.

According to Reinhart (1994) and Heldman (1994) protocols and bandwidth are the two main unresolved technical issues relevant to the data highway's architecture. Advanced protocols and increased bandwidth are crucial to establishing the full range of voice, data, text, images, high resolution video and interactive communications that are envisioned for the NII.

Major Components: Broadcast, Cable, Telcos, Networks

The technology components that will eventually constitute the NII currently exist as a disparate collection of products and services. These components are comprised primarily of broadcast services, cable companies, telcos (the seven regional Bell companies (RBOCs) and long distance companies) and various interconnected public and private electronic networks. Each component pursues its own commercial or public objectives and in most instances has its own communication protocols, information formats, and transmission capacity or bandwidth. Out of this varied mix of services and products must emerge a ubiquitous, affordable, easy to use, multipurpose, information rich and open NII.

The broadcast and cable companies represent an analog world of broadcast services with a point to multi-point topology. Together they provide a "gateway model" where information originates and is controlled at a central point and is broadcast simultaneously to multiple locations. Cable companies presently have limited capacity for "point" to "point" or two-way communication. Cable's strong suite is their installed base of broadband coaxial cable that passes ninety-seven percent of United States households (Cable Television Laboratories, 1994). Enhancements such as digital compression and "fiber to the curb or pedestal" (extending fiber beyond main trunk lines out into the neighborhoods) are transforming cable systems into high capacity digital transmission networks. The hybrid fiber and coaxial cable combination provides cable companies with the potential of providing interactive information services beyond the much "hyped" movies-on-demand. An example of this potential is seen in the recently announced joint venture between Tele-Communications, Inc. and Microsoft to deliver on-line services to personal computers via cable TV lines (Farhi, 1994).

Electric utilities also provide a potential source for a hybrid network of fiber and coaxial cable. Demand-side Management (DSM) is a plan for utilities to share a new distribution system with telephone and cable-TV companies that could carry two-way data, voice and video on a single line (Brunet 1995). The plan includes two components: (1) a hybrid network infrastructure of optical-fiber from the electrical utility office to a feeder location plus two-way coaxial cable from the feeder to residence and/or office; and, (2) a set of microprocessor-based devices--a gateway at the utility substation and intelligent interfaces at the residence or business. The DMS system would include multiple subsystems: one each for phone, data, and video services.

Telephone companies represent the world's largest circuit-switched distributed network designed for point-to-point communications. The Public Switched Telephone Network (PSTN) is a combination of technologies: fiber optics, copper wiring, satellite and microwave. Long distance carriers are responsible for the high speed lines interconnecting regional and national phone systems and for the Internet backbone.

The telephone network is being replaced with digital technology from the network on down to the customer premises. Two major issues under consideration will influence the development of the NII: (1) deployment of optical fiber to the customer premises at a cost of billions of dollars and (2) what services (such as video) in addition to voice will be allowed over the switched telephone network. Competition abounds among RBOCs, long distance providers and cable companies over the issues of local versus long distance services, value added services and delivery of video service to the home. Federal legislation will be required to resolve these competitive issues and most likely will result in more open competition among the major players.

In the minds of many, today's Internet stands as the model network to be emulated in the development of the National Information Infrastructure. The Internet represents an open system for communication where information has multiple points of origin and is sent over a distributed network of interconnected computers. It is perceived as a model because it stands in stark contrast to the concept of hub and spoke networks where information and services originate and are delivered from a central point.

The Internet is a highly successful and well regarded example of how multiple packet switching networks can be interconnected to form a network of networks. It is referred to as a network of networks because it is made up of networks interconnected by routers. Sometimes it is referred to as a "virtual network" because it presents the illusion of a single large network. This configuration has led to much success since the ability to connect multiple types of networks allows each group in an organization to choose a network technology that best suits the group's needs and budget (Comer, 1995). Its success is further exemplified in its extension into the National Research and Education Network (NREN) which has become a catalyst for the development of the high speed communications and information systems that will become the NII.

Software applications on the Internet use the same general structure know as client-server computing. The key communication protocol used on the Internet is called the Internet Protocol (IP). All computers that connect to the Internet must follow the rules of IP. Transmission Control Protocol or TCP is the companion software that provides reliable error-free communication. Together this communication protocol is known as TCP/IP. The National Science Foundation formed the backbone of the Internet up until 1992. Since 1992, a non-profit company called Advanced Networks and Services (ANS) comprised of IBM, MERIT, and MCI, has provided the high speed backbone for the Internet (Comer, 1995). ANS owns the transmission lines and computers that comprise the network. This event is seen by some as the first step toward the commercialization and privatization of the Internet.

Evolving Physical Infrastructure

How will these technology components and their attributes evolve into the National Information Infrastructure? Cerf (1991), Dertouzos (1991), Heldman (1994), Negroponte (1991) and Tesler (1991) offer some prudent observations in their writings on the subject of networked communications. Several technologies, some new, some not so new, appear in their writing. Integrated Digital Services Network

(ISDN), Asynchronous Transfer Mode (ATM), and Synchronous Optical Network (SONET) are among the most frequently mentioned technologies that impact on the development of future electronic networks. Satellite and wireless technologies are also perceived as a salient component of the overall architecture of the NII.

ISDN was conceived by the International Telegraph and Telephone Consultative Committee (CCITT) in 1971 as a scheme to replace the plain old telephone system (POTS) with an all digital network that integrated voice and data on a single subscriber line. ISDN is a network technology that provides a way of utilizing narrowband technology (N-ISDN) that enhances the installed base of copper wires for shared voice/data in a digital mode (64kbps-128kbps) and allows for phase in of broadband technology (B-ISDN) in the early stages of fiber development (Kaman,1993). Basic Rate ISDN offers speed of more than 100 kilobits per second over residential copper wire while Primary Rate ISDN offers more than a megabit per second using specialized copper access plant. The implementation of ISDN would maximize the use of existing copper plant requiring no change in customer premises wiring or equipment during the transition phases into broadband fiber optic technologies necessary to achieve the goals of the NII.

ISDN offers a framework within which existing analog networks can evolve to meet changing users needs for higher capacity broadband services (Heldman, 1994). Broadband-ISDN (B-ISDN) would replace the physical infrastructure of the public switched telephone network with optical fiber cable with transmission rates of 155 megabits to 2.4 gigabits per second. It would also utilize fast-packet switched protocols and make use of virtual channels that do not require a pre-specified bit rate. This ability to provide transport of information independent of its service type is referred to as band-width-on demand. Heldman (1994) also points out the importance of ISDN standards as numerous vendors attempt to understand and standardize various interfaces for the exchange of integrated voice, data, and video information in the form of bursty, fast packet, circuit and channel type transmission and switching. While not the definitive answer to achieving the goal of universal information services, ISDN offers a phased plan for proceeding into the future.

Asymmetric digital subscriber loop (ADSL) is another technology that phases in digital transmission over copper wires. ADSL permits transmission of a single compressed, high quality video signal (VCR quality) at a rate of 1.5 megabits per second in addition to ordinary voice phone conversations (Kapor,1993).

The framework for future high speed wide area digital networks is the photonic standard called Synchronous Optical Network or SONET. SONET supports a multiplexed hierarchy of transmission speeds of 51 megabits to 2,400 megabits per second and allows for multiplexing and demultiplexing varying data speeds without breaking down each stream into individual components (Cerf, 1991). Photonic switching research promises optical switching machines with a terabit or 1 trillion bits per second. Such capacity will be necessary in the future for transmission and retrieval of massive amounts of high resolution video and three-dimensional images.

Asynchronous Transfer Mode (ATM) is fast becoming a world wide digital communication standard. ATM is poised to become the communication technology protocol of the future (Heldman, 1994). Its strengths are flexibility and speed. ATM can handle real-time traffic like voice and video and is also effective for more traditional data communication. ATMs fixed length 53 byte cells allows the integration of data media operating at different rates. This predictability allows scalable network performance. Although it can run on just about any medium, ATM was developed with the intention to run on fiber-optic networks as defined by SONET a US standard and (SDH) synchronous digital hierarchy, a European standard.

ATM is the first technology to provide a common format (cell) for bursts of high speed data and the ebb and flow of the typical phone call. ATM is scalable and equally at home in any network, local or wide, public or private (Heldman,1994). Given its attributes, ATM could erase the distinction between local area networks (LANS) and wide area networks (WANS) to provide the widely sought after goal of seamless networking.

Wireless networking, which permits continuous access to the services and resources of land-based networks (Forman and Zahorjan, 1994), also will be an important technology component of the infrastructure. Communication on wireless networks is via modulating radio waves or pulsing infrared

light. Wireless communication is linked to the wired network infrastructure by stationary transceivers. This mobile computing capability provides a technology that enables access to digital resources at any time from any location.

Although growing rapidly--to the tune of sixteen billion dollars in licensing fees to the FCC for personal communication services (PCS) bandwidths (Arnst, 1995), wireless technology is not without problems. It is characterized by low bandwidth and is subject to high error rates and surrounding environmental interference. Current R & D efforts supported by telecommunications companies are aimed at solving these problems. The recent promising development of code division multiple access (CDMA) allows wireless systems to have ten times the capacity of old wireless systems. By limiting the time-and-place restrictions inherent in desktop computers and wired networks, the potential of mobile computi increases user accessibility to network services around the world.

Satellites, Instructional Television Fixed Services (ITFS) and microwave technologies currently provide alternative delivery systems for instructional programming to the public schools (Lane, 1993). Although primarily analog in nature these technologies will be integrated into the emerging digital information infrastructure. Several factors portend this integration.

Geosynchronous satellites (those in an orbit equivalent to the earth's rotation) provide "store and forward" applications such as computer conferencing and voice mail. Additional applications will be forthcoming from Motorola Inc.'s (Iridium) and Comsat's global satellite communications programs. Recently, Teledesic Corp (a Microsoft and McCaw Cellular Communications Inc. start-up company) announced its intentions to provide a network of 840 satellites to bring telecommunications to remote areas around the world by the year 2001 (Sugawara, 1994). Teledesic embraces the technology developed under the Strategic Defense Initiative's "brilliant pebbles" program. Other developments such as Direct Broadcast Satellite (DBS) and the recently announced Digital Satellite Services (DSS) offer digital programming to small receiver dishes (ranging from three feet to eighteen inches in diameter) conveniently located at consumer's homes. As these services penetrate the home market it becomes increasingly clear that they will inevitably merge with the NII.

The technology blueprint for the future will involve the application of common standards and communication protocols to interconnect local and wide area networks linking people together over a National Information Infrastructure. Open Systems Interconnection (OSI) seven layer architectural reference model and standard for communications among computers and terminals will provide the evolving guide for this blueprint. Fast-packet architectures will be the key to this development and will be part of both public and private networks. The resulting integrated networked environment will appear as a "virtual" network for the end user, broadening communication, giving users access to varied applications and hopefully reducing overall costs (McGee, 1994).

Asynchronous Transfer Mode (ATM) appears to be the protocol of choice for full multimedia capabilities. McGee (1994) predicts that the focus of the networking industry for the rest of this decade will be dominated by the
integration and evolution of today's multiple, specialized technologies into a fewer number of higher speed, multidimensional technologies.

The litmus test of the technologies that represent the information infrastructure ultimately, will not be judged by bandwidth capacity or number of executable operations per second but rather by the character of its content. The remainder of this paper explores potential content in the civic and education arena, with special emphasis on distance learning.

Distance Learning Opportunities

Community Services Networks

Many opportunities for networked community services are outlined in A National Strategy for Civic Networking : A Vision of Change (Civille, Fidelman, & Altobello, October 1993). Their review is replete with examples of networked applications that cut across all aspects of civic, education, health, work,

and community activities. The projects reviewed are exemplary of the salutary and empowering effects of a national strategy for civic networking predicated on a National Information Infrastructure. They illustrate how integrated networks are able to provide endless opportunities for resource sharing and collaboration among individuals and communities. Two of the most prominently mentioned projects are: the Blacksburg Electronic Village and Smart Valley.

Blacksburg Electronic Village in southwestern Virginia, is a testbed for the delivery of business, community, education, health, and library services over narrow and broadband ISDN networks. This project attempts to enhance the quality of people's lives by electronically linking the residents of the community to each other and to worldwide networks. Blacksburg has become a laboratory to develop a prototype for the concept of a National Information Infrastructure. A hallmark of this experiment is its emphasis on interactions between people rather than focusing on specific technologies. A Local Research and Education Network (LREN) is envisioned for educational uses. This local network would connect to the developing National Research and Education Network for access to database and increased access to other students, teachers and researchers. The community of Smart Valley, in Palo Alto, California, is also envisioned to develop an electronic community that will benefit all sectors of the community: education, healthcare, local government, business and home applications.

An important ingredient of both these projects is the "bottom up" approach to designing the testbed networks. Instead of a "top down" systems rule approach, the individual needs and desires of community members are guiding the development of the integrated networks and services. As Gilder (1994) has pointed out networks should be allowed to evolve as an organic process and grow from needs rather than be imposed from the top. Advances in technology will be more secure, enduring and profitable if they result from careful examination of user requirements and needs.

Distance Learning Initiatives

Plans to use the National Information Infrastructure for education and life-long learning address the challenges of the emerging global information economy identified in a previous section of this paper. Federal, state and local governments and private business have initiated programs to set the stage for meeting these challenges. Several programs in the federal government (Aeronautics & Space, Energy, Federal Communications Commission, Housing and Urban Development, Interior, and the Office of Science and Technology Policy) have launched initiatives (Gore, 1994).

These initiatives involve: (1) developing K-12 computing and communication applications supporting a new learning paradigm; (2) the development of digital libraries to utilize distributed databases around the nation and the world; (3) training programs to use the NII to enhance the skills, education and training of the American workforce; (4) distributing K-12 curriculum over the Internet; (5) regulations for reasonable rates for telecommunications by radio, television, wire, satellite and cable; (6) establishing a high speed communications infrastructure for research and educational use (NREN) and (7) the development of software, interfaces, and tools necessary for the educational use of the NII.

Current initiatives to develop the communication technologies and tools for the "information age" have the potential to revolutionize traditional educational environments and practices. Traditional educational settings where learners are passive recipients of information provided in lecture formats or from linear printed materials are fast giving way to computer-mediated-communication of multimedia information over local, metropolitan and wide area networks. Such environments change the focus from teacher control to learner control, and from highly structured learning to flexible and responsive settings that offer varied learner options. Linear presentation gives way to random access; passive attendance to active participation; rote learning to developing problem solving competency and independent thinking; information assimilation to knowledge construction; classroom facilities to authentic simulated environments. This transition from a "teaching environment" to a "learning environment" sets the stage upon which school-based and workplace learners will encounter opportunities for life-long learning.

These initiatives, we believe, signify a need to expand our perception of distance learning to encompass the opportunity for life-long learning provided by a variety of telecommunication technologies, and especially computer-mediated-communication (CMC) over the Internet.

Indications that these opportunities are increasing are evident in the public sector increase in the number and variety of on-line information services and in the tremendous growth in the multimedia software publishing business. The "big three" on-line services: Prodigy, Compuserve and America on-line now claim more than three million subscribers among them. It is predicted that on-line subscriptions will grow another thirty percent in 1994 (Eng, 1994). Sales of home learning multimedia software will reach 250 million in 1994 and are expected to reach one billion by the end of the decade (Armstrong et al., 1994). Interactivity, defined as active involvement and control by participant or learner with the entertainment or educational product is a key ingredient to the success of these two industries. The merging of computers, telephones, satellites, cable, television and wireless technologies into a transparent web of networks making a vast array of information available to homes, schools and businesses is another.

Networked multimedia applications in the commercial and home market are out pacing similar applications in the schools. The good news is that the commercial and home market applications are part of the evolving information infrastructure that is beginning to penetrate the educational market. In 1987, fewer than ten states were investing in distance learning. By 1988 two-thirds of the states reported involvement in distance learning projects (U.S. Congress, 1989).

Several ongoing programs exemplify the potential for educational applications. The Global Access Information Network (GAIN) is a project of NYSERNET, a mid-level Internet service provider in New York. The project is supported by the Apple Library of Tomorrow and private foundations. GAIN provides Internet services to five public libraries and an Indian Nation school. In addition to collaboration between local libraries and local schools, the community has benefitted from access to medical information. The National Capital Area Public Access Network (CapAccess) in Washington, D.C. works with public school librarians over a three state area. (CapAccess) provides free Internet accounts to students who use Internet mail to subscribe to school topics of interest. In Montana, the Big Sky Telegraph project links schools and libraries enabling students to study Russian with Russian pen pals oversees and to study chaos theory with scientists from the Massachusetts Institute of Technology.

High Performance Computing and Communications (HPCC) programs have spawned some exciting distance learning projects as part of the InFoMall concept (Mills and Fox, 1994). InFoMall is a program led by the Northeast Parallel Architectures Center (NPAC) to create an innovative technology transfer program for the "information age". It is intended to address the problem of HPCC software development in the "real world" of industry, education and society. The (NPAC) InFoMall is charged with converting the United States lead in HPCC technology into a global economic competitive advantage and into corresponding benefits in health care, education and society in general.

NPAC plans two demonstration projects in education through the implementation of NYNET. NYNET is a high-speed, fiber-optic communications network, based on Asynchronous Transfer Mode (ATM) technology. NYNET will interconnect multiple computing, communications and research facilities in New York State. The first demonstration project will repackage Grand Challenge scientific simulations into educational modules for school age children. The modules will run on high performance computers at NPAC and will be distributed to schools over the NYNET high-speed network. Students and teachers will become interactively engaged with the simulations and manipulate "real world" variables. The second project is titled "The Interactive Journey" and will allow interactive "real-time" tours of New York State based on LANDSAT satellite images. Students and teachers will navigate through three dimensional space and manipulate archeological, geological, environmental, business and demographic variables.

Networked applications of distance learning are occurring with increasing frequency over the Internet. Paulsen (1995) organizes computer-mediated-communication (CMC) according to four communication paradigms: information retrieval; electronic mail; bulletin boards and computer conferencing. He further elaborates on this scheme by including a dimension of interactivity distinguishing among: one-alone; one to one; one to many and many to many. This scheme allows a matrix approach for determining the interrelationship between type of communication and level of interactivity which is a useful tool for planning and designing specific learning experiences based on intended outcomes.

Chris Dede (1993) proposes a broader conceptual scheme for educational uses of the NII that includes knowledge utilities, virtual communities and synthetic environments. Dede's framework acknowledges the links between workplace and school-based learning that are necessary to address the

transformation of work brought about by the knowledge-based economy. Dede attempts to explore interactive services that meet the needs of both workplace and school-based learners. His framework relies on collaborative learning and recognizes the necessity for integrating interpersonal with technology mediated communication.

Dede's concept of a "virtual forum for learning" is in response to his perceived need for a workforce trained in ad hoc or "just-in-time" decision making and continual learning-while-doing on the job. Dede predicts that three types of applications will come to dominate distance learning provided by distributed desktop computers over wide area, high-bandwidth networks: (1) learning by assimilation; (2) learning by analogizing and (3) learning by doing. Dede's scheme capitalizes on the NII through a "virtual forum for learning" that leverages emerging technological capabilities to promote learning-on-demand within school-based and the evolving workplace environment (Dede, 1993, p. 6).

Rheingold (1993), Savetz (1994) and Weiser (1994) promote the potential of MUDs (Multi-User Dungeons or Multi-User Dialogues or Domains) as a distance learning application of "virtual communities". MUDs are typically computer programs that users log into and explore for recreational purposes. MUDs have been in existence for about ten years, the first one modeled on a Tolkienesque domain of dwarfs and treasure, warriors and wizards, swordplay and magic known as "the Land" (Rheingold 1993, p. 155). Recently, networked educational applications of MUDs have appeared. Most notably, the Jupiter Project, MediaMOO and Virtual Online University (VOU). Each of these projects is described as a MOO (a Multi-User Dimension or object oriented environment). They are database programs running on servers that allow users remote access to become active learners in a text-based virtual reality. As such, they provide a casual environment integrating virtual and real worlds. Many other applications of MUDs provide a variety of electronic classrooms, electronic tutorials and seminars.

Project Jupiter is a multimedia, international MUD intended as a working tool for designers of virtual workplaces of the future (Rheingold, 1993). MediaMOO created in 1993, is a virtual version of MIT's Media Laboratory. Virtual Online University (VOU) is the first virtual online university on the Internet (beta test begun September, 1994) (R. Donnelly, personal E-mail communication, September 7, 1994). VOU is a model for a Virtual Education Environment (VEE) that combines the academic environment of a physical world university, the wide reach of the Internet and the creative environment of a MUD.

Other networked distance learning applications build upon the "peer to peer" distributed computer environment of the Internet. The client/server functionality of this distributed environment provides individual access from microcomputers and workstations to a wide variety of information/education resources. Individuals access and interact with these resources with the four basic Internet services: e-mail; Telnet (remote login); FTP (file transfer protocol) and browsers (Gopher, Mosaic, and others). A plethora of resources are available using these tools. Until recently, however, few educational applications were available. Resources were largely information and reference databases organized for access, retrieval and research purposes. This has changed with the recent interest and development of the World Wide Web (WWW).

The World Wide Web is a hypertext-based system for finding and accessing Internet resources (Krol, 1994). Use of the World Wide Web accelerated with the development and introduction of Mosaic, a multimedia interface (browser) to Internet Resources. Web servers have doubled every four months over the three years between April 1991 and April 1994 (Berners-Lee et al., 1994) Mosaic is a hypermedia tool that has the capacity for handling, along with text, audio, still images and motion video. Mosaic executes multiple communication protocols through Uniform Resource Locators and is platform independent. Because of this functionality and its graphical user interface (GUI), Mosaic sparked an enormous interest in creating World Wide Web sites (programs running on server computers) that provided opportunities for multimedia distance learning. The popularity and impact of Mosaic has spawned the creation of other GUI browsers or clients for accessing Internet resources.

It seems fair to say that the multimedia capability of the World Wide Web browsers was the primary incentive motivating faculty and students to create distance learning activities on the WWW. Suffice it to say, that these distance learning opportunities are appearing with a frequency that makes it difficult to systematically document and access each application. For example the authors have identified and

documented numerous distance applications in the health sciences as of November 1994 as part of an ongoing project. These applications have been documented as: (1) hypertext databases text only (2) hypertext databases text and images; (3) medical image reference databases; (4) case-based medical image databases and (5) multimedia databases. The levels of interactivity provided for the learner include simple hypertext retrieval, analysis of clinical images, observation of surgical and other medical procedures (QuickTime and MPEG movies) and interactive feedback (email) of patient case evaluations. Anyone with Internet access and a WWW graphical browser can review these specific distance learning applications at the following Web site (http://wwwetb.nlm.nih.gov/).

The potential for networked collaborative on-line distance learning can be gleaned from the nascent MBone or "virtual network" that has been in existence since early 1992 (Macedonia and Brutzman 1994). MBone is an acronym for Multicast Backbone. MBone originated from the University of Southern California Information Sciences Institutes efforts to multicast audio and video from meetings of the Engineering Task Force. Multicast makes possible one-to-many and many-to-many network delivery services for applications such as videoconferencing and audio where several hosts need to communicate simultaneously (Macedonia and Brutzman 1994, p. 30). Hundreds of researchers currently use MBone to develop protocols and applications for group communication.

Multicasting has become feasible on the Internet as the result of: (1) high bandwidth Internet backbone connections and (2) widespread availability of workstations possessing adequate processing power and built-in audio capacity. Several distance learning applications have occurred using MBone: (1) conferences on supercomputing and scientific visualization; (2) Radio Free VAT; (3) Internet Talk Radio and (4) other remote learning activities such as the Jason Project and the Naval Postgraduate School Visualization Laboratory. In practice, MBone provides only one to four frames of video per second (compared with standard video of 30 frames per second) accompanied by phone quality voice. Nevertheless, MBone may be the precursor to the high bandwidth networked multimedia applications promised by the NII.

Opportunities in the Health Professions

Several major infrastructure initiatives are specifically relevant to health professions education: The Integrated Advanced Information Management Systems (IAIMS), the multi-agency High Performance Computing and Communications (HPCC) programs and the National Research and Education Network (Lindberg, 1993).

The IAIMS is a National Library of Medicine initiative begun in 1983 to promote the development of integrated computerized communications systems across academic health science institutions that would link library systems with individual and institutional databases for patient care, research, education and administration. This proved to be a forward looking initiative: IAIMS participants were the early pioneers of medical networking who experimented with and integrated information technologies in a medical environment that were the precursors to current efforts to create the NII.

Among the many goals of HPCC, the development of the National Research and Education Network (NREN) and the gigabit testbeds for advanced networking are particularly pertinent to the issues discussed in this paper (High Performance Computing and Communications, 1994). Both research and education will be advanced by efforts to connect health professional to computerized information resources involving medical imaging, biotechnology and information-retrieval tools. The advanced networking projects support six collaborative testbeds for research on very high-speed networks. Universities, national laboratories, supercomputer centers and industry are participating in this collaboration. The major goal of this collaboration is to remove current barriers to the efficient delivery of huge multimedia files in a shared high performance computing environment.

HPCC also supports projects in telemedicine and digital libraries. As part of this program the National Library of Medicine supports Internet connection grants to provide support for currently available services over the Internet. The goal for 1995 is to connect 70 to 100 medical centers to the Internet. This encourages baseline practical experience with current services and hopefully provides incentives for involvement with the imminent advanced network technologies.

These initiatives, coupled with the technological advances in the commercial telecommunications market will have an enormous influence on: (1) the clinical practice of medicine; (2) the formal education of health professionals and (3) the creation and delivery of continuing professional education.

Some Final Thoughts on the Future of Distance Learning

School, home-based and workplace distance learning opportunities will abound with the advent of the National Information Infrastructure. If the ideal of universal access (equity in access and transmission and "common carriage" or subsidized access for those who cannot afford it) is achieved the groundwork will have been established for participation by all citizens. To ensure universal participation and the achievement of the distance learning goals projected for the NII, four issues in particular require attention : (1) technology's consequences; (2) quality/relevant content; (3) purposefulness and (4) literacy. Vigilance for technology's consequences, both anticipated and unanticipated, is foremost among them. Gilder (1994), Norman (1993), Papert (1992), Postman (1992), Zuboff (1988) and others have written eloquently on the subject of technology's consequences for the design of human-machine interaction, school, home and work-based activities and the larger culture. An enormous technological implementation such as the NII is predicted to have far reaching consequences not all of which are intended or anticipated.

Individuals and institutions will have to make accommodations to technology's consequences. In the area of distance learning fundamental questions will have to be examined with regard to: (1) quality/type of content; (2)design/delivery of content; (3) teacher role/compensation; (4) student responsibilities; (5) continued teacher training; (6) role of colleges and universities/credentials/degree granting; (7) student selection/cross state and country regulations and many more (Jacobson 1994). Careful documentation and assessment of the changes brought about by these accommodations should be a significant ongoing component of an overall plan for the NII. Special emphasis should be placed on monitoring the unanticipated effects and planning for timely and effective responses. Vigilance for consequences will increase the probability that the emerging NII will achieve its intended goals.

Content, purposefulness, and literacy are inextricably bound together. Together these three variables will play a significant role in making universal access meaningful and ensuring the effectiveness of distance learning applications. It is not adequate simply for technology to provide high tech conduits for transferring information. The content traversing the conduits must be of high quality and relevant to enhancing the requisite knowledge and skills of the end user. The end user in turn must possess an abiding purpose for accessing, retrieving and utilizing the information, and most importantly, fundamental literacy and information technology skills.

In the case of distance learning, the issues and concerns relevant to content, purposefulness and literacy skills to a great extent will determine the success of the National Information Infrastructure for the average citizen.

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