NIKE:
A National Infrastructure for Knowledge Exchange

A Whitepaper Advocating an ATP Initiative on
Technologies for Lifelong Learning

October, 1994

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Abstract: This white paper advocates the development of National Information Infrastructure (NII) technologies to support lifelong learning. The immediate, predictable impact would be to overcome existing inefficiencies in the development and delivery of learning materials. An on-line marketplace will create powerful incentives to develop new materials and provide efficient means for their widespread distribution. Advanced authoring tools will allow millions of educators, students, and specialists to contribute to a growing body of learning materials.

The longer term opportunity is to integrate technologies for network-based learning and collaboration into the work environment. Knowledge workers would apply the same skills and tools used in learning — for finding, organizing, and sharing knowledge on the network — to get the job done. They would collaborate in virtual teams and organizations that cut across temporal, geographical, and institutional boundaries. They would contribute to organizational memories that preserve valuable expertise and experience when employees move on. The new way of learning, exploiting the potential of a National Information Infrastructure, will prepare a generation for a new way of working.

Available on the WWW at http://www.eit.com/papers/nike/nike.html and nike.ps

The Problem: Inherent inefficiencies in the infrastructure for developing and delivering learning materials

As American companies prepare for the 21st Century, they increasingly recognize that competitiveness depends upon a skilled, flexible, highly innovative workforce. Employees need to learn continually as they work. Employee training programs, once optional, are now essential. But training is expensive. Corporations currently spend $47 billion annually on training, and the Federal Government spends an additional $25 billion annually, on a confusing maze of 154 separate programs.

There is a growing consensus that the nation is not reaping an adequate return on its massive training investment. Courses are expensive to develop and deliver in traditional classroom formats, and there is significant redundancy and variation in quality. New learning technologies, such as CD-ROM-based interactive multimedia and simulations, are themselves very expensive to develop — requiring as many as 500 preparation hours per course hour — and are also "one off" products with uneven quality and availability. With today's declining budgets and downsizing, no single company has the capital or technology to go it alone, yet the need for easily available, quality, up-to-date learning resources is critical to competitiveness.

The problem isn't that educators are incapable of creating high quality, innovative learning materials. To the contrary, there is a vast supply of potential authors, and significant demand for their work. The problem is that the infrastructure for development and delivery of learning materials is massively inefficient.

The fundamental barrier to widespread development is a lack of sharing and reuse. In successful engineering and scientific endeavors, every new idea or product is built from the best of the existing work, and the latest products are widely distributed and available for reuse by others. But in today's environment, most learning materials are developed in isolation without coordination; information and media resources are seldom reused; course materials are authored by individuals or small teams over long periods of time, producing big standalone products that typically benefit just a handful of classes; educational entrepreneurs are locked out by high development costs and a closed market.

There are also massive inefficiencies on the distribution side. The cost of publishing in paper or video limits the market. No one except the largest corporations can afford to maintain a library with enough breadth to cover their learning needs, and access to such libraries is limited by physical proximity and delivery time. Corporate training seminars, held in auditoriums and hotel ballrooms, take employees away from their work. For that very reason the traditional delivery format shuts out lightweight, personalized, just-in-time, on-the-job learning.

The Immediate Opportunity: NII for Learning

We believe there is a tremendous opportunity to improve the cost and effectiveness of education and training programs by pooling the resources of all learning communities — corporations, educational institutions and government agencies — so that everyone can

share and reuse the best learning materials available. The opportunity is to realize the potential of the emerging National Information Infrastructure (NII) for lifelong learning. With the right catalysts, the redundancies of the current development and delivery system can be turned around, and the vast potential of our educational resources can be tapped. Anyone with a network connection could have access to the world's best learning materials, and tools for finding, organizing, composing, and applying them. Anyone with a network connection could also contribute learning modules that can build on and integrate with the work of others. Learning materials could be available where and when they are needed, on demand, customized to specific educational needs.

To realize this potential, we must extend the capabilities of current Internet information services such as the World-wide Web to create a National Infrastructure for Knowledge Exchange. The key capabilities to develop immediately are

Market Mechanisms: Develop a national, on-line marketplace for learning resources, including printed materials, videos, and multimedia software. Connecting producers and consumers through a networked market will create powerful incentives to develop new materials and provide efficient means for widespread distribution.

- Materials can be contributed by teachers, schools, companies, trade associations, government agencies, publishers, educational resource centers, libraries, museums, etc.
- Basic modules cover a single concept (10 minutes to an hour), encouraging flexibility and reuse. Third parties can add value by indexing, annotating and composing modules.
- A variety of commercial services could bring producers and consumers together (e.g., subject area directories, advertising, "What's New" and "Best Seller" lists, accreditation and evaluation, subscription-based alerting).
- A range of security, payment and royalty collection mechanisms (e.g., free unrestricted access; educational cooperatives offering materials free to members; paid subscriptions; and pay-per-view) must be developed so that information and service providers can be paid.

Authoring and publishing tools: development and wide distribution of easy to use authoring and publication tools that will allow millions of educators, students, and specialists to contribute to a growing body of learning materials. The network will support a new paradigm of publishing, one that encourages innovation in form and content. The cost of making something available will be lowered to the point where learning modules of all shapes, sizes, colors, and price tags can be offered. A new generation of network-aware authoring tools must be developed to take advantage of the resources available on the network. Authors should be able to:

- locate and retrieve relevant resources on the network using commercial directory services as well as advanced resource discovery tools
- incorporate materials in a wide variety of media types and formats, using automatic conversion services

- transform traditional course modules into interactive networked hypermedia, and enhance them with simulations, virtual reality, and access to on-line resources
- collaboratively develop complex course materials supported by distributed source management, concurrent authoring capabilities, and on-line access to subject area specialists
- easily publish their work on the network, with automated support for posting on servers, registering with directory and advertising services, filing for copyright protection, and arranging for royalty payments
- integrate their products with the full range of resources that will be available on the NII—not only libraries and scientific data but commercial information and services as well. Providing learning materials with access to commercial resources will require continued development of techniques to overcome proprietary barriers (e.g., gateways to proprietary networks, protocols for negotiating document formats).

The Big Win: Learning in the 21st Century Workplace

Developing learning technologies that exploit the inherent properties of computer networks—overcoming space and time barriers, enabling sharing and reuse of distributed resources—is just the tip of the iceberg. A truly profound opportunity comes from the integration of continuous learning into the 21st century workplace environment.

The engines of change are running at full speed: a highly competitive, global economy; monolithic enterprises downsizing and re-emerging as "virtual companies" made of highly specialized units; the ascendance of the knowledge worker... In the 21st century, employees will increasingly work in teams, assembled dynamically, often geographically distributed. With constant changes in the workforce, corporate knowledge will be captured in the information infrastructure or will be lost. No one will be able to afford to reinvent the wheel. The knowledge workers of the 21st century will *depend* on access to information, services, and expertise to get the job done. To remain competitive, they must be at leading edge, and this will require continuous and just-in-time learning.

The information infrastructure will shape the way people work. Network-based collaboration will be commonplace—and indispensable. On-line information sharing will be essential to design, manufacturing, and the delivery of services. Contact with colleagues and consultants will be more than voice and video; it will include the data and information manipulated by their software. Institutional memory will make corporate expertise available when the experts are not.

In this environment, the distinctions between learning and working, formal education and professional research, joint authoring and collaboration, become irrelevant. The skills needed by the knowledge workers of the next century—locating information, tools, or services, incorporating them into existing organizations of knowledge, delivering value-added expertise—can be acquired and developed by using the learning technologies of tomorrow. Network literacy is both learned and applied in the same real-world

environment. The infrastructure and tools developed for lifelong learning will be the same tools used to get the job done.

The mere existence of the global information network will stimulate many of these changes. But to capitalize on the potential of integrating learning and working, we need to create and support three key elements of the future learning and work environment.

Personal Web: virtual notebooks that allow learners to capture information off the network as they work, annotate it and organize it by linking it into their personal hyperwebs. The personal web grows as new questions arise and are answered, as on-line courses are taken, as personal contacts are made.

- The personal web will be a primary memory and organizing structure for learning within the network environment. As the quantity of information available explodes, the task of actively filtering, categorizing, indexing, and organizing information will be an important skill.
- The personal web will be the bridge to the larger social world of groups and institutions. Not only will individual learners get information from their classes, workgroups, and institutions, but they will share their knowledge with clients through the same network infrastructure. Personal webs will persist from school to work, and from job to job.

Organizational Memory: group webs — shared "notebooks" — that provide a medium for sharing information and coordinating work. Shared webs will be the organizational memory of classes, research groups, work teams, corporations, and government agencies. They will enable organizations as a whole to benefit from and retain the knowledge and experience that their members individually acquire.

- Information in group webs is organized by linking it to shared cognitive structures such as a map, a virtual office or campus, a CAD drawing, engineering model, or a project schedule. Almost any form of information can be included: e-mail messages, videos, hypermedia notebooks, databases, etc.
- Much of the organization arises dynamically from interactions among contributors. For example, shared information can be structured as a branching network of diagnostic questions that leads team members to the answers they need. If an answer is unavailable, the question can be referred automatically to an appropriate expert, whose response is inserted into the network for future reference. Answers can also be annotated and elaborated by members of a group as experience accumulates. The result is an **Answer Garden**, a database of commonly asked questions and answers that grows "organically" as new questions arise and are answered.
- Information in a group web can be protected so that only authorized members can access or annotate it. The structure of shared information can range from informal meeting notes to formal document libraries.

- Contributing to a group notebook will be an important collaboration skill. The practice of "writing for publication" can begin early in one's education and continue throughout life.
- Organizational memory at the corporate or institutional levels can be maintained by professionals, who capture corporate expertise explicitly (e.g., with hypermedia question/answer webs such as the "ASK" systems developed at the Institute for Learning Sciences). Corporate information managers can also seed the organization with smaller-scale group webs and coordinate their relationships.

Ubiquitous collaboration. The network information infrastructure not only provides access to information, but to people. At every level of authoring and knowledge sharing, the human collaborator is available, freed from the need to be co-located. Digital communication, both synchronous (e.g., desktop teleconferencing) and asynchronous (e.g., e-mail, joint authoring) can be invoked with the same tools as used to create and browse the information webs. Learners can find people by their self descriptions, click to contact them in real time or leave a message (in text, audio, or video formats). Providing for ubiquitous collaboration in the infrastructure will allow new forms of social organization, including

- **Virtual "tiger teams"** of specialists, assembled and coordinated over the network, with an organizational memory to capture the results.
- **Shared Virtual Spaces** for learning and social interaction. Enter a virtual office or wander a virtual campus; see, hear, and exchange stories with others you encounter; leave messages and pointers to other information in a personal or group web. SVSs provide familiar "places" on the net where individuals with shared interests in geographically dispersed organizations can meet, exchange stories and learn from each other. By documenting these stories, the organization learns too. SVSs are also a powerful substrate for simulation-based training (e.g., use them to model factories, cities, hospitals, ships, etc.). Teachers can program them to give students exciting vicarious learning experiences. Students can develop or elaborate their own environments for constructivist learning.
- Delivering such advanced collaboration capabilities will require high-speed network connectivity that few sites can now afford. Until the NII arrives, it will be necessary to explore a variety of hybrid connectivity options to enable everyone, including employees of small companies and home learners to participate. Possibilities include:

  - providing Internet access via ISDN or cable - using IP multicast, CD-ROMs and Direct TV (broadcasting from low-orbit satellites) to mass distribute multimedia course materials with large amounts of static content
  - economical, low speed (e.g., 25Mbit) ATM services that accommodate large numbers of users by allocating quality of service guarantees)

Economic Benefits

The business case for a National Infrastructure for Knowledge Exchange is succinct and compelling:

- billions of dollars in potential savings, realized by sharing and reusing learning materials
- billions more saved by eliminating most of the costs incurred in physically distributing media and by students commuting
- vastly increased supply and demand for learning materials
  - o Tools and market incentives encourage widespread authoring and publishing.
  - o Anyone with a net connection (at work or home) can take courses.
- increased learning effectiveness realized by
  - o making the very best teachers and resources available to learners nationwide
  - o making learning materials more relevant and accessible in the workplace
  - o delivering them using the same network and tools that knowledge workers use for every other aspect of their jobs.
  - o integrating them into computerized, high-tech products (e.g., the "user manual" for a new machine or process can be computer-based training module)
- increased corporate productivity achieved by providing workers with the information they need to solve problems fast. This avoids wasting time and money reinventing or rediscovering solutions that others, either inside or outside the organization, already know.
- new global markets for innovative information services — the kind of services that U.S. companies excel at (e.g., pay-per-view publishing, value added information brokering and referral, document management and search, and expert consulting). If knowledge and expertise is delivered routinely and easily on the NII, then these can be sold both domestically and for export. "If we have the best knowledge, and can deliver it, they will come."
- accelerated market growth for advanced hypermedia- and collaboration-based information technology (e.g., personal and group web authoring and browsing tools), by creating a powerful demand pull, rallying the vendor community around open architectural standards, and providing hybrid connectivity options that make such services feasible.

Why an ATP?

We see three important reasons why ATP is the right program for building a National Infrastructure for Knowledge Exchange:

1. Governments have a long established role in seeding new infrastructures with high risk technology as well as customers and suppliers (e.g., the postal system, the railroads, the highway system, and air transport). In the case of things as fundamental as information and learning, governments have the additional responsibility of ensuring equal access to all individuals, regions and industries.

2. The proposed program will highly leverage existing government and private investments in CommerceNet, NIIIP and similar infrastructure projects, as well as the $25B the Government spends annually on training. One immediate dividend: learning materials developed by disjoint government and industry training programs (e.g., NIST's Manufacturing Extension Partnership program, NCMS's Manufacturing and Education Centers, DoD's CALS Shared Resource Centers, NSF's Synthesis Coalition, the National Technical University) will for the first time be broadly disseminated.

3. The ultimate success of a National educational initiative depends on the ability to SCALE UP. A nationwide ATP project can achieve results that small-scale, local experiments can't:

   - by scaling up collaboration: from joint authorship or in-house production teams to specialization of labor (every teacher or subject-area specialist could contribute their part) and composition of materials from tens to hundreds of sources (integration of on-line information access with training materials)
   - by scaling up production, by providing an economic incentive to produce "reusable" materials (like the transition in design and manufacturing from one-off military contracts to consumer markets) and by making network publishing tools widely available (the culmination of the desktop publishing revolution)
   - by scaling up the number of people who can take advantage of the latest educational materials (like what the National Technological University is doing with video courses, but orders of magnitude greater scale because of network access)
   - by scaling up the number of people who are skilled at collaboration in virtual teams and contributing to organization memory. Without an opportunity to deploy the technology to significant populations, ideas on how to support collaboration will never leave the laboratory.

Why now?

- The NII is hot. Witness the explosive growth of the Internet and the World-wide Web.
- A unique opportunity exists to rally the information industry around open architectures and standards for advanced network services, multimedia and electronic commerce before any vendor can establish dominance by imposing proprietary ones.
- Global competition is demanding a more cost-effective approach to lifelong learning changes and higher productivity in the workplace.

Organizational Commitment

In preparing this white paper, we involved a broad range of organizations concerned with education and training: technology suppliers, content providers, education and training institutions, network access companies, and major consumers of training. We convened several planning sessions to formulate and refine the concepts underlying NIKE, test their commercial viability, and garner support for an ATP initiative. The following organizations participated in these planning sessions and have expressed interest in joining the NIKE project.

Project Management

- Enterprise Integration Technologies Corporation, manager of CommerceNet (the first and largest market trial of electronic commerce on the Internet) and several other large information infrastructure initiatives in the areas of manufacturing and training.

Technology Providers

- Hewlett Packard, Sun, Pacific Bell, and Xerox PARC — advanced technologies for collaboration and distributed information management.
- Hybrid Networks — technology for IP connectivity over cable.
- Labryinth (virtual reality on the World-wide Web)

Content Providers

- NIST Manufacturing Extension Partnerships Program and TECNet, the information infrastructure that interconnects them.
- National Center for Manufacturing Sciences — sponsor of 25 Manufacturing and Education Centers across the nation, and operator of the Education and Training Network (tm).
- DoD CALS Shared Resource Centers — eight locations around the country that assist small defense subcontractors in transitioning to a dual use economy.
- Institute for Learning Sciences, Northwestern University — Roger Schank's pioneering laboratory
- Stanford Instructional Television Network and the Stanford Digital Libraries Project.
- National Technological University — a consortium operated by 25 major engineering schools that beams courses via satellite to 600 US Corporations.
- UC Access — an on-line information service operated by the nine campuses of the University of California.
- Synthesis Coalition — a consortium of 6 engineering schools that is developing an on-line multimedia curriculum.

- Scholastic Inc. — a large publisher of educational materials for secondary schools and community colleges, and operator of a major web site offering free curriculum resources on the Internet.

Network Access Companies

- BBN Internet Services — operators of NEARNet and BARRNet, the two premier NSF regional access providers.
- Pacific Bell

Learning/Training Environments

Workplaces: Sun and Hewlett Packard corporate training centers, Focus Hope (an inner city teaching factory in Detroit).

Schools: Stanford, MIT, De Anza Community College (Cupertino, California), Technology Prep Academy (a secondary school in Richmond, CA)

State and Regional Consortia

- California Department of Trade and Commerce, Office of Strategic Technologies
- Smart Valley Incorporated and Joint Venture: Silicon Valley - regional redevelopment initiatives that are exploiting the NII to improve the Bay Area's economy, education, health care, environment and government.
- California Department of Education
- CommerceNet — a consortium of over 50 leading companies from Silicon Valley, pioneering the use of electronic commerce.
- TECNet — a consortium of New England manufacturing resource centers, now expanding nationally to link all NIST MEPs.
- San Jose Educational Network - an ambitious initiative sponsored by the San Jose Board of Education and the City Council to network every high school classroom in the city and train every one of the 1200 teachers to make effective use of networked resources.

Collectively, the organizations listed in this section are investing hundreds of millions of dollars annually developing technology and content for learning, and actually delivering training. ATP funds will highly leverage this substantial investment. Technologies developed under the ATP program will be used to connect the producers and consumers of educational materials, to integrate learning with doing by knowledge workers, to enable economies of scale by reducing redundancy and facilitating composition and reuse; to create large markets and economical mechanisms for delivery. ATP funds will also incentivize content providers to make their materials available in the NIKE marketplace. They will encourage technology suppliers to make their products compatible with NIKE's open architectural standards. And they will encourage trainers to use NIKE technology and content in their courses.