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ABSTRACT

Six papers and two abstracts of papers are presented from the 1995 CAUSE conference track on networking and telecommunications issues faced by managers of information technology at colleges and universities. The papers include: (1) "Looking to the Year 2000: Alternatives in Campus Data Networking" (Noam H. Artz and Daniel A. Updegrove), which discusses the emerging vision of the University of Pennsylvania's campus data communications network; (2) "Repackaging and Recycling: Using Information Technology to Enhance Education in the Present and the Future" (Herbert Achleitner and others), on the repackaging of information using Internet, video, and CD-ROM technologies; (3) "The Internet: Changing Relationships and Forging New Practices" (Carol B. MacKnight); (4) "Networks and Learning Environments: Responding to Growing Demands" (Carole Cotton), about the changing roles and nature of campus computer networks; (5) "Altering Time and Space Through Network Technologies to Enhance Learning" (John F. Chizmar and David B. Williams), analyses the role of computer networks in changing the place, time, and nature of learning; (6) "Managing Networked Information" (Kenneth J. Klingenstein), an abstract of a paper on the role of networking in information retrieval; (7) "The 'Business' of Telecommunications" (Alberto Forestier), an abstract of a paper on the costs of telecommunications technology; and (8) "The Classroom of the Future" (Raymond K. Neff), which anticipates the expanding role of technology in the classrooms of the future. Some papers contain references. (MDM)

CAUSE 95

New Orleans

Nov. 28 - Dec. 1

TRACK 6

NETWORKING AND TELECOMMUNICATIONS

Coordinator: Gilbert Dionne

Realizing the Potential of Information Resources:

Information, Technology, and Services

Proceedings of the 1995 CAUSE Annual Conference

Looking to the Year 2000: Alternatives in Campus Data Networking

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Abstract: At CAUSE94, a University of Pennsylvania presentation, "Designing and Implementing a Network Architecture Before It Becomes Obsolete," focused on the methodology for designing a network architecture on a decentralized, diverse campus. This presentation focuses more specifically on the emerging vision of the University's campus data communications network, and a set of structured architectural alternatives under consideration. Using the World Wide Web remains the primary vehicle for disseminating information about plans and assumptions to the campus and the world.

The authors acknowledge the assistance and long-standing collaboration of Penn colleague, Ira Winston, in the development of this paper and the concepts underlying it. A more detailed (and evolving) version of this paper, including links to the CAUSE94 paper, is available on the World Wide Web at URL, [`http://pobox.upenn.edu/~danu/cause95.html`].

Many commentators have dubbed 1995 as "the year of the Internet." Studies point to exponential growth in networks and individuals connected, Web sites and other resources accessible, traffic carried on institutional and wide-area backbones, stock prices of Internet-related companies, number of Internet (paper) millionaires, and articles about the Internet phenomenon. Less discussed, but more critical, is an understanding of strategies for accommodating (or at least coping) with this exponential growth.

At the University of Pennsylvania during the fall semester, we have been busy coping with such insurmountable opportunities as:

• Unveiling of a secure Netscape front-end to mainframe-based student record and student financial services data. Students were delighted with the new access to their records, until we withdrew the service after the "secure" Netscape encryption algorithm was cracked by two Berkeley students.

• Roll out of a new, graphical front-end to unify traditional network services by Penn's Wharton School, which dramatically increased demand

• Swamping of the central Help Desk, with the heaviest load coming from students off-campus struggling with PPP installation and configuration on Intel platforms

• Architecting a higher-bandwidth Internet gateway in cooperation with PREPnet, our regional provider

• Criticism from some students that we withheld support for Windows95, which had been released days before the start of the semester. The daily paper headline read, "University scorns Windows95"

• Upgrading overloaded campus news server and modem pools

• Queries from faculty on leave, such as, "telnet response is slow from California; what's wrong with your network?"

• Queries from staff, such as, "The Provost needs to be enabled for MOO access in order to participate in the English Department's real-time poetry discussions

Penn is not alone, of course, in facing the consequences of the growth in demand for Internet access and network support. In fact, 40 university representatives meeting in Keystone, Colorado in October reached consensus on six key network strategy issues that require attention on all our campuses (and, ideally, efforts toward cooperative solutions). These issues are:

• Remote access. Anytime, anywhere access sounds great, but modem pools are costly and inadequate for multimedia. What about ISDN, CATV, wireless, outsourcing?

• Capacity. What will the growth curve look like as Pentium and PowerPC workstations are deployed widely, GUI Web browsers proliferate, and desktop audio and video mature?

• Technical infrastructure. What roles for Ethernet, fast Ethernet, FDDI, ATM?

• Security. No one is satisfied with reusable, plain-text passwords, and amateur systems administrators can't keep pace with professional crackers.

• Network management. We all need better monitoring, diagnosis, and trouble ticketing systems.

• Financing. Price performance is improving, but not keeping pace with demand. Full-costing, marginal costing, and "library models" all have advocates -- and problems.

All six of these issues are on the agenda of Penn's Network Architecture Task Force. This paper focuses on the technical infrastructure domain.

Abut the University of Pennsylvania

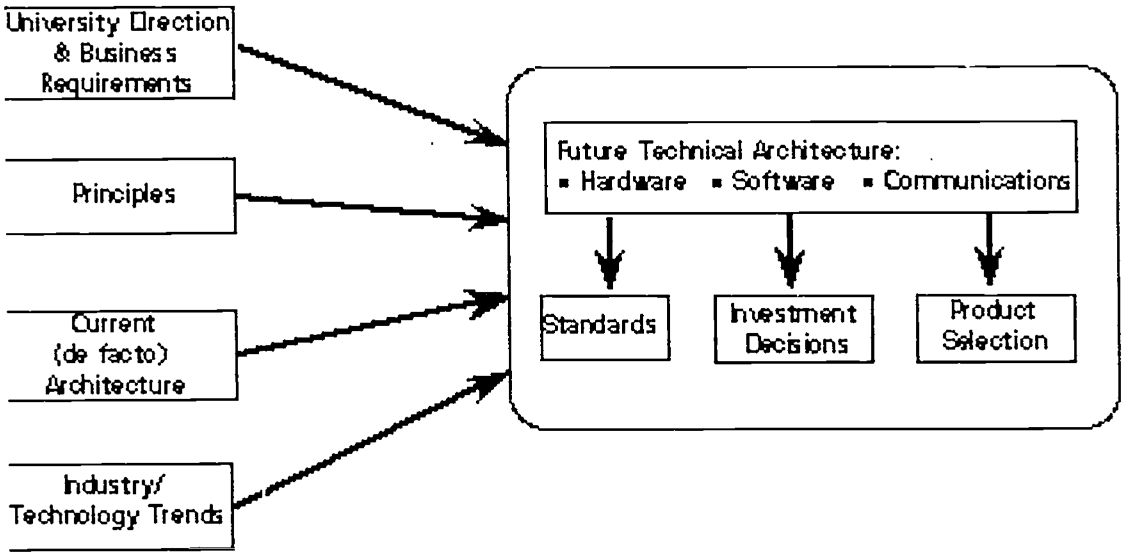
Penn is a private, research university founded in Philadelphia in 1740. Enrollment numbers 22,000, with 10,000 undergraduates in four schools and 12,000 graduate and professional students in twelve schools. Roughly 7,000 students live in campus residences; nearly all others live in walking distance. The University shares a compact, attractive campus with a 7,500-bed teaching hospital, large clinical practices in medicine, dental medicine, and veterinary medicine, and has an annual operating budget of $1.9 billion. The 23,000 staff and faculty reside in a three-state region (Pennsylvania, New Jersey, and Delaware); comparably few are within walking distance.

As one of the originators of responsibility center management, Penn has promoted autonomy, investment, and expertise in Schools and other units. Accordingly, all academic computing is managed outside the central unit, Information Systems and Computing. ISC is responsible for most core University administrative systems development and operations, data administration, a central help function, and data and video networks. (Voice services report to a different Vice President; Hospital IS, data, video, and voice services are separate.)

The Network Architecture Task Force

As detailed at CAUSE94, a Network Architecture Task Force was charged in spring 1994 to assess the current state of data, voice, and video networking at Penn, and to make recommendations for changes to these architectures during a three- to five-year planning cycle. Of the ten members of the NATF, the majority are drawn from outside ISC, including the director of Telecommunications, the director of library systems, and the director of computing in the School of Engineering and Applied Science, who serves as co-chair.

The NATF methodology, derived from work of Project Cornerstone, Penn's aggressive initiative to re-engineer business processes and deploy modern, client-server administrative systems (described at CAUSE93 and CAUSE94), is depicted below.



The Technical Architecture is a blueprint for how future technology acquisitions and deployment will take place. It consists of standards, investment decisions, and product selections for hardware, software and communications. The Technical Architecture is developed first and foremost based on university direction and business requirements. Additionally, principles are used rigorously to be sure the Technical Architecture is consistent with Penn's information technology beliefs. The current (de facto) technical architecture is taken into consideration, as well as relevant industry and technology trends.

For the discussion that follows, readers will find it useful to have access to detailed diagrams of current and alternative architectures. These diagrams are available on the Web at URL, [http://nextb.dccs.upenn.edu/techarch/natf/].

Three Basic Architectures

Three basic architectural alternatives have been defined along a continuum from least aggressive to most aggressive with respect to the reliability, performance, and functionality they enable. These three basic alternatives represent a migration path that can be followed one to the other if Penn chooses. As markets and products develop, Penn may skip one or more alternatives in the "pipeline," or implement other variations that develop.

It is important to understand that not all elements of these architectures are different. Common elements include the following:

• Internet connections: Eliminating our reliance on SMDS for connection to the Internet, FDDI is used to allow a scaled connection up to T-3 speed via PrepNet or another access provider.
• Inter-campus connections: SMDS appears more appropriate for scalable connections to remote sites within our metropolitan (e.g., New Bolton Center, Center for Judaic Studies), replacing dedicated T-1 service. HUPnet is connected via a routed connection scaling from 10 Mb/sec as necessary.
• Remote access: The analog modem pool continues to scale to meet demand, shifting to a combination of analog 28.8 bps, and digital ISDN lines (capable of supporting multiple protocols). Commercial access providers may supplement these pools especially for outlying areas.
• Advanced networks: Penn will provide coordinating support for advanced networking initiatives that may run counter to our conventional deployments. This will likely include swifter adoption of ATM and direct Internet or vBNS connections for certain projects.
• Treatment of legacy network environments: The ISN asynchronous network is eliminated early in 1996; asynchronous terminal server connections are completely replaced by Ethernet early in 1997. No new investments are made in 10-base-2 wire or electronics, and users are transitioned as buildings are renovated and rewired.

Miscellaneous elements:
• Network infrastructure servers are consolidated onto fewer platforms with better redundancy
• AppleTalk and IPX are routed campus-wide and access is provided for remote users
• Desktop hardware and software standards continue to evolve, as Windows 95 use surges
• PennNames, a system for creating a campus-wide unique user name space, transitions to feed a DCE secure core, and client/server services (including network access) transition to Kerberos.

Alternative A: Pervasive Ethernet Switches/Selective 100 Mb

Alternative A is the closest to PennNet's current condition. It preserves our current investment in the technology and operations of a central routing core, installs Ethernet switches in all buildings, continues EIA/TIA 568 as the wiring standard, but only increases speeds within and between buildings to greater than 10 Mb/sec on a case by case basis.

Major features include:

• Inter-building backbone: Collapsed backbone interconnected via FDDI remains, though with fewer, more powerful routers.
• Intra-building backbone: Buildings are connected to the backbone via Ethernet, or 100+ Mb/sec technology (FDDI or fast Ethernet) where necessary for increased bandwidth. Ethernet or fast Ethernet switches deployed in all buildings reduce the size of the collision domain within buildings and provide a scalable building interconnection.
• Wiring strategies and standards: EIA/TIA 568 continues to be the wiring standard. Ethernet switches are deployed within closets if necessary, though shared Ethernets within buildings dominate. Secure hubs prevent promiscuous listening on shared segments. Some 100-Base-X fast Ethernet outlets are deployed. Campus Ethernet connections migrate towards "personal Ethernet" to allow local hubs on 10-base-T or fast Ethernet outlets.

Alternative B: Fully Switched Core

This alternative presents a transition point between Alternative A and Alternative C. The only changes are in the central routing core ("Inter-building backbone"). Rather than a collapsed backbone of routers, the central hub now uses an ATM switch coupled to a "super router" to route between the subnets. A series of smaller routing switches, still located in a central core, start to share a distributed routing load. While management and operations continue to benefit from a single, consolidated location for this equipment, Penn moves one step closer to being able to distribute its routing load to multiple locations when necessary. The nature of the routers and switches at the center are now changing substantially, both in terms of cost and the relative functionality of each object (switching versus routing).

Since ATM switching is now a feature, some direct ATM connections are made possible into the production network either to support advanced projects now in production or servers that require the added bandwidth.

Alternative C: Pervasive ATM

This alternative represents where the Task Force believes Penn should be in 3-5 years. This is mostly dependent on the necessary investment level, but even more important on the development of products and standards in the marketplace to make deployment of or migration to this alternative possible.

Major features include:

- Inter-building backbone: Redundant central hubs, with automatic failover protection, use ATM switching between buildings coupled with a "super router" to route between subnets. An ATM "mesh" is established with some buildings serving as regional "hubs" redundantly interconnected.
- Intra-building backbone: Ethernet switches, eventually with ATM and/or distributed routing support ("edge routing devices"), are deployed everywhere to reduce the size of the collision domain within buildings and provide a scalable building interconnection.
- Wiring strategies and standards: EIA/TIA 568 continues to be the wiring standard. Ethernet switches are deployed within buildings as bandwidth requirements demand. Secure hubs prevent promiscuous listening on the few shared Ethernet segments that remain. Some 100-Base-X fast Ethernet outlets are deployed. Campus Ethernet connections begin to migrate towards "personal Ethernet" which allows local hubs on 10-base-T or fast Ethernet outlets. Limited deployment of ATM to the desktop

Three Additional Variations

Three additional architectural alternatives recognize that the marketplace may not develop in the directions we expect, and/or Penn may need to improve the performance of PennNet in advance of the availability of components to build Alternative C.

Alternative A': Pervasive 100+ Mb Backbone

In most respects this alternative is identical to Alternative A, except that in this case there is the need for all buildings to be connected to the campus backbone using a 100+ Mb/sec technology. To accommodate this bandwidth to every building, the campus backbone needs to change: the collapsed backbone is now interconnected via ATM switch to increase capacity at the core. Subnets are connected to central routers via shared or dedicated connections using 100+ Mb/sec technology.

Alternative AB': Distributed Routing with 100+ Mb Backbone

If the availability of the products needed to implement Alternative C becomes more distant, this alternative may provide some necessary solutions. It provides for a regionalized campus with several clusters of buildings connected together via 100+ Mb/sec technology, and fully distributed routing to each building.

Major features include:

- Inter-building backbone: FDDI switch deployed to handle multiple FDDI rings (or other 100+ Mb/sec technology) required in this architecture. Central routing is only for outside or inter-campus connections.
- Intra-building backbone: Clusters of buildings are connected to the backbone via 100+ Mb/sec technology (FDDI or fast Ethernet) for increased bandwidth. Ethernet or fast Ethernet switches deployed in all buildings reduce the size of the collision domain and provide a scalable building interconnection.

Alternative B': Selective ATM

This alternative allows the campus to migrate more slowly to ATM for inter-building connections.

Major features include:

- Inter-building backbone: Central hub starts to migrate to ATM switch coupled with a "super router" to route between subnets. Routing switches at the core start to distribute routing load. Some routers stay on old FDDI backbone providing connections for some buildings. Some direct ATM connections to core permitted as routing switches begin to migrate to buildings.
- Intra-building backbone: Buildings are connected to the backbone via 10 Mb/sec or 100+ Mb/sec technology (FDDI or fast Ethernet) for increased bandwidth. Some buildings are connected to the backbone directly via ATM and have edge routers installed. Ethernet or fast Ethernet switches deployed in all buildings reduce the size of the collision domain and provide a scalable building interconnection.

Network Alternative Pro's and Con's

Alt.	*Pro's*	*Con's*
A	• easy to implement today • less expensive	• perpetuates use of today's technologies
B	• starts down the road to distributed routing • may reduce per port costs of central routers • may increase overall bandwidth of the routing core	• significantly newer technologies in routing core that use proprietary protocols for distributed routing • depending on timing, ATM may still be too immature
C	• probably where we want to be ...	• can't buy it today • presumes a lot about market directions
A'	• will increase bandwidth to buildings today	• very expensive • perpetuates use of today's technologies
AB'	• will increase bandwidth to buildings today	• very expensive • perpetuates use of today's technologies • introduces additional operations issues as routing devices are distributed
B'	• allows for slower migration to ATM	• multiple generations of backbone technology difficult (and expensive) to operate and maintain

Next steps

The University's department of Data Communications and Computing Services (DCCS), in conjunction with the Network Architecture Task Force, is currently processing the above information and carrying out the following tasks:

- Accelerating legacy phase outs, notably ISN and terminal-server asynchronous services, closet electronics that are not remotely manageable, and obsolescent server architectures
- Pricing the alternatives
- Narrowing the set
- Engaging the campus stakeholders
- Interim deployment of Ethernet switches and other technologies
- Structured consultations with current and prospective vendor partners
- Constant re-assessment, including consultation with university colleagues

In addition, discu· sions are underway to
• Extend the Penn Video Network, now serving 50 buildings, including 16 residences, to other buildings on-campus and off
• Assess extension of the Bell Atlantic Centrex contracts for the University and Hospital versus purchase of one or two switches
• Determine the likely time frame by which ATM can function as the ultimate, voice-data-video integrator

Conclusions

Designing and deploying a cost-effective, high-performance, campus-wide networking infrastructure is extremely challenging, given the rapid pace of technological change, user demand, and vendor reshuffling. At Penn, the challenge is multiplied by our decentralized management, budgeting, and academic computing structures. It is becoming increasingly clear to most stakeholders, however, that in networking, we must, as our founder Ben Franklin exorted, "hang together, or we will most assuredly hang separately." The productive collaboration exemplified by the Network Architecture Task Force bodes well for Penn's networking future.

A more detailed (and evolving) version of this paper, including graphics and links to the CAUSE94 paper, is available on the World Wide Web at URL, [http://pobox.upenn.edu/~danu/cause95.html].

Repackaging and Recycling: Using Information Technology to Enhance Education in the Present and the Future

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This presentation will describe a project in which MLS students repackaged the information presented in a conference on Libraries in International Development using the Internet, video, and CD ROM technologies. Students gained practical experience, melded theory with practice, and produced tangible products to show prospective employers. Faculty gained experience in teaching using new technologies. We believe that the education of the future will be exemplified by this blend of learning, doing, reflecting, and creating products to enhance the educational experience of others.

Context

A fundamental change is taking place in the way we teach, how we deliver content, how we interact with students, and how we manage innovative educational programs. The relentless pace of globalization and technological innovation are accelerating the rate of change and will impact higher education even more in the decades ahead. Educational change is proceeding at variable rates on university campuses, driven primarily by the speed of adoption of information technology, faculty willingness to experiment with technologies, and the positive stance of administrative leadership. Additional factors include changing educational needs of students, nation-wide and global student customers, underlying economies of scale and an ever increasing competition for new students. Information technology enables universities to capture the economies of scale by going state-wide, national, and global. Smart universities rely on technological innovation to increase their market share. Technology is therefore driven by, and a key driver of, the educational market place.

As a school, the School of Library and Information Management at Emporia State University embodies the view of education described above. The following phrases illustrate how we would describe ourselves:

people first
using technology as a tool
customizing services
entrepreneurial
cutting edge
risk taking
valuing nimbleness
valuing diversity
valuing interconnectedness
repackage/recycle/reuse
multiple delivery methods for student learning
global in vision and curriculum

Striving to make the above values a part of our curriculum and our delivery of the curriculum, we prepare MLS students to repackage and customize information to meet the needs of a diverse clientele using appropriate technology such as the Internet, the World Wide Web, video production, CD ROM production, and more traditional database searching. Creativity, entrepreneurial spirit, and passion the topic of information transfer are admission criteria for our students. We offer an American Library Association and North Central Association accredited MLS on the Kansas campus and at distance sites in Denver, Colorado; Portland, Oregon; and Grand Forks, North Dakota. We have graduated students from distance sites in Lincoln, Nebraska; Albuquerque, New Mexico; and Sioux City, Iowa. We will start a new MLS cycle in Salt Lake City, Utah in June. Currently we have about 600 students enrolled in our MLS programs.

Philosophy of Education

Our philosophy of delivering our curriculum is to be responsive to the needs of working adults by providing classes in different formats. In our distance programs, students earn a degree in two years and eight months by attending weekend intensive classes offered about once every four weeks. These weekend intensives meet on Friday nights from 6:00 to 9:00, on Saturdays from 8:00 to 5:00, and on Sundays from 8:00 to 12:00. The face to face weekend intensive is supplemented by satellite, video, two way interactive classes offered via CODEC, Internet classes, home study classes, and classes in a mixed delivery format. Our goal is to be able to offer all our classes off-site and off-time in a variety of media to fit different learning styles.

This vision is consonant with that espoused by Carol Twigg in a recent article in the Educom Review calling for the creation of a national learning infrastructure. This national learning infrastructure is made possible by a variety of technology mediated learning environments "including stand-alone, computer assisted instruction (CAI) applications; networked information resources; experimentation via new modes of communication (e.g., computer conferencing); and distance learning developed by both individual institutions and consortial or statewide efforts and offered primarily, thought not exclusively, via television." This proposed national learning infrastructure would "simultaneously increase access (via the network, improve quality (through the availability of individualized, interactive learning materials), and contain costs (by reducing labor intensity in instruction"(1994:21). To her vision we would add the example of a school which is blurring the boundaries between theory and application, instruction and professional practice, and education and business.

The curriculum of the School is responsive to the idea of situated learning. We believe that a strong theory base in information transfer is necessary for preparing the information professional of the future. Our students therefore receive a thorough grounding in the appropriate theories of the psychology of information use, the sociology of information, information engineering, and management of information organizations. Then in a variety of tools courses and elective courses, they apply what they have learned in the theory courses. Recently the strength of this curriculum has received national attention. In the July/August 1995 issue of American Libraries, Ostler and Dahlin discuss the crisis in library education and end with a description of three entities who are enriching the theory and vision of library education. They describe our program in the following way.

> Emporia State University has developed a cogent new curriculum for library education at both the master's and doctoral levels.

The Project

One example of the application of our curricular philosophy to the repackaging of information is seen in the activities of a number of students and faculty last year. In May of 1995, the School of Library and Information Management hosted The Fifth Conference of Librarians in International Development which brought together one hundred twenty guests and twenty-six invited papers.

The conference was organized around the theme of "A Global Conversation about Information Transfer." Experts on the international information economy, information policy, information technology, as well as librarians who have worked on international information infrastructure projects discussed the implications of the emerging global information infrastructure. Four themes emerged:

1. New Geopolitical Order. The bi-polar world that began at the end of World War II has ended and change in the social, economic, and political order is evident to anyone who watches CNN. While it is not clear what these changes mean, it is apparent that the world is increasingly complex, dynamic and volatile.

2. New Technology. As information technology is embracing international standards, it integrates data, text, voice, and image information for delivery via networks. It is open and networked. Based on interconnectedness, it is modular and dynamic. Technology empowers knowledge professionals across the planet through real-time on-line identification and distribution of information and knowledge.

3. New Information Centers. The old storage oriented library does not work anymore. Instead a virtual, linked, global information-based organization streamlined for quality and productivity is called for.

4. New Information Environment. The stable, industrial-based system of limited competition is gone. It is being replaced with a dynamic, information-based system of unlimited competition. Markets, niche identification, and economies of scale determine the success of organizations. Old rules and ways of doing things are disappearing.

Universities as well as libraries are affected by the emergence of the new information environment. Educational markets have expanded beyond the traditional regional geographic boundaries and now serve national, as well as an international audience. Programs must be customized, timely, delivered wherever and whenever convenient to the learner.

We strongly believe in the message of the conference and in its timeliness. Part of our mission is to disseminate the content of the conference to an audience larger than that which was able to attend. Simultaneously we were able to provide our students with an educational opportunity which allowed them to apply their theoretical learning to practice and to create a product which repackaged and recycled current and timely knowledge.

Normally the knowledge created at a conference is captured at best through the publication of proceedings or may be disseminated in articles based on topics discussed. Later these ideas may also be diffused in classroom discussion. These modalities reflect the dynamics of a positivist, industrial world view regarding dissemination and its role in education. Much information gets lost.

For example, questions and answers following presentations are rarely captured for posterity. Nor is the opportunity of having experts on-site used to pursue ideas that they have presented. Most conferences continue with the old forms and procedures. Yet we have the technology in place to capture the details and nuances of a conference that enriches and adds value to the proceedings.

Modern electronic and digital information technology embody a new intellectual order reflecting the dynamics of non-linear, self organizing, self transcendent, and loosely coupled systems. Examples would include videos, CD-ROM's, listservs, and World Wide Web pages. Use of this technology can alter in fundamental ways the diffusion of ideas in classrooms.

To capitalize on this idea, the conference processes and interactions had to be captured within the context of new technology. Thus the entire conference was videotaped. In addition to the formal presentations, a wide variety of conference activities were documented. Examples include discussions among presenters, questions and answer sessions, as well as selected interviews with presenters.

The planning and organizing of the video documentation started six months before the conference occurred. A video production class was scheduled to begin in January continuing to its conclusion in the weeks immediately following the conference. This scheduling allowed the students to learn the philosophy and techniques of video documentation. The result was conference documentation by a trained production staff undertaking their third project rather than their first. High quality recording of video sequences with accompanying sound was thereby facilitated. Students benefitted greatly from this process: high level of skill acquisition, conceptual understanding of the process of production in relation to the theoretical whole, as well as a sample for their portfolio.

While undertaking the complex processes of pre-production, production, and post-production would normally be beyond the usual resources of a school, the fact that we had knowledgeable faculty in video production, students who had taken the aforementioned video production course, and technical support from our own Information Technology Lab helped reduce the complexity of such a project.

The Video and the Class

Once the conference in all of its variety and richness was captured on tape, the second phase of the project began. A number of students worked with faculty to edit the presentations of the keynote speakers into a series of videos. This was accomplished within six weeks of the end of the conference. These videos were then mailed to the group of students enrolled in the summer course on the Global Information Infrastructure. The students viewed the videos and discussed the issues they raised on a listserv expressly created for this purpose. Discussion was prompted by a question raised by the instructor. Then conversation was allowed to flow freely. Research by students was posted along with comments and critique by faculty.

Periodically the faculty printed out listserv messages covering a one to two week period. To facilitate content analysis printouts were assembled horizontally by time and vertically by subject. Themes were identified and correlated. The faculty members shared their analysis with listserv participants. Questions generated by the analysis instigated a rich process of value adding and dynamic scholarly discourse. Faculty analysis provided a key element in this digital discourse. The analysis provided the essential structure to what could have been merely a meandering conversation often exhibited in class discussion. Structure transforms information into knowledge.

This kind of teacher student interaction illustrates one way in which technology enhances and changes teaching. Class time is no longer spent delivering information since class participants viewed the video which captured the presentations of the conference key note speakers. Instead class time or listserv time is spent discussing ideas. Instead of the surface discussion which is the usual hallmark of face to face classes, students could view the video at their leisure. Then they could construct thoughtful responses to the discussion questions posed on the listserv. In the same thoughtful way, the faculty members could look at patterns which emerged in listserv discussion and shape and mold the discussion in a way different from the face to face classroom.

This kind of learning draws on what Walter Ong describes as "secondary orality." As Ong states, "This new orality has striking resemblances to the old in its participatory mystique, present moment, and even its use of formulas. . . . Secondary orality has generated a strong group sense, for listening to spoken words forms hearers into a group, a true audience, just as reading written or printed texts turns individuals in on themselves. But secondary orality generates a sense for groups immeasurably larger than those of primary oral culture, McLuhan's 'global village'" (1982:137).

The learning engendered by this combination of video and listserv class allows students the richness of multiple perspectives of a large class, access to world class thinkers on a timely topic, and the ability to assimilate the knowledge reflectively and craft responses to issues in their own time frame. By having to write their responses, they have had to draw on a deeper level of cognitive ability than an oral response calls for. Faculty also benefited from the experience of teaching in this new medium. The learning activities had to be reshaped and rethought.

The CD ROM

The next stage in the process is to involve a team of students in the creation of a CD ROM based on the original video of the conference activities. This activity is another example of the repackaging and customizing that is a vital part if the School's philosophy. The repackaging will draw on the theory of the visualization of information and on information engineering to make a new product available that is not bounded by linear constraints as is a video. Because CD ROMs will hold more information than a standard videotape, they will allow students to make more sophisticated choices in deciding how to make the information from the conference available to a user. As they log the information contained on the original video down to the sentence level, students will decide how to link ideas to make available the information in a hypertext format.

In ways not possible in real life or on video, students using the CD ROM will be able to juxtapose the ideas of different experts on the same topic and replay them at their own time. They will be able to view how the formal and informal conversations among conference participants amplified the discussion of the topic. They will be able to see the text of the speeches and hear them being spoken by the expert as they were originally delivered.

Thus the students involved in the CD ROM will be repackaging and recycling information and creating new knowledge in the way they making new combinations of information available. This kind of repackaging can continue for a number of semesters since a pool of video information has been created that can be used again and again as it is shaped for different audiences.

An initial evaluation of the success of the taping, video and CD ROM activities tells us that it is accomplishing the goals the faculty desire. It gives students an opportunity to apply their theoretical learning. It disseminates the content of a conference containing valuable information beyond what the usual life span. It allows a larger student audience to benefit from current information that can be accessed off site and off time. We are now looking forward to our next project. In 1997, the Sixth Conference of Librarians in International Development will be held at the University of Colorado at Boulder. A team of our students in the distance program in Denver will do the videotaping of the conference and have first choice of the activities of editing the video and creating the CD ROM.

This repackaging has a commercial application for the School also. Although we have done no marketing, people have begun to contact us and ask to buy copies of the video. We anticipate the CD ROM will have an equal or greater attraction for business people interested in the Global Information Infrastructure as well as for librarians and area studies faculty. As a faculty we have to decide how much effort we want to put into marketing and distributing these products. It looks like this is a project for the class in information brokering.

Conclusion

This new approach to curriculum design embodies the values and techniques of the global information economy. Some of these include seizing opportunities, sharing risks, allowing for multiple inputs and multiple outcomes. It also embodies the philosophy of the School to use technology as a tool to enhance learning. This cutting edge, entrepreneurial thrust will enable us to repackage/recycle/reuse information while giving our students the opportunity to apply what they have learned--hopefully becoming more marketable in today's competitive job market. We believe that this kind of experimental activity is the way higher education can remain viable in the 21st century.

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The Internet: Changing Relationships and Forging New Practices

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Abstract

The promise of the electronic age is one of making information accessible to people without time, place or format constraints. Today's technologies and applications pale in the face of the opportunities presented by tomorrow's high speed, commercial networks. Networks are restructuring our businesses and herald the inevitable transformation of higher education. This paper focuses on issues associated with the evolution of the way business works, drawing on influences of the restructuring of businesses on universities, and it suggests how remote access to university resources may transform the institution.

Transforming Our Organizations

Networks have changed the way business works. They have blurred the distinctions among suppliers, manufacturers, retailers, and distributors and closed the gap between the consumer and the company. Changing relationships are creating virtual companies where networks are an essential management resource. Whatever the business, the focus is on the customer connection. The customer-marketer dialog and interactive advertising over the Internet replaces the current mass-market advertising model with a one-to-one marketing paradigm aimed at achieving personalized service and flexibility that support excellent customer relations. [1]

Network communications capabilities have also changed the landscape of corporate research. Research teams are formed with the best scientists from different branches of the organization and often in collaboration with researchers from other companies—once considered competitors. The strategic use of global networks for collaboration is an important priority for American companies and sets the stage for shared discovery. Getting quality products from the lab to the market place in the shortest possible time and in the most cost effective manner is a major goal of corporate research. [2]

The success of businesses in streamlining their organizations and in using technology to become more responsive to a changing market-place has not gone unnoticed by institutions of higher education. Our cost-saving strategies are patterned after those of the corporate world and our long-range plans are peppered with such terms as downsizing, reengineering, total quality management, productivity, empowerment, outsourcing, and customers. Like the business environment, higher education strives to improve quality, contain costs, and increase access among its highest priorities. Restructuring higher education means reevaluating alternative delivery systems, curricula, organizational structures, technologies, and personnel. [3]

Downsizing and Restructuring

With declining sources of revenue and escalating costs, the price of a college education has outstripped many families' ability to pay. Universities and colleges have already begun downsizing their institutions, helped by early retirement programs, department mergers, communication technologies, and powerful software programs that shifted some of the workload from staff to faculty, thus reducing the need for certain types of secretarial services. Secretaries who could search, retrieve and catalog electronic information as well as handle managerial tasks became important assets to the department, others found their jobs eliminated.

Improvements in student administrative support services (admission processing, registration, financial aid, and billing) represent another area where transformation of business processes has led to better student services and reduced operating expenses. For example, when overall costs of college operations grew at a higher rate than inflation and revenues remained static, Babson College embarked on a major reengineering project. Its purpose, writes President William F. Glavin,

> is to reduce, streamline, and simplify the administrative operations of the institutions, freeing students, parents, employers, faculty, and staff from bureaucracy and paperwork so that they may devote more of their time and resources to learning and teaching. To this end, we envision a work place which focuses upon the delivery of high quality services to our customers through the efforts of cross-functional, self-directed teams, and responsive, easy-to-use, information systems, and technologies." [4]

While administrative services have used technology and better business practices to help reduce costs, there remains the need to find a less expensive way to deliver education. Technology, it is suggested, holds the key to this dilemma with the possibility of reaching and retaining a wider audience. However, technology represents a significant capital investment and requires a transformation of governance, assessment, and relationships with students.

Empowering Employees

In a networked environment, every level of the organization has access to more information than it can possibly digest. This makes the traditional hierarchical approach to information, where those at the top control the information while those at lower levels have limited access, no longer applicable. Today, people at the lower levels have access to external information that brings the competitive pressures facing higher education right to their desktops. In the business world, this result has led to a flatter organization with more opportunities to participate in the decision-making process. This trend has yet to appear in universities to any major extent, although there is evidence that electronic communication "reduces overall miscommunication, equalizing participation levels, weakens status systems, and emphasizes informational rather than normative influences." [5]

We need to pursue strategies that promote the successful practices of the Internet such as collaborative development of resources and services, direct participation in decision-making, and innovative ideas that spring from unexpected sources. [6] Information gaps among administrators, faculty, and staffs can be bridged if the electronic internal information-sharing structure also incorporates their insights. Frequent reviews of strategic plans are also important in that they keep in the forefront of our minds the future of the institution and our place in a market-based environment. Only a well-informed university community can recognize and respond to opportunities, unmet student needs, competitive information, and achieve the goals of a shared vision and mission for the campus. The right leadership can make it happen.

More than ever, students are everyone's concern. Their needs and objectives will influence the curriculum, the design of learning materials, and the delivery of instruction. If reengineering teaching and learning is about anything, it is about providing differentiated services to a diverse student body. [7] Information technologies make it possible to offer customized services with assistance from experts from different fields and in collaboration with other institutions and organizations.

Administrative Response to Change

Despite the fact that higher education has emulated business goals in administrative services and become more responsive to students' needs, colleges and universities have adopted instructional innovation very slowly. For example, one would expect that innovations designed to enhance instruction in large classes would be especially attractive to institutions with a high student-faculty ratio.

This is not the case, according to Siegfried, Getz, and Anderson [8] who found no "association between that ratio and any of the innovations aimed at teaching large classes more effectively, such as video projectors and wireless microphones." They reason that some colleges and universities are insulated from the competitive pressures that would force them to stay on the cutting edge in information technologies. For some institutions, differentiation in curriculum and proximity to the student's home town creates market power. But for those prestigious colleges and universities not driven to innovate more quickly, Siegfried et al. recommend that the governing boards need to explicitly encourage their institutions to be more progressive by identifying new practices to be adopted that the board can evaluate and then reward administrators for managing change successfully.

The resurgence of interest in undergraduate education on the part of university presidents offers some ground for optimism. The reality remains that faculty have not been promoted for infusing technology into the curriculum. Thus, faculty have generally shied away from the extensive time commitment required to become adept at using and managing new information technologies. The traditional criteria for promotion are still classroom teaching, research, and service with research generally given preeminence over the other two.

Administrators must work closely with faculty to find alternatives to the current instructional model and a means of controlling institutional expense and student costs.

Technology, by itself, cannot overcome bureaucratic disincentives. Success in integrating technology into the teaching process depends on early engagement of faculty in the planning process where training, support services, and recognition for their work in instructional technology are a part of the strategic plan.

With current competitive forces and the new educational alternatives available to students, universities can no longer refuse to invest in technology; they can only determine rate of implementation. A teaching infrastructure—linking computer, video and telecommunications technologies with the home, institution, and workplace—must be in place for instructional technology innovations to thrive. A flexible learning environment that focuses on the learner will depend on an infrastructure to facilitate technology-mediated learning.

Many universities have linked their classrooms, offices, and residence halls. Some have also included the local community in their network, and most would like to be able to extend their campus resources to distance learners wherever they may be. The argument is not whether one delivery system for teaching and learning should replace another. Rather, faculty should have the technological capability and be encouraged to experiment with technologies in their pursuit of the best mix for learning without compromising quality, and the institution should focus on making education available year-round—thus, reducing the time required to get a degree. These issues—an interactive infrastructure, a reward system, and a strategy for managing change—are some of the pressing issues that presidents must confront as they make choices about how scarce moneys are to be spent.

Collaboration and Distance Learning

New opportunities precipitated by advances in communications have brought universities and telecommunications companies together. In spring 1995, New York University offered a 16-credit graduate program entirely through an interactive network. NYU's collaborator, NYNEX, New York's main telecommunications company, linked each student's home to an NYU computer-base of instructional videos and group-communications servers through an Integrated Services Digital Network of high-speed telephone lines. Using the NYNEX ISDN service, NYU teleprogram students access video lessons on demand and participate in online computer laboratories as if they were in on-campus labs. According to Richard P. Vigilante, director of the Information Technologies Institute and founder of the Virtual College, online instruction provides busy adult students with a far richer learning experience than they would traditionally receive by just attending their evening classes. [9] Success with this delivery system will encourage promotion and expansion of other NYU courses aimed at students who want alternatives to classroom attendance and education-on-demand.

In addition to creating course materials for local use, some institutions are developing resource materials with an eye to sharing them internationally. The World Wide Web Server for Virology at the Institute for Molecular Virology, University of Wisconsin-Madison, was designed to disseminate virology-related information to scientists, students, and the general public. Included in the resources available are computer-generated images and animations of virus structures, topographical maps of virus surfaces, digitized electron micrographs, and much more. Not only is the server an important reference resource, but it can also be used as a forum for teaching.

Virologists are invited to participate in the bionet.virology USENET newsgroup and to share their course syllabi with new instructors. Being able to customized the virology server for use by their own students offers another exciting possibility. From the research perspective, it is simple to obtain structured data from a variety of sources and view animations of interactive visualizations of these data on their own computer. Researchers are encouraged to submit additional virus visualization to the virology server, thus, increasing its value to virologists throughout the world. "Ease of access to rendered structure data is expected to catalyze speculation and collaboration among virologist." [10] The uniqueness of this collection of resources is that it can serve both instructional and research purposes.

The "Making of America" is an ambitious collaborative project between Cornell University and the University of Michigan. Together, they are building a distributed digital library in the humanities—specifically 19th century U.S. history materials. Funded by the Mellon Foundation, the first phase of the project includes converting to digital image form 5,000 volumes from the holdings of the two library systems and making them available across the two campuses. As a part of the project, there are plans to conduct evaluation studies on user acceptance of digital surrogates and on the costs associated with the development. [11]

It is intended that this digital collection of books, articles, manuscripts, drawings, architectural blueprints, business records, maps, and other materials will include approximately 100,000 volumes in the next few years and will encompass a variety of disciplines bearing on the history of America. Project collaborators assume that "providing worldwide network access to such an electronically integrated collection of 19th century American history will open new opportunities for interdisciplinary research." [12] The project represents one of several "virtual" collections in specific fields which are being created and made available electronically, increasing the ability of students and faculty to share important historical resources.

Networks are the glue that hold collaborative projects together. They facilitate the cross-fertilization among disciplines and synergistic collaboration among the public and private sectors. Many of the projects currently underway are leading to the creation of significant teaching resources and research materials which can improve teaching and enhance research capabilities.

Approaching a Virtual Community

There is a shift away from schools as the central site for learning towards the home, businesses, libraries, museums, and other organizations. [13] Freeing students to learn at times and places of their own choosing requires new ways of thinking about the process of teaching and learning and the uses of university space and personnel. Distance learning presents a great opportunity to restructure educational methods to facilitate new delivery modes for a diverse population. However, many instructional television programs and Internet courses remain tied to traditional classroom and correspondence course metaphors, respectively. For the technology to succeed, it must have the underpinnings of an appropriate instructional model, and the faculty must have access to a full range of multimedia tools and support people to develop and implement new learning materials. Use of new technologies may likely be a participatory team effort bringing faculty, delivery personnel, and instructional designers together. [14]

Information technologies call for a new set of faculty-student relations. Faculty will move from lecturing to mentoring, giving more guidance to individual students and becoming active participants in the learning process, using a similar model to that of the graduate scientific research faculty and their students. In this teaching-learning interaction, students will shed passive note-taking for more immediate processing of information and problem solving. Classes will extend beyond the allotted time over the Internet. E-mail access to the faculty frees learners from the time and place constraints imposed by faculty office hours and gives students an opportunity to improve the quality and amount of communication with faculty. Students say that they form a closer relationship with their instructor and with other students through electronic mail and bulletin boards, that they get more timely and constructive feedback. There is a definite sense of community that evolves and a gradual transformation from passive learning to more self-directed learning.

Responding to Diversity and Distance Learners

One important contribution that information technologies can make is in addressing different cognitive styles. Some people learn best by reading, others by seeing, listening, teaching their peers, working in groups or some combination of these modes. Only a small percentage of the population are strictly auditory learners, yet this has been the predominant delivery mode. Furthermore, traditional pedagogy focuses on only two of seven human intelligences identified by Gardner:

the linguistic and logical-mathematical intelligences as reflected by intelligence test and other measures of ability.[15] (The other five intelligences are spatial, bodily-kinesthetic, musical, interpersonal intelligences, and intrapersonal intelligence.) Educational experiences that promote the various multiple intelligences and interlinkages need to be considered in the design of optimum electronic learning experiences.

Another important contribution would be the provision of just-in-time learning. The military, government, and industry have been successful in providing just-in-time training for problems that may arise on the job and must be solved before work can be continued on various projects. Expert systems help tank mechanics, power plant operators, income tax personnel, and a host of other workers learn on the job. Thinking about how people learn on the job is becoming an important research area. Designers are currently interpreting how people work and how the work gets done. This knowledge will be incorporated into tomorrow's powerful work systems and tools in an effort to support a productive business environment and have ramifications for higher education (see [16]).

Some faculty have also begun to apply simulations and smart tools as teaching-learning aids in their courses. Marie-Michèle Boulet [17] has developed an intelligent advisor system (Conceptual Database Modeling Advisor, CODAMA) for use in her two distance learning courses, "System Analysis" and "Design and Information Technology." The CODAMA, an adaptive system, assists distance learners in each of the several stages involved in database design. The system provides an on-demand learning environment which erases the boundary between learning and doing for distance learners.

The Choices We Make

Positioning Ourselves in Light of New Competition

The cost-effectiveness of communication also means that institutions of higher education can expect new competition. Britain's Open University recently delivered its first course on a CD-ROM. At universities around the world, technology is toppling the ivory towers. Approximately 4,000 corporate engineers currently "earn advanced degrees at their workplace via satellite from the National Technological University, now one of the largest engineering schools in the nation." [18]

Rochester Institute of Technology (RIT) offers graduate and undergraduate degrees including health systems administration, management, environmental management, applied computing, telecommunications, software development and management to students in 16 states. RIT recently has enrolled 150 high school students in a pilot program. Courses are designed to use a blend of four technologies: videotapes, conference calls, computers, and print material. Some cou ses are also supported by other technologies, including picture phones, electronic blackboards, or audio cassette tapes.

Another virtual institution with impressive enrollments is Maryland's College of the Air which specializes in part-time education for military personnel in Europe and Asia, using computer-conferences and voice-mail to allow students to communicate with instructors and with each other. The College offers 10 telecourses per semester via the Maryland Center for Public Broadcasting to approximately 10,000 students.

Competing with colleges and universities is a private company, Jones International Ltd., which operates cable television companies and Mind Extension University. Mind Extension University offers certificate and graduate degree programs in education, business, and library science. These graduate programs are delivered over the Jones Education Networks and are sponsored in cooperation with Colorado State University, the University of Arizona, and the George Washington University. In fall 1996, Jones International Ltd. is scheduled to launch two new networks: a Health Network and a Language Network—both are considered to be principal markets for distance learning.

International University College, also a creation of Jones International Ltd., is a recent newcomer to the growing list of competitors. It offers a Masters Degree in Business Communication and is billed as a low-cost alternative to traditional courses in higher education. Instructional materials for this degree program will be produced on videotape, and faculty members will use the telephone and electronic mail to correspond with students. The audience will be international and attract people not served by traditional colleges.

Internet courses are also fast breaking ground with over 30 accredited universities offering more than 650 courses over the Internet in 1995. Many of these offerings use the Internet primarily for its communications facilities. Nova Southeastern University, for example, grants M.S. and Ed.D. degrees using online technologies for communication and for discussion of the curriculum. Students have immediate access to electronic mail, bulletin boards, and formal, real-time electronic classroom sessions. Another example is Britain's Open University which plans to offer several courses and programs over the next year using the Internet as the communications medium between students, their tutors, and the university administration. Degrees offered will be the Masters in Open and Distance Education and the postgraduate computing courses which lead to an M.Sc. in Computing. In contrast, the Indiana University East and several other college programs use the Internet exclusively, registering students and providing all learning materials (tutorials, exercises, texts, and guides), assignments, and tests online.

However, it is likely that most institutions will continue to support teaching with a mix of media—some blend of networking technology combined with satellite, cable television, and CD-ROM—at least until speedier connections make transmitting multimedia over networks the norm.

Increasing the Value of Existing Resources

The Internet has significantly changed the way business is being conducted in the United States and abroad from marketing and selling products to the development of new products with customer participation. It has revolutionized the way business communicates by enabling them to put on-line marketing literature, product documentation, catalogs, and discussions about the performance of a specific product at other sites. In essence, the Internet is the world's largest store, the world's largest public library, the world's largest directly connected community, and the world's largest umbrella for public education.

The Internet is already changing the relationship between faculty and students and enhancing and facilitating student learning. Al Filreis, University of Pennsylvania, speaks often about some of the benefits of teaching his course on Modern American Poetry online. The silent ones in class, he says, found their voices online. Further, in reading each others statements, students became more aware of details and the consequence of their arguments and spent serious amounts of time thinking about poetry. [19]

Capitalizing on students' enthusiasm for web assignments, Daniel Anderson, an instructor in the Computer Writing and Research Laboratory at the University of Texas at Austin, created a web service for his American literature class. The American Literature Survey Site features fiction by American authors, papers, student reviews, and transcriptions of class discussions. A message board was added to allow Internet users to comment on students' essays. As the web site developed, individuals outside of the class began to respond. University students were surprised and motivated by the interest and comments of the outsiders, who one day just appeared. Other classes soon joined, allowing multiple perspectives about texts to take shape. Professor Anderson says it is a pretty amazing, new way of teaching.

One of the remarkable things, he notes, is the increased life expectancy and "membership" of the class. "The resources that the students developed are being made use of more now than even when the course was in session. Most students are still on the site listserv and receive feedback from all over the country. The site is showing the possibilities for students to interact with and impact an audience on a large and possibly long term scale." [20]

Many activities that impact on student learning are now available on the Internet. The examples given above demonstrate the value of online faculty-student interaction and intense small group discussions on specific topics. It is worth mentioning that students no longer lose touch with home town contacts and friends who are attending other schools. To this list, they continually add new people for mentoring and advising, encouragement, sharing experiences, and help with assignments. Some of these activities were once the responsibility of individual faculty to manage and are now available globally, 24 hours a day, 12 months a year from everyday people to experts in a particular field.

Up to now, faculty have typically spent very little time involved in what the literature cites is needed to assure quality: student-centeredness, attention to the teaching and learning process and gaining the feedback to assure educational effectiveness. However, when 25% of the freshman class drop out (most of whom leave for reasons other than lack of intellectual ability) and 55% do not graduate within four years, the institution needs to examine more closely its educational practices. The availability of the Internet, with its low-cost global communications, appropriateness for collaborative work, on-line software, and unique databases, gives us reasons to rethink the role of faculty and the use of technologies in order both to enhance student learning and reduce costs. In a networked society, we can expect that faculty will spend much more time locating or creating teaching materials and in organizing them into appropriate blocks of learning for a diverse student body. How will their restructured role change learning? One view is that:

> ...students will spend more time learning by themselves and with their peers and much more time engaged with powerful, interactive technologies, and will spend less actual time--but more creative, intensive, and focused time--with faculty members. Faculty, in turn, will work with greater numbers of students but "teach" much less [in the classroom]. [21]

Distance learning, as a supplement to existing university life, will play an increasingly larger role in providing greater opportunities for all learners and will have a profound effect on higher education as it blurs the lines between high school and college and degree programs and shifts society toward lifelong learning. [22] The possibility of taking distance learning courses at convenient times throughout the year will create enormous competition for students among higher education institutions. Since the full cost of an education will likely become the individual's responsibility, greater numbers of students will attend universities part-time and be highly motivated to shop around for the best solutions to their educational needs, whether they be in non-degree or degree programs held on- or off-campus.

If the Internet is to totally reshape education, it will have to move from the glitz of home pages to a conveyor of instructional content. Nevertheless, technology, in one form or another, will radically change the way society learns and provide some exciting resources for teaching and learning.

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Networks & Learning Environments: Responding to Growing Demands

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ABSTRACT

The nature and roles of campus networks are changing as its usage spreads across the campus, around the world and into an ever-increasing number of offices, dorm rooms, labs and classrooms. Technologically, it is evolving to include new forms of data like voice, image and video, as well as new technologies like FDDI and ATM.

In turn, these vast changes in network infrastructure will pave the way for introducing entirely new forms of management and learning as well as for increasing the effectiveness of the existing models.

How are institutions responding to what has become a seemingly never-ending demand for network access? Based upon the results of five annual surveys of higher education institutions, this paper will provide a trendline analysis of change -- between 1991 and 1995 -- and will focus on the areas of networks, network-based services, distance learning and other forms of technology-based learning environments. All analyses will compare the results for the entire higher education community in contrast to the major Carnegie classes.

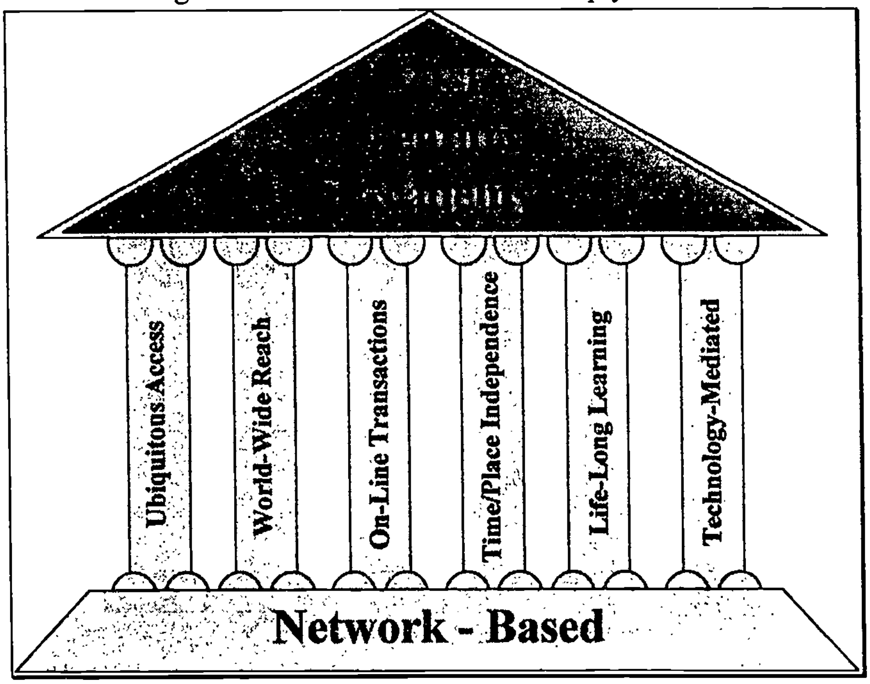
Introduction

This paper will examine the changing roles and nature of campus networks as its usage spreads across the campus, around the world and into an ever-increasing number of offices, dorm rooms, labs and classrooms.

The data for this paper are derived from our survey of Higher Education conducted during the spring of 1995, combined with data from four previous surveys conducted annually from 1991 through 1994. The text is further augmented by personal knowledge as well as by comments obtained from interviewing many leading Higher Education trendsetters. We begin by understanding the operational framework, within which the "21st Century Academy" will function.

The 21st Century Academy...

The following model is not intended to imply that we are entering an era in which all institutions will look alike. In fact, it is much more likely that we will enter the 21st century with not one model, but rather many. Further, we should expect a much higher level of differentiation among institutions, as they struggle to operate along the continuum of their core competencies in order to compete in an increasingly competitive market environment.



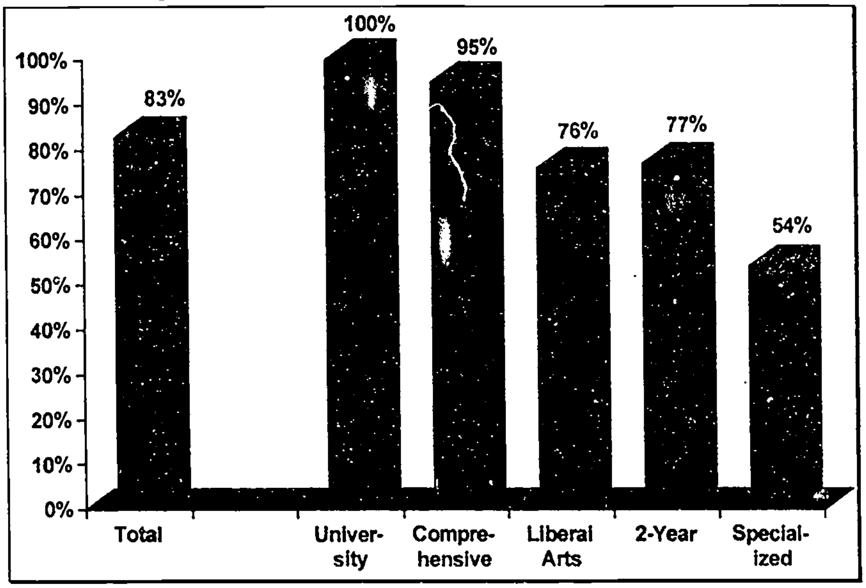
If not now, then in the near future, most institutions will plan and optimize -- to varying degrees -- along the following operational priorities: Ubiquitous Access; World-Wide Reach; On-Line Transactions; Time & Place Independence; Life-Long Learning; Technology-Mediation and Network-Based Operation. Will all institutions be fully engaged across these parameters by the turn of the century? Not likely! Clearly, not all institutions will offer courses on a World-Wide basis, but many students and faculty are likely to extend their research and collaborative undertakings to places outside the United States. Likewise, not all will offer corporate training or complete degree programs through distance learning, but some community colleges will offer English as a second language and skill certification on machine tools and CAD/CAM software. From the President's desk, to the janitor's closet, these operational priorities will drive performance and decisions for all stakeholders!

What role will technology play in all of this? Technology provides a base platform -- an infrastructure -- upon which higher education can re-frame itself in terms of both management practices and the delivery of instruction and research. And there is no technological element more important than the network...

Networks: The Enabling Infrastructure

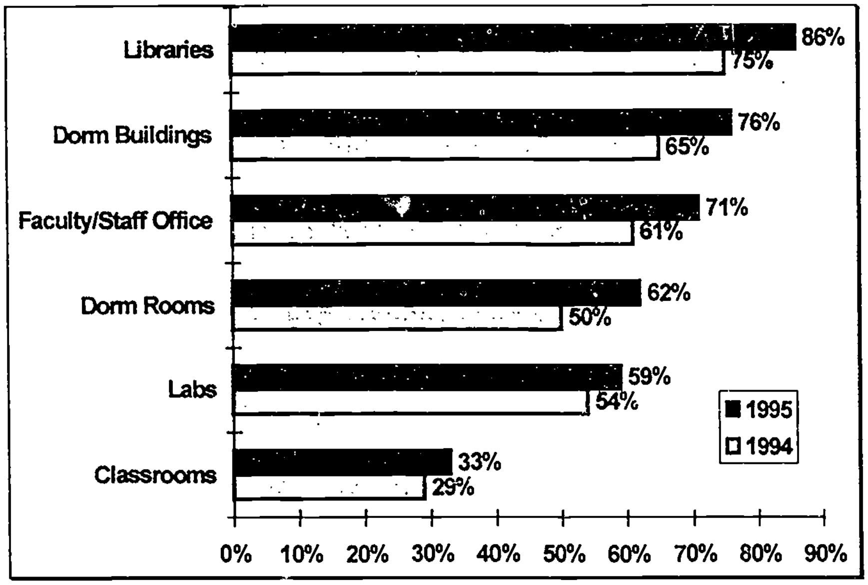
Access to networked-based resources is rapidly becoming the major enabler of the academic mission. Available networking technology is creating an unprecedented facility for sharing and collaboration among educators as well as presenting new expectations for services to students. How are institutions responding to what has become a seemingly endless demand for network access?

The first step in response to the networking challenge is, of course, to implement a campus backbone. Let's begin our look at campus networks by considering the change, since 1993, in the penetration of campus-wide networks. Overall, the percentage of institutions with a campus network increased slightly from 73% in 1993 to 75% in 1994 and finally to 83% in 1995.



Penetration of campus networks is now quite high, with 83% overall and 100% for universities. But the mere presence of a campus network is just the first step. The next issue concerns the types of buildings -- and therefore functions -- which are connected to the campus backbone. By looking into the types of buildings that are connected, we can understand how fast backbone connectivity is growing in key areas.

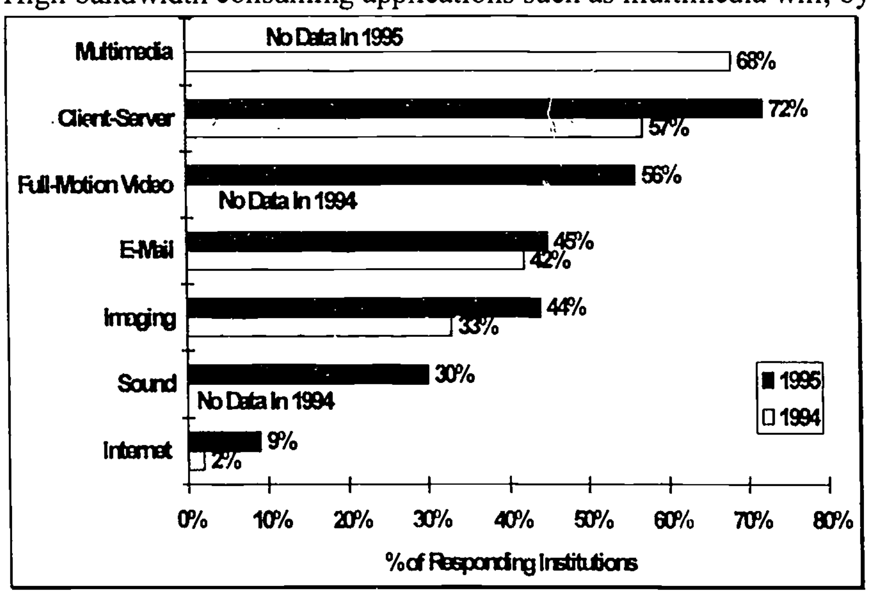
We have been measuring backbone connectivity by space category since 1991 and have found that the connectivity of all space categories has grown significantly. The following chart details connectivity growth between 1994 and 1995 in all space categories as follows: Classrooms grew from 29% to 33%; Dorm Rooms from 50% to 62%; Labs from 54% to 59%; Faculty/staff offices from 61% to 71%; Dorm Buildings from 65% to 76% and Libraries from 75% to 86%.



What's Driving Bandwidth Demand?

Bandwidth and money... who among us will admit to having enough? Campus-wide applications, like CWIS (Campus-Wide Information Services), e-mail, library access, client/server, and Internet applications -- along with increasing volumes of users -- each and all contribute to an ever-increasing demand for more bandwidth.

High bandwidth consuming applications such as multimedia will, by their nature, increase the demand for bandwidth, but the volume expectations of lower applications like e-mail also factor strongly into institutions' bandwidth requirements. In 1994, Multimedia topped the list, with 68% of all institutions responding. Further, the responses across the major Carnegie classes do not differ dramatically and range from a low of 21% in comprehensives to 29% in universities. In 1995, we decided to divide Multimedia into its two major

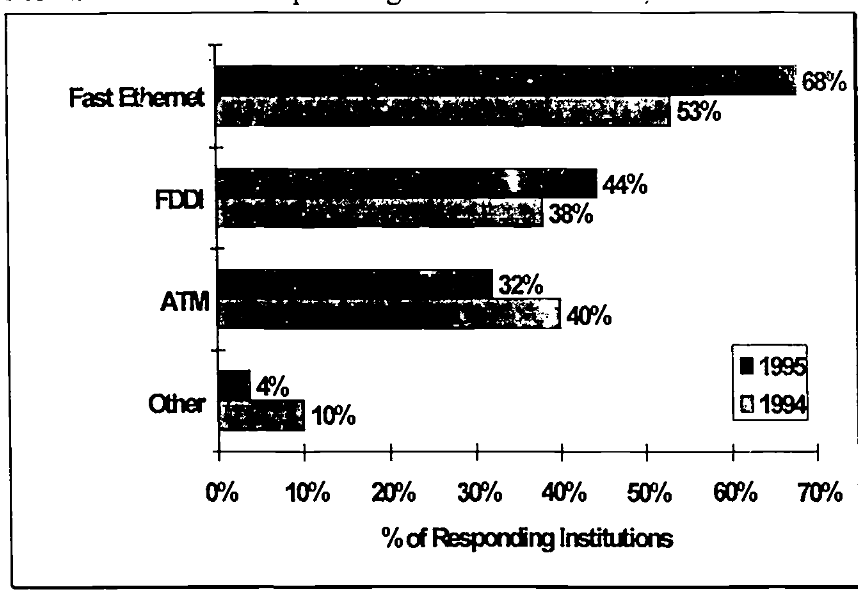


components of full-motion video and sound. The results indicate that full-motion video placed in the top three applications, while sound is near the bottom of the list, with only 30% of institutions responding. What's driving demand for full-motion video? We can only speculate that it is likely driven by the increasing demand for network based instructional and research resources.

That client-server is at the top of the list is not a surprise. It is surprising, however, to find that so many institutions indicated e-mail as a major driver. E-mail was supposed to be a trick question. E-mail, by itself, is not a bandwidth hog, but an exponential increase in the number of e-mail users changes the equation. With just under half of all institutions responding to the e-mail category, we might infer that all institutions are gearing up for essentially ubiquitous access to e-mail. It appears that even the musicologists don't want to be Luddites!

Demand for bandwidth is an ever-present concern that comes with the territory of networking in higher education institutions today. Given the vast increases in "connected" campuses, along with the demand for high bandwidth applications, such as multimedia and imaging, we would expect to find many institutions planning to increase their network bandwidth... and we did. Overall, 68% are either currently -- or planning to -- increase bandwidth. We have estimated that more than 2,000 institutions are bandwidth shopping.

For those institutions planning to add bandwidth, which technologies are they planning to add? Fast Ethernet tops the list, with 68% overall -- up from 53% in 1994 -- and its demand is strongest in 2-year (75%) and specialized institutions, with 80% responding. FDDI is next, with 44% responding overall and up from 38% in 1994. It appears to be favored among comprehensive (43%) and specialized institutions (60%). ATM, with 32% -- down from 40% in 1994 -- continues to be favored by the largest institutions, with 59% of those with over 10K enrollment, responding.



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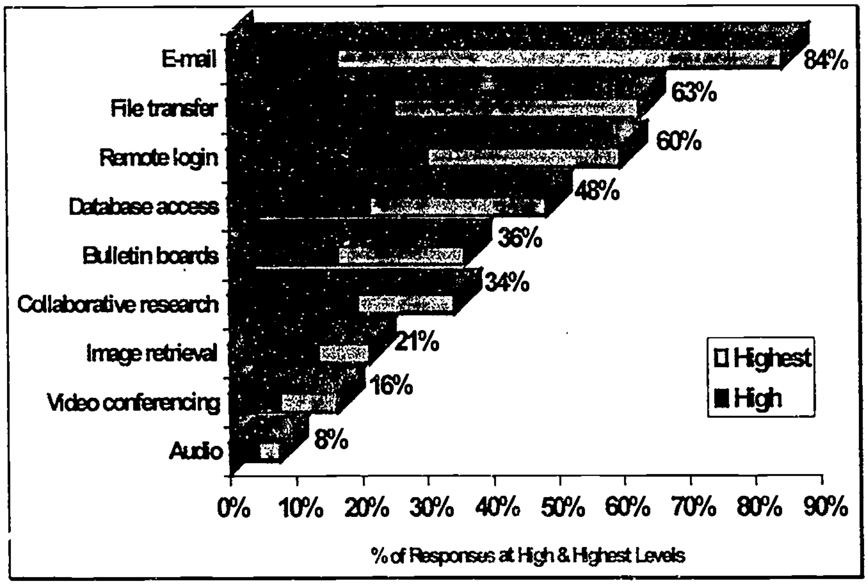
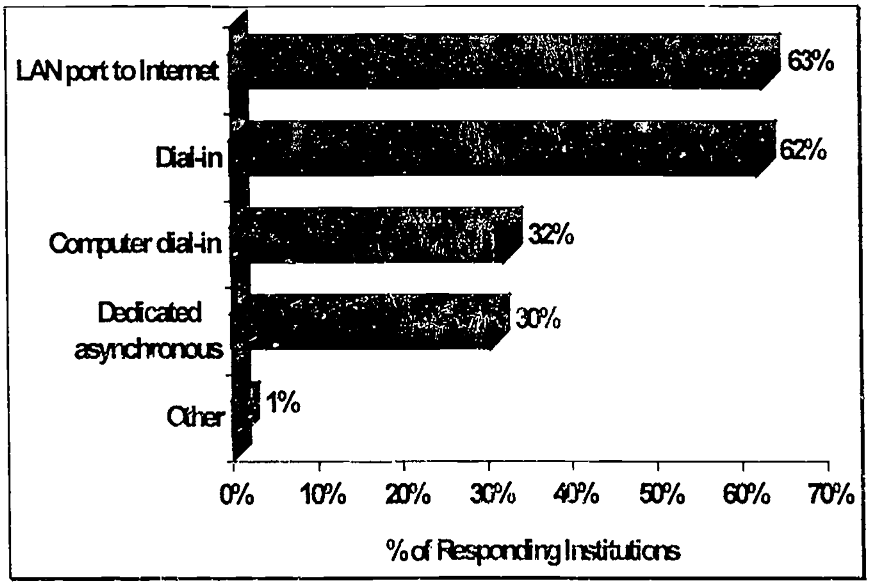
The Net

The Internet... the much-touted solution to all problems, large and small... offers an enormous array of opportunities. Which Internet applications enjoy the highest use in higher education? We asked respondents to rate their institution's usage on a low-to-high scale of 1-5. The following chart describes the proportion of "high" and "highest" responses. For two years in a row, we found e-mail and its companion, file transfer, as the two highest-rated applications. In fact, for all applications -- except bulletin boards -- usage increased. Further, as we looked across the Carnegie classes, we found that Universities had the highest rate of usage, while 2-year schools had the lowest usage, across almost all applications.



... But all Internet access is not created -- or implemented -- equally! And given the 62% "dial-in" response to the question of what level of Internet access is provided, we can assume that "some number" of users -- across all Carnegie classes -- are accessing the Internet, at least some of the time, through dial-in. This results either because it is their only option or because it is the only option which is time and place independent. For example, most students and faculty may have network access to the Internet when in their office or in specific on-site labs, but may be relegated to dial-in when in their dorm rooms or homes. LAN port to the Internet, with 63% responding, was the most frequently mentioned form of Internet access. In general, the frequency of this response was positively correlated



with enrollment. As an example, over 80% of all respondents with over 10K students responded. In contrast, only 42% of those institutions with fewer than 1,000 students mentioned this form of access. Dedicated asynchronous access was mentioned by only 30%. The universities and comprehensives lead with somewhat over 42% responding, while only 17% of the liberal arts colleges responded.

So much for the present networking situation. What is the prognosis for the future? From the perspective of campus network users, there is both good and bad news. The good news is that network investments needed to enhance basic infrastructure and to increase bandwidth are likely to continue. The bad news is that demand will continue to outstrip supply as more users "login" and demand more access... to send and receive more data, in more forms, to more locations, across the campus and around the world. The future looks like a continuing game of "catch up!"

And, networks aren't the only "catch-up" game being played in higher education. Our data suggest that technology integration into the curriculum is on an upward curve. The following section provides a view into what higher education institutions are doing today.

Technology-Mediated Learning: Are We There Yet?

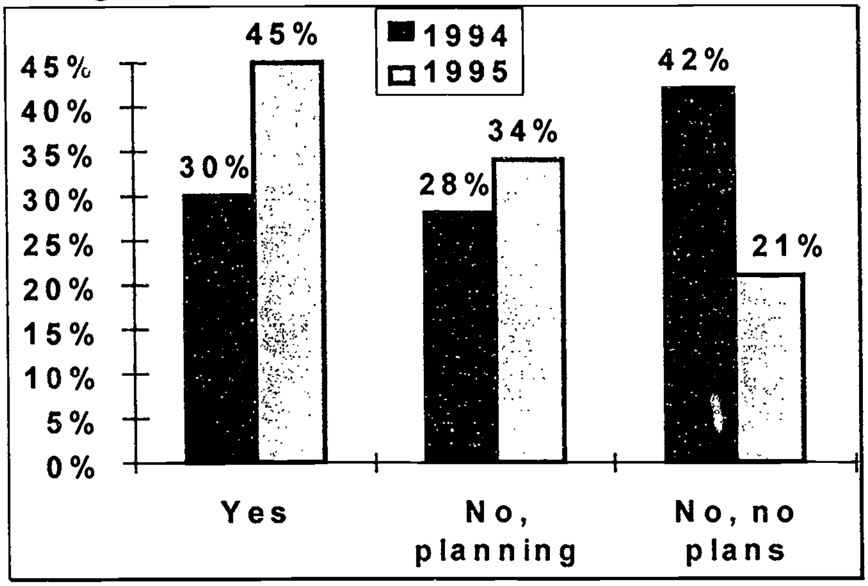
There are many who believe that education across all dimensions will be transformed as the boundaries become more porous -- or even disappear -- between home and school, education and entertainment, K-12 and higher education and formal education and life-long learning, thereby enabling education to become more time and place independent.

Perhaps the first formal step on the pathway to time and place independence is that of technology-mediated learning -- either distance or on-site. Technology-mediated learning means different things to individual institutions and to the individuals within them, and it encompasses many levels of the educational spectrum. In this section, we'll take a broad look at how technology-mediated learning is used in higher education today.

Distance Learning Involvement

To understand the current -- and planned -- state of distance learning activity in higher education, we begin by asking: How many institutions are either currently or planning to engage in distance learning?

Looking at the overall level of distance learning activity, we found that 45% -- up from 30% in 1994 -- of higher education institutions are currently engaged in some form of distance learning; 34% are planning (up from 28% in 1994) and only 21% -- down from 42% in 1994 -- have no plans. And there are further discernible patterns across the Carnegie classes. Combining the responses for "currently" and "planning," we find that 79% of all institutions are affected. Not surprisingly, there are marked differences across the Carnegie classes. The comparable responses for all other institutions are: Universities -- 96%; Comprehensives -- 92%; Liberal Arts -- 47%; 2-Year -- 85% and Specialized, with 80% responding.



The commitment to engage in distance learning represents just one dimension of the overall picture of distance learning in higher education. A second key dimension is to understand what proportion of the total student enrollment is affected. As we might have expected, the percentage of students affected ranged widely from a high of 60% down to a low of only 1%. Overall, the mean percentage of affected enrollment was 11%.

Distance Learning Spending

Another key element in understanding the magnitude and nature of distance learning involvement is the scale and allocation of funding for this activity. Distance learning funding is not always treated as a separate budget area, but instead, buried within many individual budgets, and, therefore it is difficult to accurately project the total spending in this area. We have estimated spending at $1.2 billion dollars...but it is likely to be understated. Perhaps more important than the total amount, is how distance learning spending will be apportioned. Understanding this split tells us much more than how expenses are apportioned. It provides clues into the nature of the distance learning activities to be offered.

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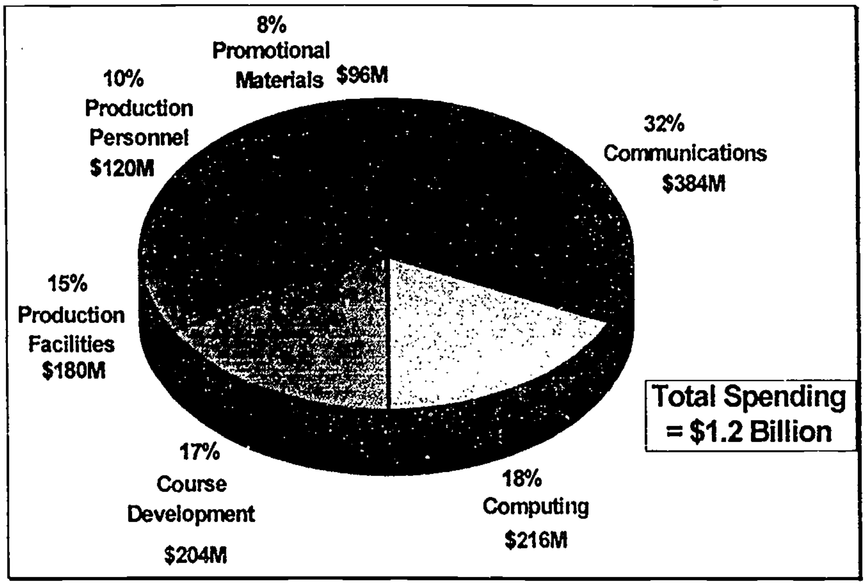
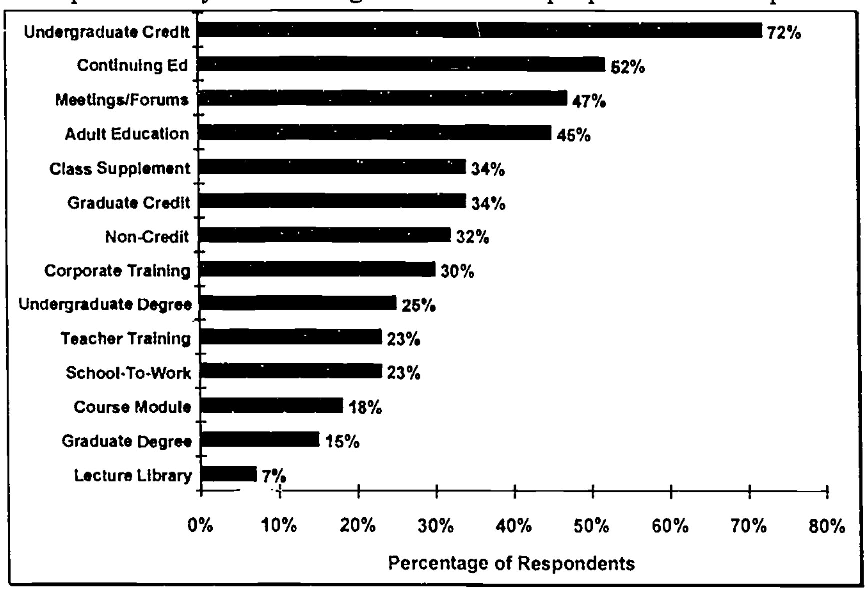
We tested for allocations in six main expenditure categories: communications; computing; production facilities; production personnel; promotional materials and course development. Finding that 32% will be devoted to communications, or even that 18% will be spent on computing is not surprising. It is enlightening, however, to discover that 42% will be spent on production personnel and facilities and course development. Each of these three areas contributes to the development and production of specific distance learning programming. The ratios do change, however, across the Carnegie classes, and range from a high of 54% in universities to a low of 36% in liberal arts.



How Is Distance Learning Used?

It is particularly interesting to ask what proportion of respondents indicated that distance learning was used in the "real business" of higher education -- that is, to award undergraduate and graduate credits toward degree credentials. We found the following use patterns by institutions that have distance learning programs: 72 percent grant undergraduate credits (2-year schools lead); 34 percent grant graduate credits (universities and comprehensives lead); 25% grant undergraduate degrees; and 15% grant graduate degrees (universities lead).

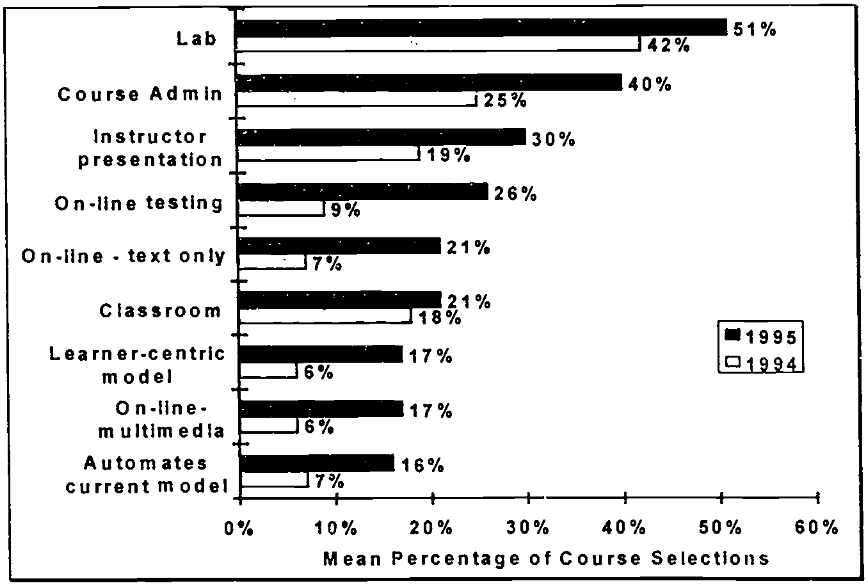


These data present only a baseline understanding of where we stand today. Perhaps the more intriguing issue may be to address the longer-term questions that are beginning to enter into discussions of distance learning: Will distance learning be used increasingly to offer complete undergraduate and graduate degree programs, and if so, will this new medium enable more aggressive and previously unused competitive tactics in the pursuit of new students? Will this result in chaos and unfair competition among educational institutions, or will we perhaps see educational resources distributed in a manner which better meets the needs of all Americans? Who will win, and who will lose? Stay tuned...

So, Are We There Yet?

The prognosis for the future is rosy, but many would argue that the present, when looking across the entire higher education landscape, is quite bleak and that it will take years -- perhaps decades -- before most institutions will be able to implement new learning models -- either on-site or distance -- across the curriculum.

What are institutions doing today? How is technology used in courses? The following chart describes the mean proportion of course sections using various forms of technology. We might have expected that 51% -- up from 42% in 1994 -- of all lab sections would use some form(s) of technology, but were pleasantly surprised to find that technology was involved in the mainstream instructional activities of approximately 20 percent or more of all course sections for the following uses: in the classroom; on-line materials; on-line testing; instructor presentation, as well as course administration. Further, it was very encouraging to be able to account for a 16-17% presence of emerging activities like on-line testing and on-line access to multimedia materials.



While the data and analyses may not reflect a realization of utopia, it does appear that technology integration is on an upward curve. What are the impediments to faster progress? Certainly, there are legitimate concerns with regard to funding, technological maturity, the cost-benefit analysis of these new learning models, as well as the propensity of higher education to resist change. These are not insignificant challenges. With luck, these challenges will be offset by the vision and leadership of many who believe that funding can be found and solutions can be implemented if institutions -- and their leaders -- are willing to focus more on institutional effectiveness and less on the status quo!

Altering Time and Space through Network Technologies to Enhance Learning

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Abstract

This paper maintains that networking technologies offer a better learning environment for students while providing opportunities for reducing the cost of the learning process. A key outcome of advances in networking, the Internet, telecommunications, and client/server computing, is that they are serving to alter the limitations of time and place. The authors discuss their experiences from the perspective of teaching in economics and the arts. They have created learning strategies that make use of these technologies for communication and access according to a matrix showing the interaction of time and place. These include private news groups for each class; e-mail collaboration between students and between students and instructors; electronic submission and critique of work; electronic posting of grades, handouts, notices, schedules, etc.; electronic exhibit areas for multimedia and World Wide Web class projects; Internet-wide critique of work; Internet-based research projects; and the use of localized Internet servers dedicated to instruction.

Altering Time and Space through Network Technologies to Enhance Learning

John F. Chizmar, Department of Economics
David B. Williams, College of Fine Arts
Illinois State University

A paradigm shift is taking place in higher education. According to Barr and Tagg (1995), the paradigm that has governed our universities is one that defined a university as "an institution that exists *to provide instruction.* Subtly but profoundly we are shifting to a new paradigm where a university becomes an institution that exists *to produce learning.*" (p. 13) We are beginning to recognize "that our dominant paradigm mistakes a means for an end. It takes the means or method— called "instruction" or "teaching"—and makes it the [university's] end or purpose.... We now see that our mission is not instruction but rather that of producing *learning* with every student by *whatever* means work best." (p. 13)

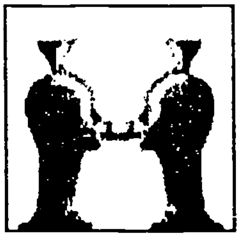
Our paper addresses the following questions: will computing and networking technologies offer a better learning environment for students? Will these technologies improve our ability to help students produce learning while reducing the cost of instructional? We believe that the answers to these questions is a resounding "yes," if computing and networking technologies are used to create learning strategies that involve students as active partners in their own learning.

In the search for active learning strategies, we are guided by two principles stated by Cobb (1993, p. 20):

- The student and teacher share responsibility for the quality of a process— the process of the student's learning (only indirectly and secondarily the quality of the teacher's teaching.)
- The core motivation, for both student and teacher, should be the satisfaction that derives from improving the quality of the student's learning.

Our goal as teachers in using computing and networking technologies is, to use a metaphor, to be a "guide on the side" instead of a "sage on the stage." To return to Barr and Tagg's (1995, p. 24) terminology, our goal is to move from an "instruction paradigm," in which a faculty member's role is "actor" and knowledge is transferred from faculty to students, to a "learning paradigm," in which a faculty member's role is "inter-actor—a coach interacting with a team" and students discover knowledge for themselves. We illustrate these contrasting paradigms in Figure 1.

Sage-on-the-Stage



Guide-on-the-Side

Figure 1. Two instructional strategies: The Sage-on-the-Stage and the Guide-on-the-Side[1]

Enhancing the Learning Process through Networking Technologies

In order to understand how technologies can support and enhance the quality of student learning and increase active participation by students, we share, in this paper, our experiences with implementing active learning strategies that use computing and networking. Chizmar teaches undergraduate statistics and econometrics courses in a networked computer classroom where each student works on a computer workstation connected to the campus network and the Internet.

Williams teaches two seminars on developing and designing computer applications in the arts. The first course focuses on designing multimedia applications with Powerpoint, Authorware, and HyperCard; the second course focuses on designing electronic arts exhibits on the Internet using a Web server, HTML coding, and a variety of graphics and music creative software tools. These courses take place in a traditional conference room with a computer teaching station, an overhead display, and a connection to the campus network and the Internet. Williams's students also use a portable computer-lab-on-wheels on occasion in the classroom—a number of laptop computers are available on a cart, with wireless infrared networking—and they have access to a networked computer lab for work outside of class.

Networking and Internet connectivity is critical to our teaching strategies. We use a combination of AppleTalk for local networking and file sharing and TCP/IP connectivity to the Internet through MacTCP over Ethernet or Token Ring to the campus backbone (ISUNet). Chizmar's web server is WebStar running on a Mac PowerPC in the economics department computer lab. Williams's web server was originally a Mac server, but is now an SGI Indy running a Netscape server from the College of Fine Arts.

The network and server facilities that we have in place, provide for our students, to use Larry Smarr's phrase, a "window into knowledge space" (1992). Smarr asserts that we are experiencing today the fruits of a major transition from a world of one person, one computer to a world of the "meta-computer," a computer of computers. In this new world, a personal computer becomes a "window into knowledge space" and a gateway to virtual resources. But meta-computing does more than provide a looking glass through which to see the world. We believe that meta-computing also creates a looking glass that reflects back to the learner an image of him or herself working with other learners. Meta-computing enables learning by providing diverse modes of communication and access to a creative, virtual collaborative space for students.

Here is just a sample of some of the learning activities possible in our networked, meta-computing environment at Illinois State University:

- Private news groups for each class
- E-mail collaboration: student-to-student, student-to-instructor, and instructor-to-student
- Electronic submission and critique of work
- Electronic posting of grades, class handouts, notices, schedules, etc.
- Electronic exhibit areas for class projects
- Internet-wide critique of work
- Internet-based research projects.

In the remainder of this paper, we present examples of how we implement these activities in our classes. We find it useful to view these activities in terms of a time-and-place matrix, a concept we borrowed from writings on groupware strategies (Johansen 1992) and adapted to our work. A key outcome of the advances in computer networking and the Internet is that they are serving to *alter the limitations of time and space*. Each cell in the matrix (see Figure 2) demonstrates this by representing unique combinations of time and place events in fully networked learning environments. We start with same-time/same-place (representing the traditional classroom) and progress clockwise through different-time/different-place. You will see that, while we employ strategies that cover all the cells, they differ in Williams's use of networking to enhance creative opportunities for his students and Chizmar's use of networking to enhance collaborative activities.

Same-Time/Same-Place Instruction: Traditional Meeting Places

Same-time, same-place describes the traditional classroom, rehearsal room, conference room, or computer lab. Our definition of "place" here includes both physical space (e.g., the classroom) as well as virtual class space (e.g., a dedicated server holding students' work and instructor's materials much as a work room or team room would be used).

Most efforts at incorporating technology into instruction have been focused on this cell of the matrix. This cell includes any meta-computing learning strategy that improves the ways in which students traditionally learn within the confines of meeting for 50 minutes, three times per week (same time), in the same classroom (same place). Such strategies include collaborative or groupware applications and experiences, in-class demonstrations, practical experiences especially with simulations, experiences with software applications, and in-class access to student and course on-line files. Chizmar makes use of simulation and in-class electronic collaboration and feedback within the same-time/same-place cell of the time-place matrix. Williams uses the computer for demonstration, hands-on practice, and critique of student work within this cell.

Time and Place Matrix

Time \ Place	Same	Different
Same	Traditional classrooms and meeting places	Virtual classrooms, distance experts, distance tutors
Different	Computer labs and team on-line servers	E-mail, news groups, Gopher and Web servers

Figure 2. The time-place matrix showing instructional activities possible in a networked learning environment.

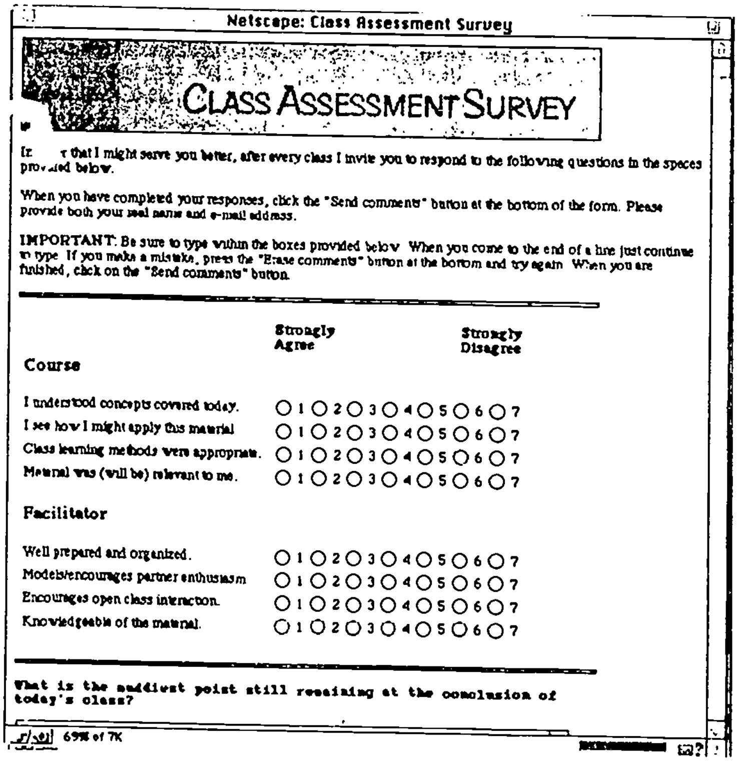
Economics. Chizmar uses statistical computing in a local area network setting to augment traditional face-to-face classroom instruction and to achieve the recommendations of the American Statistical Association and the Mathematical Association of America for the teaching of introductory statistics courses. These recommendations suggest that teachers should motivate students by showing them statistics at work in real applications, problems, cases, and projects; use real data and statistical computing; foster active learning; and downplay formal training in probability in favor of "exploring how useful ideas of statistical inference can be [learned] independently of technically correct probability." (Garfield and Ahlgren, 1988, p. 46)

The last recommendation presents a conundrum. How can students gain an intuitive understanding of the concepts of probability by eschewing its formal study? Answer—through the use of computer simulation. Chizmar presents the central idea of a sampling distribution through a series of Monte Carlo simulation experiments. The Monte Carlo experiments give students an intuitive understanding of the Central Limit Theorem and can easily be answered using statistical computing. From their computer workstations in class, each student generates 20 random samples of the same size from the same population and for each sample calculates the mean and median. They then send Chizmar an e-mail message which contains their 20 means and medians. Again, within the class time, Chizmar combines each students response with the responses of the other students and then e-mails these class distributions of the means and medians back to the students for further analysis.

Chizmar uses e-mail and a class LISTSERV to augment an active learning strategy called "think-pair-share." This activity takes place collaboratively during class time. To help students clarify their thinking, Chizmar asks each student to write an e-mail message to the class LISTSERV, explaining, *in words their fellow students will understand*, a particularly difficult concept, a p-value for example. Students then read what other students have written and discuss differences or similarities with their teammates. The advantage of the LISTSERV in this context is that students know that their message is sent to the entire class. This version of "think-pair-share" is based on Meyers and Jones (1993) observation that "when we direct students to write to each other, they usually write with more clarity and precision." (p.25) Klass (1995) has also observed when using LISTSERVs for political science writing activities, that when students write to a larger audience, in contradistinction to writing to the instructor, their writing in substantially better.

Chizmar also uses network computing to provide frequent feedback on the quality of student learning through a technique called the "One Minute Paper."[2] A typical One Minute Paper asks students to respond, in the final minute or two of class, to two questions: (1) What is the most important thing you learned today and (2) What is the muddiest point still remaining at the conclusion of today's class?

The first question is intended to focus students on the big picture, i.e., what is being learned, and the second to provide specific statements of what students want to know more about, i.e., how well it is being learned. Chizmar has incorporated these question plus a set of Likert-scale questions developed by Shulman (1995) into a Netscape form (see Figure 3) which students complete at the conclusion of every class.[3] The form creates a tab-delimited text file of the students responses which can be easily analyzed in Excel and Minitab. Furthermore, because the form also asks students to provide their e-mail addresses, Chizmar can respond immediately via e-mail to any student who seems particularly "muddy."



Netscape: Class Assessment Survey

CLASS ASSESSMENT SURVEY

In order that I might serve you better, after every class I invite you to respond to the following questions in the spaces provided below.

When you have completed your responses, click the "Send comments" button at the bottom of the form. Please provide both your real name and e-mail address.

IMPORTANT: Be sure to type within the boxes provided below. When you come to the end of a line just continue to type. If you make a mistake, press the "Erase comments" button at the bottom and try again. When you are finished, click on the "Send comments" button.

	Strongly Agree						Strongly Disagree
Course							
I understood concepts covered today.	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7
I see how I might apply this material	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7
Class learning methods were appropriate.	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7
Material was (will be) relevant to me.	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7
Facilitator							
Well prepared and organized.	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7
Models/encourages partner enthusiasm	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7
Encourages open class interaction.	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7
Knowledgeable of the material.	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7

What is the muddiest point still remaining at the conclusion of today's class?

69% of 7K

Figure 3. A Netscape form for the "One Minute Paper"

Before the next class, Chizmar creates a Pareto chart (a quality principles analysis tool) of the students' feedback and fashions an e-mail message back to the students which contains the chart plus their verbatim responses to the One Minute Paper from the previous class. Students find the latter practice informative because it tells them, in unabridged language, that other students are muddy about the same points as they. Chizmar begins the subsequent class with a discussion of their responses, in essence, with feedback on student feedback. Chizmar observes that student responses became more thoughtful and useful as it becomes clear that he really does intend to use student feedback to manage and guide the course.

Fine Arts. Williams prefers a constructionist strategy of teaching with a strong emphasis on learning projects. A key strategy for the use of class time is viewing and critiquing work in progress. The guidelines for statistical study with emphasis on motivation, real-world problems and projects, and the downplay of formal training, apply here in the arts as well.

Williams uses the teaching workstation and its connection to the network to quickly access student work from the department server where class and private student folders permit electronic storing of assignments and work in progress. Students have an on-line folder for their work that only they and the instructor have access to. Having electronic access to all student projects makes it easy to quickly show and compare portions of students' work and to isolate examples of problem areas in software and instructional development that need class attention. When hands-on is needed for learning new software development tools, as in Chizmar's class, the portable lab-on-wheels can be rolled into the classroom.

Same-Time/Different-Place Instruction: Lowering the Walls of the Classroom

Same-time/different-place computing lets us expand beyond the classroom. Here is where we "lower the walls" and open the "window into knowledge space." Using the power of network connectivity and advances in cable and the telephony, collaboration takes on an expanded meaning. Any group of people can be brought together for a meeting at the same "time" without regard to "place." We can hold text-based conferences (on-line chat groups), audio conferences (phone conferencing), and full-audio and video conferencing right from our desktop (desktop video presentations). Tutoring can be offered remotely. Mentors or experts can be brought into the classroom from anywhere in the world. Many programs are now offering their courses and degree programs on-line, letting students complete some, if not all, of their work remotely.

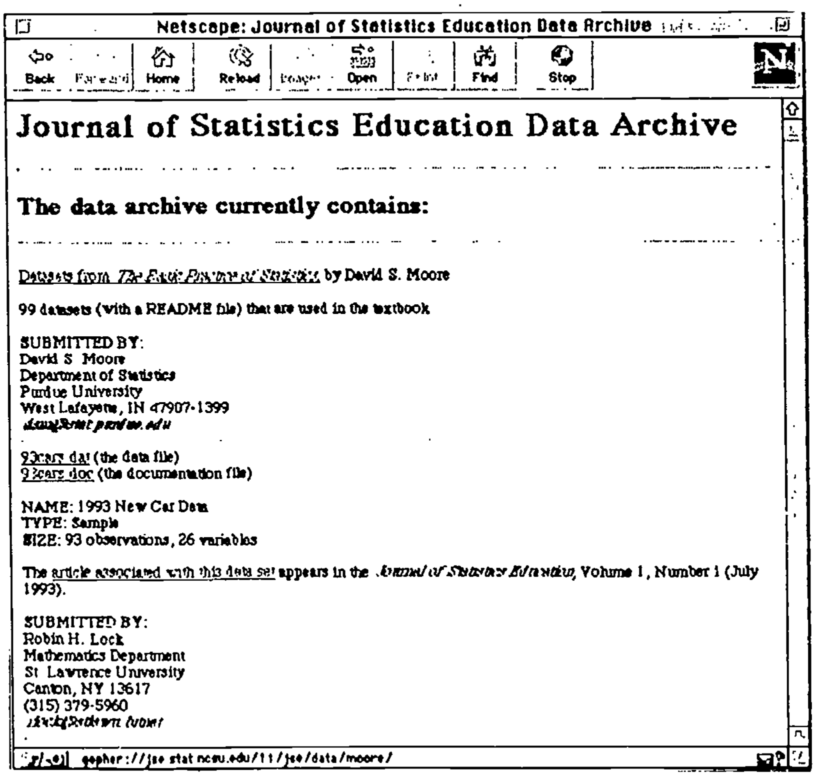


Figure 4. A web page view of the on-line Journal of Statistics Education.

Fine Arts. Williams uses the teaching station's connection to the Internet as a way to open the classroom to world-wide people resources. Active participation from the class on USENET newsgroups provides input and assistance from people throughout the Internet for information, problem solving, and even critique of student work. The newsgroups provide informal distance experts. Prearranged e-mail (using Eudora) and chat conferences are scheduled to synchronize with class time so that distance experts can share their talents, contribute to a class discussion, or help the students solve particularly difficulty problems or locate resources. Using Fetch, TurboGopher, or Netscape, a particularly rich resource of graphic images or music sound files can be queried and the files downloaded to the classroom for discussion and experimentation.

Economics. Chizmar uses the student station's connection to the Internet similarly. Students, working in teams, use Netscape to access laboratory experiments designed to actively engage them in the study of statistics. One experiment, entitled "An Internet Journey" and adapted from an article written by Rossman (1994), asks students to answer a series of conjectures about life expectancy and density of people per television set in various countries. Working in teams of two, they link to an on-line journal, the *Journal of Statistics Education*, and retrieve a set of the data files across the Internet and import them into the statistical software, Minitab, for further analysis.

Future applications. There are other same-time/different-place activities which Williams and Chizmar intend to implement in the future: desktop video conferencing to bring distance experts and demonstrations into class in real time, prescheduled on-line tutoring for students with the instructor or a graduate assistant through controlled use of Internet chat groups (IRCs), and even the possibility of permitting students to attend the class remotely through desktop video conferencing.

Different-Time/Same-Place Instruction: Virtual Shared Space and Computer Labs

This cell includes any learning activity which gives the instructor and students physical or virtual use of a dedicated workspace, any time they choose. Virtual team rooms, so to speak. We both provide local servers of information dedicated to class use, both for personal storage of work and for shared storage. This cell also would include dedicated physical workspaces. Our students have access to networked computer labs which they can use for "different-time" computing activities.

Chizmar and Williams both use a series of Web pages to organize on-line course content, where materials dedicated to their courses are stored. Students can find electronic versions of hand-outs and course syllabi. The well-worn plea for another copy of a lost handout is now followed by the rejoinder of "just download a new copy from the class server." Grades are posted electronically after each assignment for those students who give the instructor permission to post grades. We make a GIF graphic image of a class spreadsheet and post it in the class server space where only the students in the class have access for downloading. Course materials for Williams's class can be viewed at http://orathost.cfa.ilstu.edu/public/oratClasses/ORAT389.88Seminar/InternetModels/internetmodelshome.html and Chizmar's class, at http://138.87.168.39/Jack_Chizmar/ECO131/Eco131home.html.

Fine Arts. Williams's class makes extensive use of this cell and the virtual team room concept. Students construct off-line multimedia arts exhibits in the first semester course (Software Design in the Arts) and on-line multimedia exhibits in the second semester course (Internet Models for Artistic Expression). For these courses, students select a theme to develop for an exhibit which will be used throughout the semester. They then begin to design and accumulate a variety of digital imagery for their exhibits in private folders on the class server: digital graphics, digital video clips, MIDI music files, digital sound samples, text documents, and so on. Learning how to prepare such imagery, suitable to the multimedia platform they are working with (e.g., slide-, icon-, card-, or document-based tools), and of high aesthetic design quality, is a key goal of the course. The students then combine these images with Powerpoint, Word, Authorware, and HyperCard for the first semester course; HTML and Web page design for the second semester course. Examples of the work from the Internet Models course can be viewed through Netscape at http://orathost.cfa.ilstu.edu/public/oratClasses/ORAT389.88Seminar/InternetModels/exhibits95.html.

Williams provides each student with a private folder where only that student and the instructor can gain access to the materials. Special "drop folders" are created for submitting work electronically; files can be "dropped" in but only the instructor can take them out. Williams also creates on-line folders for each class project where students can share the results of their work with the class, and for the Internet Models course, with the Internet community at large. In fact, Williams requires his students to announce their completed projects on the Internet newsgroups and invite the public to electronically critique and react to their work. A local USENET newsgroup is created just for the class; this serves as an electronic bulletin board for the students and the instructor. Posts for help, advice, announcements, helpful tips, and coordinating student teamwork all circulate through the class news group over the semester. Williams feels that a LISTSERV would provide a more controlled environment for a collective newsgroup over the Internet. LISTSERVs are a good way to implement on-line critiques of work where several on-campus classes participate, or better still, where the same class at several different campuses share work with one another.

Figure 5. An example of a student arts exhibit on Brazilian music

Economics. Chizmar has begun to experiment with out-of-class team projects. While exams and projects assess student understanding equally well, projects (especially team projects) more than exams are themselves instruments of learning. Because students teach each other, team projects promote student learning and empower students to own their own learning. The benefits of team projects can be substantially enhanced with the use of networking technologies which help to ameliorate a major complaint of student team members—that it is difficult to schedule a common time and place when everyone can meet to work on the project. Instead, telecommunication and networking technologies expand place and time by permitting students to collaborate in the same place, but at different times.

Different-Time/Different-Place: Access to the World of On-line Information

The different-time/different place cell represents true "anywhere-anytime" computing. The freedom to participate at "different times" and "different places" lets the instructor and the students plan and control their participation and use of network resources to suit their own schedules and preferences. Through the World Wide Web and Gopher, data, software, and a wide array of graphic images, sound and music files, and digital movies can be transported to the classroom for use and demonstration. There are millions of servers with full-text documents, abstracts, on-line library catalogs, MIDI music files, digital sound samples, graphic images and digital video clips, software, and statistical data. The list is endless. Any location on the Internet containing these resources can be accessed at anytime.

Electronic mail, of course, is the most widely used different-time/different-place technology. With extensive use of e-mail for both students and faculty at Illinois State University, we have found that it has a great "social-leveling" or "equalizing" effect. When you interact with people through text only, people anywhere in the world, some of whom you have never met, the exchange is free from biases that are caused by visual appearances. We have found that students are much more likely to seek help from us via e-mail, then make an appointment to see us in our offices. We have also found that students are more likely to seek help from each other through e-mail, or from anyone in the world for that matter. One student from Williams's class convinced Guy Kawasaki to help him with his assignment simply because Mr. Kawasaki was impressed and intrigued by the way the student presented the problem to him (and found his e-mail address besides); another student managed to get help with multimedia copyright law by convincing a Harvard law student, through e-mail, to find the copyright information in the Harvard library.

Other examples of using networks for different time/different place collaboration include electronic newsletters and journals, and electronic forums or LISTSERVs and USENET news servers.

Economics. We have already discussed Chizmar's electronic adaptation the One Minute Paper. Chizmar also uses computing to augment another CQI (Continuous Quality Improvement) teaching strategy, the Quality Circle. A circle of six to twelve student volunteers meets weekly with Chizmar to provide advice and feedback on course management issues. Through the Quality Circle, students experience the direct application of simple statistical tools and procedures to a problem they know intimately—achieving learning of highest quality. Chizmar uses e-mail to facilitate the work of the Quality Circle—devising a fishbone diagram, constructing a class survey, composing recommendation to improve the course—and a LISTSERV to involve the remaining members of the class in the work of the Quality Circle any time, any place.

Fine Arts. This cell in the time-place matrix is another important one for Williams's classes since students must conduct an extensive amount of research in developing their theme and thematic materials for the multimedia projects. One of the first projects in the Internet Models course is an Internet Treasure Hunt. The dual goals of the project are to acquaint the students with the basic Internet client tools for news, gopher, ftp, and web and to get them started with researching their topic area. The treasure hunt asks them to locate sites for graphic images, sound files, content information on their topic, information on copyright related to multimedia and the Internet, experts that can help them with their project, and grant and funding resources should they hypothetically need to seek financial support for the project.

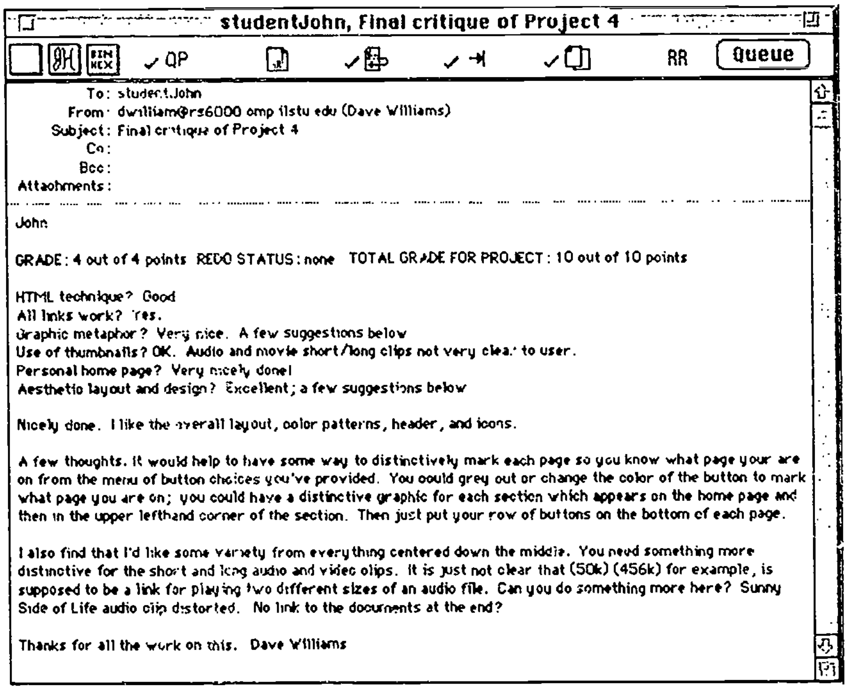


Figure 6: An example of a e-mail critique of student work.

Williams also uses both on-line newsgroups and e-mail extensively in his class. Students are encouraged to use e-mail to communicate and collaborate with each other, and with the instructor. Through a combination of e-mail and newsgroups, students begin to think in terms of the learning process and the course of study being a 24-hour-a-day, seven-days-a-week experience, rather than a 50-minute-a-day, three-days-a-week experience; students, the instructor, and peers and experts worldwide, are always within reach.

Student work is submitted electronically through the class drop folders, and all work is critiqued with feedback being returned electronically to the student through e-mail. Figure 6 shows a sample e-mail critique. A standard template is used for each project that emphasizes the key objectives and criteria for the project. With on-line course materials, electronic submission of work, and e-mail critiques, no hardcopy or paper work exchanges hands during either of the fine arts courses (except for the class registration list and grade submission which still use op-scan forms!).

Reducing the Cost of Instruction

So far, we have addressed the question of whether using networked technologies can improve the quality of student learning and increase active participation by students. Obviously, our answer is a resounding "yes." In the conclusion of this paper we would like to address the question of whether we can show a reduced cost of learning per student as the result of the innovations we have discussed.

Notice that we state the question in terms of the cost of learning per student rather than in terms of the cost of instruction per student. In this distinction, we agree with Barr and Tagg (1995) when they say, "Under the Learning Paradigm, producing more with less becomes possible because the more that is being produced is learning and not hours of instruction. Productivity, in this sense, cannot even be measured in the Instruction Paradigm [university]. All that exists is a measure of exposure to instruction." (p. 23)

This distinction is not the usual ploy of defining away the problem, but rather of defining the problem properly in the first place. If we take learning as the proper metric, then we have no choice but to adopt learning strategies that produce active, involved learners. The lecture-discussion, the primary means of producing instruction in American universities, does produce a lower cost of instruction than active learning strategies. But we have increasing evidence that the lecture-discussion is ineffective at producing learning. As stated by Guskin (1994), "the primary learning environment for undergraduate students, the fairly passive lecture-discussion format where faculty talk and most students listen, is contrary to almost every principle of optimal settings for student learning." (p. 6)

We also need to consider that increases in learning are difficult to demonstrate empirically because of what economists call "satisficing" behavior on the part of students. When given the opportunity through an active learning strategy, say, to learn more or to learn the same amount as previously more cheaply, students may rationally choose the latter because they too face competing demands—other classes, jobs, leisure—for their time. It strikes us, however, that insisting that there must be empirical evidence that active learning strategies coax out more learning than the lecture-discussion format is a little like insisting that before doctors could prescribe penicillin there must have been controlled experiments that demonstrated penicillin's effectiveness. Doctors who prescribed penicillin did not need a study to see that their patients got better. Teachers who use active learning strategies do not need a study to see that their students learn more.

As a consequence, asking whether active learning strategies produces instruction at lower cost than the lecture-discussion, asks the wrong question. Rather we should be asking whether the learning produced by whatever strategy can be produced more efficiently. Here is were technology enters the picture.

As we have shown, networked computing, and, in particular, meta-computing, can be used to adapt already proven active learning strategies and produce the same or increased learning more cheaply. In terms of what? Primarily in terms of faculty time.

As faculty ponder whether to adopt more active learning strategies, they rationally compare costs and benefits. From a faculty member's perspective, the cost of the technological backbone is a sunk cost. The sunk nature of the backbone is illustrated in a recent Doonesbury cartoon (November 28, 1995). Mike Doonesbury engages a colleague in the following dialogue:

Mike: Hank, what's a Web site?
Hank: It's an Internet presence.
Mike: What's on it?
Hank: It doesn't matter. Build it and they will come.
Mike: Why do we need one?
Hank: Because the technology exists. Also, everyone else has one.
Mike: What's my motivation?
Hank: Fear. Greed. Take your pick.

Universities have built it, but will faculty come? The primary cost that faculty members face as they ponder change is the cost of their own time. As it becomes clearer to faculty that they must give up the instruction paradigm in favor of the learning paradigm, faculty members will seek out ways to produce acceptable levels of learning with smaller and smaller investments of their own time. In this paper, we have discussed ways in which technology can be used to produce learning a lower cost in terms of faculty time.

The real question is what forces will cause faculty to change from an instruction to a learning paradigm, from the sage-on-the-stage to the guide-on-the-side. It is clear that this change is very costly in terms of faculty time, and that incentives must be created to induce this change. Perhaps Doonesbury is correct and the answer is "fear and greed." We rather hope that the answer lies in a deeply felt understanding that the raison d'être of a university is not to produce instruction but rather to produce learning and that the traditional teaching strategies are ineffective. Again, in the words of Barr and Tagg, a university's purpose is "not to transfer knowledge but to create environments and experiences that bring students to discover and construct knowledge for themselves, to make students members of the communities of learners that make discoveries and solve problems." (p. 15)

Author Notes

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Footnotes

[1]These figures were digitally created by D.B. Williams from an original graphic of a sage-on-the-stage-like image by an unknown artist. We have not been able to identify the source of this image.

[2]Cross and Angelo (1988) and Light (1990) discuss the One Minute Paper.

[3]The Netscape form is only the latest incarnation of the One Minute Paper. Chizmar migrated from asking students to respond to the One Minute Paper first using paper and pencil and then using e-mail. The primary advantage of using the form is that it substantially reduces the analysis time—from over one hour to less than 15 minutes.

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Managing Networked Information

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ABSTRACT

Information aggregators such as campus information systems and community networks are becoming key navigational beacons in the electronic world, gathering information, both physically and logically, from a disparate set of sources and providers and integrating them into a coherent information space to users. Unfortunately, the operations of such services remains highly fragile and manual, limiting their scalability. This presentation will discuss some lessons learned in managing large-scale networked information and presents an emerging protocol that automates the critical steps in the provision of volatile on-line information.

PowerPoint presentation available,
see http://cause-www.colorado.edu/conference/cause95/c95track-6.html

The "Business" of Telecommunications

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ABSTRACT

Creating a balance between the delivery of telecommunications network services and fiscal responsibilities is a new challenge for telecom technocrats. We need to understand and communicate that the network cannot continue to provide current levels of performance while other functional areas, departments, and facilities within the institution are asked to reduce costs. Technology solutions must prove their value and rate of return. Telecommunications managers will be competing with everyone else for limited funds and resources. Managerial and marketing skills, COQ (cost of quality), cost avoidance, and other cost/productivity issues will be key issues in this paper.

Paper Not Available

THE CLASSROOM OF THE FUTURE

Dr. Raymond K. Neff
Vice President for Information Services
Case Western Reserve University

ABSTRACT

This is a time of transition from blackboard and chalk and use of the overhead projector to the general-purpose projection system capable of handling all formats of digital and analog media and the classroom where there is a networked computer at each seat. Distance learning opportunities abound and are being explored, especially in the health science and engineering disciplines and professions where there are continuing education requirements. The ability to deliver credit-courses to homes and business locations represents a potentially significant revenue source for universities in the years to come. Our classrooms of the future must be designed to accommodate the widest range of distance learning situations. We now have the opportunity to link people and information resources in our region by using videoconferencing and video mail. Extending the classroom to wherever the student is located is the logical end of these early ventures. Information technology, properly developed, will produce the customized electronic learning environment we believe will be the hallmark of higher education in the twenty-first century.

THE CLASSROOM OF THE FUTURE

Dr. Raymond K. Neff
Vice President for Information Services
Case Western Reserve University

The classroom of the future is, as a matter of principle, wherever the student is. On campus, this means they are in traditional academic buildings, libraries, laboratories, the professor's office, and, last-but-not-least, the residence halls and fraternity/sorority houses. With the evolving global information infrastructure (a.k.a. information superhighway), we have the ultimate delivery vehicle for "distance education." At Case Western Reserve University, we have implemented a campus-wide 100% fiber optic network in all of our academic and residence buildings and are using it to prototype new instructional methods. This paper is a progress report on our designs for the classroom of the future and how we are presently using them.

The format of the classroom of today is based on a twelfth century model! It was the educational innovation of its time, and its time was when books were rare, and lecturers read from them to their class of students, who were basically copyists. Students did not take notes in class; they took a form of dictation. The shape of the lectern we use today reflects its original purpose which was to hold the larger, hand-copied book at a reasonable angle for reading to the class. The word lecturer, in fact, is derived from the Latin root infinitive "legere" meaning "to read." In Britain today, Lecturers (Latin root word) are called Readers (English root word). Thus, the foundation of the classroom of today is solidly in the middle ages.

As to other innovations, the blackboard, with slate and chalk, was introduced into higher education by way of engineering schools in the third decade of the nineteenth century. The electrified "Magic Lantern" slide projector entered the classroom during the last decade of the nineteenth century; movie projectors, photographic slide projectors, tape recorder/players, and phonograph players were introduced into classrooms during the early decades of the twentieth century, and the overhead projector, which many of our colleagues have still to master, came out of the bowling alley at the end of World War II. The computer was first used in the classroom by attaching time-sharing terminals to television sets, and this became a standard method of bringing the computer into the classroom by the late-1960's. By the mid-'70's large-screen projectors of computer displays had become practical, but these early systems for lecture-hall sized classes were frightfully expensive. By the mid-'90's, the evolution of information technology for the classroom has come far, and we have many cost-effective options from which to choose.

In this paper, we will show how to integrate many of these possibilities and bring full multimedia order from the seeming chaos. Our order comes from the singularly important transformation of all formats of classroom media from the analog domain to the uniform format of digital, binary-encoded data. Once information is transformed into the digital medium, it can then be displayed and manipulated with relative ease. Most significantly, digitally encoded information can be transmitted at very low cost, so that where the information is stored and where it is used can be widely dispersed. The implications of this for education are just now starting to be grasped by the education community.

The classroom of the future will likely be built in three different models:

The most common (model I) will be the simple extension of the familiar lecture hall with the use of large-screen projection as the output display from a multimedia computer and the lectern being augmented with digital controllers. Model II will put a personal microcomputer system at each student's seat; and model III will involve linking the instructor to remotely located students using an extension of a video-teleconferencing system. In any particular situation, one can have a mixture of these different models, so that the most prevalent version of the classroom of the future is likely to be a hybrid of all three models. At Case Western Reserve University, we are using several classrooms which have the functionalities implied by these models; we have also built versions which are hybrids of models I and III.

General-purpose projection systems

Modern classroom projection systems have evolved to a point where they can provide high resolution viewing such that students can see demonstrations and other "effects" better than they ever could in the "classroom of the past." When these projectors are attached to a high-speed digital network, a remotely located student and the teacher can be linked together as effectively as if they were in the same room. This is especially relevant in considering computer-oriented multimedia, because in many respects, the workstations of tomorrow will combine high-quality video display screens with the ability to process the multimedia information in just the ways we want it, customized to the time and the purpose of the particular learning situation.

At CWRU, we have adopted a standard of two high-resolution projectors per classroom. Each may have an independent or common video source. Why two? With today's display technologies having roughly 0.8 - 1.3 million pixels, there simply are not enough pixels of information with one display. With two, it is easier to use teaching methods which feature the paradigms of compare-and-contrast, before-and-after, type A-versus-type B, etc. A common occurrence in classrooms so equipped is to use one projector to hold the outline for the class session and the second to work through the details, whether using the computer, video or photographic sources; another scenario uses one projector to display the professor's class notes and the other to display computer simulations. Interestingly, with two projectors, our experience is that the use of the blackboard is much reduced.

Our projectors are general purpose and can handle a wide variety of media sources, including computer display output (ranging from ordinary personal computers to the highest performance workstations), carousel-type-35mm photographic slides, videotape/videodisc, 16mm movies, broadcast/cable television (using NTSC signaling). One important peripheral used with the projector is a desk-top document video camera; such a combination of devices duplicates all of the functionality of an overhead projector and replaces the use of acetate foils and grease pencils with ordinary pencil/pen and paper. If the document camera handles color, then the projected images reflect that. The principal advantage of this arrangement is in a distance education setting where remote students can readily see the transmitted images from the document camera which otherwise might be difficult to make out when using a wider-angle television camera suitable for viewing the instructor and/or the class itself. It is worth noting that we use projectors which can accommodate both NTSC (the standard for North American television) and RGB (red-green-blue) signaling. As configured at CWRU, the dual projection system is coupled to a dual stereo sound system to generate high-quality audio information in the classroom. This sound system is balanced so that when both projectors are employed, the dual stereo systems do not interfere with one another.

It is our experience that the use of even one computer projector in the classroom can cause the instructor to divert his/her attention from the students and be drawn to the screen display. The loss of eye contact with the students can reduce the effectiveness of the learning experience. To remedy this problem, we have installed a high-quality video monitor in the podium, so that the instructor can switch between the projected image and the students with simple eye movements. This has proven to be a satisfactory solution, and so we have replicated it for both projectors in a classroom.

Mobile computers

At Case Western Reserve University, we have developed a concept where the student and the professor both bring their portable computers to class. (They also take them to the library and to laboratories and use them in their residence halls.) Because connectivity with the campus network is so important, each student's desk, wherever the student may work, is equipped with a network information outlet which "docks" with the mobile computer. The newly developed PCMCIAinterface adapter card for Ethernet networking is one cost-effective way to connect a high-speed network to a portable computer by using a microcomputer interface now becoming standard for this type of machine. Thus, each student is fully "informated" as s/he participates in any type of classroom-based learning. When a computer projection system is integrated with these multiple computers, each person can contribute to the class by showing whatever information is pertinent. The computer can realize its potential power to illuminate a point of discussion by tapping into electronic libraries worldwide. It can also serve to demonstrate a relationship, simulate an event or process, or simply be an efficient note taker and organizer. With so much potential, it is not possible to catalog all the possibilities here.

For undergraduate students, our campus features a residential living style.

The computer and the network are right at home in our residence halls and fraternity/sorority houses. This is because we put a network outlet at every student's desk. Now with 92% of these students having a computer on the network (computer ownership at CWRU is voluntary, but highly recommended), the virtual classroom is open for learning 24 hours per day. Access to faculty has also increased because the students use the network to contact faculty when they encounter a stumbling block. Faculty and students now work together more synchronously.

The network currently brings our students a wide range of computer-based information resources from various electronic libraries, permits a variety of person-to-person exchanges (e-mail, voice mail, and video mail), and provides some 39 channels of television, including 24 "educational" and 15 "entertainment" channels. To give just a few examples: For students learning a foreign language, there are both "passive" media like the evening news in Russian from the SCOLA channel or "active" media like conversing with another student in Japanese at Waseda University (Tokyo) over the Internet. In our virtual physics laboratories (we have real ones, too), students can perform thousands of experiments in a mere afternoon. To eliminate drudgery, data acquisition is automatically displayed in graphical formats. Students like this electronic learning environment where relationships among phenomena can be discovered and explored.

Diversity in computer configurations

One of the most common problems in equipping a classroom with a computer is in designing the particular computer configurations to be supported. To simplify this just a bit, we have three basically heterogeneous types of computers: those based on Intel processors, those based on the Macintosh Operating System, and those based on some "flavor" of UNIX. Should each classroom support all three? At another level of detail, what should each specific hardware configuration be? What speed for the processor? How much RAM? Hard disk capacity? Local CD-ROM? etc. The number of possible configurations is daunting, and implementing the ultimate configuration for each feature is ruinously expensive. There has to be a better way.

Another family of problems has to do with the instructor's initialization of the classroom-based computer system. If the computer is permanently installed in the classroom, then at the end of one class, the instructor for the next has to initialize the computer, and often, this takes more time than what is allotted between classes, and the problems do not stop there. Even if the software can be copied and made operational in this period, there may still be a latent problem because the classroom system may not match the configuration which the software requires, and it may not be until the software is used that this problem becomes known. Clearly, this "can of worms" can be both messy and embarrassing to the instructor. There has to be a better way.

At CWRU, we have been using a model where computer use does not require that there actually be a computer in the classroom! We use the standard classroom dual projection system, as described above, together with the computer in the professor's own office and connect them over the campus network. In this way, we solve both the equipment diversity problem (by using the professor's computer which is properly configured to run the appropriate software) and the initialization problem (since before the scheduled class the professor can allocate sufficient time to set up and rehearse the planned computer usage). The "trick" for our solution is in how to control the remote computer from the classroom. Our approach uses the keyboard and mouse-pointer as input devices attached to the network in the classroom and the appropriately configured computer with fully operational software network-attached in the professor's office. A centrally located (and operated) analog video/audio switch connects the (digital) computer network to the classroom display systems (both projectors and the instructor's podium monitors, as well as the audio subsystems) using the fiber optic cabling in the campus network. There are also economic implications of this solution because as described herein, each classroom does not need to be equipped with a set of high-end computers. There is the cost of the central analog video/audio switch but this is easily justified by the cost savings for the computers themselves when considering it as a campus-wide solution and investment. It is interesting to note that with the newly emerging network hardware standard called ATM (Asynchronous Transfer Mode), it will be possible to eliminate the analog switch entirely; the ATM switch will take its place in the purely digital domain. It will be necessary however to return the signal to the analog mode when attaching to the classroom's projectors and video monitors. Because the campus-wide network is key to the evolution of the classroom, we will next take up some of the most important elements of the network and its hardware and software infrastructure.

The campus-wide network infrastructure

The classroom of the future does not sit in isolation; it depends critically on the campus-wide network and its extensions into the regional and global telecommunications grids. Earlier we saw that the campus-based network provided a very useful service in connecting separated components of a single computer system. We also will use the network to connect people who are separated by distance, particularly the teacher and his/her students.

At Case Western Reserve University, we are using our campus-wide network to provide multi-site videoconferencing which extends the classroom beyond the bounds of a single building and even the campus itself. (By the term multi-site videoconferencing, we mean connecting two or more locations using video/audio and computer signaling to form a virtual meeting, on-campus or off.) But why is this necessary? At CWRU, we believe that our educational mission can be better fulfilled by bringing our classroom to students who live and work at a distance from the campus. For post-baccalaureate programs, this type of educational experience can be especially productive. We are currently using it in several professional school programs, including engineering, social work, nursing, and medicine.

Consider a situation in which students are assigned to a learning environment located at a distance from the guidance of the advisor/teacher.

Medical students and nurses in hospital-based training programs is just one possible instance in which a videoconferencing system can meet the need to conquer the distance from the campus. For some master's-level engineering students, the distance learning network reduces their travel costs and both the effort and time commitments necessary to sustaining a meaningful educational experience.

Key to extending the network beyond the campus is the emergence of a new type of communications technology called ATM. All of the major national and virtually all of the international telecommunications carriers have committed to this new technology. At CWRU, we are evolving our internal network to ATM, so that it will be able to interdigitate seamlessly with the ATM networks of these common carriers for full multimedia, digital information exchange. Because ATM offers the capability of merging video/audio with computer-based data in a flexible multimedia package, we will eventually have an integration of information formats which facilitates education. Because, in the future, we will transmit and receive video information in the digital domain, we will be able to offer other varieties of computer-based information, especially from digital libraries, to augment the virtual classroom. As we envision it now, the additional information can be placed in another window on the same display device as the video conference. A simple extension of this idea occurs when we want to link students in work groups. Because our campus' residence hall rooms are all wired for video and data, as well as for telephone, we can marry a video camera to a computer and originate multi-site videoconferences among a set of students' rooms. Use of a video mail feature will provide a record of what has occurred, so that a team member who was absent from the virtual meeting will not have missed out entirely.

In graduate-level professional education, we see the importance of using the extensions of the campus network to bring the university and its information environment to the offices and laboratories where our students and faculty interact in their training. By using the same advanced communications technologies of ATM and SONET (Synchronous Optical NETworking), which our telephone and television vendors will be using, the university will facilitate the extensions of the network to off-campus locations, including hospitals, clinics, physicians' and dentists' offices, law offices, social work agencies, and governmental agencies.

By combining the distinct technologies of personal computers, digital television, electronic libraries, and videoconferencing, the classroom of the future will take advantage of multimedia information from campus-based servers as transmitted over advanced ATM network-based delivery systems to desk-top learning stations. Upon this technology base, it will be possible for the university of tomorrow to offer a form of time-shifted learning, i.e., providing learning opportunities to students which they can use at their own convenience. Time-shifted learning has the advantage of breaking up the rigidity of scheduled classes which universities may find increasingly limiting in meeting the needs of their non-traditional students. Time-shifted learning will clearly be useful in continuing education programs, as well. This type of system will expand our community of potential students by providing more options for meeting their multiple needs. Readily available information and increasing the access to it are part of the information technology infrastructure we are developing.

Another significant aspect of the new learning modalities is the built-in capability of replaying a learning segment. We know well that all students do not learn at the same pace, and that they relate new information to that which they already know. Since these students have different experience bases upon which their newly acquired information is to be integrated, they will not be incorporating it in the same way. Being able to replay and to learn a new subject at the depth appropriate to the purpose of the user will give the student a capability far beyond what s/he is offered in the classroom of today in our "one-size-fits-all" formats for presenting information. The logical extension of this idea is to use information technology to deliver customized instruction. The validity of this concept is based on the differential "inputs" of prior experience each student brings to the learning situation and on the increasingly important learning goal of attaining differentiated levels of achievement as "outputs."

It has been our experience at CWRU that students learn better with computers because, with computers, learning is more likely to seem like fun! Students spend more time "on task" when using a network-based computer, and as a result, they get better grades and flunk out less. Use of the computer seems to have the potential of offering more success at the college level, which for us is the real meat of the "six-sigma" total quality management philosophy.

Extending the classroom to wherever the student is located is the logical end of these early ventures. Information technology, properly developed, will produce the customized electronic learning environment we believe will be the hallmark of higher education in the twenty-first century.