Proceedings of 2nd International Conference on Information Technology Based Higher Education and Training, Kumamoto, Japan
July 4-6, 2001

Building a Computing Intensive University for the Information Age: Lessons Learned for the 21st Century

Saul K. Fenster, David F. Ullman, and Gale Tenen Spak
New Jersey Institute of Technology

fenster@njit.edu, ullman@njit.edu, spak@njit,edu

Abstract

Building a robust technology infrastructure is a necessary, but insufficient requirement for building a computing intensive university. The philosophy of computing intensiveness must be reflected in all aspects of a university's mission – instruction, research, public service, and economic development. In addition, the culture of computer support must evolve to one of supporting customers, not merely computer users for a university to reap the full benefits of computing intensity.

1. Introduction

Technology and science are reshaping our world and providing a true global information society, with computing and other information technologies taking a leading role. As pivotal technologies for the new millennium as the printing press and steam engine were for the one just ended, computing and information technology are transforming the very foundations of our society. As we progress into the Information Age of the 21st century, we can truly appreciate the new forms of communication and information access that have been brought forward by the power of computers. The characteristics of an information-based society are increasing knowledge generation and the demand for its use at an exponential rate. New Jersey Institute of Technology recognized the potential impact of computing on commerce and learning more than two decades ago and in 1983 embarked on an ambitious plan to become a *computing intensive* university. Investments over the last 18 years have transformed the university. Today computing intensiveness manifests itself not just in the ubiquitous availability of computers on campus, but also in the ubiquitous ways in which the technologies have been adopted and the university has transformed itself - realigning itself to the needs of an information society, yet remaining a student and learner-centered, urban, public research university. Today computing and information technology are an intrinsic part of the campus culture, as vital a part of the university's infrastructure as the bricks and mortar of its physical plant. They underpin every aspect of the university's mission.

This transformation has required careful planning, reflective thought and an entrepreneurial spirit – while always recognizing that technology's aim is to help customers, not simply users. The transformation into a *computing intensive* university involved not only the building of technology infrastructure, but also evolving the organizational structure for doing work across all sectors of the university. This paper discusses NJIT's experiences in building a customer-centered, *computing intensive* university.

2. The transformation – some examples

A number of examples help illustrate the results of this transformation:

- In 2001 approximately 65% of courses use some form of technology to assist in teaching, learning, or delivery. This may be as simple as course web pages where an instructor provides a web site to download course lecture slides, sample examinations, or homework solutions. However, it also includes approximately 10% of courses offered in a full distance-learning mode, the many of which leverage the advantages of asynchronous communication and learning tools to replace in-class discussion. The traditional role of faculty members in providing value-added communication, collaboration, and coordination to the individual and group classroom experience by encouraging debate and inspiring critical thinking is preserved in the distance learning courses with the use of such tools to create virtual learning communities. Synchronous distance learning courses are also available using interactive television and other broadcast technologies. Faculty also may present or supplement course content using streaming video clips or animations, and conduct evaluations using on-line quizzes.

- Approximately twenty percent of enrolled students each semester are taking at least one course in a distance-learning mode. In addition, another two thousand students participate annually in non-credit distance learning programs courses for continuing professional education.
- Two Bachelors degree programs, five masters degree programs, and ten graduate certificate programs (12 credits each) are available entirely in an on-line/distance learning mode.
- In 1992 NIIT opted against providing 'telephone registration' for students and instead modified and secured its legacy-based student information system in order to allow students to register themselves for courses. Arena registration transformed to *self-registration*. Over the years a full suite of *Let the Customer Do It Himself/Herself* on-line student service functions have been developed, eliminating many of the obstacles that students typically associate with traditional administrative processes. Today network and web access have eliminated the constraints of time and place for a host of on-line student service functions which include admissions application processing, academic degree requirements and catalogs, course schedules and registration, billing statements and credit card payments, vehicle registration for campus parking, grade reports, transcript requests, degree audits, name and address changes, financial aid status, library services and others.
- The NJIT Library has access to articles in over 10,000 journal titles, all but approximately 300 of which are available on-line. A Virtual Private Network (VPN) provides secure access to library databases when library patrons are off-campus from any place in the world with Internet access. An on-line real-time chat service is available for assistance from reference librarians.
- Freshman level engineering and architecture students are introduced immediately to computer-aided design and visualization work that other programs offer to upper-level undergraduates, often as an elective.
- All mathematics courses at the undergraduate level are taught using MatLab, a mathematical computing and visualization tool. As students learn the theories of mathematics, they also learn how to use problem-solving tools to be applied in their upper-level applied science and engineering courses.
- E-Mail has been a regular form of campus communication since the mid-1980. All students are issued e-mail accounts and they regularly use them to converse with faculty and advisors, submit assignments, and exchange documents among group members. Students have convenient web access to their e-mail from anywhere on or off-campus. At graduation, students can keep their e-mail addresses for life.
- An on-line purchase requisitioning system with electronic approvals has been in place since 1987. Faculty and staff can track the status of any purchase requisition and the release of formal purchase orders all on-line. Receiving reports for goods and services are also posted on-line.

3. The transformation – some recognition

The use of computers and information technology to improve processes, whether they are instructional, research, or administrative is only one aspect of NJIT's story. The main goal in the improvement of business processes is improved or even new services that are delivered to customers, whether they are faculty members, students, or staff. Recognition of these process improvements are illustrated in these two examples:

- NJIT has been ranked among the top schools in each of the fours years in which the U.S. magazine *Yahoo! Internet Life* has conducted its ranking of the 'Most-Wired" universities. The survey looks at a number of factors for the use of computing and information technology in academics, general and student services, and social life. During the last three years, NJIT has been the top-ranked public university. Although we recognize the pitfalls inherent in such a survey, NJIT's consistent presence among the top schools is a measure of the investment the university has made and its recognition of improving customer services as the single most important outcome of technology investment.
- In 2000, for the fifth consecutive year, students from the New Jersey School of Architecture at NJIT took top honors in the annual CADDIE Awards competition. Sponsored by *CADALYST* magazine, this international competition recognizes excellence in design visualization using computer-aided design (CAD) software. This year NJIT students once again swept first, second, and third places in the full-time undergraduate student still image division of the competition and for the first time took top honors for animation. No other school has come close to finishing in top honors for five consecutive years in this international competition. This recognition of excellence in design visualization for the New Jersey School of Architecture is a result of the School's strategic decision to introduce computers into the design studio in 1988.

4. How the transformation took place

The story of transformation at NJIT is not one of simply building a robust technology infrastructure (although it is a necessary requirement). The transformation that took place at NJIT was influenced by the early work of some pioneering researchers, and has been continued by strategic choices that have incorporated *computing intensity* into all aspects of the university's mission

4.1. Computerized Conferencing and Communications Center

Dr. Murray Turoff came to NJIT in 1973 from the White House Office of Emergency Preparedness where he had developed the first computer conferencing system. He came to NJIT with a vision of developing and evaluating computer-mediated communication technology to facilitate group decisions so that groups might act with their collective intelligence instead of the lowest common denominator. In 1978 he and Dr. Starr Roxanne Hiltz published *The Network Nation: Human Communication via Computer*, which was cited by *Time* magazine (November 25, 1985, p. 100) for its influence on new ways of thinking about computers, and has become the defining document and field of reference for computer-mediated communications. Turoff and Hiltz directed the Computerized Conferencing and Communications Center (CCCC) at NJIT from 1978 until 1993, where they developed the Electronic Information Exchange System (EIES). EIES was later tailored specifically for asynchronous computerized conferencing among a faculty member and students, eventually traded marked as the *Virtual Classroom®*, and in 1989 used for the first distance-learning course using asynchronous communications. Researchers at CCCC were early pioneers in developing protocols and applications for information exchange on the World Wide Web, and first brought campus access to the WWW in 1992.

Turoff and Hiltz' vision and the work of CCCC provided significant momentum to further explore new forms of communication and information access and deploy them on the NJIT campus as additional dimensions of *computing intensity.*

4.2. The 1983 computing master plan

In 1983 the university developed a computing master plan that first adopted the strategic direction of *computing intensity*. Among many initiatives, the plan took several strategic steps that would begin to change the campus culture and laid a strong foundation for the future:

- In 1985 NJIT became the first public university to begin issuing personal computers and software to all incoming full-time freshman, for use at home or in a residence hall. Upon graduation, students were allowed to purchase the computer for a nominal fee.
- A fiber-optic network was developed with on-campus connectivity to growing campus computation resources, but more importantly, with external access to the Internet and supercomputer facilities.
- E-Mail became a regular form of communication.
- Computer-aided design and manufacturing resources were installed for architecture and engineering programs.

4.3. Computing intensive instruction programs

On July 1, 2001, NJIT officially opened the doors of its new College of Computing Sciences. In establishing this new college, NJIT is building on the largest computer and information science educational program in the state of New Jersey and in the New York metropolitan region, and one of the oldest and largest in the nation. The new College will open enrolling approximately 27% of NJIT's total student enrollment of 8800. Although NJIT has experienced an almost astonishing growth in the number of students interested in computing related fields, the university's reputation as "the" place to study computing in the state was carefully developed with significant and serious outreach programs to high school programs throughout the state. In conjunction with NJIT's Center for Pre-College Programs, computer science faculty developed special high school programs, programming contests (e.g. "Computer Olympics"), as well as regular visits to high school college nights in order to build interest in NJIT and computing major programs. Recently launched at the undergraduate level, an Information Technology degree program allows students to, in essence, 'double major' in IT and one of over 20 separate application areas. The new degree program provides what every industry needs: trained IT professionals in a specific discipline.

The results of these efforts bring a student body to campus that is interested in computing as a profession. This large student body is a rich resource of student talent and intellect for faculty research and development assistance, as well as a pool of potential support technicians for the university computing support organization. In reality, a *computing intensive* campus needs a significantly–sized critical mass of students interested in the profession and in learning both inside and outside of the classroom. Today NJIT offers twenty-one separate degree programs at the bachelors, masters, and doctoral level that are directly related to computing and information technology careers. From computational biology to professional and technical communication, the university designs educational programs that keep pace

with the advances in applications of computing and information technology. The university's remaining ninety-eight programs make significant use of computing and information technology as an important "tool of the trade". All degree programs endeavor to educate a "complete professional", one that has developed an enterprise view of the discipline, and technology's role in the discipline. These are supplemented by a full-range of non-credit professional development and training programs.

4.4. A computing intensive research university

A research university is one conduit through which science and technology flow into society. As a *computing intensive* research university, NJIT has a number of multidisciplinary and integrated research groups, all leading to new knowledge and applications of computing and information technologies that will improve processes and products for industry. Researchers continue to push the envelope of current computing and information technology capabilities, creating new ideas and applications. As discussed above, the Computerized Conferencing and Communications Center played an important role in shaping the university's vision on computing. Today several other research initiatives are furthering that vision and furthering contributions to society.

- *New Jersey Center for Multimedia Research* (NJCMR) – Now in its third year of operation, this partnership between NJIT and Princeton University leverages intellectual assets and research infrastructure at both institutions to make significant research contributions in a broad range of multimedia technologies to enhance the competitiveness of New Jersey's multimedia related industry. NJCMR operates the Multimedia Production and Internet Delivery Studio (MPIDS), where researchers and industry partners create courseware and other multimedia products for education using the latest in multimedia and internet technologies.
- *New Jersey Center for Wireless Telecommunications* – A partnership between NJIT, Princeton University, Rutgers University, and Stevens Institute of Technology, this Center leverages intellectual assets and research infrastructure at the participating academic institutions to make significant contributions in a broad range of wireless technologies that will enhance New Jersey's wireless industry; to develop new wireless technologies, and advance the application of these technologies. Researchers are currently developing systems to support a high-speed, low-cost wireless Internet.
- *Center for Manufacturing Systems (CMS)* - CMS brings together full time professional engineering staff, university researchers, and students in a broad program of research, development, direct technical assistance, education and training, targeting all areas of the manufacturing sector. CMS integrates several special purpose facilities with advanced laboratory and pilot scale equipment available for collaborative work with industrial partners. Among the special facilities in CMS are the Simulation and Animation Laboratory, which provides access to state of the art computer-aided design software for design of prototypes; and the Manufacturing Automation Laboratory a prototype 'factory floor' which uses the latest in robotics and network technology with advanced machine tools to manufacture physical prototypes. Together, the two facilities provide an industrial quality CAD/CAM environment.

A significant aspect of these and other R&D efforts is the solicitation, development, and implementation of large-scale technology research and development projects, primarily focused on developing partnerships with industry. Through such public and private partnerships that make the university's facilities, expertise, and rich technology infrastructure available, and through economic development efforts with several dozen new high-tech firms residing in the university's on-campus business incubators, NJIT helps to grow new technology business ventures that fuel the economy.

4.5. A computing intensive public university

As a public *computing intensive* university, NJIT gives back to the state. When the New Jersey Presidents' Council and the New Jersey Commission on Higher Education identified the need for a comprehensive technology plan for the state's system of higher education, NJIT's President was asked to co-chair the effort. The planning effort resulted in legislation providing $50 million to fund technology infrastructure at the New Jersey's forty-five colleges and universities with a public mission. Subsequent initiatives establishing a *New Jersey Virtual University* involved the leadership of a distinguished NJIT faculty member and NJIT's Associate Vice President for Distance Education. NJIT also led the effort to plan and build a high-speed broadband network to link together New Jersey's colleges and universities for increased communication and collaboration in teaching and research. NJEDge.Net – New Jersey's Higher Education Network is housed at NJIT and NJIT's CIO chairs its Board. The University Librarian at NJIT is a member of the executive board of *VALE* – the Virtual Academic Library Environment of New Jersey, a statewide consortium of public and private libraries in

higher education, pooling resources for digital library services.

4.6. A computing intensive urban university

An urban university should always give back to its community. As an urban *computing intensive* university, NJIT gives backs to the greater Newark, NJ community. Each year approximately 400 undergraduate students participate in 'service learning', where they receive college credit for developing websites, providing technical training, programming and LAN set-ups for local community and non-profit organizations. Faculty, researchers, and the Division of Continuing Professional Education collaborate on extensive workforce development efforts with computing and information technology professions.

5. The 1998 Information Services and Technology plan

In 1998 NJIT formally adopted an Information Services and Technology (IST) Plan, the result of a yearlong planning effort with university-wide representation. Building on the *computing intensive* theme of the 1983 computing master plan, the IST Plan adopted a set of IST goals that were incorporated into the university master plan, formally defined a technology infrastructure necessary to support and expand university activities, and implemented an annual means to maintain that infrastructure. The annual funding of this technology infrastructure is essential to long-term viability. With the new economics of information technology, there is a constant, if not accelerating, rate of change in the underlying technology that makes the economic life cycle of many technologies very short. This concept is surprisingly different from traditional 'bricks and mortar' infrastructure maintenance issues.

5.1. Fundamental technology infrastructure requirements

The IST Plan's six-component description of technology infrastructure necessary to support a *computing intensive* university is illustrated in Figure 1, and briefly summarized next. The infrastructure first starts with a "foundation" of human resources and well defined procedures, adds four "pillars" of hardware and software technologies, and then delivers a first "level" of value-added content to customers.

5.1.1. Basic support component. The Basic Support Component aims to maximize the benefits of computing and information technologies while minimizing the frustrations typically experienced by users of those technologies. Customers should have a single point of contact to report repair problems, get simple information, ask for help in an emergency, and receive training on basic technology services. In other words, a customer service department within the central computing organization – one that coordinates all customer services whether they be faculty, student, or staff. The old lines between what was one time called academic computing vs. administrative computing are often blurred. Help desk services, computer maintenance, training, and faculty development programs are all aspects of this infrastructure component.

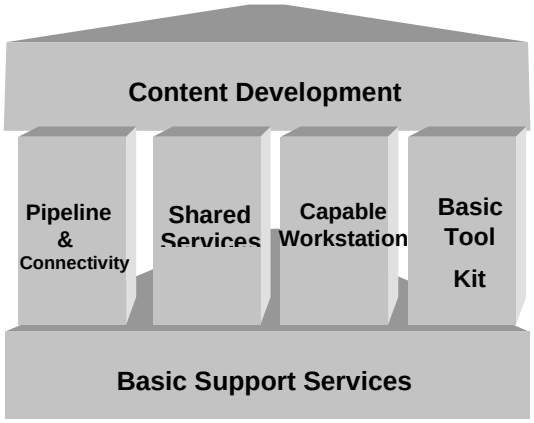

Figure 1 – Technology Infrastructure Requirements

5.1.2. Pipeline and network connectivity component. The Pipeline and Network Connectivity Component recognizes a network centered computing environment with users having universal access to services anytime from anyplace. Bandwidth requirements are almost insatiable as a new generation of multimedia applications are developed and delivered to customers over robust wired and wireless networks that are not just campus-based. In a network-centered computing environment, the old physical security concerns of a central data center are now augmented with network security concerns. Customers need to be authenticated and provided access to all services for which they are authorized and entitled. These are all issues for the Pipeline and Connectivity component.

5.1.3. The shared services component. The key to a network-centered computing environment is providing an environment where all services appear to be standard network services available to any customer that authenticates himself. A universal ID ties together a distributed computing environment that appears as a single central service, with the customer customizing his interface to those services. Portal technologies are providing the technology framework to implement this

concept of shared services. Implementing shared services requires a strong team of systems administrators able to manage a distributed computing environment with significant amounts of computation resources, disk storage, and other applications.

5.1.4. Capable workstation component. The Capable Workstation Component recognizes the entry point to the network-centered computing environment is a capable workstation (desk-top or notebook computer; windows, Mac, or Unix; personal computer or graphics workstation, etc.), appropriate to each customer's need. Many customers will bring their own, and others will use university resources in public labs, classrooms, and other facilities around the campus. NJIT has provided incoming freshmen with a 'capable workstation' since 1985. The capable workstation is as fundamental to a faculty member's job as a telephone and should be provided with the same ease in which a telephone is issued

5.1.5. Basic tools component. The Basic Tools Component looks to provide software "tools of the trade" for all customers. This includes university-wide standards for web browsing, terminal emulation, virus protection, mail clients, word processing, spreadsheets, statistical software, databases, and a host of other applications and basic utilities. Centralized licensing and management of software helps ease an administrative burden and reduce software piracy. Customers must be able to obtain the latest versions of software upgrades with a minimum of effort.

5.1.6. Content component. Finally, the Content Component provides fundamental content services, which leverage the hardware and software technology infrastructure to advance teaching, learning, research, and administrative support. Much of this is seen in web-based applications, among which are systems that provide on-line access to library databases, registration and degree audit systems, and on-line course delivery and discussion systems used in both traditional and distance learning course venues.

6. Changing the culture of computer support

Perhaps the most important and least obvious requirement for creating a *computing intensive* university is the need to change the culture of support in computing organizations. Many older and senior level computing support personnel learned of computing during an earlier era – the mainframe era, where scare expensive resources forced organizations to follow a policy of "protecting computers from the users". Also, younger and more junior professionals learned computing during the PC era with little appreciation of the need for procedures and best practices with the paradigm shift from personal computing to work group computing.

Computing organizations today must evolve to customer service organizations, where greater emphasis is placed on understanding the needs of the customer, and how technology fits in to the greater issue of supporting those needs. The culture must change from computer-centric to customer-centric. Alter provides an appropriate framework illustrating this significant paradigm shift that is appropriate for all organizations and all computing professionals. Figure 2 illustrates that technology is only one aspect of the mix that produces new products or services for IT customers.

Figure 2. Customer Support Perspective

7. Conclusions

In summary, NJIT's experiences have shown that computing intensity within higher education is not just access to computing power, but also manifests itself with new forms of communication and information access. A robust technology infrastructure is a necessary but not sufficient condition for success. The technologies must be integrated and used to transform into all aspects of a university's mission – instruction, research, public service, and economic development, and planning must involve stakeholders from each of these constituencies. Finally, the culture of support must become customer-centric and not computer-centric.

8. References

Alter, S., *Information Systems: A Management Perspective*, Addison-Wesley, New York, NY, 1999.

Dolence, M. G. and D.M. Norris, *Transforming Higher Education: A Vision for the 21st Century*, Society for College and University Planning, Ann Arbor, MI, 1995.

Hiltz, S.R. and M. Turoff, *The Network Nation*, MIT Press, Cambridge, MA, 1993.