Learning Tools for the 21st Century

Enhancing Education through the Intelligent Application of Computer Technology

NEC Computer Systems Division

A Division of Packard Bell NEC, Inc.

Introduction

In 1882, electricity flowed from Edison's power station in New York City. Since then, electric light has replaced gas lamps and candles, and computer technology has been successfully integrated into everything from ovens to automobiles improving food to fuel economy without requiring any significant increase in user training. Still, the methods used to teach our children have remained largely unchanged and computers remain a luxury and often a burden to educators in our classrooms.

It is ironic that Edison, a man with only 3 months of education, has made possible an opportunity to create a revolution in learning that will impact the quality of life for children and adults. While we have harnessed computer technology as an extension of our minds in business and pleasure, it has not been properly utilized to accelerate and broaden the learning experience for our children.

In 1998, the United States will spend $358 Billion on the education of elementary and secondary students.[1] Of this, only $4.3 Billion, or 1.2%, is used to purchase information technology. While nearly 45% of U.S. office workers have individual access to computers, the number of computers in primary education, provides only 4.5% of the students with individual access, or one computer for every 22 students.[2] (Figure 1).

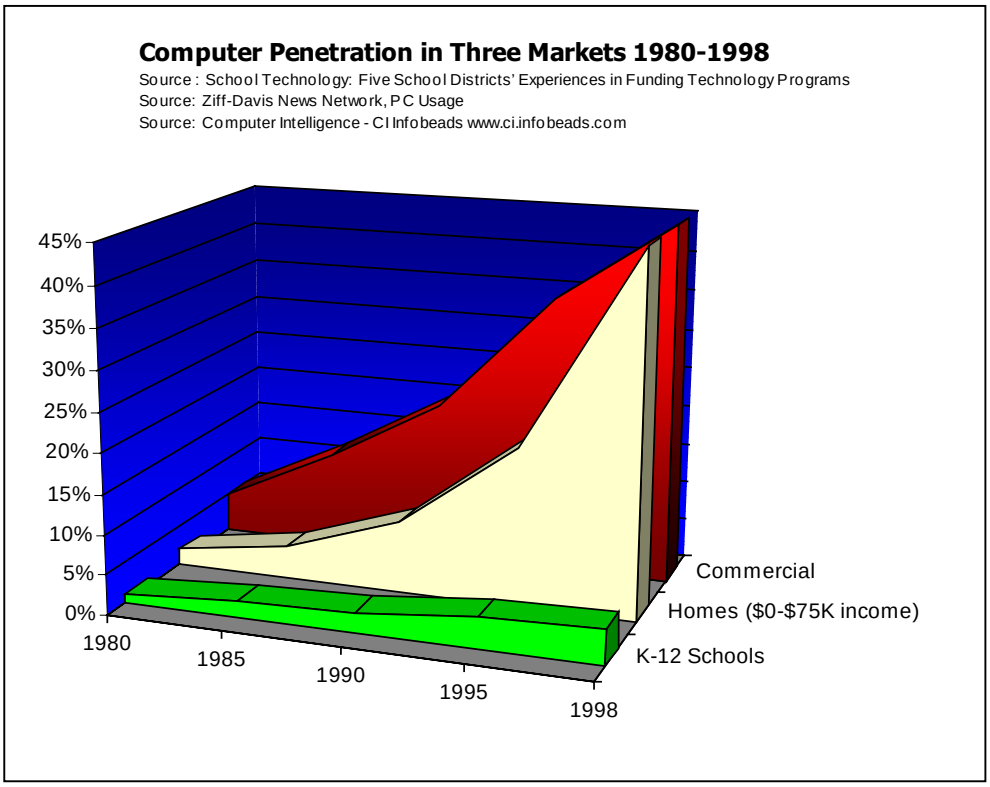


Figure 1 – Computer Penetration in Three Markets

Lacking a better solution, the educational community purchases feature filled computer equipment that does not address the durability and flexibility requirements of our schools. The features of today's computers render them too costly and complex to be used as mainstream educational tools. These factors prevent schools from achieving a one-to-one ratio between computers and students and therefore from using computer technology as a primary learning tool in the classroom.

[1] Source: U.S. Department of Education, National Center for Education Statistics, "Common Core of Data" and "Financial Statistics of Institutions of Higher Education," surveys and unpublished data. (prepared January 1998)

[2] Source: School Technology: Five School Districts' Experiences in Funding Technology Programs

Personal computers have accelerated our business communications and broadened our information access at work because so many people have personal computers. Without this same level of computer participation in the learning experience both inside and outside the classroom, students will never have a better alternative to books and paper.

Properly integrated technology in our schools will:

- allow teachers to readily tailor lessons and receive electronic texts with up to date information directly from the publishers during the school year
- provide engaging interactive assignments that better illustrate the principles being taught and adapt to students having difficulty with the subject matter with tutor-like help
- replace heavy outdated textbooks with light weight, durable, and low cost portable media

Without a far greater number of computers in schools, computer technology will remain in the back of the classroom and fail to provide the same advantages to our children's education that it has to other aspects of our lives.

In this paper, we will discuss how NEC can work with educators and publishers to meet the cost, durability, and flexibility requirements of the educational market, achieve greater acceptance of computer technology as a learning tool, and revolutionize education in the 21st Century.

"In poll after poll, parents say technology is essential to a child's education. Many educators believe it's the missing linchpin of school reform. Business leaders consider it a mandatory part of a student's preparation for the workplace. And policymakers at every level of government are spending more money on it each year." – Milken Exchange, Education Week, Taking Technology's Measure, by Andrew Trotter.

Our Vision

NEC Computer Systems Division began an initiative to move more computers into our classrooms in December, 1997. President Bill Clinton, in his January, 1998 State of the Union address, outlined four goals for education that aligned well with our direction:

1. *Provide access to modern computers for all teachers and students;*
2. *Connect every school in America to the Information Superhighway;*
3. *Develop effective software in all subject areas, and*
4. *Give every teacher the development they need to help students use and learn through technology.*[3]

NEC CSD has a way that this can be achieved. We have aligned ourselves with the industry's leading hardware and software manufacturers, and through these alliances, we can make possible a shift in the way that technology is both perceived and utilized in the classroom and at home.

NEC Computer Systems Division is partnering with industry leaders to launch a historic step forward in electronic education. Our mission is to provide every child in grades Kindergarten through 12th grade the opportunity to accelerate their learning and broaden their educational horizons. One of the major factors that has kept many software vendors from bringing the latest technology into the field of education is that there are too few platforms on which the software can be utilized in today's schools.

We wish to bring about a dramatic increase in the availability of computers to today's students and teachers in the school and at home and help meet President Clinton's first goal for education.

We will make available vertical solutions that include server products to support the connection of schools to the Internet. These products can be purchased with the help of the E-Rate program.[4]

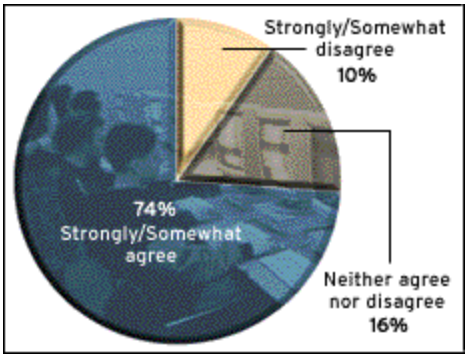
Through our software vendor partnerships we will cause a shift from learning about technology to learning with technology. The future of electronic education is with software that allows the student to learn at their own pace, through the use of new pedagogic methods focusing on higher-order reasoning and problem solving skills. Interactive computer-based instruction makes possible individualized education accommodating the needs, interests, current knowledge, and learning styles of each particular student. Self-pacing obviates the need for teachers to target their presentations to a hypothetical "typical" pupil, leaving part of the class behind while other students become bored, restless and inattentive. This will help meet the third goal: Effective software.

Students are not the only beneficiaries of this technology, teachers will also benefit by being able to monitor and assess the progress of students and

[3] Source: Background on President Clinton's State of the Union Address to Congress, January 23, 1996; Whitehouse Web Site: http://www.whitehouse.gov/WH/New/other/challenge.html#education

[4] More information on the E-Rate program can be found in the E-Rate section on page 7.

maintain portfolios of student work. Communications between students, parents, and administrators will be greatly enhanced. Exchange and consultation with peers and experts will be facilitated through access to remote information and resources on the Internet. The most important advantage to teachers will likely be the opportunity to expand their own knowledge and professional capabilities, helping meet President Clinton's fourth goal: Teacher development.



The Public's View -
Do you strongly/somewhat agree or strongly/somewhat disagree that computers have improved the quality of education? SOURCE: National Computing Survey, Microsoft/Intelliquest, 1995.
Note: 2,802 people polled by telephone.

Figure 2 - Public believes computers have improved education.

Connecting schools and homes is a crucial step in the success of this vision, allowing each student to gain an exciting new way of extending learning past the end of the school day. Parents are convinced that computer have already improved the quality of education at school (Figure 2) and retail sales to homes with school aged children show they believe the benefit continues at home.

Through the interconnection of schools and homes, parents will have a greater opportunity to interact with teachers and become more involved in their child's education. Teachers and parents corresponding through an electronic system can communicate day to day progress. Students will gain access to learning and reference materials from local schools while at home and, with inter-community cooperation, between other schools in the U.S.

Ideally, repositories of curriculum materials and relevant information will be maintained at publishers on the Internet and licensed by schools for less than the price of textbooks. This will reduce the need to duplicate these materials at each learning location and ensure timely content. On-line tutors, familiar with the curriculum, or interactive on-line teaching aids could provide students with help day and night.

The possibility also exists for interconnection of schools and homes across the country sharing virtual classrooms and expanded curriculum, with class projects spanning schools, states, and even countries. Distance learning is available for rural students allowing them access to the same resources available to urban students.

Students unable to attend regular classes due to physical disabilities will be able to learn and interact with other students through home-based technology.

The hardware portion of this solution will be the most crucial and innovative part, including new interfaces customized to the intended audience. Kindergarten though second grade students will be presented with an interface designed with their motor skills, dexterity, and attention span in mind. As the proficiency of the user increases, so will the level of complexity of controls, extending from kindergarten students to teachers and parents.

The design must include considerations for various types of input including voice, mouse, touch-screen and keyboard, with flexibility to support input devices for various age groups. Alternative input devices for the physically disabled must also be considered.

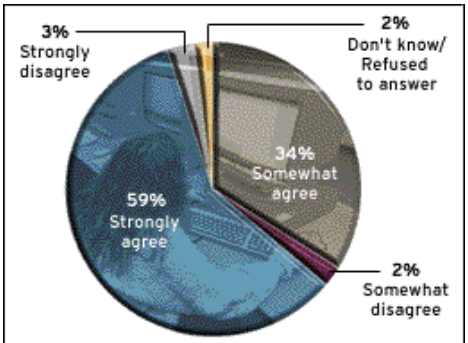
Students must have access from home to the school curriculum, being able to transfer work between sites by wire or through the use of lightweight, durable, and low cost portable media.

Analysis

Overview

Our analysis of the educational market and research into some of the problems that may arise when introducing new technology into the classroom fell into four general categories. These categories were acceptance, cost, flexibility, and durability of the solution.

We divide our analysis of the particular problems associated with the introduction of new technology into our educational system into these categories and explore them in the following section.



The Educators' View
Would you strongly agree, somewhat agree, somewhat disagree, or strongly disagree with the following statement: The use of computer technology in the classroom has improved teaching and learning in my school district.
SOURCE: Global Strategy Group for Jostens Learning Corp., 1997.
Note: 582 teachers and 419 superintendents polled by telephone.

Figure 3 - Educators believe computers have improved teaching and learning, but less than public.

Acceptance

While many factors affect the acceptance of a new technology in education, the two largest opposing factors are adult concerns with regard to politics and technical skills of the educational staff. Costs, support skills, effectiveness, and application of the solution in an educational environment are of particular concern. Although the public is convinced that computer have improved education (Figure 2), educators are less convinced. (Figure 3)

Conversely, children are highly flexible and current installations of computer technology in homes and in classrooms show they readily accept them and enjoy the experience. The intense growth of the retail market for home computers is also a contributor to educational acceptance.

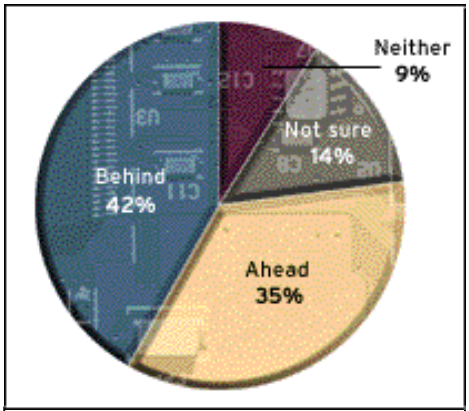
The high political profile of education ensures new solutions will encounter great scrutiny before they will be embraced. Naturally, communities are unlikely to expose their children to an educational solution that is not understood or that has questionable effectiveness. Acceptance can only be gained if there is evidence proving the approach provides accelerated or broadened learning resulting in better student test scores.

Public opinion will largely affect the financing of more technology in the classroom, so the introduction of any educational solution must be accompanied by substantial marketing information to educate the general public with emphasis on educators and parents. As politicians and the general public conduct their cost-benefit analysis, the implementation costs and effectiveness data developed through independent research and past performance of similar systems must be well presented.

Acceptance of technology into the classroom by teachers, policy makers and taxpayers is a concern that must be dealt with from the onset. Government, school boards, technology companies, community organizations, parents, teachers and students must be persuaded to embrace this initiative through focused marketing efforts.

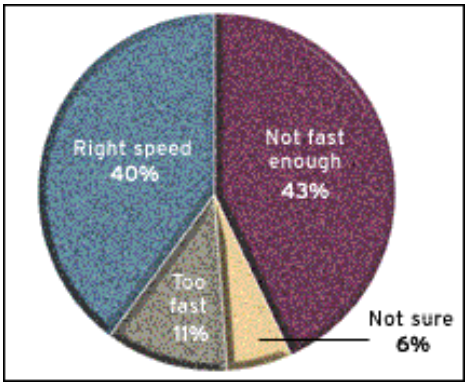
NEC should consider providing rebates to districts that utilize the solution effectively to improve test

scores. The resulting betterment of education coupled with the marketability of such success stories will provide considerable marketing tools to NEC as we grow the educational market.



"When it comes to the public schools in your community, do you think these schools are ahead of the curve or behind the curve in using computers and up-to-date technology to teach students?" SOURCE: Peter D. Hart Research Associates Inc. for the Milken Exchange on Education Technology, 1997.
Note: 506 voters polled by telephone.

Figure 4 – Public perceives schools are behind the curve using computers



"Generally speaking, would you say that the introduction of computers and up-to-date technology into public schools is happening too fast, at the right speed, or not fast enough?" SOURCE: Peter D. Hart Research Associates Inc. for the Milken Exchange on Education Technology, 1997.
Note: 1,012 voters polled by telephone.

Figure 5 – Public perceives computers not introduced into classrooms fast enough

The scarcity of computer skills in today's education staff and its relationship to supporting the technology is also a major barrier to acceptance.

Many teachers are concerned about computers in the classroom. As new teachers with better computer skills join the work force, teachers lagging in computer skills may feel threatened. Current teachers often do not have the time to become proficient with the computers or incorporate them into the curriculum effectively in conjunction with their other responsibilities. These concerns are based upon experience with current technology in the classroom, and must be mitigated by reducing the burden of support and technical expertise required for new solutions.

NEC must focus on making computers for education less intrusive, leaving educators to focus on using rather than supporting the technology and involving it as an aide to education. Still, specialized training to educators will help make educational computing more accessible by building a bridge between their current skills and what is necessary to effectively use the products.

Cost

System Costs

System hardware and software costs that represent the start-up costs, although minimal when compared to the total cost of ownership (i.e., infrastructure, training, support), must be lowered to allow existing school budgets to support the implementation of technology-based learning in schools and homes.

In addition, NEC Computer Systems Division must develop creative new financing plans and help schools understand how to take advantage of existing funding projects from the U.S. and state governments.

Creative Financing

NEC CSD can create and implement various forms of creative financing to ease the financial burden on schools and families that have several school age students in the home. First, NEC should implement a leasing program with flexible 3 to 5 year terms. Second, NEC should develop a loan program for parent / student purchases with features that support low-income families for system purchases directly related to K-12 education. Lastly, NEC should investigate and work with Federal, state and local governments to identify other avenues of assistance, such as tax breaks for manufacturers and developers that provide product below market price.

E-Rate Program

One avenue schools have to ease their information technology costs is the E-Rate program. The Federal Communication Commision's (FCC) E-Rate program subsidizes schools that qualify by providing discounted rates on a wide variety of telecommunications and related services. Created under Section 254(h) of the Telecommunications Act of 1996, E-Rate qualified schools and libraries can

Schools and Libraries Discount Matrix		Discount Level	
% of students eligible for national school lunch program	Estimated % of US schools in category	**urban discount (%)**	**rural discount (%)**
<1	**3**	**20**	**25**
1-19	**31**	**40**	**50**
20-34	**19**	**50**	**60**
35-49	**15**	**60**	**70**
50-74	**16**	**80**	**80**
75-100	**16**	**90**	**90**

Figure 6 - E-Rate Discounts are Substantial

receive lower rates on a wide variety of telecommunications and related services. The location of the school and the percentage of students eligible for the national school lunch program determine the level of discount. (Figure 6)

E-Rate dollars are available to support the purchase of Internet connectivity. Schools can also use E-Rate discounts on "non-content" Internet access. These include e-mail and the technology needed to build internal networks. NECCSD products that can be purchased with these funds include network file servers and related software. Computers other than those used to run a network, software, and modems do not qualify for the discounts.[5]

The E-Rate program promises to remove much of the disadvantages rural and poor urban schools currently have.

There are also state run programs to support the purchase of information technology equipment not available using E-Rate discounts. California and Texas are two notable examples, and other state programs are being created that should be investigated by NEC.

Schools in California can take advantage of funds available through the "Digital High School" (DHS) program, signed into law by Governor Pete Wilson. This initiative calls for a significant investment in technology (i.e., computers, Internet access, and software) for every one of California's 1.6 million high school students. This plan provides for the following:

- A one-time grant of $300 per student, matched by local school districts, to install comprehensive computer networks on each of California's 840 public high schools.

- Permanent, annual funding of $45 per student, matched by local school districts, for maintenance and upgrades of these networks.

With this local matching fund, the typical high school will be able to invest approximately $1 Million dollars on its computer network and provide Internet access for every student and teacher. This program, overall, will provide $1 Billion across the state over a four-year period.

Schools in Texas can take advantage of funds available through the "Telecommunications Infrastructure Fund" (TIF). The TIF is an assessment that was created by House Bill 2128, 74th Legislature (Public Regulatory Act of 1995) which levied taxes on sellers of telecommunications services based on telecommunications revenue. The seller is required to collect and remit sales tax so the revenue can be used for:

- Local telephone service
- Associated services such as call waiting and caller ID
- Long distance telephone service
- Facsimile service

[5] Fund for Learning Consulting Firm Web Site, "E-Rate Basics", http://www.fundsforlearning.com/ebasics.html

The funds collected are used to make awards, grants, and loans to rural and urban school districts, institutions of higher education, and public libraries for projects and proposals that provide training, equipment, curriculum, and delivery of courses for distance learning and tele-medical services.

How Much Will Improving Technology in Schools Cost?

A 1997 U.S. Department of Education study analyzed various computer configurations in the classroom and concluded that networked computers at each student's desk would have a start-up cost of approximately $3,100 per seat and an on-going cost of $900 per seat.[6] This study assumes fairly costly computers such as laptops with none of the costly infrastructure in place. With 50 Million students in the U.S., the start-up cost would exceed $156 Billion with on-going costs in excess of $45 Billion per year. (Figure 7)

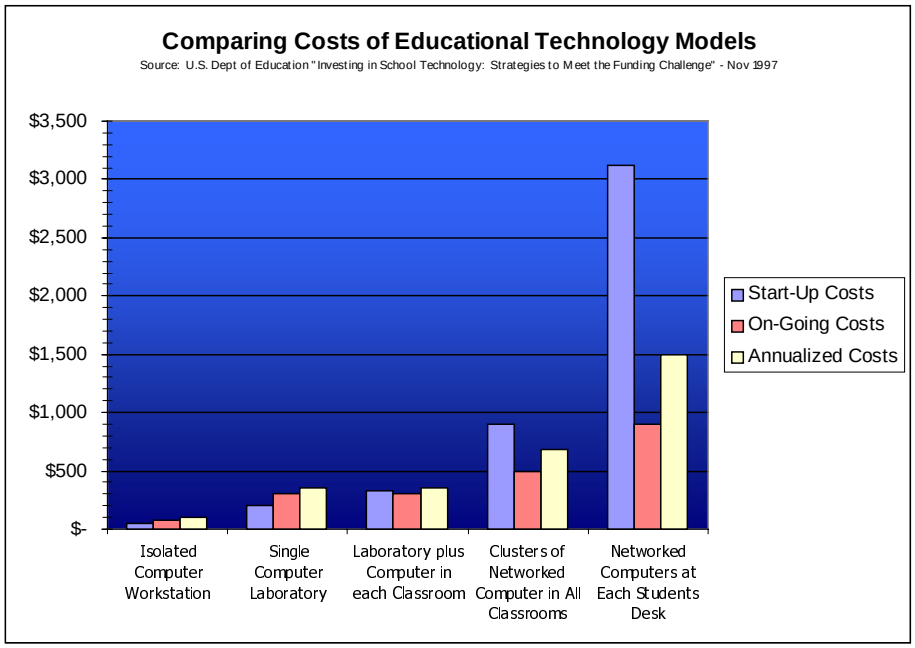


Figure 7 - Networked Computers are Costly

Funding programs that overcome the infrastructure costs are well on their way to putting Internet and network infrastructure into every classroom by 2001. Together with a low cost computing solution, the annualized costs for a highly computerized solution in schools can be reduced significantly.

Financial support for technology in the schools is on the rise, as the public pushes for better technology from their political representatives, votes for bond referendums, and allows some increase or redistribution of taxes for educational improvements.

When compared with the overall expenditures on education in the U.S. overall, our current and anticipated expenditures on information technology is relatively small.

Information Technology funds rose from $4.3 Billion for the 1996-1997 school year to $5.2 Billion for the 1997-1998 school year (Figure 8, next page), however the total U.S. expenditures on primary and secondary education is in excess of $358 Billion dollars.

[6] Source: U.S. Dept of Education "Investing in School Technology: Strategies to Meet the Funding Challenge" - Nov 1997

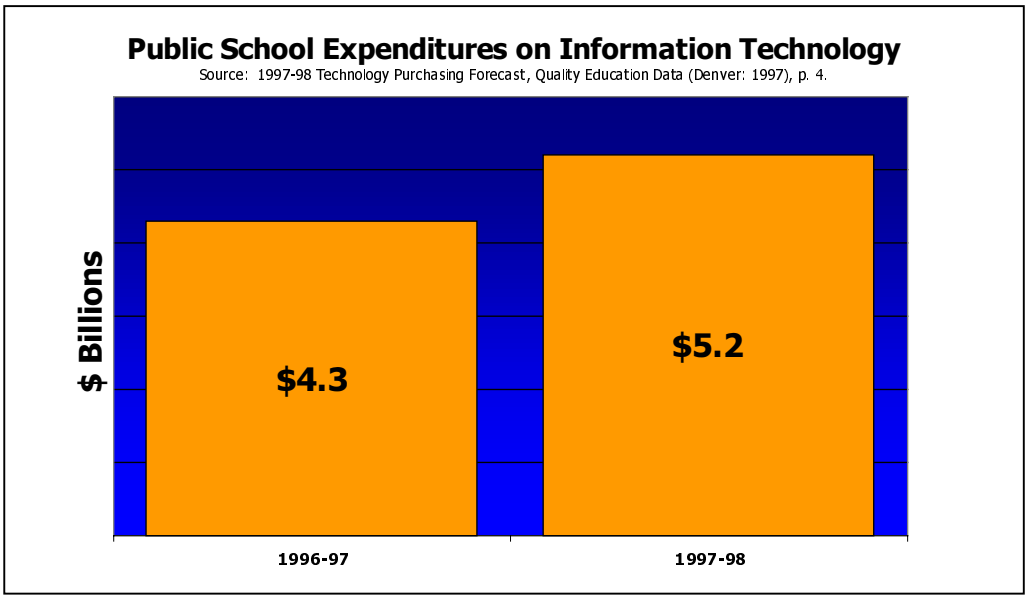


Figure 8 - Significant Increase in IT Expenditures

Increasing that budget to $20 Billion dollars, the amount recommended to fund a technologically robust classroom, pales in comparison to the overall educational budget. (Figure 9)

The concept of a one-to-one ratio of computers to students in the classroom and at home will essentially double the number of systems required to extend the learning day and allow more parent/community involvement. A system hardware solution that minimizes cost and supports a dual use approach is needed.

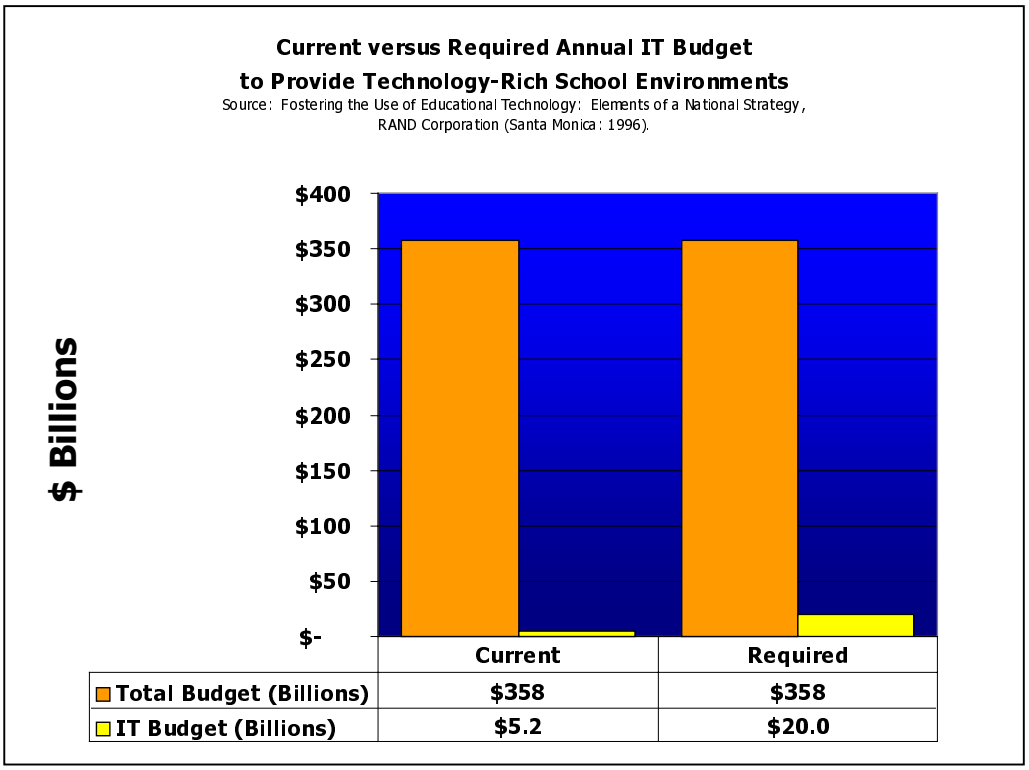


Figure 9 - Required Annual IT Budget Small with Relation to Overall Budget

The solution to minimizing hardware and software costs is two-fold. Centralized system management, software application updating and data storage reduces support costs significantly and minimize dual deployment of high cost components. Educational computing in the home benefits from this approach too, since students carry only inexpensive devices between school and home. Internet access from homes to school networks coupled with a low cost system for use both at home and in the classroom would reduce the cost of components carried back and forth.

Total Cost of Ownership (TCO)

The largest part of the total cost of ownership of a system is actually represented by the installation, training, system administration, user support, and hardware and software maintenance.

The solution to minimizing total cost of ownership is influenced by the technology adopted and the way in which it is implemented. Limiting the number of subcomponents and simplifying controls will lower overall service and support costs. Complex solutions provide opportunities for configurations to become misadjusted and most dramatically impact support requirements. Managing a system, together with the associated end-user IS and support, costs more than one and a half times the initial hardware and software purchase. (Figure 10)

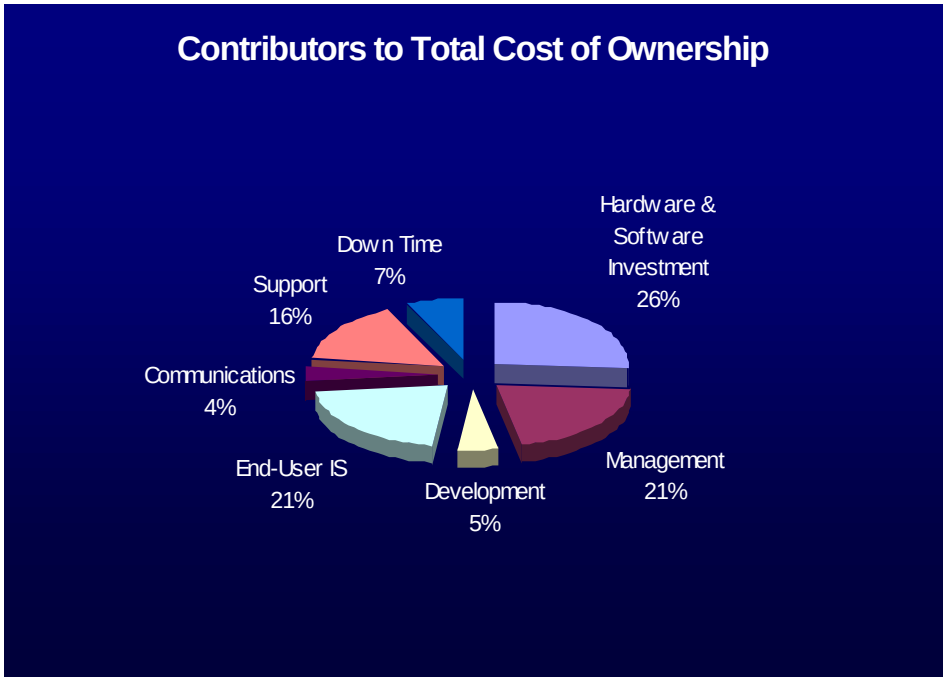


Figure 10 - Management & End-User IS cost nearly twice as much as initial hardware & software purchase

NEC should develop simple and inexpensive devices for this market and back them with service programs that ensure functional units are available to students and teachers to minimize downtimes.

NEC must offer programs that provide on-site support when schools do not have the staff or technical capability to ensure systems are maintained and functional at all times and programs with aggressive response and repair times. In areas where this is not feasible, NEC should provide on-site spares and training for local administrative personnel.

Additionally, implementing technology investment programs that provide rebates or free units (spares) based on the volume of units purchased (e.g., one free unit for every fifty purchased) should be considered. Lastly, consider implementing warranty/insurance plans that protect school and students against theft, damage, and misuse.

Infrastructure Costs

The extensive use of computers, LANs, WANs and internet access will have major cost impacts to existing school buildings. Placement of significant numbers of computers within a school can result in additional heat dissipation that will require new installations or upgrades to environmental cooling systems. Most existing schools were not built and wired with heavy computer use in mind.

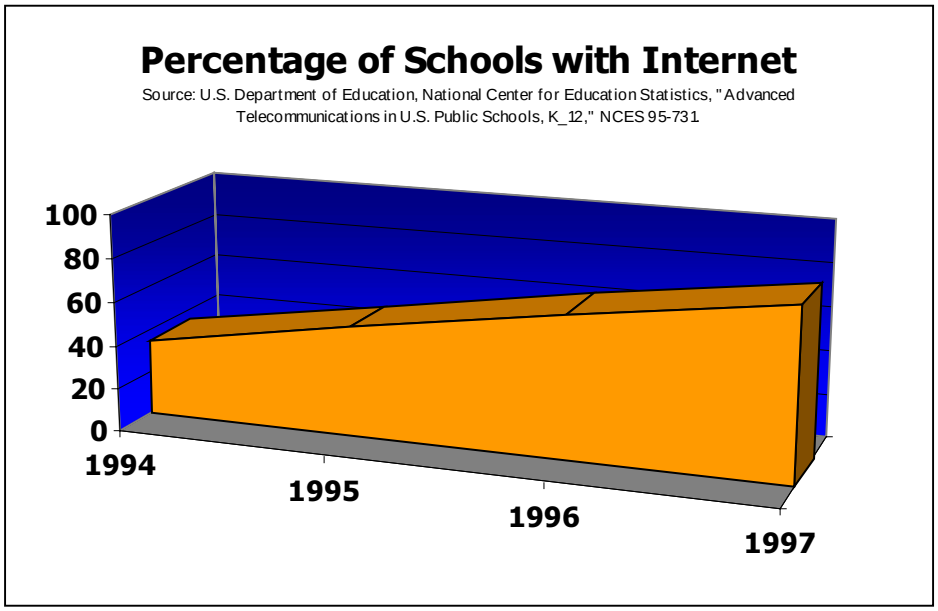


Figure 11 - Most Schools have Internet Access

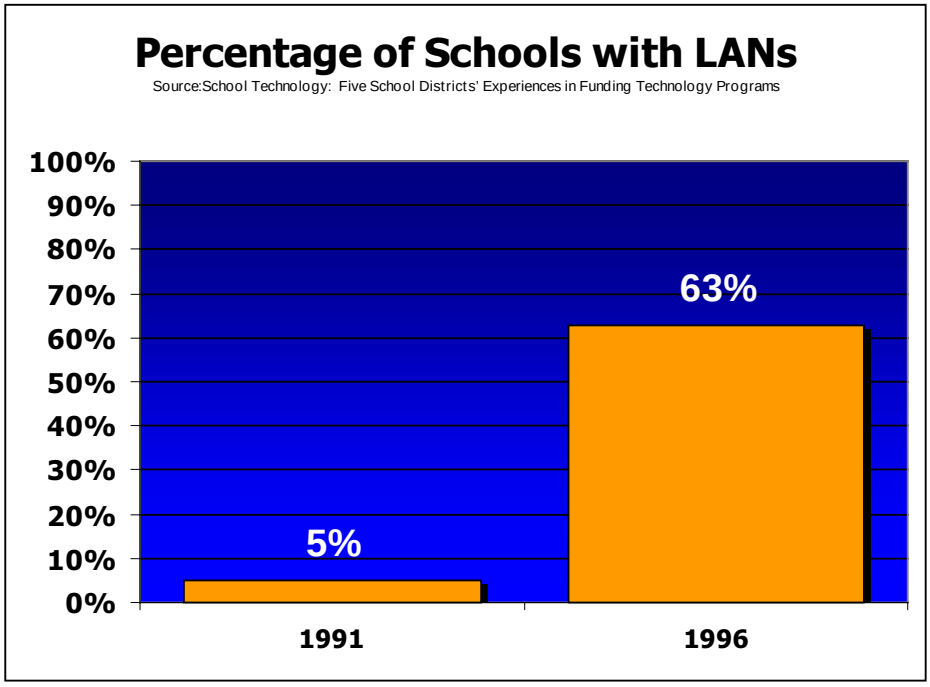


Figure 12 - Dramatic Increase in LAN Usage

However, utilization of wireless technologies could lower school remodeling and construction costs and centralized data storage and processing power can greatly reduce the impact on electrical and heating, ventilation, and air conditioning (HVAC) requirements.

Even with these hurdles, the number of schools with Internet connections has risen steadily from only 35% in 1994 to 78% in 1997.[7] (Figure 11)

Additionally, the percentage of schools with LANs grew more than twelve-fold in just five years, from 5 percent in school year 1991-92 to 63 percent in school year 1996-97.[8] (Figure 12)

Although these statistics show real progress, the criteria used to respond are unclear. Internet access or LAN usage does not imply to what degree students have access to them, or how limited that access may be.

The majority of students are located in urban centers with access to high bandwidth communication links near high-tech business activities. The student population found in rural areas and in poor urban areas is at a disadvantage due to the lack of access to these resources, but the E-Rate program, discussed earlier in this paper, should eliminate much of this disadvantage.

[7] SOURCE: U.S. Department of Education, National Center for Education Statistics, "Advanced Telecommunications in U.S. Public Schools, K_12," NCES 95-731.

[8] GAO Report to Congressional Requesters, School Technology, Five School Districts' Experiences in Funding Technology Programs, p. 8

System Obsolescence

Currently most schools with computer systems are utilizing hardware and software that is outdated. Remarkably, 35% of all computers in classrooms as of 1996 were still Apple II computers manufactured from the 1970's through the early 1980s.

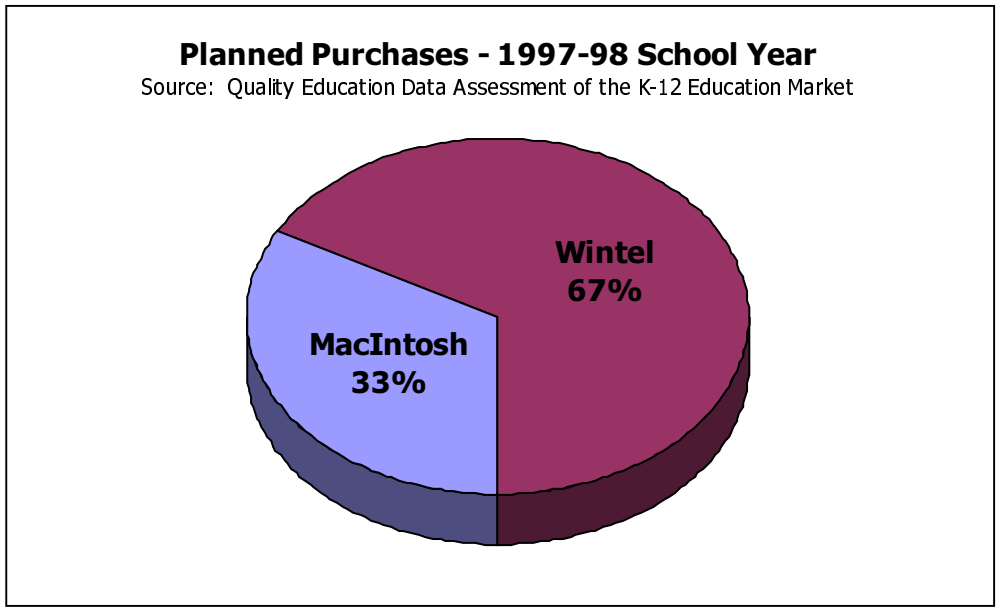


Figure 13 - Apple Market Deteriorating

This equipment is completely incapable of supporting multimedia education curricula and presents a large opportunity for new information technology sales. Apple's stranglehold on the educational market is loosening as QED reports that two-thirds of new educational computer purchases are of Windows-Intel (Wintel) systems rather than Apple. (Figure 13) This trend is occurring more rapidly in secondary schools than in primary schools.

Regardless of which type of computer is purchased, the short life cycle of personal computers burdens school budgets. It is important that educators and policy-makers view the purchase of computer equipment not as a one-time expenditure but as an on-going budgetary expense. In addition, educators and policy makers are reluctant to appropriate additional funds for timely replacement of computers in the classroom since they are not a mainstream educational tool. The NEC solution must integrate software tools and third party products to present an effective solution that is an integral part of teaching.

Obsolescence can be mitigated by designing components that rapidly become outdated and can be upgraded into a centralized processing system, and designing low-cost clients that don't need to be upgraded often. In this manner, schools can upgrade a central unit when improvements are available without affecting the large quantity of client systems.

Training Costs

Educational staff development and training is paramount to the success of Learning Tools for the 21st Century initiative.

As schools continue to acquire hardware and software, the benefits to student will increasingly depend on the skill with which teachers are able to use these new tools. Teachers currently receive little technical and administrative support to aid in the integration of technology into their curricula.

One program in place to help educate teachers and staff is the "Technology Literacy Challenge Fund". $200 million dollars in grants were made available for all 50 states and $425 million is requested for 1998. The Challenge Fund program is intended to achieve the following four goals by 2001:

- All teachers in the nation will have the training and support they need to help all students learn through the information super highway;
- All teachers and students will have access to modern computers in their classrooms;
- Every class room will be connected to the Information super highway; and
- Effective and engaging software and on-line learning resources will be an integral part of every school curriculum.[9]

***Cost** is an issue that enters every aspect of our lives and the life cycle cost of this technology initiative is not an exception. The United States spends billions of dollars annually equipping, maintaining and staffing our school. This initiative need to utilize the existing funding level and minimize cost increases when and wherever possible.*

Local governments and school boards best address the solution to training and professional development. These organizations must allot sufficient time for teachers to acquire knowledge and expertise to integrate technology into their curricula. They should allocate sufficient financial resources to train and develop the expertise required for teachers entering the profession and for tenured instructors. Federal studies indicate at least 30% of all federal expenditures for educational technology should be allocated to professional development and to ongoing mentoring and consultative support for teachers. Schools and school districts should be encouraged to provide time for teachers to familiarize themselves with available software and content, to incorporate technology into their lesson plans, and to discuss technology use with other teachers. Finally, both presidential leadership and federal funding should be mobilized to help our nation's schools of education to incorporate technology within their curricula so they are capable of preparing the next generation of American teachers to make effective use of technology.

NEC can help by providing technical training for teachers and administrators on our education products and by hosting curriculum related training.

Flexibility

Students with special needs often cannot take advantage of computer in the classroom. The portion of the student population that has learning disabilities, behavioral disorders or physical disabilities deserve and require equitable access to the same information and resources as able-bodied students.

Public school districts and other educational institutions must include individuals with disabilities in their programs and activities. Accessibility to computer technology in the classroom helps schools to meet their legal obligations under Section 504 of the Rehabilitation Act of 1973, the Americans with Disabilities Act of 1990, and the Individuals with Disabilities Education Act. Currently, all States

[9] Department of Education, Summary of the Budget 1998, pg 13

receive Federal funds under the Technology-Related Assistance for Individuals with Disabilities Act, which requires the States to purchase and use electronic and information technology that is accessible to individuals with disabilities.[10]

Technology may present special challenges to students with learning disabilities, behavioral disorders, emotional problems, or physical disabilities, but it may also provide them with unique opportunities for more effective learning. In the case of such students, equal access may not imply equitable access; special measures must sometimes be taken to ensure that they are afforded the maximum possible benefit from the use of educational technology. Children with certain mobility or sensory impairments, for example, may be able to use single-finger devices, joysticks, mouthsticks, or other specialized hardware to provide input to the computer. Students unable to enter data on a conventional keyboard will be able to achieve the same effect through the use of "eye gaze" technology. A "single switch" device together with special keyboard scanning software allows disabled children to select first a row, then a column, from a "virtual keyboard" depicted on the monitor. Those who are unable to use a mouse may be able to employ an alternative device together with a specialized screen display to emulate conventional point-and-click operations.

***Flexibility** is required of the system taking a number of things into consideration including design, cost, and implementation perspective to allow equitable access.*

Assistive output technologies for students with disabilities include magnification programs for low-vision students and systems that use voice synthesis technology to read out screen information or the contents of printed documents to blind students. Both local and wide-area networks may be used to permit students with various forms of mobility limitations or communication impairments to access and exchange information, making available valuable learning resources that might otherwise be inaccessible. Technology also has the potential to significantly expand the educational opportunities available to children with learning disabilities currently the largest category of students with special needs. NEC's solution must provide a suitable interface for the connection of these devices.

Race, ethnicity and socioeconomic status are factors that must be considered in the widespread deployment of computers and technology in the U. S. school systems. Cost, as previously discussed, can be abated through designs tailored for the classroom, creative financing, rebates for test score improvement, and government financial support. Together with universal internet access, the globalization of schools through interconnection will greatly diminish gaps in education occurring along socioeconomic lines.

Durability

Educators have found that today's business computers that assume mature users are unsuitable for classroom use. Business computers and operating system software are designed to be flexible. That flexibility is implemented with arrays

[10] US Department of Education, Computer Accessibility technology Packet, pg 1

of hardware and software controls that can be misadjusted, removable parts that can be easily lost or damaged, and slots where intruding pencils and gum can easily cause damage.

Young children, who at times have difficulty keeping pencils operational, are regularly expected to manipulate one of the most complex machines our society has ever produced. Systems in the classroom and in the home need to be durable, closed to intrusion, simple to configure, and priced to allow repair or replacement due to damage, loss, and other forms of mischief. These criteria will be a challenge to meet while retaining acceptable levels of performance and serviceability, however they too must be addressed in our system designs.

***Durability** in system design must take into account that this equipment will be utilized by young children that in some cases have difficulty keeping pencils operational, let alone computer technology.*

Learning Tools Today

Today, schools are purchasing traditional desktop and laptop computers without modifications. Unfortunately, the cost of even the least expensive computers today is prohibitive to educational institutions and their designs are targeted to business users who demand many features and can be expected to use the product with an interest in keeping it operational.

Our strategy is to continue selling standard NEC product into the educational market today, but migrate to a configuration that is more cost effective and less prone to damage in the near future. By being more affordable, these systems can be purchased in greater numbers so that the new device can be better integrated into the classroom and the curriculum.

To change the computer's status from a device for augmenting education to a primary provider of the curriculum, schools need to be able to increase the student-to-computer ratio so that every student has access to a computer. Our strategy is to provide a vertical solution that allows schools to move computers into the mainstream curriculum.

Our concept for the next generation of computers in the classroom involves a laptop-sized device in an intrusion resistant and cost reduced package.

Figure 14 - Versa PowerSlate Concept

The Versa PowerSlate concept uses current laptop technology, removing the most costly components such as the LCD panel and fragile or easily removed components like the CD, floppy, PCMCIA slots, and keyboard. The functions of these parts are supported using lower cost CRT displays, field-replaceable keyboards, mice, and audio headsets. Operating systems and educational software are loaded onto the internal hard drive via the network or a drive interface on the port bar.

LCD panels generate less heat and take up less space than CRT displays, however their pricing and fragility today makes them impractical in the classroom. Marketing efforts showing total cost of ownership for LCD panels may eventually overcome the purchase price concerns.

To protect the unit, the shell of the PowerSlate should be held together with Torx® or some other uncommon fastener, and covered with a removable rubberized case for shock protection. The case should also be ink and pencil resistant and as featureless as possible to make it an uninteresting and uninviting surface for graffiti, reduce opportunities for breakage, and allow easy cleaning.

This concept product uses an L-shaped stand, anchored below a typical CRT monitor, to dock the PowerSlate vertically. The stands rise up the side and include an integrated port replicator (Figure 14 - yellow) and rail mechanism that

prevents incorrect docking. Students can remove the inexpensive and lightweight PowerSlate unit (Figure 14 - red) for transportation and homework. Input is accomplished via devices connected to the standard keyboard, mouse, and serial ports on the port bar. These standard devices can be replaced with 3rd party input devices for students with disabilities.

A similar dock with peripherals is available for home use, and can be ordered with an integrated modem. Using the original PowerSlate with new port replicators, advanced connectivity solutions such as ISDN or ADSL could insure investment protection.

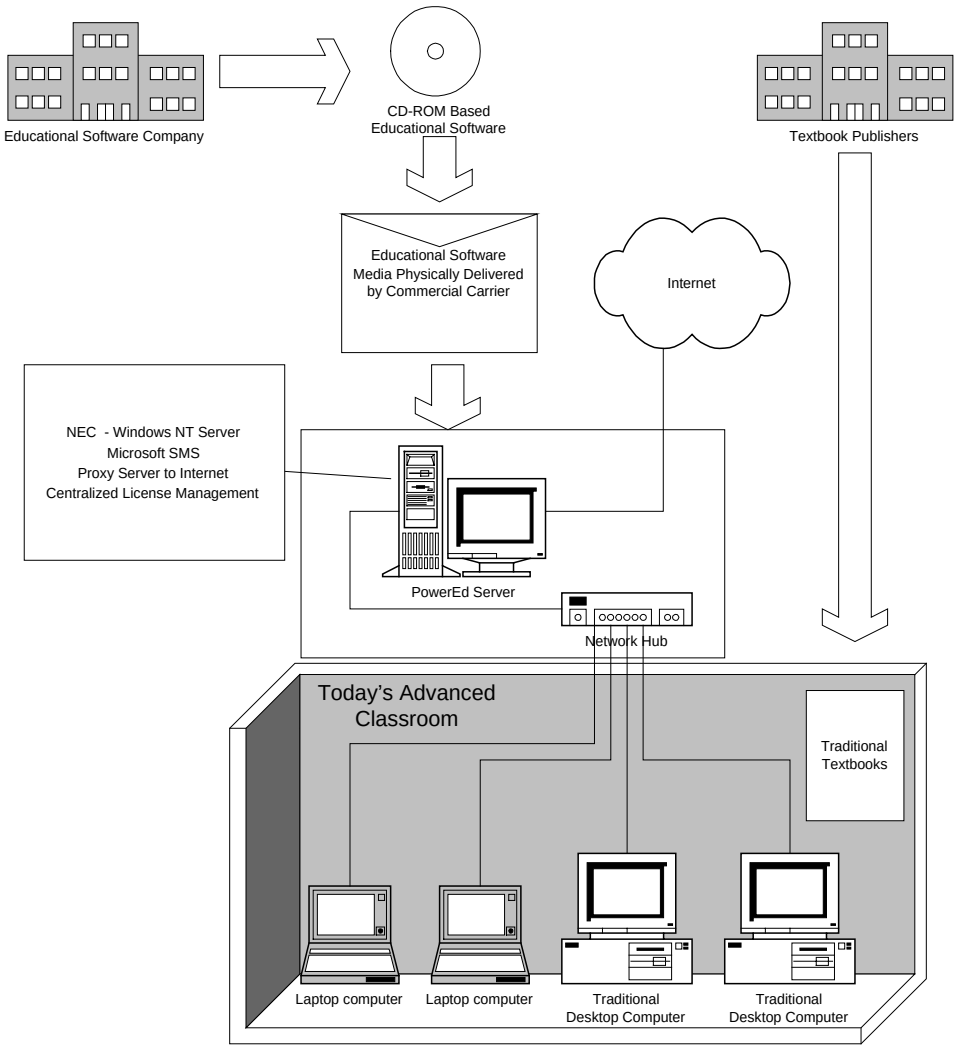


Figure 15 - Today's Advanced Classroom

Large capacity hard drives will be needed to allow multimedia content to reside on the hard disk, while network connections provide access to the Internet and the schools central repository of software and electronic curriculum.

The Versa PowerSlate concept system (Figure 15) runs standard Microsoft Windows-based educational titles as well as web-based HTML and Java titles developed with partners in our initiative. The web-based HTML content is accessible from home and the hard-disk based curriculum is lighter and more easily updated than traditional textbooks. A licensing scheme must be developed in conjunction with software suppliers to allow school and home use.

A key element in the PowerSlate concept and our migration path into future solutions is the educational server solutions. By focusing upgrade costs on relatively few servers, greater performance can be achieved as technology advances. The classroom computing devices will eventually have to be upgraded, however not until major advances change the very nature of the content they must display and with which users must interact.

NEC should consider the formation of an Educational Services Group that provides training courses and other support services to schools. Training course should include highly technical classes for IT professionals on installation, preventive maintenance, and service. Classes on how to integrate the products into the curriculum and enhance learning must also be offered for teachers.

With this model, school district personnel can install and manage the Power Education server and PowerSlate solution themselves, or choose to subcontract our Educational Services Group to remotely manage the educational servers and PowerSlates to keep them running smoothly. Twenty-four hour on-site service should be standard for the servers, and the PowerSlate units should be covered with a mail-in warranty, with an option for a "Roll-Call" UltraCare program that delivers replacement PowerSlate units the next business day or optionally on Saturdays and repairs servers in four hours. Subscribers to the Roll-Call program have all PowerSlate serial numbers tracked in a national database by NEC, a toll-free number on the PowerSlate unit, and both the serial number and the toll free number in the firmware.

Should a school's PowerSlate unit be lost or stolen and later recovered, NEC would pay to have it shipped back to its owner. We should also be prepared to cooperate with law enforcement authorities under the permission of our customers if NEC Power Education equipment is involved in a theft or vandalism situation.

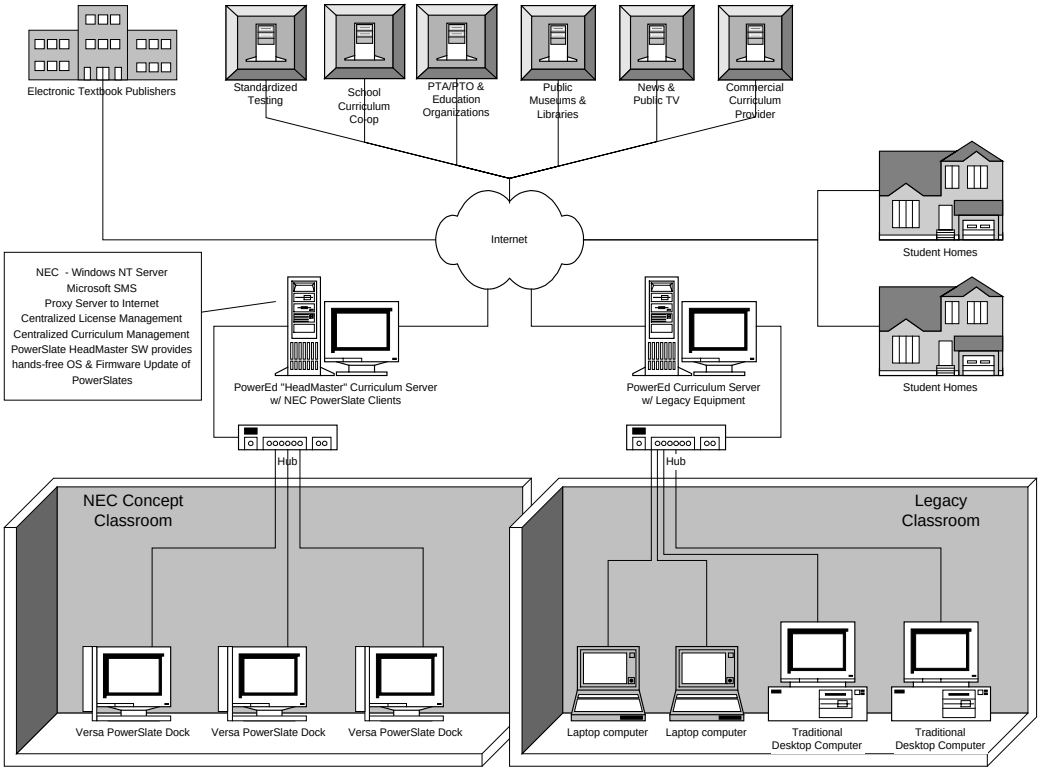


Figure 16 - Versa PowerSlate Concept

The PowerSlate concept begins as a hybrid laptop-NetPC with central servers supplying the software at the schools and libraries. (Figure 16) Traditional PCs or a second PowerSlate dock can be used for homework.

Each student should be equipped with audio headsets. Taken further, Versa PowerSlate technology could be integrated into classroom furniture to protect the most expensive components such as LCD panels.

Today, there is already software that can allow all student and faculty computers in a district to receive updated software and electronic curriculum materials using Microsoft's System Management Server. Using this solution, information technology administrators can conduct configuration and support from a central site.

With proper setup, network access can be simplified enough so students can deposit their information in a directory where it can be retrieved either at home, school, or the library. All applications and data storage should be performed at the server end reducing the processing, power, and bandwidth requirements on the client. If physical media is required, there exists today storage media that can be written and read without physical contact, allowing the media to be reasonably tamper proof.

Learning Tools for the 21st Century

The next generation of educational product will continue to centralize the most complex parts of the system. This allows personnel with the appropriate expertise to operate the system and manage a large geographical area from a small base of operations. It also elegantly addresses the issue of security and power usage by reducing the value of capital equipment exposed to damage or theft, and reducing power consumption and heat generation associated with current student interfaces.

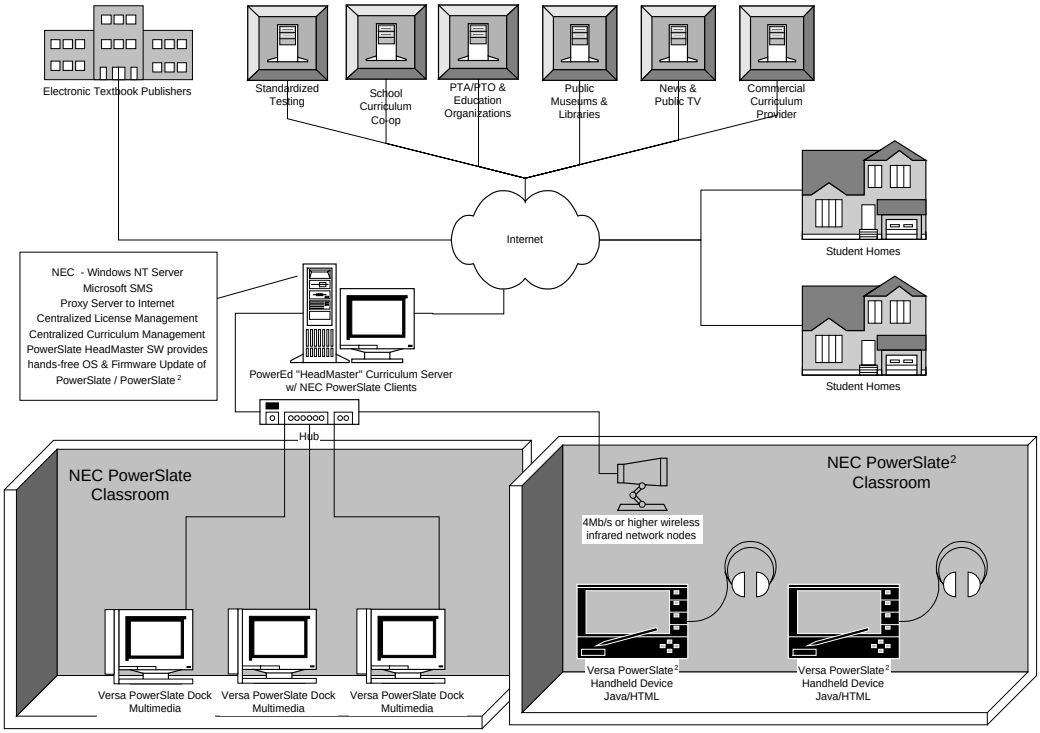


Figure 17 - PowerSlate^2 Wireless Solution

A system with centralized processing also implies that only input and output must flow between the student interface and the central unit. This significantly reduces the data that must be transmitted, making distance learning possible on a low-cost device but requiring powerful central processing.

With central processing, the power and bandwidth requirements of the student device may be low enough to consider a wireless solution. (Figure 17) But central processing represents a single point of failure so redundancy is important.

Central processing also means the PowerSlate is useless without a connection to the school. This reduces the likelihood of the portable PowerSlate becoming a target for theft.

Besides the hardware and software, the electronic classroom may provide an impetus for several other new ventures. It seems logical that standardized testing could be conducted electronically, with national results and feedback to individual school districts occurring rapidly enough to take corrective action during the same school year.

Schools could become curriculum providers not only for themselves, but for others, with curriculum co-ops giving rise to shared resources across the Internet.

PTA/PTO and professional teaching organizations could become more immediately involved in education as could public museums, libraries, and other points of interest. Finally, commercial curriculum providers may grow more rapidly. Today there exist commercial and non-profit content providers such as

The Corporation for Public Broadcasting and Public Broadcast System (PBS). Tomorrow, these and others may join in the development of rich curriculum that can be licensed for use over the Internet or new delivery services.

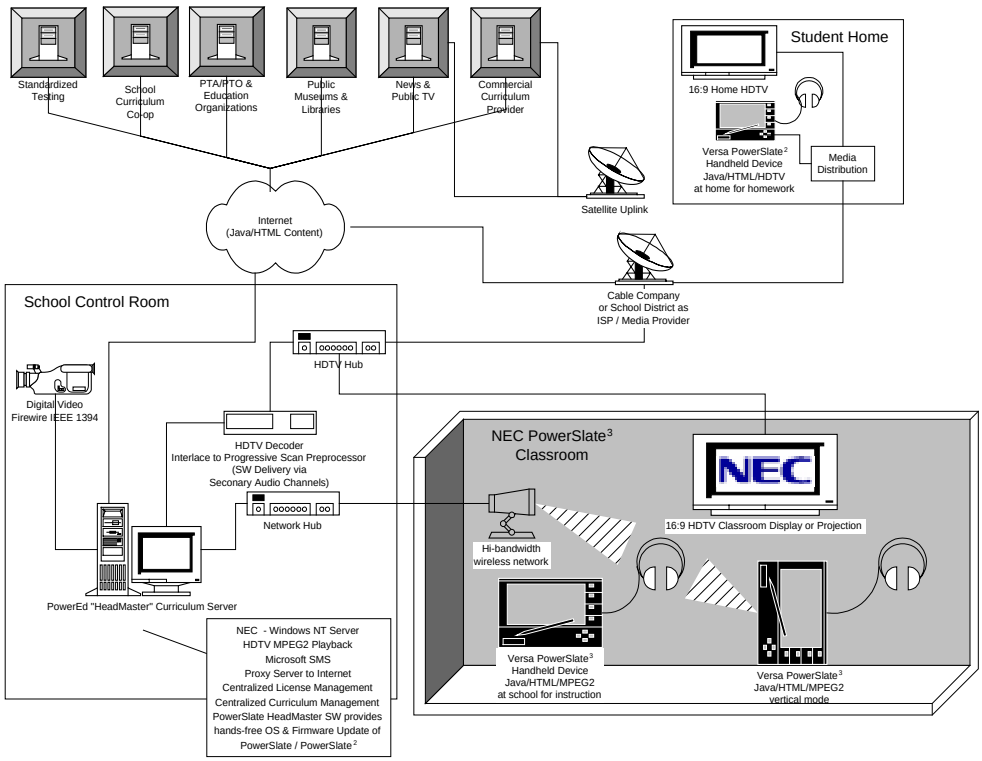


Figure 18 - Digital Video and Wireless PowerSlate

As we move into the third phase of Learning Tools for the 21st Century, new technologies such as Low Earth Orbit (LEO) satellites may play a part. These systems include high and low bandwidth two-way communications and transmit and receive from virtually anywhere on Earth. LEO satellite networks promise to be the ideal equalizer in educational content delivery to urban and rural classrooms and to classrooms in underdeveloped nations.

ADSL, an emerging high bandwidth communications technology, may also provide new opportunities distance learning, but will likely generate an even larger gap service availability between rural and urban schools if introduced as a wired solution.

Organizations such as the United States Internet Council (USIC) are working with government and industry to improve the bandwidth available to households in an effort to leverage the Internet for K-12 education, distance learning, and to foster electronic communications. This is critical to the success of education beyond the classroom, since most educational software utilizes high bandwidth content such as full-motion video and animation.

As digital HDTV is adopted, the processing power, bandwidth, and interactivity available through these new devices should be explored as a possible solution to delivering educational content to homes and schools. (Figure 18) The adoption rate of HDTV will be critical to this application. The problem of sharing the HDTV between education and family entertainment or even between several students cannot be adequately resolved until HDTV is ubiquitous and at least as inexpensive as today's televisions.

Nonetheless, it seems plausible that with technologies such as Firewire (IEEE 1394) allowing the interface between video equipment and computers, digital video and HDTV will become an ideal platform for development and distribution of educational materials in the future.

It is our goal to ensure NEC plays a major role in this future.

Credits

Learning Tools for the 21st Century
Enhancing Education through the Intelligent Application of Computer Technology

was developed by:

Don Gray
Vice President, NECCSD Government & Education

John Hoeft
Program Manager, Education

Lafayette Randle
Sr. Program Manager, Education

Dean Zimmermann
Director, Government & Education

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