A School Administrator's Guide To Planning for the Total Cost of New Technology

CoSN
ADVANCING K-12 TECHNOLOGY LEADERSHIP

Acknowledgements

The Consortium for School Networking is a non-profit association that promotes the use of telecommunications to improve K-12 learning. Its members include state departments of education, state networks, school districts, schools, individuals and companies that are committed to this goal.

CoSN launched its "Taking TCO to the Classroom" project in 1999 to help school leaders understand the long-term costs involved in building and operating a network of computers. That way they will be able to budget adequately to cover all the associated costs—and build and operate their networks in the most cost-efficient way to achieve their technology goals.

The project is made possible through the financial support of several corporate sponsors. However, CoSN is responsible for creating all the materials associated with the TCO project and retains editorial control over them. Sponsors provide input and feedback, but the ultimate responsibility for project materials remains with CoSN.

Throughout this project, CoSN has benefited from input supplied by staff members of the National School Boards Association, the Council of the Great City Schools, the American Association of School Administrators, and the Association of School Business Officials International. This revision of CoSN's first white paper on the topic was made possible by contributions from Intel Corp., Citrix Systems, Inc., Dell Computer Corp., NetSchools Corp., Sun Microsystems Inc., Chancery Software Ltd., eChalk LLC and National Semiconductor Corp. The white paper was prepared by Sara Fitzgerald of Funds For Learning, LLC, project director of "Taking TCO to the Classroom."

Related materials continue to be updated, improved and posted on CoSN's TCO Web site, http://www.classroomtco.org.

For more information, contact CoSN, 1555 Connecticut Avenue NW, Suite 200, Washington, DC 20036. Phone: 202-466-6296. http://www.cosn.org.

Introduction

At the advent of the 21st century, American schools are devoting more and more financial and staff resources to the task of incorporating technology into the classroom.

This revolution in learning is occurring for many reasons. Increasingly, parents are demanding that their children have access to the latest technology—and school officials and politicians are responding.[1] Governments at all levels are making more funds available to support technological improvements. The "E-rate" program, created by the Telecommunications Act of 1996, has provided an infusion of funds to help schools and libraries get wired and connected to the Internet. And there is growing evidence that if technology is incorporated wisely, it can improve the learning experience.

But when a school district purchases computers or installs a network, the cost of the hardware is only one small part of the expenses it can expect in subsequent years if it is going to use those technological resources effectively.

In this, a district's technology budget is no different from its transportation budget. When a school district buys a new bus, the expense doesn't stop with the cost of the vehicle. There is gasoline to keep it running, maintenance to keep it well tuned, repair bills when it breaks down, increases in insurance premiums and the salary of an additional driver—expenses that all must be covered year after year.

If school districts don't do this kind of planning for their technology budgets, there may not be enough money available to provide teachers with adequate training, to maintain new computers or to replace them when they become obsolete. Districts may fail to budget for increases in power consumption or necessary improvements in their physical plant. They may connect their computers to the Internet, but forget about the additional telecommunications costs associated with making that connection. As a result, America's investment in educational technology could fall short of its expected return—or even produce a backlash against spending additional dollars on new technology.

As a major Silicon Valley newspaper noted in late 1998: "The question asked in the mid-'90s, amid the optimistic din created by high tech, was, 'How do we get more computers in our classrooms?' Swiftly, that question has given way to one more difficult—'How can we afford to keep them?' "[2]

The goal of "Taking TCO to the Classroom" is to provide school administrators and technology directors with tools so that they can better estimate the total cost involved when they build a network of computers and wire their classrooms to the Internet—a concept known in the business world as Total Cost of Ownership. "Ownership" in this context includes all of the costs associated with using and maintaining networked computers, no matter whether a school district owns or leases them. TCO traditionally also includes calculations of costs that may not turn up in a budget, but that can still have an impact on school district operations—for example, when computers sit idle because they need to be repaired or when teachers can't use them because there is no money available to train staff members.

"Taking TCO to the Classroom" is an ongoing project because there has been very little hard data collected on the long-term costs associated with operating and maintaining technology in

schools. Many of the projections cited in this report were developed in the mid-1990s, as policy makers began to lay the groundwork for a major push to wire the nation's classrooms. Now, as more and more school districts have installed computers, built networks and connected classrooms to the Internet, more "real world" numbers are becoming available. Further, alternatives to traditional networks of computers are now being proposed for school settings.

Increasingly, school and government leaders are awakening to the need to monitor and manage these costs. For instance, in 1996, North Carolina, in its Long-Range State Technology Plan, advised schools to consider Total Cost of Ownership, which it defined as "acquisition, annual maintenance and upgrade fees," along with five other factors when they selected software and hardware.[3] More recently, in January 2001, the California Department of Education released a state technology planning guide that said, "Technology planning needs to be comprehensive and include consideration of the long-term implications of the choices made. . . . Hardware purchased should meet district needs and have the lowest cost of ownership over the long term." [4]

It is hoped that this document will promote a process of better defining those costs, and ultimately, creating guidelines to help school administrators determine whether they have provided adequate funding for all of their expenses so that they can truly understand the "total cost" of their technology decisions. By better understanding the "problem," administrators will be in a better position to evaluate proposed "solutions."

In detailing these costs, we do not want to deter school administrators from making an investment in technology. Rather, we want to help them plan for that investment, so that they do not "bite off more than they can chew." This will help ensure that when school districts integrate new technology, they don't do it for technology's sake or simply because it is "this year's fad," but rather to make long-term improvements in the educational experience and ensure that more real learning can occur in the classroom.[5]

A Quick Checklist for Technology Budgeting

After a district has purchased computers and installed a networking infrastructure, here are the major expenses and technology decisions for which school administrators must be prepared. These issues are covered in depth in this white paper.

✔**Retrofitting:** When your district is ready to build a network, has it budgeted adequately to upgrade electrical capacity, improve heating, cooling and ventilation systems, beef up security systems and remove asbestos and lead found in older buildings? These costs can be reduced if a school district plans for future networking requirements when school buildings are constructed or renovated. In certain cases, wireless solutions may offer potential cost savings.

✔**Professional Development:** Has your district budgeted an adequate amount for staff training, including the cost of trainers, materials and substitutes if training is conducted during school hours? Training costs should represent a large component of a district's technology budget. If staff members are not properly trained, teachers will not understand how to integrate technology into the curriculum, support staff will not keep up to speed on hardware and software developments and the district will fail to achieve the maximum return on its technology investment.

✔**Software:** Has your district budgeted adequately for network management software, computer-based curriculum materials, applications and productivity software and the software needed to adapt technology to the special needs of users? A wide variety of software applications will give school districts greater flexibility, but will also increase the costs for support and staff development. Software licenses also need to be managed efficiently to save money and protect a district from penalties for license violations.

✔**Support:** Has your district budgeted adequately to maintain its network and other hardware and to help others solve their software and hardware problems? The way in which a district deploys a network, and the variety of software and operating systems that it chooses to support, will determine the kind of support that it will need. Some new approaches have been designed to address the particular challenges that school districts can face when they try to provide their own tech support.

✔**Replacement Costs:** Has your school district budgeted adequately to cover the costs of replacing computers and other peripherals? The life cycle of even the most advanced multimedia computer is still only about five years. Businesses now generally plan on a three-year life cycle for desktop computers.

✔**Connectivity:** Has your district budgeted adequately to cover the costs involved with connecting schools to each other and to the Internet? Lower-bandwidth connections will generally cost less but will involve a tradeoff in the complexity of the information that can be shared and the amount of time it will take to download files or access information.

What Is Your School District's Total Cost of Ownership Type?

	The "TCO-Savvy" District	The "Doing the Best We Can" District	The "Worry About it Tomorrow" District
Professional Development	Devotes 15-30% of its budget to staff development	Provides some staff training, but not at times that are convenient or when staff is ready to put the lessons to work	Assumes that teachers and staff "will learn on the job"
Support	Provides computer support at a ratio of at least one support person for every 50 to 70 computers or one person for every 500 computers in a closely managed networked environment	Relies on a patchwork of teachers, students and overworked district staff to maintain network and fix problems. Does not track the amount of time its network is down or computers are not in use	Relies on the "hey Joe" sort of informal support
Software	Recognizes that the greater diversity of software packages and operating systems, the more the support that will be required. Makes provisions for regular upgrading of software packages	Utilizes centralized software purchasing, but choice of application and respective support left to individual schools and/or staff members	Expects support personnel to manage whatever software happens to be installed on a district computer
Replacement Costs	Budgets to replace computers on a regular schedule, usually every five years, whether leased or purchased	Plans to replace computers when they no longer can be repaired	Assumes that when computers are purchased with 20-year bonds that they will last forever
Retrofitting	Recognizes that many school buildings will require modifications of electrical, heating and cooling systems, as well as asbestos removal, to accommodate new technology, and budgets accordingly. When possible, makes these improvements when schools are being built or renovated.	Understands minimum and recommended requirements for electrical and other infrastructure improvements and incorporates them when funding is available	Pulls the wires and then blows the fuses
Connectivity	Plans its network to provide connections that provide enough bandwidth to manage current--and future--needs, especially multimedia applications	Has the bandwidth it needs today, but has no plan for scaling it upward as demand grows	A phone and a modem, what more do you need?

Estimating the Total Cost of Technology

For a number of years, the business world has developed several models for calculating what's known as the Total Cost of Ownership (TCO)—all of the expenses associated with deploying, maintaining and troubleshooting a personal computer in the workplace. Businesses use these calculations to make strategic decisions on how to build their networks and control their costs.

Consultants have determined that TCO can vary from industry to industry, reflecting how computers are used and how a company designs its network. TCO calculations can also vary based on the formula used to compute it. Some TCO models cast a wide net and try to quantify all of the "soft costs" associated with a computer, including how much time employees waste playing with their computers or trying to troubleshoot their own hardware or software problems.[6]

The business world bears some resemblance to the administrative side of a school district, where networked computers, if used effectively, can increase productivity and achieve efficiencies. Traditional business models for TCO, however, may be less useful in the classroom setting, where computers are not used in the same way as they are in an office setting or customer service center.

For instance, in 1997 International Data Corp. surveyed 400 school officials and calculated that the Total Cost of Ownership for a school with 75 computers was $2,251 per year per computer, while a comparably sized small business had a TCO of $4,517 per computer, or more than twice that amount. IDC said this difference resulted from four factors: schools purchase less expensive computers at larger discounts than businesses do, educational software packages are priced lower than business software applications, schools generally use roughly half the number of people that businesses do to support the same number of computers, and schools typically use their computers for five years (or more), compared to three years for businesses.[7]

Most school districts—and analysts' cost projections—have tended to focus on the out-of-pocket costs associated with building and maintaining a network. Traditional business Total Cost of Ownership calculations, however, usually go beyond that to produce a more complete picture. For instance, one school district might calculate that it spends less per computer than another district because it spends less on support staff. The first district may have either created an efficient network that can be managed centrally with fewer staff members, or it may not be providing adequate staff to trouble-shoot the problems of its computer users. Unless the school district calculates how much time is wasted when networks are down or computers don't work, it won't understand what its true costs are.

As one TCO expert writes, "Organizations, regardless of size or nature can use client satisfaction, service levels and business risk as performance measures. In the end, optimizing [Information Technology] requires looking beyond bottom-line costs and taking into account people, process, finance and technology."[8]

Thus the "cost" of technology is not the same thing as the "Total Cost of Ownership." However, before school districts can calculate their TCO, they must first understand all of the out-of-pocket costs associated with operating and maintaining a computer network.

It is likely that traditional TCO analysis will first gain a foothold on the administrative side of a school district, where computer use more closely parallels the experience of the business world, and where productivity enhancements may be more easily identifiable. However, some kind of TCO analysis can prove just as useful in instructional settings.

As time goes on, school administrators can be expected to learn more about calculating the additional costs associated with Total Cost of Ownership, such as the loss of productivity or wasted investment when computers aren't repaired on a timely basis, when staff members are required to trouble-shoot their own computer problems or when computers sit idle because teachers haven't been taught how to integrate technology into their lesson plans. When administrators reach that stage, they will be much better equipped to make decisions about managing their networks and planning their budgets.

The Big Picture

Although the Total Cost of Ownership for a school district may be less than that of a business, the cost is still substantial. Many school districts recognize that their initial investment will be a large one, and support it with bonds, federal or state grant money or corporate donations. What is harder to prepare for are the long-term costs of operating and maintaining that investment in computers and networking.

How much will it cost? The answer, of course, will vary from district to district, based on differences of size, geography, age of physical plant, patterns of staffing and school management, teaching styles and, naturally, what kind of technology is deployed and how extensively. School districts vary widely in terms of the role technology plays in the district, both on the administrative and instructional side.

What follows is a summary of some of the best available guidance on the overall cost of wiring a school district, as well as individual budget components. The experience of a typical school district may be quite different, as it is likely to encounter funding constraints along the way, and different schools within the district may be at different stages of development. As part of its ongoing work, CoSN's TCO project continues to explore ways that schools could collect and share useful data about the costs of operating their networks.

Districts that have already made a substantial investment in wiring their classrooms now typically spend between 2 and 4 percent of their overall budget on technology; but many planners argue that even more should be spent.[9] A 1998 study conducted for the Milken Exchange on Education Technology found that among 1,990 districts in 27 states, 5.6 percent of their capital budgets, on average, was spent on technology and 3.4 percent of their operating budgets.[10]

A number of studies have attempted to project the cost of wiring the nation's schools on a per-student basis, usually to come up with the estimated cost across the nation or a state. Each makes slightly different assumptions, and includes different items in its budget categories. Most of the analyses are now several years old, and since then some costs have been reduced and newer technologies, such as wireless delivery, have matured.

The details of the studies are provided, when available, in Appendix A. While school districts must be careful in applying a nationwide average projection to their own situation, the studies should provide some guidance about the magnitude of the costs they can expect.

In a frequently cited 1995 study, McKinsey & Company, Inc. calculated the cost per student of implementing several scenarios. Among the models and their projected costs:

The Classroom Model, in which every classroom is connected with networked computers at a ratio of five students per computer, with a T-1 connection permitting long-distance transmission of data, video and voice: one-time costs of $965 per student and ongoing costs of $275 per student per year over 10 years.

The Partial Classroom Model, in which only half of each school's classrooms are wired: one-time costs of $610 per student and ongoing costs of $155 per student per year over five years.

The Lab Model, which assumes each school is connected through a computer lab of networked computers with 10 analog telephone lines per school: one-time costs of $225 per student and ongoing costs of $80 per student per year over five years.[11]

Lower costs per student do not necessarily suggest efficiencies that will be achieved but rather networks with fewer capabilities. The McKinsey numbers, now more than six years old, may also be somewhat out-of-date in light of recent improvements in the efficiencies that can be achieved by making an investment in a centrally managed network and lower telecommunications costs.

In 1998, another consulting group, Integrated Technology Group, LLC, developed a spreadsheet for the National Center for Supercomputing Applications to help school districts estimate the total costs of improving their technology infrastructure. While the estimate varies depending on the circumstances of each individual school or district, it projects that the total cost of a technology program will run above $500 per student per year for the first five years, once all the necessary technology system components, including infrastructure and facilities improvements, staff training, support, personnel, subscription services and curriculum development, are taken into account. This estimate also includes spending for distance learning hardware, telecommunications systems and services, computer upgrades and replacement, inflation and factors reflecting the type and location of the school.[12]

In a 1997 study that looked specifically at the state of New Jersey, the cost was pegged at $417 per student per year, over a five-year period. That figure, however, did not include the cost of retrofitting or expenditures for such items as computer furniture and lighting modifications, which together would be expected to raise the cost to between $475 and $550 per student.[13] In California, the Department of Education prepared a four-year technology plan in 1996 with a projected total cost of $1,987 per student over four years, or $496 per year.[14]

A 1996 MIT study projected that the per-pupil costs of connecting schools to the information superhighway would range from $212 to $501, depending on the complexity of the network, with ongoing costs of $40 to $105 per pupil per year. The upper figure was the projection for a network in which every school would have a local area network and a 56 Kbps connection to the

district network, and the district, a T-1 connection to the Internet. A more expensive model was also detailed.[15]

In a 1995 RAND study of the technology implementation costs experienced by eight "pioneering" school districts, the expense ranged from $142 per student to $490 per student per year. In this analysis, the cost of cabling and special furniture was amortized over 10 years, instead of the five years used by many of the models.[16]

Several studies have projected the cost of building local area networks and wiring classrooms to the Internet to be roughly about $500 per student per year. However, many factors, including the age of the school district's physical plant and its technology investment to date, will determine the precise figure.

Currently, most U.S. schools are spending much less than these models. Quality Education Data projected that in the 2000-01 school year, districts would spend, on average, $113.11 per student on instructional technology. More specifically, QED projected that $44.17 per student would be spent on computer hardware, $26.61 on networks, $10.08 on software, $10.38 for service/support, $4.70 for peripherals, $14.16 on Internet services, $4.60 for professional development, $4.21 for supplies (such as disks, paper and toner) and $2.56 for computer training. According to QED's analysis, professional development represented 4 percent of the total and service/support represented 9 percent. (QED noted its total figure does not equal the sum of the categories, because it was calculated separately for greater precision.)[17]

An informal 1998 survey of 29 school districts in the Council of the Great City Schools, which represents the nation's largest urban school districts, found that their technology budgets provided, on average, about $124 per student, a figure that was close to QED's nationwide projection for that year. The districts' spending ranged from $584 per student to $22 per student.[18]

The MIT study projected that for simpler networking connectivity models, the ongoing annual costs would typically be one-half to one-third of the start-up costs. For more complex models, the ongoing costs would be one-fifth to one-fifteenth of the start-up costs. Over the range of available projections described above, ongoing costs were approximately one-fifth of the start-up costs. The Gartner Group, by comparison, advised its business clients in mid-2000 that their ongoing costs could be expected to be about 60 percent of the cost of their installation.[19]

Another way to think about projecting the Total Cost of Ownership is to think about how the total pie for technology is sliced—and how the price of those budgeted items will change over time.

In most models, the purchase and installation of hardware and retrofitting old buildings represents the bulk of the costs initially and when amortized over five years. In most of the projections, these kinds of expenses represent between 40 and 60 percent of the costs, depending on the assumptions and how costs are categorized. (See Appendix A for details.)

Over time, however, the bulk of the costs are expected to shift to the kinds of expenses that cannot be covered by the capital budget, namely personnel to provide computer and network support and training to teach the staff how to use the technology and to help teachers integrate it into the curriculum. Hardware costs, however, will remain a significant line item, as computers and other peripherals will need to be replaced on a regular basis.

In the first years of deployment, the largest share of the technology budget is normally devoted to hardware in the form of networks and new computers. As time passes, a greater proportion of the budget should shift to staff development and support.

The real-world experience of school districts, however, often doesn't match what is considered to be the ideal. After surveying the experience of 400 school- and district-level officials, IDC reported in its Total Cost of Ownership study that schools were spending 55 percent of their total costs on hardware, and 16 percent on networking, with 9 percent of the budget spent on software, and only 6 percent on training and 6 percent on service and support. Another 5 percent was spent on supplies and 1 percent on online services.[20]

In the RAND study of the group of early-adopter schools, over a five-year period the average school spent about 46 percent of its technology budget on hardware, 10 percent on staff development, 27.5 percent on support personnel and about 4 percent on materials. The study's authors concluded that when the number of school computers is relatively modest (such as one to every seven to 11 students), the costs for support staff, staff development, materials and supplies will tend to dominate the budget. But when districts push to achieve a lower number of students for each computer, the costs for hardware, software and infrastructure will represent a larger share of the overall costs.[21]

As more and more computers are installed in the nation's schools, educational leaders and policy makers are recognizing that schools must devote more attention to staff development if they are to achieve their technology goals. A number of grant programs have tried to address this problem, and many states are now requiring schools to devote a higher proportion of state-provided dollars to staff development. In addition, many government and non-profit grant programs now require school districts to devote a certain portion of their technology budget, or a portion of their grant budget, to assessment, to review what they have actually accomplished with technology.

In most models of technology implementation, the initial deployment costs are proportionately larger because they include such one-time purchases as networking hardware, wiring, retrofitting a school's physical plant and consulting studies. Once school officials get through that stage, they may think they've covered most of their expenses. The truth is, the costs are just beginning.

Getting Down to Specifics

Much has been written about the initial costs of hardware and the standards schools should follow when they deploy computers and networks.[22] What is more difficult to plan for are other elements of the budget—expenses such as staff development, retrofitting buildings, and

replacing obsolescent computers. Here are some more specific guidelines, based on a variety of cost studies, and the experience of some school districts over time.

Retrofitting

One cost that will vary widely from school district to school district is the amount that must be spent to wire an existing physical plant. Retrofitting is not traditionally part of Total Cost of Ownership analyses, but it is a cost that school districts frequently face—and sometimes fail to anticipate.

The best time to wire a school is when it is under construction, or in the case of an existing building, when it is being renovated or expanded. Wiring existing schools will involve additional costs, including, in some cases, the cost of asbestos and/or lead removal, new lighting and modifications to meet the requirements of the Americans with Disabilities Act.

For the purpose of producing a nationwide figure, the McKinsey study estimated that 65 percent of American schools were more than 35 years old and had not undergone a major renovation to support technology. The study projected that some of these schools would use wireless technology, but that would not be practical in every case. To wire older schools, the consultants projected it would cost an average of $65,000 per school for asbestos removal and other infrastructure improvements. New schools were assumed to have adequate wiring; schools that were between 5 and 35 years old were assumed to require wiring, but not asbestos removal.[23]

The costs of wiring an older school building can be substantial—and often unanticipated. However, the costs can be trimmed if this work is performed when a building is constructed or renovated.

McKinsey also projected that 23 percent of the nation's schools would require an upgrade of their electrical system and another 4 percent, improvements to their heating, ventilation and air conditioning (HVAC) systems. It estimated that the average school would spend $240,000 on electrical upgrades and $31,800 on HVAC. It also projected that the average school district would spend $355 per computer on new furniture and $350 per room on security improvements.

A study for the Council of Educational Facility Planners International and based on 30 construction projects in the Midwest found it cost $1,500 per "classroom equivalent" for infrastructure in new construction and $3,000 per "classroom equivalent" in renovation-modernization projects. That cost included one additional 20-amp 100VAC circuit, six empty data box drops and six duplex outlets. Additional electrical service, it said, would cost a minimum of $50,000.[24]

It has been projected that up to 10 percent of the total cost of technology systems and related building modifications could be saved if both initiatives are planned and implemented at the same time.[25]

The real-world experience of school districts can, of course, be very different. Large urban school districts trying to wire buildings that date from the 19th century can face monumental challenges in improving their electrical capacity and pulling wires through walls. For instance, it

cost the School District of Philadelphia $1 million to wire a single large high school building at the end of the 20th century. [26]

Districts may find that they can avoid some of the costs of retrofitting older buildings if they are able to take advantage of wireless solutions. Wireless approaches can also easily extend networks to portable classrooms, or to buildings that will be wired in the future. In addition, some districts prefer the flexibility that some wireless solutions can offer in deploying computers and connectivity right to a classroom when it needs them.

Currently, the bandwidth capabilities of wireless solutions are less than those of the best wired solutions, so school districts will need to carefully evaluate how they intend to use a network and whether a particular solution is technologically feasible and will meet their bandwidth needs. Nevertheless, many school districts are moving in this direction to help manage their costs and increase the flexibility of their networks.

Professional Development

The budget item that arguably is most critical to a school district's ability to achieve its technology goals is staff development. If teachers and other staff members do not understand how to use new technologies and incorporate them into the classroom, a district's technological investment will not achieve its desired results.[27]

To underscore this point, the U.S. Department of Education recommended in 1996 that school districts set aside 30 percent of their technology budgets for staff training and development. As the department noted at the time, "If there is a single overarching lesson that can be culled from research about teacher professional development and technology, it is that it takes more time and effort than many anticipate."[28] In September 2000, the National Center for Education Statistics reported the results of a survey that indicated that teachers who receive at least 32 hours of training in technology integration over a three-year period said they felt prepared to use technology in the classroom. Unfortunately, only 12 percent of those surveyed said they had received that much.[29]

Today many state departments of education require that districts devote between 20 and 30 percent of their state technology grant money to staff development as a way of promoting that component of the technology budget.[30] And corporate grant programs and government funding sources are also targeting this area for greater attention.

In a 1995 school technology guide, the Massachusetts Software Council noted that many businesses match every dollar they spend on computer hardware or software with another dollar for training. While it acknowledged that that figure was probably too ambitious for most school districts, it recommended that at least one-fourth of a school's technology budget be set aside for that purpose.[31]

Currently, however, schools are spending much less than that. In the 2000-01 school year, Quality Education Data projected that the average district would spend only about 4 percent of its technology budget on staff training.[32]

One of the largest components of the cost of staff development can be substitute teachers, when it is determined that the teaching staff needs to be trained during their regular work hours. The

McKinsey model assumed that a district planning to network all of its classrooms would have to hire substitute teachers at a cost of $100 a day, as well as the equivalent of 1.5 full-time staff members to conduct training, and cover the cost of training materials.[33]

The NCSA/ITEG model, meanwhile, called for a minimum of five days of training per year per teacher and two days per year per administrator, as well as an additional six days per year of informal peer-to-peer training. The model adopted 30 percent of the budget for staff training as the goal to which districts should aspire, but considers 15 percent to be the minimum acceptable.[34]

The 1996 RAND study of eight schools found that the cost of staff development ranged from $15 to $35 per student per year, with most schools spending about $25. As a share of their technology budgets, the percentages ranged from 5.5 percent to 22 percent, with the average among them pegged at about 10 percent.[35]

The U.S. Department of Education and many state departments of education now recommend that districts designate 20 to 30 percent of their technology budgets for staff development. The reality, however, is that most school districts spend much less.

Smart Valley, a mid-1990's initiative by Silicon Valley companies to network schools and other community institutions in that area, approached the issue another way. It recommended in a school networking guide that "an average starting point" should be to allocate approximately $1,500 per year for each person requiring training.[36]

In its four-year technology plan, the California Department of Education assumed that the typical school with 700 students and 33 staff members would spend $2,000 per staff member for staff support, materials and mileage and $35 an hour for trainers (with a projected 2,000 hours required per school).[37]

Inadequate staff training will lead to under-utilization of computers—and a loss of return on a school district's investment in technology. The Milken Exchange survey of technology directors found that on average, 5.9 percent of their district's computers were not being used. The second most important reason why, cited by 50 percent of overall respondents, was that "teachers are not trained to use them."[38]

It's important to remember that despite these budgetary benchmarks, staff training is not a "one size fits all" sort of proposition. Individual teachers and staff members can vary widely in their previous experience with technology and their readiness to learn. So-called "early adopters" may not need much training, but they may also not be the best people to serve as trainers. Some staff members are likely to be more enthusiastic than others about incorporating technology, and many of them may be able to serve as mentors to those who still prefer to teach "the old fashioned way." Those who are less positive about working with technology will likely need more one-on-one support.[39]

New tools are available to help school districts define and measure the technological capabilities of their staffs. For instance, the California Technology Assistance Project (CTAP) has created a Technology Assessment Profile tool called CTAP[2] to help teachers and student teachers measure their own proficiency level and locate resources to improve their kills. ISTE, the International Society for Technology in Education, has developed standards, called NETS•T, to better define what skills teachers need to use new technologies and integrate them into the classroom. Another approach, called TAGLIT (for Taking a Good Look at Instructional Technology), is designed to help schools assess the readiness of their leaders, teachers and students. CoSN is also part of a group effort, called the Collaborative for Technology Standards for School Administrators (TSSA) that is working to develop skill standards for school administrators. [40]

The issue, however, may not be teachers' individual technological capabilities, but rather their ability to integrate new technologies into the classroom experience, particularly when not all students can access a computer at the same time. According to a survey released by NetDay in May 2001, roughly nine out of 10 teachers say they feel comfortable using computers and the Internet, but two-thirds believe that the Internet is not well integrated into their classroom. Two-thirds view the Internet as a good resource, but not a fundamental change to the way they teach.[41]

Finally, a school district must not forget to provide adequate staff development for its own technology staff. If those staff members are not encouraged to increase their own knowledge about new and evolving technologies, the school district will not be able to make the best possible decisions when it comes to planning for and purchasing new technology. Districts that devote adequate resources to staff development should also see a corresponding drop in the cost of providing tech support because staff members will be in a better position to address their own problems without having to seek help from others.

Software

In business settings, the cost of software can sometimes equal the cost of hardware, and generally runs about one-fourth to one-fifth of total hardware costs. In the school environment, however, it is proportionately much less, usually representing 10 percent or less of the total budget.[42] Among the schools in the RAND study, software costs ranged from 4 to 10 percent of their technology budgets, and averaged about 8 percent across the schools. None had purchased site licenses for more than five or six "tool-based" programs (and the average was closer to three). In addition, the authors reported, schools had saved money through economies of scale by building large libraries of CD-ROM and videodisc products.[43]

The McKinsey model calculated that "content" in the form of software and online subscription fees would represent 14 percent of the total cost of its "classroom" model and 20 percent of the cost of its less expensive "computer lab" model. Over time, it said, the share of the pie taken up by content would grow to about 21 percent of the classroom model's annual budget, and 26 percent of the computer lab model.[44]

Many calculations of the costs of networking schools provide only for basic application software, not the costs of software that could be considered more purely instructional or part of the budget for curriculum materials. Note, too, that some of the cost models were developed before schools began developing their own direct connections to the Internet, saving online subscription fees, if not telecommunications costs, and before they began making substantial use of the resources of the World Wide Web, many of which are available for free. However, there may be hidden costs

associated with the use of free Web resources, in terms of the amount of time it may take a teacher to identify those resources and organize them for their students to use.

In the 2000-01 school year, QED projected that the average school would spend $10.08 per student on instructional software and $14.16 on Internet services, but that figure, of course, is an average of both technologically advanced schools and those that have not yet made a substantial technological investment.[45] Over the past three years, the software cost has stayed about the same, while the amount spent on Internet services has risen.

Limiting the diversity of software titles that a district uses is one way to help control other parts of the TCO equation, by limiting the number of staff that will be needed to support the applications and the amount of training staff members will need. However, this may entail tradeoffs in terms of meeting users' needs for particular kinds of applications or instructional offerings. Many businesses also find that TCO can be controlled if software packages are upgraded at the same time across the company, and if employees are encouraged to use the same version of the software if they work at home. Money can be saved, too, when the installation and upgrading of software can be controlled centrally over the network.

These perceived advantages to centralized management have led school districts to begin to use so-called thin client networks and Application, or Education, Service Providers, which will be discussed in more depth later on. As another way of controlling costs, some district-level instructional technology staffs specify which software packages they will be willing to support, and require school-level personnel to provide their own support if they insist on using a non-standard package.

Tech Support

After computers are installed, a school district will need people to help maintain its network and other hardware, and to help users solve the problems they encounter with their computers and software packages. The number of support staff required will depend on several variables, including the number of workstations and the variety of operating systems and software applications that must be supported.

School districts typically spend less than businesses do to purchase software. Limiting the diversity of the applications supported is one way to help control support costs, but there may be other, negative tradeoffs.

In its TCO comparison between businesses and schools, IDC found that schools have "extremely low" levels of support, usually one person for every 500 computer users, compared to the 1:50 ratio it found in the business environment.[46] Further, when an educational PC fails, IDC said, it can get taken out of service for several days, while a business computer is usually repaired or replaced within an hour or two. When the Milken Exchange asked district technology directors how long it took to fix a problem when something broke, and gave them the option of responding in hours or days, the average number of hours reported was 5.6 and the average number of days, 3.6.[47]

It's easy to understand why this happens. When a computer breaks down at a business, an office worker generally becomes totally unproductive. When a school network crashes, teachers are expected to go back to teaching "the old fashioned way" until it is fixed. If a classroom computer malfunctions, students are simply expected to "double up" on the computers that are still working.

School systems often fall back on technologically savvy teachers or students to help with support. (The Milken Exchange study found that 39.6 percent of the districts surveyed said they "frequently" used teachers to provide support and 11.5 percent frequently relied on students.[48] An online survey conducted in fall 1999 by CoSN and the National School Boards Association suggested those numbers were even higher.)[49] Unfortunately this can mean that teachers are pulled away from their primary duties. And when support is inadequate, the district will lose some of the value of its investment in technology when hardware is not repaired quickly. More than 29 percent of respondents in the Milken survey said one reason computers were sitting idle in their schools was because they needed to be repaired.

The frustrations that lack of support can create were described by a 1998 congressional General Accounting Office study of how five school districts covered their technology expenses. The report noted: "Officials in all five districts reported having fewer staff than needed. Some technology directors and trainers reported performing maintenance or technical support at the expense of their other duties due to a lack of sufficient support staff. Some district officials also noted high stress levels among district technology trainers or maintenance staff trying to serve many school sites. One result of a lack of staff was lengthy equipment downtime when computers and other equipment were not available for use. In several districts, repairs for some equipment reportedly took as long as two weeks or more. Equipment downtime means reduced access for teachers and students, and several officials observed that this may frustrate teachers and discourage them from using the equipment."[50]

Reviewing the available literature reveals a range of recommended levels of support. The state of Maryland, for instance, completed a four-year technology plan in late 1998 with a funding projection that assumed that there would be one support person for every 500 PCs.[51] In another guide to school networking published by the state of Washington, the "fully-staffed" model assumed that each full-time technician would support between 100 and 250 users.[52] Highly standardized networks can reduce the number of support staff required by a factor of 10, according to some estimates—from one staff person for every 50 to 70 computers to one for every 500 to 700.[53]

So how much tech support does a school district need? The answer is, it depends.

The state of Michigan recently tried to create a model to help school districts calculate an appropriate level of tech support for their networks. The project staff began by surveying school districts around the state and was surprised to discover that there was no correlation between the level of tech support and school users' satisfaction. Some districts provided relatively good tech support, but users' expectations were also high and in their view, the support fell short of what was needed. Conversely, some districts provided sub-standard levels of support, but users apparently had such low expectations that they reported that they were satisfied.

The Michigan project began with a formula for calculating tech support that was developed in the 1980s by a private industry initiative.[54] In July, 2000, the project released a draft worksheet that attempted to adapt the formula to the realities of the K-12 world. As part of the calculation of their needs, schools were supposed to count the number of computers, printers and peripherals they owned and then to calculate a factor based on the number of users. (Although most school-based users are not at the same computer all day, the way computers are used in the business world, each new user will inevitably increase the demands on the tech support staff because of the need to manage such things as passwords, user profiles and e-mail boxes.)

The Michigan formula also takes into consideration the number of software applications that need support, the need for curriculum support and other considerations such as Web site management, telephone system management and whether the school district provides video services.

The project identified a number of special factors that could have a major impact on a district's needs. Tech support needs were expected to increase if:

- the district was large geographically;
- the district had more than 10 buildings;
- the buildings were old and generally badly wired;
- most computers were more than two years old and generally of poor quality;
- the district had to support a wide variety of brands, models and types of computers;
- software installation and network maintenance were not performed centrally; and
- the district relied heavily on distance learning or a technology-based curriculum.[55]

A determination of tech support needs, the project concluded, should be tied to a district's own technology goals. A district that is attempting to be "state-of-the-art" will likely have greater needs for regular support than will a district where technology is merely an after-thought. As in business, though, managing rising tech support costs will probably be a major challenge for many school technology directors.

School districts typically do not support their computers and networks with the same level of staffing that businesses do. The result is that there is substantially more "down time" in the educational world. More centralized control of networks with network management software is one way of reducing the number of support staff that will be needed. Reducing the number of operating systems and applications that are supported is another.

In late 1999, CoSN and the National School Boards Association asked members of NSBA's Technology Leadership Network what strategies they were trying to pursue to control the costs of tech support. As more than 90 percent of the districts that responded had all of their schools connected to a Wide Area Network, and 83 percent of them had a Local Area Network in each school, they could be considered among the most technologically advanced of the nation's districts. Larger districts were over-represented in the sample, but responding districts represented a wide range of sizes.

Asked to choose from a list of strategies for controlling tech support costs, about nine out of 10 respondents identified four that they had tried: limiting the ability of teachers and students to modify the way computers are configured, standardizing the model of computer used, shifting to a centrally-controlled district-wide network and relying on teachers and non-tech support staff to provide support.

The latter approach, of course, does not really save any money from a TCO standpoint, it simply transfers the cost to another part of the budget, namely teacher salaries. Depending on how much a school district is relying on informal support from teachers, the tech staff may be able to demonstrate that a school district is devoting the equivalent of several teacher positions to fill this gap.[56]

A critical part of monitoring tech support needs is benchmarking. Fewer than 40 percent of the districts that responded to the CoSN/NSBA survey said that they tried to track the adequacy of their tech support by maintaining records on such things as the amount of time their network was down or the number of computers that needed repairs. Unless school districts attempt to measure the results that their budget for tech support is able to achieve, they will have no way of discerning whether they are doing an adequate job, and whether additional dollars can make a qualitative difference.

Increasingly, however, technology leaders are recognizing the importance of providing adequate support. In its January 2001 education technology planning guide, the state of California said, "It is important that school districts plan for adequate technical support for hardware, software, and local and wide area networks. The technology plan should state how teachers obtain technical support, the expected response time, the number of full-time staff needed for technical support, whether students will be involved in providing technical support, and how they will do so. If technical support will be provided in-house, districts are strongly encouraged to establish the maximum number of machines that each technical support person can maintain and ensure that as the amount of technology expands, the level of technical support is maintained according to the pre-determined ratio."[57]

Thin Clients and Application Service Providers

Because of the challenges of providing adequate tech support and managing growing school networks, more districts are taking a closer look at so-called "thin client" networks and Application Service Providers.

In a thin-client network, very little computing power resides in the desktop device. Most of the applications run on a centralized server. This approach requires a very reliable network and substantial bandwidth but means that less money will have to be spent on desktop computers or appliances. Districts that want to evaluate this approach will want to review what kinds of applications they want or need to run and whether they will be appropriate for this kind of network infrastructure. Software programs that incorporate extensive multimedia features or involve the manipulation of large amounts of administrative data may be more difficult to support. Further, the district will probably have to be prepared to devote more resources to network configuration and management.

In fall 2000, the Broward County, FL, school district launched a pilot project to evaluate the costs and capabilities of thin clients. Eight different vendors participated in the project, and the district plans on sharing its results as it proceeds. [58]

Taking this one step farther is the Application Service Provider. This approach involves putting a third party in charge of a school district's applications and running them on the third-party's servers. This will probably involve tradeoffs in the amount of flexibility a district will be able to enjoy, but should provide savings in the costs of providing tech support and network management.

TCO experts believe this approach is well suited for customers who want more predictable costs when their network grows and in instances when it is hard for a customer to retain qualified tech support people. (Many school districts complain that it is hard to find tech support staff when they can earn higher salaries in private business.) TCO specialists advise, however, that contracts with Application Service Providers should be carefully written to provide protections in case problems occur down the road. School districts will also want to review how their own data will be managed and protected in these kinds of arrangements, and whether those controls are adequate.[59]

Donated Computers

One of the big challenges tech directors face when they try to standardize computers in a school or district is the impact of donated computers. Often, well-meaning local businesses and residents may offer to donate older computers to schools—and schools that desperately need technology often agree to accept them.

Experienced technology directors, however, recognize that these computers will often create more headaches than they are worth. While the computers may be free, there are usually substantial costs associated with taking an inventory of them and then upgrading them to the standards of the district's network. Sometimes districts can run into problems when software licenses are not transferred properly. When the computers are extremely old, it will turn out that the business has simply transferred its hardware disposal problem to the over-worked tech staff at the school.

In late 2000, Congress moved to liberalize the deduction a business could enjoy when it donated computers to a school. Most tech directors now advise that it is a good idea to have a policy in place specifying what kind of computer a school district is willing to accept. This can also protect the district technology staff if it turns out that principals are accepting sub-standard computers for their schools and then expecting the tech staff to support them. The school districts of Denver and Hillsborough County, FL, are among those that now post their donations policy on their Web site. The Houston Independent School District, meanwhile, now requires that computer donations be coordinated through its Technology and Information Systems Division. It charges a school $50 to evaluate whether a computer is compliant, and then any costs associated with bringing it into compliance. If it is not cost-effective to upgrade the donated computer, it is sent to the warehouse for auction.[60]

Some districts *have* successfully channeled donated computers into low-income homes that might not otherwise have a computer and occasionally into vocational-technology courses involving computer repair. Occasionally a potential donation could be large enough that it

would, in fact, create a new standard for an individual school or small district. Further, thin-client networks may enable a district to manage a mix of older-model computers on the same network.

However, because the variety of operating systems and hardware models will always tend to increase the costs of providing support, school officials should be well aware of the potential negative impact of a donated computer before they agree to accept one.

Replacement Costs

When a school district has just installed dozens of brand-new multimedia computers, it's easy to forget that the day will come when they will need to be replaced. Although wiring, racks and electrical closets are presumed to have a life cycle of about 20 years, that's not the case for computers, servers and peripherals. They are expected to have a life cycle of between three and five years, depending on the equipment and the assumptions of the budget plan.

Thus it makes sense for a school system to purchase new computers on a five-year cycle and to replace them on the same cycle. Sometimes a district will decide to channel older machines to simpler uses, but that can ultimately lead to additional costs in the areas of support and maintenance.

In the Denver school system, for instance, the district assumed that when it purchased a new computer, it would not automatically get rid of it when it was five years old; rather it assumed that 10 percent of the district's computers would be retired each year. However, when it calculated the costs associated with leasing computers, it assumed that all units would be rotated at the end of a five-year lease.[61]

Unfortunately, most school districts' budgeting practices do not make it easy to set aside money for future purchases. "A school that receives a sum of discretionary money in one year is likely to lose any of the funds it has not expended by the end of the fiscal year," one school budgeting expert noted. "As a result, schools are often unable to make a large coordinated purchase of computers and associated equipment at one time. Moreover, they are prevented from saving money to make such a purchase to replace a computer lab once it has become obsolete."[62]

To help meet their tech support needs, tech directors are increasingly negotiating contracts with strong service warranties or lease agreements under which computers will be replaced on a regular schedule to increase standardization. In April 2001, the Hillsborough County (FL) Public Schools drew press attention when the district signed a five-year exclusive agreement, worth more than $50 million, to purchase the district's computers from one manufacturer. The arrangement included additional training for the technology staff and rebates for employees and parents when they purchased computers from the same manufacturer.[63]

School districts should be prepared to replace a computer every five years.

Because many school districts may be unable to predict when they will have the financial resources available to replace a computer, many experts recommend that they should purchase computers with as much processing power and memory as they can afford. That way, the

hardware will be better able to handle new or expanded software packages as they become available.

Districts may also find that they will have to pay fees to dispose of computers when they can no longer be used.

Connectivity

The costs of connecting to the Internet are a relatively small proportion of the total costs of educational technology. Although these costs have usually been included in projections of what it would cost to wire the nation's schools, they are not always included in a Total Cost of Ownership calculation because a business's computers may not be connected to the Internet or a Wide Area Network.

In the McKinsey computer lab model, connection costs represented only 8 percent of the budget initially and 15 percent of ongoing costs; in the model when all classrooms were connected, these costs represented 4 percent of the initial deployment costs and 7 percent of the ongoing costs. The study assumed that regular telephone lines would be the primary means of Internet connection in the computer lab model, while T-1 lines would be used in the classroom model.[64]

Since 1997, the percentage of public school classrooms that are connected to the Internet has skyrocketed, from only 27 percent in 1997 to 77 percent in the fall of 2000, according to a May 2001 study by the National Center for Educational Statistics. And those connections aren't just the simple dial-up connections of the past. NCES found that 77 percent of schools had a dedicated connection at a rate of at least 56KB. Twenty-four percent of schools reported that they had an ISDN, wireless or cable connection.[65]

E-rate discounts have enabled school districts to purchase substantially more bandwidth than they otherwise might be able to afford. Although telecommunications costs tend to be higher in rural areas than in urban centers, that factor is reflected at most levels of the E-rate discount matrix. In addition, some states have built statewide educational networks that provide schools with very low-cost or free access to the Internet.

Many technology directors are discovering that whatever bandwidth is made available, a school district will find ways to put it to use. School districts may decide that they can afford to purchase only a certain level of connectivity—for instance, a 56 Kbps Internet connection instead of a T-1 line. However, there will be a tradeoff in terms of the speed with which students and staff can communicate, connect to the Internet, and download graphic and video-intensive files. This, in turn, could have an impact on how staff members and students spend their available time.

Districts would be well advised to assume that their future bandwidth needs will increase, and to plan a connectivity solution that can grow as those needs grow.

Budgeting Considerations

This paper has attempted to detail the breadth of expenses that can be expected if technology is to be successfully implemented in a school or school district. Some of the expenses will probably be covered by the district's capital budget, while others will need to be supported on an ongoing basis by the operating budget. School districts frequently get technological improvements "kick-

started" by a large, and often extraordinary, infusion of funds from a bond measure, a state or federal grant, a donation of corporate dollars or equipment, or even a program such as the E-rate. What is important to remember, however, is that the district must be willing to commit itself to a long-term investment in technology spending, or the computers, networks and other kinds of hardware that are typically purchased with these dollars will simply go to waste.

Although the costs per student of building a technology infrastructure are often expressed on an annualized basis over a five-year period, the cost of purchasing hardware will usually be highest in the first years. Nevertheless, computers and networks will require ongoing maintenance, support, and, in the case of computers and peripherals, regular replacement—costs that will continue after the initial installation. In addition, teachers and other staff members will continue to require new training as new pieces of hardware and new software applications are introduced.

Unfortunately, many school districts are forced to rely on strategies such as issuing bonds to purchase hardware that will need to be replaced well before the bonds are repaid. This can make it harder for districts to come up with sources of funds for their ongoing technology operating expenses.

In its 1998 study of five school districts, the GAO wrote: "Program components that were hardest to fund, technology directors and others said, were those heavily dependent on staff positions (maintenance, training, and technical support). Staffing was difficult to fund because some funding sources could not be used for staffing and because some sources were not well suited for this purpose. For example, bonds and special levies passed by the districts we reviewed could only be used for capital expenditures. Officials also pointed out difficulties both in using one-time grants for ongoing staff positions and in attracting funding for staff from outside supporters."[66]

Just as many businesses are often tempted over time to cut computer support and training costs to improve their bottom line, school districts often fail to budget adequately for these kinds of expenses when they are trying to balance their budgets. The results, from a Total Cost of Ownership perspective, can be very similar.

After a school district makes a major investment in new hardware—through, bonds, grants, special appropriations, or corporate donations—it often can be hard to find the dollars to support the ongoing costs of staff development, support and hardware replacement.

"Shrinking the IT budget simply shifts the costs down the line and, in large companies, we often find that old-style TCO methodologies pushed 50 percent to 70 percent of IT dollars off the books and straight into business units. This is most often found in vulnerable help desk and training areas. . . ," noted one TCO consultant. "Cuts in end-user desktop training budgets resulted in an increase in user-induced outages, diminished technology utilization, poor productivity, peer support that disrupted normal operations and covert staff hiring." [67]

Substitute "school districts" for "large companies" and "schools" for "business units" and the description could easily describe technology budgeting in many districts. Administrators may not

have the tools in place to understand and calculate the real financial impact of their budgeting decisions, but the results are the same for the computer user and the overall enterprise.

The Gartner Group has reported that "end-user operations," that is, the time wasted on system failures and unproductive user activities, generally represent the largest component of Total Cost of Ownership, at 45 percent. Even when school districts budget adequately for Gartner's other key components—capital costs, administration and technical support—these end-user costs are usually unbudgeted, but still significant. Gartner argues, in fact, that when support budgets are trimmed too aggressively, every $1 in budgeted savings can actually lead to $4 worth of lost productivity.[68] As schools and teachers are increasingly judged on the basis of the performance of their students, productivity losses should become an even more important factor in school budgeting decisions.

These new challenges may require school administrators to think differently. As one study notes: "Market forces drive a company to examine its production costs and the overall efficiency of its operations. . . . Potential new technologies are investigated, cost-benefit analyses are conducted and a system is selected based on its potential to positively impact production, efficiency and (hopefully) market share. The final outcome is a company that remains competitive in the marketplace. In stark contrast, local education agencies typically engage in a less linear, and less logical series of decisions. . . . [Technology] decisions are based on the amount of dollars available, the assumed potential that technologies have for impacting students and the belief that schools need technology in order to fulfill their mission. Note that, unlike the business community, efficiency and productivity do not drive this decision-making process."[69]

The kind of centralized decision-making that generally leads to reductions in the Total Cost of Ownership is not always easy to sell. A case study of reducing the level of client-server support at Intel Corp., for instance, found: "To deliver a successful project, Intel's IT department had to convince the rest of the corporation to change its PC buying habits. This was no small task, and one that was approached with a great deal of trepidation. Specifically, IT wanted to take the power of choice away from the users. This was not a popular proposal. Most Intel organizations thought of their power to select their own PC technology as an unquestioned right." Ultimately, the Intel study concluded, the project succeeded in large part because of the support of Intel's president and chief operating officer, Craig Barrett.[70]

Similarly, TCO initiatives in school districts should be supported by the district's top administrators if they are to succeed. And administrators must recognize that there may be a price to pay in the costs of long-term maintenance and support if individual schools are permitted to make their own decisions on how technology will be deployed.

Getting a handle on TCO and technology costs will not be easy—not at a time when school technology expenditures are rising rapidly—possibly to between 3.2 percent and 8 percent of current educational budgets if the goal of wiring the nation's classrooms is to be achieved. But the magnitude of that spending is sure to bring new scrutiny—and new pressures—on school budgets.[71]

In a 1995 article, four McKinsey consultants wrote: "While the [technology] funding challenge sounds reasonable in aggregate, numerous pressures are squeezing education budgets at national, state and local levels. The Department of Education forecasts that increases in real operating

costs and student enrollment will drive annual spending to rise by 2.6 percent each year. In addition, systematic underinvestment in schools' physical plant has left the nation with an estimated $101 billion capital deficit. And these demands come at a time when governments are under pressure to do more with less. . . .

"All the same, it should be possible to secure adequate funding through a combination of reducing costs, reprogramming existing funds, and launching new initiatives in the public and private sectors."[72]

The ultimate goal of this project is to develop a consensus on how much should reasonably be devoted to these cost components, and to make technology planning and budgeting easier and more effective for school administrators. It took many years for businesses to learn the language of Total Cost of Ownership; now school administrators have the opportunity to build on that experience to suit the requirements of their own environment.

Once administrators understand the true costs associated with introducing technology, they will have new tools with which to plan their budgets for the 21st century. They will be better equipped to protect their district's significant investment in technology. But most important, they will be able to evaluate whether the technology is truly serving their district's educational goals.

Notes on Sources and Additional Resources

Although the authors of this white paper have attempted to keep the links cited below current, with the passage of time that has become increasingly difficult.

The Consortium for School Networking does maintain a long list of additional resources on many of the topics discussed in this white paper. Readers are encouraged to refer to those resources for updated information and Web citations. The list is available at http://www.classroomtco.org/resources.

[1] According to the education marketing company Quality Education Data, U.S. public school districts are expected to spend $5.8 billion on technology in the 2000-01 school year, including funds for hardware, networks, software, service, staff development, computer training, peripherals, Internet access and related supplies. From the 1995-96 school year to 1999-00, the ratio of students to computers improved from 10:1 to 5.1:1. Quality Education Data, "Technology Purchasing Forecast, 2000-01," and "2000 QED National Education Database" cited by Jeanne Hayes, QED, at the Consortium for School Networking's 2001 Annual Conference. See http://www.qeddata.com for more information.

[2] Slonaker, Larry. "Schools Find Hidden Costs of High Tech," San Jose Mercury News, December 21, 1998.

[3] The North Carolina plan is available at http://www.dpi.state.nc.us/Tech.Plan/Long-Range.Tech.Plan.html.

[4] California Department of Education, "Education Technology Planning: A Guide for School Districts," released in January 2001, is available at http://www.cde.ca.gov/ctl/techplaninfo.html.

[5] Much has been written about the value of improving the technological capabilities of schools and best practices for technology planning. Those topics are outside the scope of this document. It assumes that a school district has already made or is about to make a substantial investment in computers and networking. In addition, technology plans often incorporate improvements in the school district's telephone infrastructure and videoconferencing and distance learning capabilities. While the same principles of effective budgeting apply to these technologies, their costs are not specifically covered here.

[6] For instance, one model, developed by the Gartner Group in the late 1980s, estimated that every PC running Windows 3.1 in a "loosely managed" networking environment really cost $11,000. Using slightly different criteria, the International Data Corporation estimated the TCO for the same PC was $5,100. Gartner pegged the total cost of a networked computer running Windows 95 at $9,784. Forrester Research Inc. and Zona Research Inc. have put the

cost at about $2,800. The Gartner approach is described at http://www.microsoft.com/Education/planning/implement/tco/default_sch.asp.

[7] International Data Corporation, "Understanding the Total Cost and Value of Integrating Technology in Schools: An IDC White Paper Sponsored by Apple Computer, Inc.," 1997. Available at http://www.apple.com/education/k12/leadership/LSWTF/IDC1.html.

[8] Nelson, Gerry, "TCO: The Next Generation," MIDRANGE Systems, November 30, 1998.

[9] Washington State Office of the Superintendent of Public Instruction and Northwest Regional Educational Laboratory's Northwest Educational Technology Consortium, "A Guide to Networking for K-12 Schools," 1998. Available at http://www.netc.org/network_guide/. McKinsey & Company, Inc., "Connecting K-12 Schools to the Information Superhighway," 1995. Available at http://www.uark.edu/mckinsey.

[10] Solmon, Lewis C., "Progress of Technology in the Schools: Report on 27 States," 1998 study for the Milken Exchange on Education Technology. Available at http://www.mff.org/edtech/.

[11] McKinsey.

[12] Zeisler, Alfred, "Technology Implementation in Schools: Total System Cost and Funding Opportunities," presentation at "Grants and Funding for Technology Conference," sponsored by eSchool News Communications Group, November 1998. More information about the "Technology and Facilities Modification Investment Worksheet," developed by Integrated Technology Education Group, LLC of Short Hills, NJ, for the National Center for Supercomputing Applications, is available upon request through http://www.ncsa.uiuc.edu/IDT.

[13] Division of the Ratepayer Advocate, State of New Jersey, "Before 2000: Funding Technology in New Jersey's Schools and Public Libraries by the End of the Century," 1997. Available at http://www.njin.net/rpa/schools.htm. Al Zeisler of Integrated Technology Education Group and Lee McKnight of Massachusetts Institute of Technology were primarily responsible for preparation of the report.

[14] California Department of Education, "Connect, Compute, and Compete: The Report of the California Education Technology Task Force," 1996, with additional calculations. Available at http://www.cde.ca.gov/ftpbranch/retdiv/ccc_task/ccc.htm.

[15] Rothstein, R.I. and McKnight, L., "Technology and Cost Models of K-12 Schools on the National Information Infrastructure," 1996. Available at http://rpcp.mit.edu/Pubs/k12costs/CSTB.pdf.

[16] Glennan, Thomas K. and Melmed, Arthur. "Fostering the Use of Educational Technology: Elements of a National Strategy, " (RAND), 1996 Available at http://www.rand.org/publications/MR/MR682/contents.html. The original survey, "The Cost of High Technology Schools," by Brent Keltner and Randy Ross, was discussed in Melmed, Arthur, ed. "The Costs and Effectiveness of Educational Technology," November, 1995. Available at http://www.ed.gov/Technology/Plan/RAND/Costs/

[17] QED, "Technology Purchasing Forecast, 2000-01."

[18] Council of the Great City Schools, "Organizing K-12 Information Technology Resources," unpublished survey, with additional calculations.

[19] Rothstein and McKnight. Gartner Group citation from the company's 3rd Annual TCO Conference, "Managing TCO Effectively: Bridging the Gap Between Business and IT, Dallas, Texas, March 15-17, 2000.

[20] IDC.

[21] Melmed.

[22] Many resources are now available online to help school districts develop technology plans and build computer networks. Many manufacturers of networking equipment provide helpful information on their Web sites. Additional background can be found at http://www.classroomtco.org.

[23] McKinsey.

[24] Meeks, Glenn E., Fisher, Ricki and Loveless, Warren, "Implementation Costs for Educational Technology Systems," A CEFPI Brief on Educational Facility Issues, December 1997, available at http://www.cefpi.org/issue7.html

[25] Zeisler, Alfred. "Determination of Potential Cost Savings that Could Result From a Systems Approach to School Facility Design and Technology Specification," prepared for the schoolwire.org Web site and presented at the "Grants and Funding for Technology Conference," cited above.

[26] Westall, Robert, director of networking, School District of Philadelphia, at "Taking TCO to the Classroom" workshop, Consortium for School Networking's 2001 annual conference, February, 2001.

[27] Staff development was the focus of the CEO Forum's 1999 report "Professional Development: A Link to Better Learning." Available at http://www.ceoforum.org.

[28] U.S. Department of Education. "Getting America's Students Ready for the 21st Century: Meeting the Technology Literacy Challenge," 1996. Available at http://www.ed.gov/Technology/Plan/NatTechPlan.

[29] "Teacher's Tools for the 21st Century: A Report on Teachers' Use of Technology," National Center for Education Statistics, September 2000. Available at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=20000102.
[30] Education Week, "Technology Counts '98: An Education Week/Milken Exchange on Education Technology Report on Schools and Reform in the Information Age," 1998. Available at http://www.edweek.org/sreports/tc98/.
[31] Massachusetts Software Council. "The Switched-On Classroom's Technology Planning Guide for Public Schools in Massachusetts," 1994. Available at http://www.swcouncil.org/switch2.stm.
[32] QED, "Technology Purchasing Forecast, 2000-01."
[33] McKinsey.
[34] ITEG.
[35] Glennan and Melmed, citing Keltner and Ross, with additional calculations.
[36] Smart Valley Inc., "Technical Guidebook for Schools," 1995. Available at http://www.svi.org/netday/info/guidebook.
[37] California Department of Education, "Connect, Compute and Compete."
[38] Solmon.
[39] Strategies for dealing with teachers' differing attitudes toward technology are detailed in educator Len Scrogan's book "Tools for Change: Restructuring Technology in Our Schools," published in 1997 by the Institute for Effective Educational Practices.
[40] More information about the CTAP project can be found at http://ctap2.iassessment.org. The ISTE standards can be reviewed at http://cnets.iste.org/teachstandintro.html. The TAGLIT project can be reviewed at http://www.taglit.org and the status of the TSSA standards can be found at http://cnets.iste.org/tssa/index.html.
[41] NetDay survey, "The Internet, Technology and Teachers," released in May 2001. Press release available at http://www.netday.org/news_survey.htm.
[42] IDC.
[43] Keltner and Ross.
[44] McKinsey.
[45] QED. "Technology Purchasing Forecast, 2000-01."
[46] IDC.
[47] Solmon.
[48] Ibid.
[49] Further details of the CoSN-NSBA survey are available on the CoSN TCO Web site, www.classroomtco.org/checklist/support.htm.
[50] General Accounting Office, "School Technology: Five School Districts' Experiences in Funding Technology Programs," (Letter Report, 01/29/98, GAO/HEHS-98-35). Available at http://www.gao.gov/archive/1998/he98083t.pdf.
[51] Maryland Business Roundtable for Education Committee on Technology in Education, "State of Innovation: The Maryland Plan for Technology in Education, 1999-2003," prepared for the Maryland State Board of Education, December 1998.
[52] Washington State.
[53] Arizona Society of Technology Directors, Technology in Arizona: A K-12 Perspective, 1997. Available at http://www.aztea.org/resources/whitepaper/.
[54] The Project Athena formula is described in the Arizona technology guide cited above.
[55] Details of the Michigan project are available at http://techguide.merit.edu.
[56] The technology staff of the Fairfax County, VA, school district, for instance, demonstrated to school leaders that if every teacher was forced to spend one hour a week troubleshooting his or her own problems, and if tech-savvy teachers were helping their peers at least 1.5 hours a week, that represented the equivalent of 330 FTEs worth $16.5 million in salaries. Although Fairfax is a large district, if the same formulas are applied to a district with only 35 teachers, the district would still be devoting the equivalent of one FTE teacher a year to tech support.
[57] California Department of Education, "Education Technology Planning: A Guide for School Districts."
[58] More information about the Broward County project is available at http://www.broward.k12.fl.us/emergingtechnology/thin.
[59] Gartner Group
[60] The Denver school district spells out questions to ask prospective computer donors and its criteria for accepting donations at http://edtech.denver.k12.co.us/tech/order/donations.html. The Hillsborough County policy can be reviewed at http://apps.sdhc.k12.fl.us/sdhc2/technology/standards/Donations.htm. The Houston policy is detailed in a memo available at http://www.houstonisd.org/technology/Donations%20Memo.pdf.

[61] The Denver school district conducted a TCO analysis as part of five-year tech plan. It can be accessed at http://edtech.denver.k12.co.us:8080/tech_plan/costs/cost.html.
[62] Picus, Lawrence O., "The Challenges Facing School Districts in Budgeting for Technology," white paper prepared for "Smart Budgets for a Digital Age," 1997, sponsored by Bell South Foundation. Available at http://www.bellsouthfoundation.org//pubs/budget/budget2-1.htm.
[63] A press release describing the agreement is available at http://www.sdhc.k12.fl.us/~public.affairs/pressreleases/2000-2001/signing.htm.
[64] McKinsey.
[65] National Center for Education Statistics, "Internet Access in U.S. Public Schools and Classrooms: 1994-2000," May 2001, available at http://nces.ed.gov/pubs2001/2001071.pdf.
[66] GAO.
[67] Nelson.
[68] See "Lowering Total Costs in Education," http://www.microsoft.com/education/planning/implement/tco/default_sch.asp.
[69] Tetreault, Donald, "Educational Technologies: What Are They and What are the Costs?", white paper prepared for "Smart Budgets for a Digital Age," 1997, sponsored by Bell South Foundation. Available at http://www.bellsouthfoundatino.org//pubs/budget/budget3-1.htm.
[70] Henry, John and Harkins, Malcolm, "Reducing the Cost of Client/Server Support: A Case Study of Intel Corporation," Revision 2.1, February 20, 1997.
[71] Glennan and Melmed.
[72] Meisel, Ted, Nevens, T. Michael, Singer, Margot and Tate, Karen A, "World Class: Schools on the Net," The McKinsey Quarterly, 1995 Number 4, pp. 31-41. Available at http://mckinseyquarterly.com/computer/wocl95.htm.

Appendix A: Details of Cost Projections

McKinsey Projection of the Cost of Connecting Schools to the Information Superhighway, 1995

Model	Initial Costs Per School	Ongoing Costs Per School	Initial Costs Per Student	Ongoing Costs Per Student
Lab	$125,000	$45,000	$225	$80
Lab Plus	$255,000	$85,000	$460	$150
Partial Classroom	$340.000	$90,000	$610	$155
Classroom	$555,000	$165,000	$965	$275

These projections assume 5.7 schools per district, 533 students per school, 31 teachers per school, 21 classrooms per school and 25 students per classroom. The Lab Model assumes each school is connected through a computer lab with 25 networked computers and 10 analog telephone lines. The Lab Plus Model is similar, but assumes that a computer and modem is provided for each teacher. The Partial Classroom Model assumes that only half of each school's classrooms are wired and that a T-1 connection is available for long-distance transmission of data, video and voice. The Classroom Model assumes that every classroom is connected with networked computers at a ratio of five students per computer. Initial deployment costs include the purchase and installation of equipment and first-year operating expenses. Ongoing costs include usage charges, equipment and content upgrades, and professional development and support. Costs of the Lab Plus and Partial Classroom models are amortized over a five-year deployment schedule; the costs of the Classroom model are spread over a 10-year deployment schedule. The model assumes that most schools will use telephone company connections, except for some rural schools where wireless radio connections were assumed.

Cost Components, Computer-Based Infrastructure

	Initial Costs, Lab Model	Ongoing Costs, Lab Model	Initial Costs, Classroom Model	Ongoing Costs, Classroom Model
Hardware	34%	17%	51%	14%
Professional Development	19%	31%	14%	41%
Content	20%	26%	14%	21%
Connection within School	12%	5%	13%	4%
Systems Operation	8%	6%	4%	13%
Connection to School	7%	15%	4%	7%

Hardware includes multimedia computers, printers, scanners, furniture stations and security stations, and necessary building upgrades or retrofitting for some schools. The ongoing hardware costs assume a computer replacement cycle of seven years and a five- to 10-year replacement cycle for the other equipment. The models assumed that each school already has 14 multimedia computers. Professional development costs include substitute teachers and staff support to help teachers integrate technology into the curriculum. Costs of training courses are also included. Content costs include prepackaged software and access and usage charges for online services. The costs for "Connections within School" include the materials and labor for installing Ethernet LANs as well as file servers, hubs and routers, as well as file servers for the district. The projection assumed that a wireless LAN is deployed in about half of the buildings needing retrofitting. It assumed that 7 percent of classrooms were already connected to a LAN. "Systems Operations" costs include resources shared across the district dedicated to designing and operating the system. The "Connection to School" includes installation, access and usage charges for both the schools and the district. Except for some rural schools, wireline connections are assumed (POTS for the Lab models and T-1s for the Classroom and Partial Classroom models).

New Jersey School Study, 1997
Costs Per School Over Five Years

The average cost per student to implement this plan is $417 per year over five years. The figure does not include related physical facility changes. The model assumes that the average New Jersey district has four schools (fewer than the nationwide average) and that the average school has 515 students, 37 teachers and 35 rooms.

Component	Cost	Share of Total
Computer Equipment	$346,125	32%
Distance Learning Equipment	$83,850	8%
In-School Network	$39,220	4%
District Network	$32,132	3%
Internet Connection	$27,810	3%
Telephone System—on Premises	$31,200	3%
Training	$137,500	13%
Support	$377,814	34%
TOTAL	$1,075,652	100%

Computer equipment includes computers, printers and other peripherals, software and servers. Distance-learning equipment includes interactive full-motion video systems, as well as video systems and video and distance learning content materials. "In-School Network" includes local area network wiring and electronics costs. "District Network" includes networks that link schools within a district, including routers, networking equipment, and telecommunications costs. "Internet Connection" represents a district-wide network connection to the Internet, including telecommunications costs. "Support" includes staff for technology systems, repair costs for equipment and supplies for equipment.

California Department of Education
Four-Year Cost to Reach Benchmarks, 1996

These projections are based on the assumption that an average school has 700 students, 33 staff members, 27 classrooms and two other networked rooms. A calculation of the statewide costs is included in the original analysis.

	Assumption for Average School	4-Year Cost, Average Room	4-Year Cost, Average School	Percent of Total
I. Staff Development and Support				**21%**
Trainers	2,000 hours of training @$35/hour	$2,414	$70,000	
Staff support, materials, mileage, etc.	$2,000 per person (33 staff members)	$2,276	$66,000	
District-county technical support	.3 FTE=$15,000 per year for 4 years	$2,069	$60,000	
School site technical support	.5 FTE=$25,000 per year for 4 years	$3,448	$100,000	
4-Year Total		**$10,207**	**$296,000**	
II. Learning Resources				**27%**
Computer software	$2,000 x 29 rooms for 4 years	$8,000	$232,000	
Upgrades	$200 x 29 rooms for 4 years	$800	$23,200	
Other multimedia materials and services	$500 x 29 rooms for 4 years	$2,000	$58,000	
Communications (connect charges, etc.)	$1,265 per school per month x 12 months for 4 years	$ 2,094	$60,720	
4-Year Total		**$12,894**	**$373,920**	
III. Hardware and Telecommunications Infrastructure				**40%**
Computers	6 computers @ $1,525 x 29 rooms	$9,150	$265,350	
Special interfaces	$700 for each of 29 rooms	$700	$20,300	
Scanners	$675 for each of 29 rooms	$675	$19,575	
Networked laser printers	$1,100 for each of 29 rooms	$1,100	$31,900	
Color printers	5 @ $400 each (shared by school)	$69	$2,000	
Audio recorders and players	5 @ $75 each (shared by school)	$15	$375	

Headphones	174 (1 per computer) @ $30	$180	$5,220	
Liquid crystal presentation panels	5 @ $1,100 (shared by school)	$190	$5,500	
Video capture boards	5 @ $350 (shared by school)	$60	$1,750	
Video cameras	5 @ $600 (shared by school)	$103	$3,000	
Videodisc players	5 @ $325 (shared by school)	$56	$1,625	
Television monitors	$500 for each of 28 rooms	$483	$14,000	
VCRs	$350 for each of 28 rooms	$338	$9,800	
Overhead projectors and screens	$500 for each of 28 rooms	$483	$14,000	
Fax machines	2 @ $400 (shared by 29 rooms)	$27	$800	
Telephones	$50 for each of 28 rooms	$48	$1,400	
High-speed copiers	2 @ $5,000	$345	$10,000	
Telecommunications infrastructure	$74,000 per school	$2,552	$74,000	
Furniture and Security Equipment	$2,700 for each of 29 rooms	$2,700	$78,300	
4-Year Total		**$19,272**	**$558,895**	
IV. Maintenance Upgrades and Replacements	**Replacements represent 15 % of installed hardware**	**$5,844**	**$169,475**	**12%**
GRAND TOTAL (4 Years)		**$48,217**	**$1,398,290**	

RAND Corp. Data on Eight Pioneering High-Tech Schools, 1995

	Lowest in Range	Highest in Range	Mean	Median
Annual Cost/Student	$142	$490	$333	$390.5
Number of Students	310	1,800	977	850
Students: Computers	11:1	1.5:1		
Hardware	29.64%	66.75%	46.11%	43.77%
Software	3.88%	10.40%	7.84%	8.61%
Infrastructure	2.19%	7.10%	4.89%	5.21%
Staff Development	5.57%	22.29%	9.85%	7.73%
Support Personnel	3.28%	39.48%	27.4%	31.6%
Materials	1.75%	6.33%	3.83%	3.82%

Costs of hardware and software are amortized over five years. Infrastructure includes special furniture and cabling and is amortized over 10 years. Cost of initial professional development for teachers is amortized over five years. Cost of new staff, staff development, materials and supplies was treated as an annual expense.

MIT (Rothstein and McKnight) Projection for School-Based LANs with Central Connection to the District and to the Internet, 1994

Projection assumes that the average school district has six schools with 518 students, 257 teachers, 25 other staff, and 20 classrooms. Model assumes that each school already has seven computers capable of running graphical Internet applications. Model includes 60 computers per school, a 56Kb network connection to the district office, a T-1 connection to the Internet and 20 dialup connections. This was the second most expensive model of five that were detailed by the study.

ONE-TIME INSTALLATION COSTS	LOW	HIGH
SCHOOL-LEVEL		
Local Area Network	$20,000	$55,000
Personal Computers	$60,000	$120,000
File Server	$4,000	$15,000
Connection to Hub/District Office	$500	$2,000
Router and CSU/DSU	$2,600	$5,000
Retrofitting (major)	$10,000	$25,000
TOTAL	**$97,100**	**$222,000**
DISTRICT-LEVEL		
File Server	$2,000	$15,000
Router	$2,000	$5,000
District LAN	$2,000	$5,000
Data line to WAN/Internet (T-1)	$1,000	$5,000
Dialup Capabilities (20 lines)	$16,000	$32,000
Training (40-50 staff/school)	$50,000	$150,000

ONE-TIME INSTALLATION COSTS	LOW	HIGH
TOTAL	**$73,000**	**$212,000**
ANNUAL OPERATING COSTS		
SCHOOL-LEVEL		
Replacement of Equipment	$3,000	$8,250
Connection to Hub/District Office (56Kb)	$1,000	$5,000
TOTAL	**$4,000**	**$13,250**
DISTRICT-LEVEL		
Internet Service (T-1)	$10,000	$42,000
Dialup Lines	$3,000	$5,000
Support (2-3 staff/district)	$66,000	$150,000
Training	$15,000	$35,000
TOTAL	$94,000	$232,000
One-Time Costs Per Student	**$212.47**	**$501.14**
Annual Costs Per Student	**$39.77**	**$104.69**

Breakdown of Model's Costs When Startup Costs Are Amortized Equally Over Five Years, Excluding PC Purchases

Budget Component	%
Hardware	36%
Support	33%
Training	13%
Telecommunications	11%
Retrofitting	7%

Hardware is defined as wiring, routers, and servers, including installation, maintenance and service of hardware and telecommunications lines. Training is defined as training of teachers and other school staff to use the network. Support is defined as technical support of the network. Retrofitting includes modifications to facilities to accommodate the telecommunications infrastructure, including costs for asbestos removal, electrical systems, climate control systems, added security and renovation of buildings to accommodate networks. Wireless and coax-fiber systems were not evaluated because the technologies were considered to be too new at the time of the study. The cost of educational software is not included.