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ABSTRACT

This thesis examines the cost and benefits of communication networks in K-12 schools using cost analysis of five technology models with increasing levels of connectivity. Data indicate that the cost of the network hardware is only a small fraction of the overall networking costs. PC purchases, initial training, and retrofitting are the largest one-time costs for starting the network, and network support is the largest ongoing annual cost that schools must face. Over the first 5 years, support and training together comprise 46 percent of the total costs of networking schools. Costs are significantly reduced when aggregated at the district and state levels due to increased purchasing power. Using the Internet's CNN Newsroom to evaluate the benefits of K-12 networking reveals that students using CNN Newsroom placed more emphasis on the use of computers for school projects than did other students with similarly high access to technology. Lack of training and support was the biggest barrier for teachers and students, highlighting the need for school funding of the human infrastructure in addition to the network infrastructure. (Contains 48 references.) (GR)

Networking K-12 Schools:
Architecture Models and Evaluation of Costs and Benefits

by

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A.B., Computer Science, Harvard College (1990)

Submitted to the Sloan School of Management and
the Technology and Policy Program
in Partial Fulfillment of the Requirements for the Degrees of

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ABSTRACT

Network connectivity within K-12 schools is growing rapidly, spurred on by encouragement and financial support from the government and the private sector. Fanfare surrounding the Internet adds to schools' desire to develop networking infrastructure quickly. However, computer networking can be a vital technological tool to improve education only if all stakeholders clearly understand both the benefits and the costs of the technology.

This thesis examines the costs and the benefits of networks in K-12 schools. To examine costs, five technology models are developed with increasing levels of connectivity. For each model, a range of one-time and annual costs are computed. These costs are extrapolated to the national level to examine the costs to network all U.S. schools.

The data from the models indicate that the cost of the network hardware is only a small fraction of the overall networking costs. PC purchases, initial training, and retrofitting are the largest one-time costs for starting the network. The costs for the wiring and equipment are typically not as high. Support of the network is the largest ongoing annual cost that schools must face. Over the first five years, support and training together comprise 46% of the total costs of networking schools. Costs are significantly reduced when aggregated at the district and state levels due to increased purchasing power.

To examine the benefits of networking in K-12 schools, this thesis evaluates the use of a new product, Internet CNN NEWSROOM. Students using Internet CNN NEWSROOM placed more importance on the use of computers for schools projects than did other students with similarly high access to technology. A novelty effect accompanied the technology, in which initial excitement and extensive use of the product diminished over time. The greatest barrier to use of Internet CNN NEWSROOM effectively by teachers and students was a lack of training and support for this prototype service; this impediment highlights the need for school funding of human infrastructure in addition to network infrastructure. The study reveals a fundamental shift in students' opinion of a computer's purpose – from typing and gaming to information retrieval and communication.

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Chapter One

Introduction

1.1 INTRODUCTION

On a brisk sunny day last March in Northern California, U.S. President Bill Clinton stood perched atop a ladder, donning electrician's gloves, to install seventy feet of red, white, and blue category-five wire at Ygnacio Valley High School. Other top U.S. officials joining him in the task of wiring up schools included Vice President Al Gore, Education Secretary Richard Riley, Commerce Secretary Ron Brown, and FCC Chairman Reed Hundt. On that day, the administration unveiled its plan to couple $2 billion in federal grants with private donations to wire every classroom in the country by the year 2000.[1]

The federal government is not alone in its enthusiasm for networking K-12 schools.[2] State and local governments, teachers, parents, and corporate America have called for a greater effort to install telecommunications infrastructure within schools. With broad support from multiple constituencies, many schools have begun to take the plunge into implementation of information infrastructure. Several developments suggest that the rate of network connectivity among K-12 schools will continue to grow rapidly:

[1] San Jose Mercury News (1996)
[2] K-12 schools include U.S. public and private schools with students in grades kindergarten through twelve.

- The federal government is committed to have every classroom in the U.S. connected to the National Information Infrastructure (NII) by the year 2000.
- A number of telephone and cable companies have announced plans to connect schools in their service areas at low or no cost.
- Modern, high-speed networks have been installed at a number of progressive, pioneering K-12 schools.
- The Internet, a global network of networks that connects an abundance of educational resources, is experiencing phenomenal growth.

However, to date, there is relatively little known about the costs and benefits of connecting schools to the information infrastructure. The lack of research in this area is distressing given the enormous financial and human resources that the public and private sectors are committing to K-12 networking. Just a few years ago, the lack of data in this area may have been justified due to the dearth of case studies; there were very few schools with networking infrastructure from which to gather cost and benefit data. However, in 1996, there exist a significant number of pioneering, early adopter schools that have installed and make use of information infrastructure. Therefore, it is imperative at this time to examine how these schools have successfully developed networking infrastructure, how much it has cost them to do so, and how the technology benefits them in their task of educating students.

Educators, school administrators, parents, politicians, community leaders, CEOs, regulators, and students all have a role in influencing the prominence that computer networking, and technology in general, are given in K-12 education. Cost and benefit data should be vital in forming policies governing the use of networking technology in education. It is hoped that this thesis will provide information to help formulate education and telecommunications policy in this country. As the information in this thesis becomes outdated, as it will in an age of rapidly advancing technology, this study should provide a methodology for updating the information it contains.

1.2 STATEMENT OF THESIS

This thesis assumes that computer networking can improve education within schools. The unique capabilities of computer networks can make education more interesting and more effective. However, networking will have a net positive effect on education only if all stakeholders clearly understand both the benefits and the costs of the technology. Without a clear understanding of both benefits and costs, the implementation is unlikely to achieve its intended goals.

It is vital that stakeholders understand the technology's benefits and limitations. If they do not understand, they will reject the technology since it does not meet their misguided or excessive expectations. Oettinger (1969) describes numerous examples of the failure of technology in schools because the true features and benefits of the technologies were not clearly communicated to teachers and school administrators. If users of technology do not fully understand its features, they will be disappointed when they do not encounter the capabilities they expect and will be unaware of the capabilities that the technology does truly provide.

This condition is true especially in the case of K-12 school networking. Given the enormous publicity surrounding the Internet today, some people assume that networking can solve many of the resource constraints facing schools. While networking does provide unique capabilities to schools, it is vital that schools understand that Internet connectivity will not serve as a panacea for their educational, administrative, and financial problems.

It is also vital that stakeholders understand the true costs of the technology because insufficient budgeting for technology will ensure minimal and inefficient use of the technology. The true cost for technology exceeds the purchase price of hardware and software. Stakeholders must be aware of all cost factors including technology support, training, and administration.[3]

This cost augmentation is particularly true in the area of computer networking. Networking is a complex technology that requires professional technical support. Additionally, computer networking is a new technology paradigm; training is an essential cost item that will enable users to understand how to use networks effectively.

1.3 SYNOPSIS OF FINDINGS

1.3.1 Costs

This thesis attempts to enhance the use of educational networking by shedding light on the costs and the benefits of networks in K-12 schools. To examine costs, five technology models are developed. Each model represents a technical model for a school as it proceeds from a state of stand-alone computing to one of ubiquitous networking. These models, building on prior research, use empirical data from a sample of technologically advanced schools and school districts. For each model, a range of one-time and annual costs is computed. These costs are extrapolated to the national level to examine the total cost to network all U.S. schools.

The data from the models indicates that the cost of the network hardware is only a small fraction of the overall networking costs. PC purchases, training, and retrofitting are the largest one-time costs for starting the network. The costs for the wiring and equipment are typically

[3] Technology budgeting in the corporate world does consider the greater augmented cost. For example, recent Gartner Group PC cost-of-ownership studies show that five-year costs can exceed $40,000 per PC – the major cost component being PC administration and end-user support. (Business Wire, 4/10/95)

not as high. Support of the network is the largest ongoing annual cost. Over the first five years, support and training together comprise 46% of the total costs of networking schools.

The costs to network a school are complex and challenging to estimate. The costs for most schools will fall into a bounded range, but each particular school will vary greatly depending on its individual needs and characteristics.

There are two major discontinuities in the curve of increasing school networking. The first jump in cost arises when the school installs a local area network (LAN). The school and district must pay to have the LAN installed and employ full-time support staff. The second jump arises if and when the school decides to purchase enough PCs to support widespread concurrent network access. Currently, the number of networkable PCs in most schools is inadequate; there would be a significant cost to provide multiple PCs in every classroom in the U.S. In addition, many older schools will require expensive electrical and retrofitting work to support the increased number of PCs in the school. In the intermediate stages between these jumps, the costs are not as great.

The startup costs for the network increase at a faster rate than the annual ongoing costs as the network architecture complexity increases. The divergence indicates that the most significant hurdle a school will face is the initial investment costs in the network and computers.

Purchasing of technology equipment at the state and district levels can significantly reduce costs. Schools stand to save much money by pooling resources and purchasing power with other schools in the district and at the state level. When schools share a high speed data link or support staff, the costs per school drop considerably.

This research suggests that a number of programs would have a significant impact on the total networking costs. If all schools coordinate purchasing at the state level, cost savings at the national level could exceed $2 billion. If schools were given free Internet connectivity, the total annual costs for school Internet connections would be reduced by $150 - $630 million. However, since costs for telecommunications lines and services represent only 11% of the total costs, tariff rate reductions will have a relatively small impact.

Finally, as the costs of networking schools are better understood, a new question arises: how will these costs be financed? Many states have programs to fund networking in schools. The federal government has a role, although, as the administration says, the NII will be built by the private sector.[4] A number of states have initiated cooperative ventures between businesses and schools. An expansion of these programs may be the key for successfully networking K-12 schools.

1.3.2 Benefits

To examine the benefits of computer networking in K-12 schools, this thesis evaluates the use of a new networked multimedia information service, Internet CNN NEWSROOM, in Lexington High School. Students using the service were compared to two control groups that did not use Internet CNN NEWSROOM. As a new educational product, it is not surprising to find that the product contains technical glitches and is not well integrated into the curriculum. However, research based on focus groups and user surveys indicate that it provides valuable educational benefits in the classroom.

Internet CNN NEWSROOM generated a considerable novelty effect among student users. In their first few months of using the product, students expressed great enthusiasm about the product and displayed a sharp increase in technology usage. However, after the novelty effect

[4] Information Infrastructure Task Force (1994), p.2.

wore off student interest in Internet CNN NEWSROOM and attitude towards technology retreated from their formerly high levels.

Students using Internet CNN NEWSROOM placed more importance on the use of computers for schools projects than did other students with similarly high access to technology. These students also made increased use of computers and networks for school work and claimed to have a greater increase in experience with the Web than students without access to Internet CNN NEWSROOM.

While students using Internet CNN NEWSROOM placed more reliance on computers as the year progressed, students using technology but not Internet CNN NEWSROOM placed less reliance on computers over the same period. The former group, in using content-rich Internet CNN NEWSROOM, began to view computers as valuable for class work. The latter group, without access to Internet CNN NEWSROOM, was not able to find good information resources for school projects using computers.

The greatest barrier to use of Internet CNN NEWSROOM effectively by teachers and students is the lack of knowledge about using computers, the Internet and the Internet CNN NEWSROOM interface. User training is a necessary prerequisite for proper use of the technology. Although students complained about glitches in system performance, they were not excessively bothered by them.

The teacher and students stated that the video presentation of current events was much more powerful than text. However, while students expressed a great interest in using video clips from Internet CNN NEWSROOM for their research reports, most said that they were more difficult to use than text.

Users cited Internet CNN NEWSROOM's archive search capability as its single greatest benefit. Other key benefits of the Internet version include the quick access to the desired content. The teacher cited two other benefits – the ability to access all the content and accompanying material at a single Internet site and increased exposure to the Internet due to her experience with Internet CNN NEWSROOM.

This study indicates that there is a fundamental shift in the primary use of computers by students. Students who have not used the Internet or on-line services viewed computers as having three functions – word processing, typing instruction and game playing. On the other hand, more experienced computer users emphasized other more powerful uses for computers including information retrieval and communication.

1.4 REVIEW OF K-12 NETWORKING COSTS AND BENEFITS LITERATURE

Public debate over the role of technology in education has been manifest since the formation of a unified educational system in the U.S. in the 1920s.[5] Whitehead (1929) argues that the use of simple technology in the classroom can make education more effective. He extols the benefits of using technology – a surveyor's chain and compass – to supplement lectures in history and geography. However, he warns that "the provision of elaborate instruments is greatly to be deprecated." In his words, A. N. Whitehead was one of the first people in the modern age to recognize both the potential benefits and costs of technology in education.

Oettinger (1969) provides an early critique of computer technology in the classroom. He argues that instructional technology can lead to genuine improvements in technology only if it is at the

[5] As described in Olson, Jones & Bezold (1991), in the 1920s the government acted to consolidate the small one-room school houses that dotted the country into centralized school districts near population centers. The number of school districts was reduced from 150,000 to 17,000 as part of a national policy to unify and standardize education in the country.

behest of teachers and is accompanied by judicious planning and an understanding of its costs, benefits and limitations. He faults policy makers, consultants, administrators, and businesses for pushing technology without meeting these conditions.

The case of computer networking as an educational technology is no different. Oettinger's three prerequisites – planning, stakeholder buy-in, and an understanding of costs and benefits – are necessary for a successful network implementation. There is extensive research describing best practices for planning and achieving buy-in for technology in schools. Given the universal nature of these problems, the recommendations are relatively similar across all technologies including computer networking. However, research on the costs and benefits are particular to each technology. As stated above, the existing body of research on the costs and benefits of K-12 networking is inadequate. It was only in the past year that a few notable publications addressed the subject directly. This section will review eight recent publications that examine K-12 networking costs and benefits.[6]

Carlitz and Hastings (1994) responded to the recent launch of the NII as a policy set forth by the Clinton/Gore administration. They acknowledged that, of the NII stakeholders, schools have much to gain but are the least capable of understanding and integrating the new technology. Carlitz and Hastings responded to this need by developing a set of "stages of connectivity" through which schools could progress in connecting to the NII. The paper, while not a how-to manual, is directed at schools to provide them with basic technical and cost information to use in successfully developing infrastructure. The stages of connectivity outlined in the paper are:

1. Network gateways – i.e. bulletin board systems (BBS)
2. Internet dialup

[6] The publications are reviewed in chronological order since some of the later works derive from earlier work.

3. Serial Internet connections through serial line interface protocol (SLIP) or point-to-point protocol (PPP)
4. LAN connectivity through SLIP/PPP
5. Higher speed options, such as integrated service digital network (ISDN), leased lines, frame relay or switched multimegabit data service (SMDS)

For each of the connectivity stages, Carlitz and Hastings provide a brief technical description, with intermittent discussion of typical costs, along with a brief discussion of benefits and limitations. The paper provides an excellent introduction of networking issues to schools. It does not attempt to provide a systematic analysis of costs or benefits of K-12 networking, nor does it examine the policy issues faced by stakeholders.

Massachusetts Telecomputing Coalition (1994), also directed at school decision makers, develops six "K-12 Internet connectivity models":

1. Standalone Dialup
2. Shared Modem – school LAN shares a modem
3. LAN Gateway/Portage – school LAN has an information server
4. Standalone Peer Dialup – using SLIP/PPP
5. Network Model/Router
6. Desktop Internet – with a dedicated Internet connection

For each of the six models, the paper describes costs, services available, connectivity capabilities, appropriate user levels, and relative advantages and disadvantages. The paper demonstrates effectively that the lower models, while initially less expensive, are not scalable and are much more expensive when there are more than a handful of users. A connection choice decision guide provides the reader with an easy-to-use decision analysis tool to choose the ideal model for any school. The models developed in Massachusetts Telecomputing Coalition (1994) and in Carlitz and Hastings (1994) provided the basis for the development of the technology models in this thesis.

Rothstein (1994), a U.S. Department of Education working paper, represents the author's first analysis of K-12 networking costs. It developed architecture models based on Massachusetts Telecomputing Coalition (1994) and Carlitz and Hastings (1994). The report went further in using extensive empirical data to develop cost estimates for each of the models. It discussed the policy implications raised by those cost estimates. It did not examine the benefits of educational networking. This thesis presents the author's latest findings based, in part, on this initial research.

Barreca (1994) is a study done for the Telecommunications Technology Forecasting Group, whose advisory board includes representatives of major local and long-distance telephone companies. The paper summarizes the models and costs developed in Rothstein (1994). It argues that the costs would decrease for each of the models if schools were to use ISDN technology, a technology jointly developed by the telephone companies. The impetus for this paper was partly in response to the chapter in Rothstein (1994) that discouraged the use of ISDN in schools because of its high per minute usage rates and its inability to provide high-bandwidth connectivity above 378 kilobits per second (Kbps).[7]

Telecommunications Industries Analysis Project (1995) was commissioned by the Telecommunications Industries Analysis Project, a cross industry-government group with representatives from domestic and international telecommunications firms and state utility regulatory agencies. This report was also issued in response to Rothstein (1994). The paper examined the costs of broadband (i.e., greater than 45 megabits per second (Mbps)) networking, in contrast to Rothstein (1994) which did not go beyond wideband (1.5 Mbps) networking. The

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[7] Changes in ISDN tariff rates in a few states over the past two years have addressed at least the former argument. However, in most states, ISDN rates are still exorbitantly high. See "A Steep Hurdle to Web Shortcut" (*New York Times*, 3/25/96, p. D1) that demonstrates that ISDN usage for Internet access costs hundreds or even a thousand dollars monthly in many areas of the U.S. The latter argument about bandwidth scalability and other issues including local ISDN monopolistic structures have not changed (see Rothstein (1994)).

report focused on the costs of local exchange carrier (LEC) network investment to provide broadband connectivity to all schools. Pricing of school network connectivity was not included because the current broadband pricing structure was prohibitively expensive for schools.

Telecommunications Industries Analysis Project (1995) compared the costs of networking schools in three different models:

1. Teacher-only access (1 PC per classroom) – $4-6 billion annually over five years; $0.2-1.2 billion annually over twenty years
2. Team-of-students access (7 PCs per classroom) – $10-12 billion annually over five years; $0.2-2.9 billion annually over twenty years
3. Universal access (26 PCs per classroom) – $27-31 billion annually over five years; $1-9 billion annually over twenty years

For each of the three models, the costs for software, Internet access, and network investment over a five-year and a twenty-year broadband deployment schedule were estimated. The report contains three major conclusions: school costs greatly exceed LEC network investment costs; accelerating deployment increases network investment costs; and the number of PCs per classroom did not effect the network investment costs. The report does not take into account the installed base of PCs in the classroom.

In contrast to the previous publications that focused on networking costs, U.S. Congress, Office of Technology Assessment (1995) provides an in-depth analysis of the benefits of networking, and technology in general, in K-12 schools. It finds that "communications technology is one of the biggest changes technology offers classroom teachers."[8] In a brief overview of networking cost issues, the report summarizes the findings of Rothstein (1994). In turn, this thesis elaborates on some of the networking benefits described in U.S. Congress, Office of Technology Assessment (1995).

[8] U.S. Congress, Office of Technology Assessment (1995), p. 2.

McKinsey (1995) is a pro bono project performed by McKinsey & Company, the management consulting firm, for the National Information Infrastructure Advisory Council (NIIAC)[9] The report outlines the benefits of NII connectivity, infrastructure options and costs, and the challenges to capturing the benefits. The report examines four infrastructure models:

1. Lab (one lab with 25 networked PCs per school) – $11 billion initially; $4 billion annually
2. Lab Plus (Lab plus one computer and modem per teacher) – $22 billion initially; $7 billion annually
3. Partial Classroom (1.5 Mbps connection, Ethernet LAN, half of classrooms have 1 PC per 5 students) – $29 billion initially; $8 billion annually
4. Classroom (all of the above plus all classrooms have 1 PC per 5 students) – $47 billion initially; $14 billion annually

All four models include a district server and LAN; school server and peripherals; professional development; and support. The deployment phase is five years for the first three models and ten years for the fourth model. The report's three major conclusion are as follows:

- Hardware purchase and installation constituted the largest one-time cost.
- Support and training costs were significant while connectivity costs were not.
- Video and voice networks could be added without much extra cost.

McKinsey (1995) developed a weighted average cost for each of the models. This methodology is different from the cost ranges developed in Rothstein (1994) and in this thesis. The report

[9] The National Information Infrastructure Advisory Council (NIIAC) was created by executive order at the end of 1993 and formally established and appointed in early 1994. The thirty-seven member advisory panel represents many of the key constituencies with a stake in the NII, including private industry; state and local governments; community, public interest, education, and labor groups; creators and distributors of content; privacy and security advocates; and leading experts in NII-related fields. The NIIAC has the responsibility of advising the Secretary of Commerce and the Administration on a national strategy for promoting the development of the NII and the Global Information Infrastructure (GII).

also includes costs for non-networking computing items such as printers and furniture. However, on the whole, the findings in McKinsey (1995), Rothstein (1994), and this thesis are similar.

The latest research in this area, Glennan and Melmed (1996), takes a different approach to examining costs. The report presents an in-depth analysis of the technology costs for five technologically advanced schools and three technologically average schools across the U.S.

Within the schools studied, funds spent annually per pupil on technology was in the $180-$450 range. The report recommends a $300 target for U.S. schools, which represents a 300% increase over the current actual technology expenditures in schools. The report admitted that a fundamental shift in the country's thinking about educational technology will be necessary to secure such an increase in funds. The report also stated that, although there is some research attesting to the effectiveness of technology in schools, more research is necessary to make conclusive statements about its educational value.

The report examines all computer technology costs with the schools and does not record separate line items for networking infrastructure. It ignores the significant one-time costs associated with rapid deployment of networking and NII connectivity (including LAN installation and Internet connectivity setup). Finally, the small sample size (eight schools) used in the report represents a case study of educational technology and does not necessarily provide results generalizable to the entire U.S. education system.

The recent emergence of these studies on the costs and benefits of computer networking in schools begins to supply some information in this area. However more research, particularly research syntheses of cost and benefit data, is necessary to support informed debate on the role of computer networking in schools.

1.5 THESIS OVERVIEW

Chapter two presents a set of five technology models, each of which represents an increasing level of telecommunications infrastructure in a school. The chapter describes the technical capabilities and the initial and ongoing costs for each model. Cost projections for all U.S. public schools are determined by aggregating the school cost data. The aggregate cost data is used to determine the financial benefits of various policies that may reduce the total costs to wire up schools.[10]

Chapter three examines the benefits of computer networking in schools. It provides a brief survey of current research on the benefits of educational technology and educational networking. It describes the types of services that schools can receive for each of the five architecture models developed in chapter two. The chapter presents a case study of the benefits of high-speed educational networking at Lexington High School. Due to its significant investment in networking, the school is able to make use of a new educational service, Internet CNN NEWSROOM. The chapter describes the benefits the school receives from using networked multimedia services such as Internet CNN NEWSROOM.

Chapter four explores policy and product recommendations in educational networking. The policy recommendations are directed at policy makers, regulators, and school officials to reduce costs and increase benefits for schools. The product recommendations are directed at educational software developers and publishers to identify the features of Internet-based educational products that meet the needs of teachers and students.

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[10] The results in this chapter are based on Rothstein (1994) and represent work done initially at the U.S. Department of Education and subsequently at the MIT Research Program on Communications Policy. Initial cost data was collected through research done at the Department of Education. Subsequent research at MIT has provided updated cost estimates.

Chapter Two

Architecture Models and Costs

2.1 INTRODUCTION

Estimating the costs of telecommunications services in K-12 schools in the U.S. is a daunting task. Each of the 110,000 public and private schools across the country has different needs for technology expenditures. Some schools hold technology in great esteem and desire to have more resources at their disposal. Other schools see technology as irrelevant or unhelpful in educating children. Because local funding constitutes the majority of a school's budget, the financial resources available to schools varies by community and state. In communities that allocate significant funds for education, schools have the financial resources to purchase modern, powerful computers and other technology. In communities that choose not to or are unable to allocate abundant financial resources to education, schools are unable to make significant technology expenditures. Additionally, the amount of technology currently found in schools varies greatly; in some schools computers and technology are ubiquitous, while in other schools high-tech equipment is an electric pencil sharpener and a touch-tone telephone.

The variety of technology needs and resources is due to the decentralized, autonomous nature of the public and private school systems in the country. There is no centralized planning authority for U.S. schools. The U.S. Department of Education, created in 1980, promotes education in the country but does not have any power or authority over schools. Therefore, the rate of adoption of technology in schools will continue to vary from school to school.

Given a diverse technology adoption rate among schools, this chapter presents a series of five technology models for schools in connecting to a national information infrastructure. Each of the five models has a different level of technical complexity, cost, and functional capability. Schools will migrate to different models based on their own needs and financial resources for technology. However, to take advantage of many of the networked multimedia educational services, schools will require a minimum level of connectivity and technical infrastructure. This chapter examines the total costs of networking K-12 schools through five models and evaluates the impact of cost savings programs.

2.2 COST MODELS OF K-12 NETWORKING

Networking K-12 schools is not a one-shot deal. Technology is a recurring expenditure for schools since they require continual equipment upgrades and purchases. The five technology models described in this chapter represent a continuum of telecommunications infrastructure construction that schools may implement over time in establishing broadband network connectivity.

Every year, schools answer two key questions concerning the use of funds to purchase technology:

- What additional capabilities do we desire that will be enabled through technology?
- How will we allocate our expenditures to achieve those capabilities?

The former question provides the impetus for the technology models developed in this chapter. Each successive model presents an expansion of the features and capabilities available with expanded digital telecommunications infrastructure. As the model increases in functionality, the costs to implement the model increase as well. The models do not address the issues of fund allocation among different technologies and products as described in the latter question.

A school will likely begin its connection to a data communications network with a simple, low-cost configuration. As the school builds expertise and develops a need for greater capability, it will upgrade to a higher level of connectivity. Not until the school acquires telecommunications infrastructure similar to the fourth model is it able to take advantage of multimedia educational services. The fifth model presents the costs for putting a PC on every desktop along with a high-speed Internet connection.

These models are representations of the network technology used in schools. While a level of complexity and detail is omitted from these models, the simplicity is helpful because the models encompass broad cross-sections of network and school configurations.

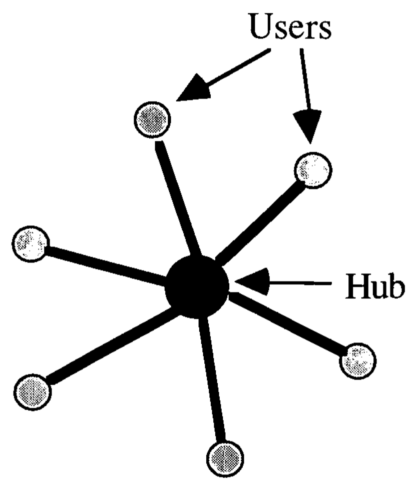
The scope of the school networking models includes digital data communications networking based on Internet networking technology. Analog video point-to-point networks, analog voice networks and voice-mail systems are beyond the scope of these models. Audio and video functions are possible in digital format over the Internet data network, but many schools will still use separate video and voice networks. The costs of these systems are important to consider, but are not modeled in this thesis.

Although these models exclude voice and video networks, schools should not consider these networks to be wholly distinct from data networks. Some schools have integrated their voice and video networks with the school data network. The sharing of resources among the multiple networks can be effective in providing significant cost savings. As a school installs a LAN and puts computer data connections in every classroom, there are minimal added costs to concurrently install other types of connections.

2.2.1 Architecture of the District Network

The star network architecture, illustrated in Figure 1, is the underlying design for the models. The star network connects multiple sites to a central hub.[11] In the school network, each school building is connected to the school central hub. In most cases, the district office is the most appropriate site for the central hub, because it also represents the bureaucratic center of the district.

Figure 1. Star Network



SOURCE: Newman, Bernstein, and Reese (1992)

From two to ten schools should connect to a single hub, depending on the size of the schools. In most cases, the hub will reside at the school district office. However, in cases where there are a great number of schools in a single district, the district should be divided into multiple clusters of 4-6 schools each. Each of these school-clusters will have a group hub, probably at the district office, which will contain the center of the network for those schools.

[11] Many telecommunications networks are built using a star network design. Internet service provision and local loop telephony provide two examples among many. In the former case, subscribers dial in to the Internet service provider's central hub from where they connect to the Internet. In the latter case, all homes in an area are connected to a central office switch, through which all calls are routed.

There should be a connection between the school LAN and the district office hub. With this configuration, every classroom has a connection not only to every other class in the school but also to the central school district office. The connection from the district office to the Internet should be a higher bandwidth connection since all schools are connecting to the Internet through this single line.

Schools can reap significant cost savings through adoption of the star architecture design. When multiple schools connect through a single hub, schools share network costs. Since networking infrastructure contains economies of scale, each school pays less for its share of the total cost than if it connected separately.

This design gives schools stronger purchasing power since school districts can negotiate volume discounts for purchase of equipment for the entire district. The design also allows schools to share resources, such as the data line to the Internet, training programs, and full-time support staff, that each school might not be able to afford individually. Therefore there are costs both at the school and at the district level for networking schools across the country. Sellers and Robichaux (1995) and California Department of Education (1994) also advocate the use of a star configuration through a community or district hub.

Schools have benefited most from technologies that are mature and reliable. Cutting-edge technologies have been less successful in schools due to the instability of the technologies and the large amount of resources required to support them. The models assume the use of mature technology and transmission media. Therefore, this thesis excludes new technologies such as wireless and coax-fiber hybrid systems. However, given the rapidity of technological change and marketplace evolution for networking products and services, there is a need for research and evaluation of wireless and cable alternatives in schools.

2.2.2 Cost Areas

The cost models presented in this paper include four types of costs – hardware, training, support, and retrofitting. The items included in these categories are:

- Hardware – Hardware includes wiring, router, server, PCs, including installation, maintenance, and service of the hardware and telecommunications lines.
- Training – Training includes instruction of teachers and other school staff on use of the network.
- Support – Support includes technical support of the network.
- Retrofitting – Retrofitting includes modifications to the school facility to accommodate the telecommunications infrastructure. This may include costs for asbestos removal, electrical systems, climate control systems, added security (e.g., locks, alarms, and surveillance equipment,) and renovation of buildings to accommodate network installation and operation.

The following cost area is outside the scope of the models:

- Educational software – This thesis does not include the costs for educational software and applications. It assumes that schools use free educational versions of Internetworking software, such as web browsers and email applications, that schools can download over the network. Schools may desire to purchase commercial educational software programs. The costs for this software may be high, but are not included in the models. Further economic analysis of software costs and their evolution in the network scenarios analyzed below is necessary.

2.2.3 School Characteristics

The models describe the costs for a typical school and school district, as derived from U. S. Department of Education (1994), and represent the average costs of all U.S. schools and school districts. Many schools will differ in significant ways from the typical school, and will therefore face somewhat different costs than those presented in the models.

The average school has about five hundred students and twenty classrooms. It employs 27 teachers and 25 other school staff. The average number of schools in a school district is about six.[12]

In 1992 there were, on average, 23 computers in each elementary and secondary school, and 47 computers in each upper secondary school.[13] About 15% of these machines, or 3-7 machines per school, are capable of running the network protocol (TCP/IP) to access the Internet. During the three years from 1989 until 1992, the number of computers in schools grew by 50%. Using a 50% growth rate since 1992, there are, on average, approximately seven networkable PCs in every school. Seven PCs is sufficient for the first two models, but is not sufficient for establishing multiple connections in every classroom throughout the school. Therefore, from model three upwards, there is a line-item cost for purchasing additional PCs.

National Center for Education Statistics, U. S. Department of Education (1995), provides a profile of networking in schools across the country, as illustrated in Figure 2. One-quarter of schools has neither a LAN nor a connection to a WAN. Twenty-six percent of schools have a local area network but no connection outside the school. Thirty-five percent of schools have an Internet connection along with the school LAN. The remaining 14% of schools use their LAN to

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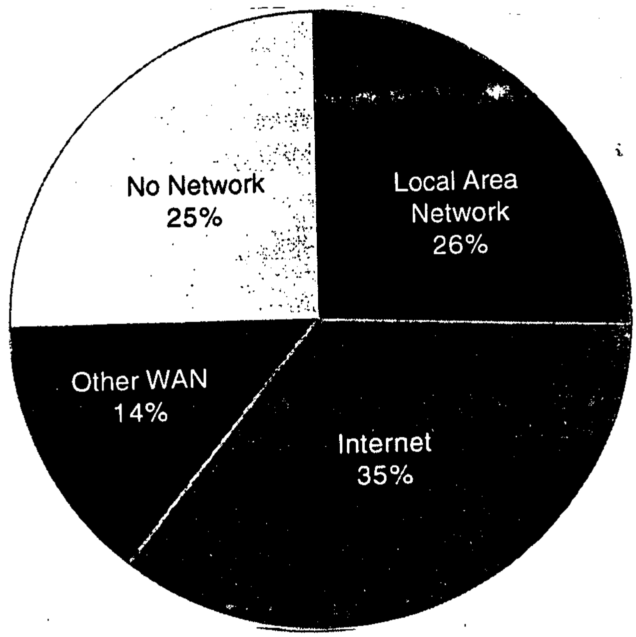
12 The projections assume a national enrollment of approximately 44 million students in 85,000 public schools within 15,000 school districts.
13 Anderson (1993), p. 14.

connect to another WAN, usually a commercial on-line service such as America Online and Compuserve.

Figure 2. Network Access of U.S. Public Schools



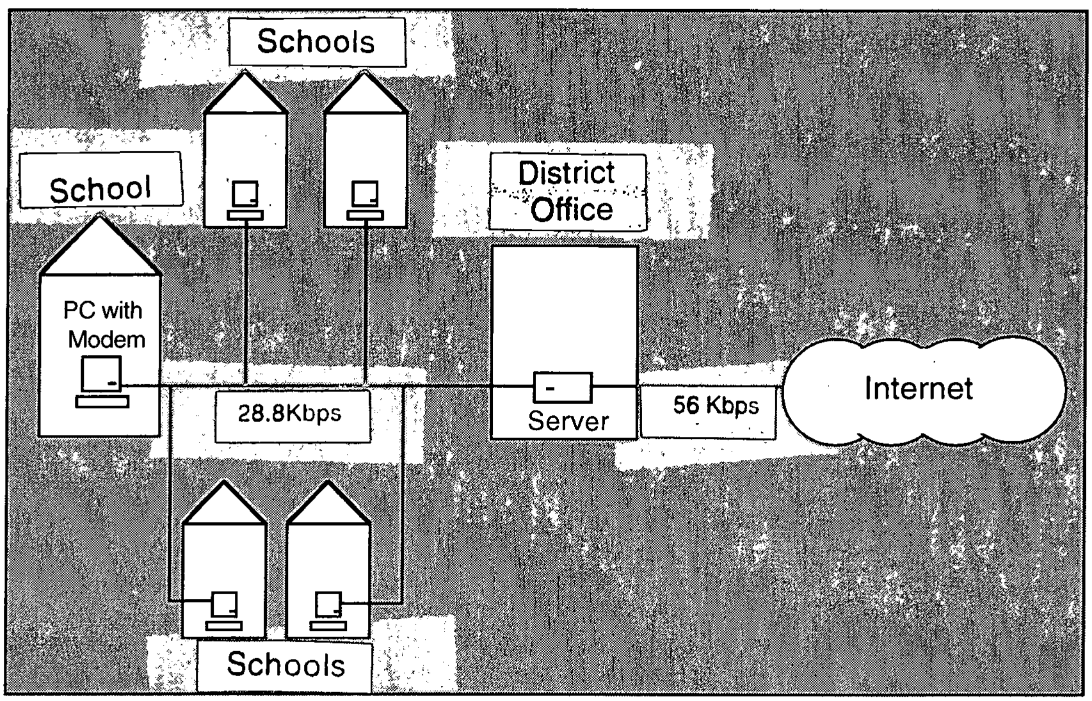
Source: National Center for Education Statistics, U. S. Department of Education (1995)

2.2.4 Cost Models

MODEL 1: SINGLE PC DIALUP

Model one, illustrated in Figure 3, represents the most basic connectivity option for a school. The school has no internal LAN within the building. There is a single connection to the district office over a modem and standard phone line. The district office connects to the Internet through a 56Kbps line from its server.

Figure 3. Single PC Dialup Model



SOURCE: Rothstein (1994)

This model is a low-cost option for schools. Many of the services and benefits envisioned for the NII will not be widely accessible in schools using this model. Given the limited functionality of the system, only a few teachers in the school require training.

Table 1 lists the cost items associated with this model.

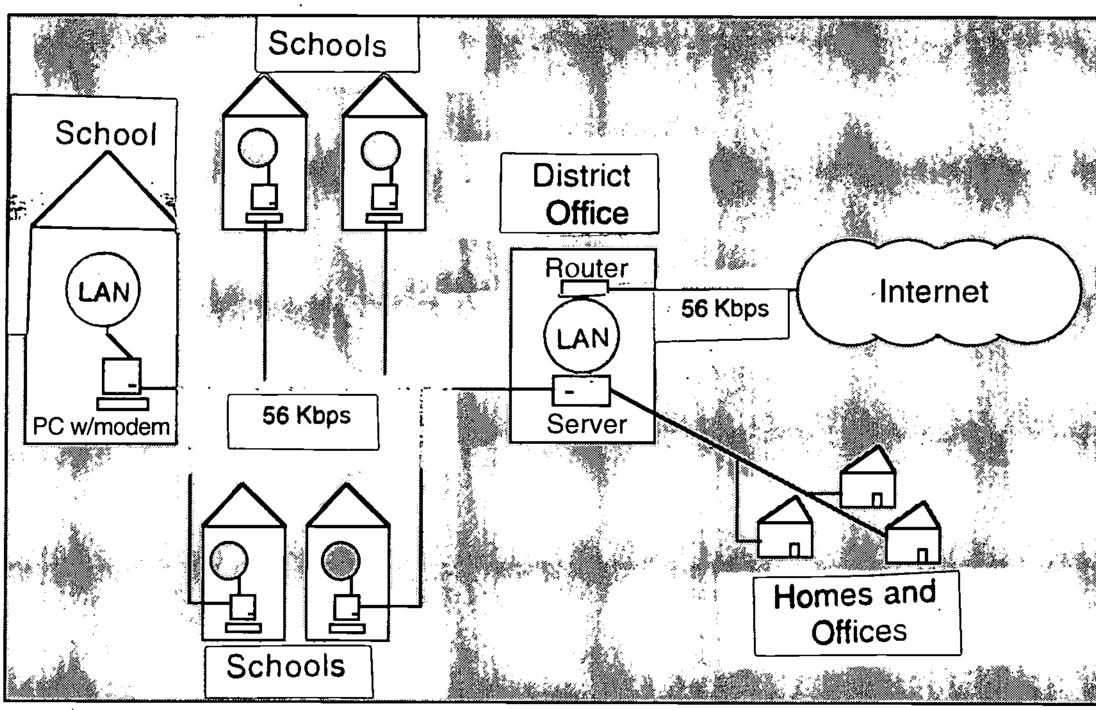
Table 1. PC Dialup Model Costs

		Low	High
SCHOOL COSTS			
One-time Installation Costs			
Telephone Line		$100	$250
Modem		$100	$250
	Total:	**$200**	**$500**
Annual Operating Costs			
Replacement of equipment		$50	$150
Telephone line (10 hrs/month)		$150	$1,000
	Total:	**$200**	**$1,150**
DISTRICT OFFICE COSTS			
One-time Installation Costs			
File Server		$2,000	$10,000
Data line to WAN/Internet (56Kb)		$500	$2,000
Training (2-4 teachers per school)		$1,000	$10,000
	Total:	**$3,500**	**$22,000**
Annual Operating Costs			
Internet service (56Kbps)		$3,000	$10,000
Support		$2,000	$10,000
Training		$1,000	$5,000
	Total:	**$6,000**	**$25,000**
TOTAL U.S. ONE-TIME COSTS		**$0.07 B**	**$0.37 B**
One-Time Costs Per Student		**$1.58**	**$8.47**
TOTAL U.S. ANNUAL COSTS		**$0.11 B**	**$0.43B**
Annual Costs Per Student		**$2.43**	**$9.78**

MODEL 2: LAN WITH SHARED MODEM

In model two, as illustrated in Figure 4, there exists a LAN within each school. By connecting the modem to the LAN, every computer on the network has access to the Internet. However, this model supports only a few users at a time, limited by the number of phone lines going out of the school. The model includes modems and phone lines, so that faculty, students, and parents can gain access to the school system remotely on weekends and after school hours.

Figure 4. LAN with Shared Modem Model



SOURCE: Rothstein (1994)

The cost for installation of the LAN in each school is significant. This model assumes the use of copper wire (category 5) as the medium for the network since it is presently the most affordable and scalable option for schools. The model requires a $100 - $150 cost for the wiring and network cards for every networked computer. Including the costs for the accompanying hardware and labor, the costs per PC are $400 - $500. Therefore, for the school model with 60

- 100 connected PCs (3-5 PCs per classroom @ 20 classrooms), the total LAN costs are $20,000 - $55,000.

Model two also is a relatively low-cost option for schools. However, many of the services and benefits envisioned for the NII are still not widely accessible in this model. Table 2 lists the cost items associated with this model:

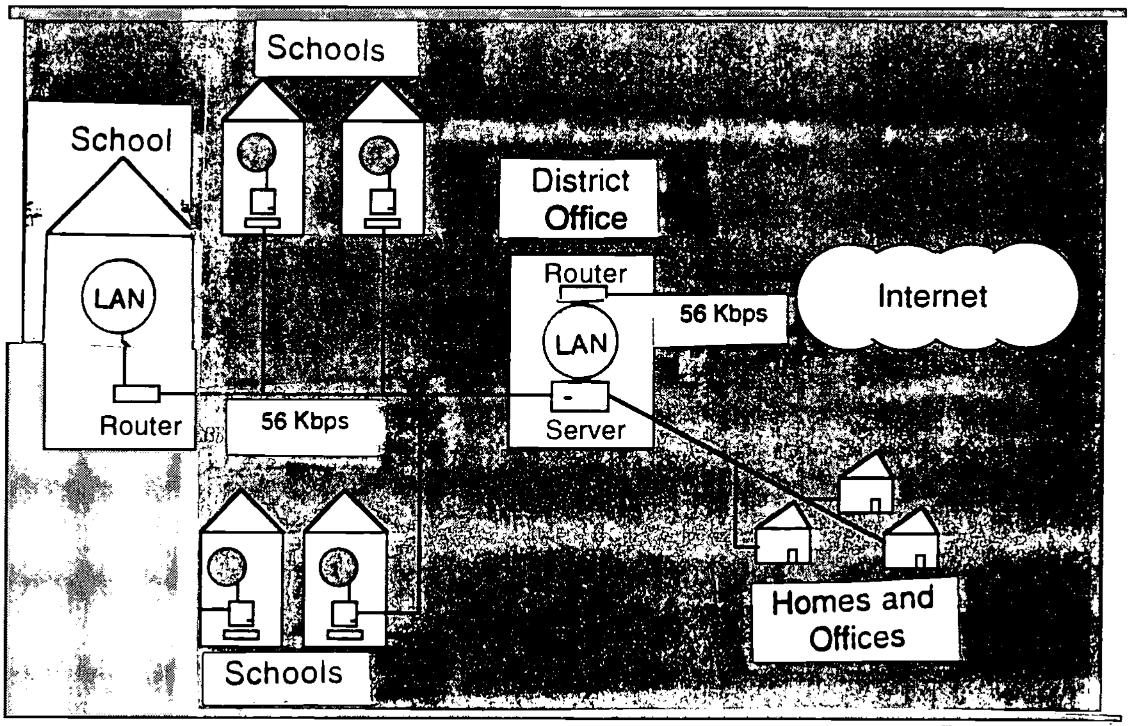
Table 2. LAN with Shared Modem Model Costs

	Low	High
SCHOOL COSTS		
One-time Installation Costs		
Local Area Network	$20,000	$55,000
LAN Modem	$300	$1,000
Retrofitting (minor)	$2,000	$10,000
Total:	**$22,300**	**$66,000**
Annual Operating Costs		
Replacement of equipment	$3,000	$8,250
Shared telephone line (40 hrs / month)	$600	$2,000
Total:	**$3,600**	**$10,250**
DISTRICT OFFICE COSTS		
One-time Installation Costs		
File Server	$2,000	$10,000
District Local Area Network	$2,000	$5,000
Data line to WAN/Internet (56Kb)	$500	$2,000
Dialup Capabilities (2 lines)	$2,000	$4,000
Training (train 5-20 staff per school)	$1,000	$10,000
Total:	**$7,500**	**$31,000**
Annual Operating Costs		
Internet service (56Kbps)	$3,000	$10,000
Dialup Lines	$300	$500
Support (1-2 staff per district)	$45,000	$90,000
Training	$10,000	$20,000
Total:	**$58,300**	**$120,500**
TOTAL U.S. ONE-TIME COSTS	**$2.01 B**	**$6.08 B**
One-Time Costs Per Student	**$45.64**	**$138.07**
TOTAL U.S. ANNUAL COSTS	**$1.18 B**	**$2.68 B**
Annual Costs Per Student	**$26.83**	**$60.88**

MODEL 3: LAN WITH ROUTER

In this model, as illustrated in Figure 5, each school uses a router instead of a modem to connect to the district office hub. With the router, multiple LAN users within the school may access the Internet concurrently.

Figure 5. LAN with Router Model



SOURCE: Rothstein (1994)

Since the router allows multiple users of the system, there is an opportunity to expand the entire network infrastructure. With this infrastructure, it is reasonable to support one PC in every classroom. Therefore, there is a requirement to purchase 15 additional PCs for the average school to use in addition to its small initial stock of TCP/IP-compatible machines. Assuming district-level purchasing, the district is able to negotiate favorable PC prices ($1,000 - $2,000 each). Support and training costs are higher since there are additional users of the system.

Additional dialup lines are required to accommodate remote access. There are also significant retrofitting costs for the electrical system, climate control system, and enhanced security.

Table 3 lists the cost items associated with this model.

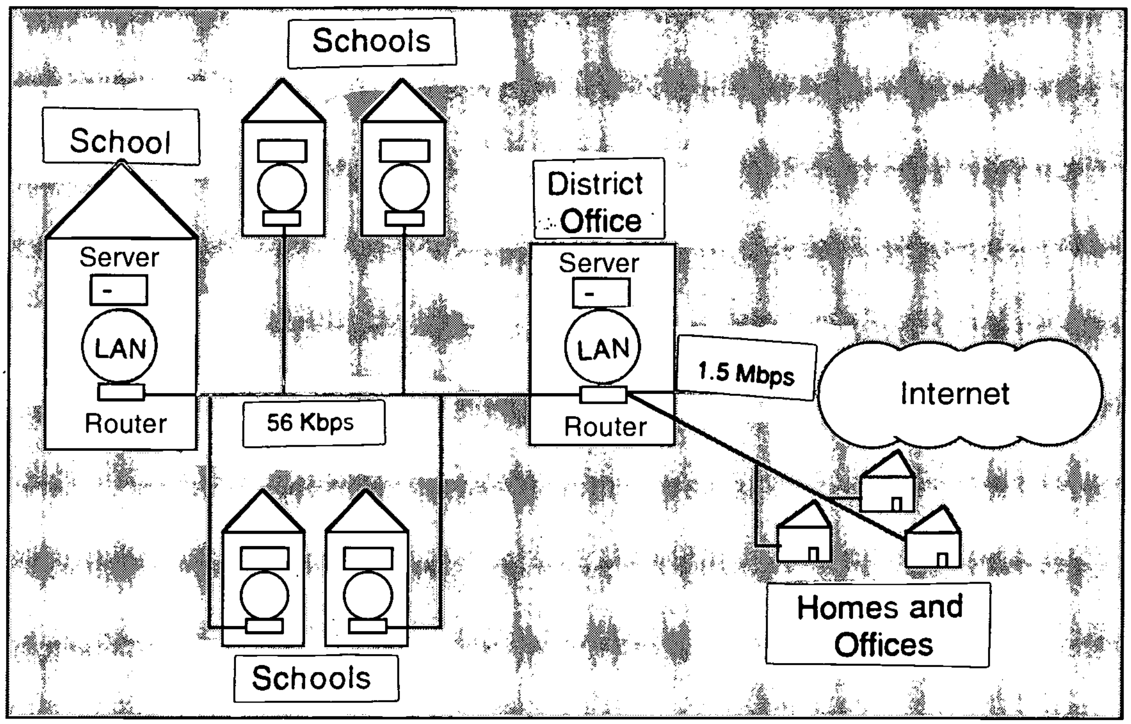
Table 3. LAN with Router Model Costs

	Low	High
SCHOOL COSTS		
One-time Installation Costs		
Local Area Network	$20,000	$55,000
Personal Computers (15 machines)	$15,000	$30,000
Router	$1,000	$3,000
Connection to Hub (14.4 Kb or 56Kb)	$50	$1,000
Retrofitting (major)	$10,000	$25,000
Total:	$47,050	$114,000
Annual Operating Costs		
Replacement of equipment	$3,000	$8,250
Connection to Hub (14.4 Kb or 56Kb)	$500	$10,000
Total:	$3,500	$18,250
DISTRICT OFFICE COSTS		
One-time Installation Costs		
File Server	$2,000	$15,000
Router	$2,000	$5,000
District Local Area Network	$1,000	$5,000
Data line to WAN/Internet (56Kb)	$500	$2,000
Dialup Capabilities (8 lines)	$8,000	$16,000
Training (10-20 staff per school)	$1,000	$10,000
Total:	$15,500	$53,000
Annual Operating Costs		
Internet service (56Kbps)	$5,000	$10,000
Dialup Lines	$1,200	$2,000
Support (1-2 staff per district)	$45,000	$90,000
Training	$10,000	$20,000
Total:	$61,200	$122,000
TOTAL U.S. ONE-TIME COSTS	$4.13 B	$10.49 B
One-Time Costs Per Student	$93.90	$238.30
TOTAL U.S. ANNUAL COSTS	$1.22 B	$3.38 B
Annual Costs Per Student	$27.63	$76.85

MODEL 4: LAN WITH LOCAL SERVER AND DEDICATED LINE

In this model, as illustrated in Figure 6, a local file server in every school gives schools the ability to store information locally without accessing the district network. There is a higher bandwidth connection from the district office to the Internet (1.5 Mbps) to allow greater Internet access.

Figure 6. LAN with Local Server and Dedicated Line Model



SOURCE: Rothstein (1994)

In this model, the network can effectively serve the entire school. As a result, the model requires an extensive training program and a well-staffed support team. The cost of the connection to the Internet is also higher due to the larger bandwidth connection. There are significant retrofitting costs for the electrical system, climate control system, and enhanced security.

Table 4 lists the cost items associated with this model.

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Table 4. LAN with Local Server and Dedicated Line Model Costs

	Low	High
SCHOOL COSTS		
One-time Installation Costs		
Local Area Network	$20,000	$55,000
Personal Computers (60 machines)	$60,000	$120,000
File Server	$2,500	$15,000
Connection to Hub/District Office (56Kb)	$500	$2,000
Router and CSU/DSU	$2,600	$5,000
Retrofitting (major)	$10,000	$25,000
Total:	$95,600	$222,000
Annual Operating Costs		
Replacement of equipment	$3,000	$8,250
Connection to Hub/District Office (56Kb)	$1,000	$5,000
Total:	$4,000	$13,250
DISTRICT OFFICE COSTS		
One-time Installation Costs		
File Server	$2,000	$15,000
Router	$1,000	$5,000
District Local Area Network	$1,000	$5,000
Data line to WAN/Internet (1.5 Mbps)	$1,000	$5,000
Dialup Capabilities (20 lines)	$16,000	$32,000
Training (40-50 staff per school)	$50,000	$150,000
Total:	$71,000	$212,000
Annual Operating Costs		
Internet service (1.5 Mbps)	$10,000	$42,000
Dialup Lines	$2,000	$5,000
Support (2-3 staff per district)	$66,000	$150,000
Training	$15,000	$35,000
Total:	$93,000	$232,000
TOTAL U.S. ONE-TIME COSTS	$9.19 B	$22.05 B
One-Time Costs Per Student	$208.89	$501.14
TOTAL U.S. ANNUAL COSTS	$1.74 B	$4.61 B
Annual Costs Per Student	$39.43	$104.69

Using this model as a baseline for connecting to the NII, these figures are indicative of the costs of connecting K-12 schools across the country to the NII.[14] These estimates indicate that there

[14] As described in Information Infrastructure Task Force (1994), the NII:

> promises every...school...in the nation access anywhere to voice, data, full-motion video, and multimedia applications. Through the NII, students of all ages will use multimedia electronic libraries and museums containing text, images, video, music, simulations, and instructional software.

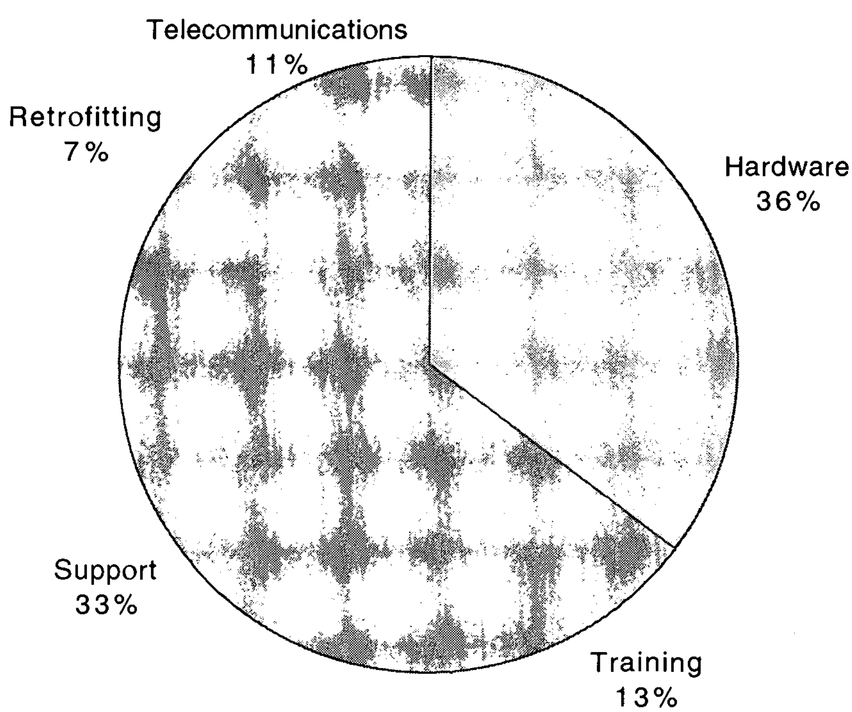
In models four and five, the school has access to these NII services.

will be $9.2B - $22.1B in one-time costs with annual maintenance costs of $1.7B - $4.6B. At the per pupil level, this is equivalent to $209 - $501 in one-time installation costs and an ongoing annual cost of $39 - $105.

In this model, hardware is the most significant cost item for schools. The cost for PC purchases represents more than half of the one-time installation costs. However, the value of the PCs goes well beyond their use as networking devices. Therefore, the costs for PC purchases should be allocated across other parts of the technology budget, and not only to the networking component. By allocating the PC costs to other budget items, the hardware costs for network connectivity drop considerably.

Figure 7 illustrates the average of low and high cost estimates, excluding PC purchases over the first five years of deployment.

Figure 7. Breakdown of Costs for Model Four



SOURCE: Rothstein and McKnight (1995)

These projections assume amortization of the initial startup costs over five years using the straight-line method. Costs for support of the network represent about one-third of all networking. Support is a vital part of the successful implementation of a school network. Therefore, it is important that schools and districts allocate sufficient budget amounts for support. Support and training together comprise 46% of the total costs of networking schools. Costs for telecommunications lines and services represent only 11% of the total costs. This amount is lower than the costs assumed by much of the technology community, including the telecommunications service and equipment providers.

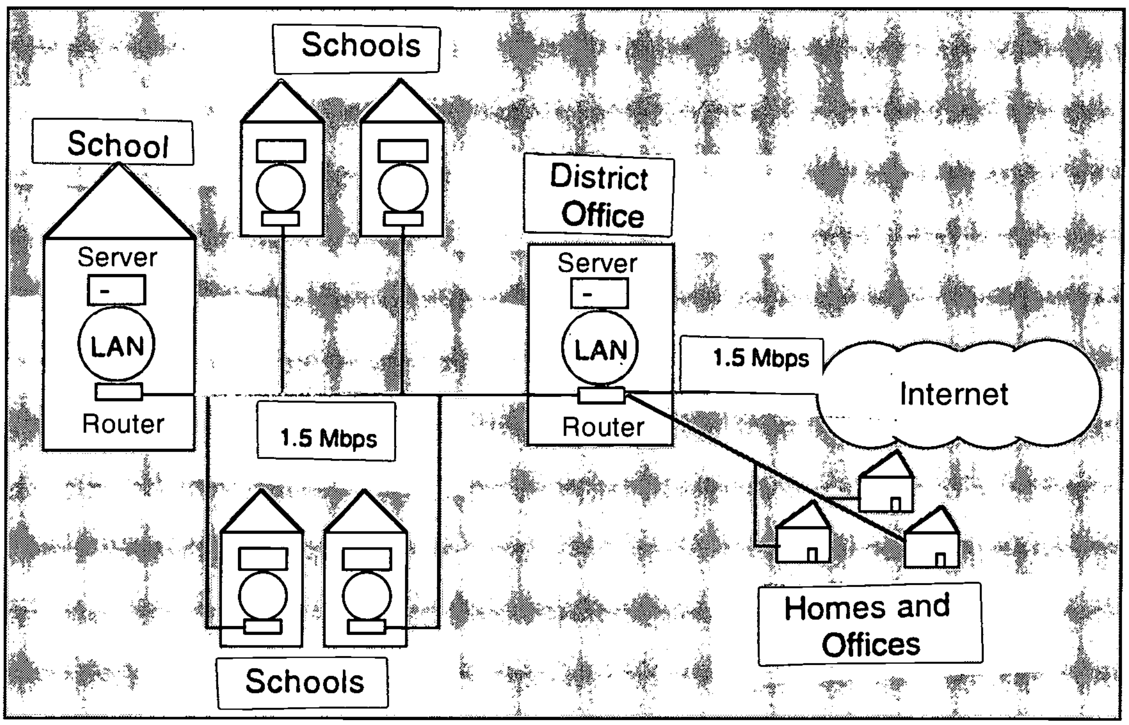
Schools today are not allocating their technology budgets effectively for this cost structure. Overall, districts spend less than fifteen percent of their technology budgets on training, but they spend fifty-five percent of the budget on hardware and thirty percent on software. Furthermore, only six percent of elementary and three percent of secondary schools have a full-time, school-level computer coordinator for technical support.[15]

[15] U.S. Congress, Office of Technology Assessment (1995), p. 19.

MODEL 5: UBIQUITOUS LAN W/LOCAL SERVER AND HIGH-SPEED LINE

Model five, as illustrated in Figure 8, represents a full, ubiquitous connection to the NII. In this model, there is a PC on the desktop of every student and teacher. A high-bandwidth connection to the school supports large numbers of concurrent users of the system.

Figure 8. Ubiquitous LAN with Local Server and High-Speed Line Model



SOURCE: Rothstein (1994)

In this model, the network can effectively connect every desk in every classroom. A majority of the expenditures for this model are made to put PCs on every desktop. Since there are five hundred students in an average school, every school requires approximately 450 new PCs. Since the network is ubiquitous, the model requires an extensive training program and a well-staffed support team. The cost of the connection to the Internet is also higher due to the high-speed line going into the school. The file server is larger to accommodate the large number of networked PCs. The dialup system is larger to allow many students, teachers, and parents to access the system remotely. The retrofitting costs are substantial since the typical school requires extensive electrical work to accommodate the hundreds of new PCs that consume voltage and produce heat. In addition, the model school makes expenditures on air conditioners and security locks to protect the new equipment.

Table 5. Ubiquitous LAN with Local Server and High-Speed Line Model Costs

	Low	High
SCHOOL COSTS		
One-time Installation Costs		
Local Area Network	$40,000	$100,000
File Server	$2,000	$15,000
Connection to Hub/District Office (1.5 Mbps)	$1,200	$5,000
Router and CSU/DSU	$25000	$7,000
PC on every desk (450 new machines)	$450,000	$900,000
Retrofitting (major including electrical)	$70,000	$250,000
Total:	$565,700	$1,277,000
Annual Operating Costs		
Replacement of equipment	$6,000	$15,000
Connection to Hub/District Office (1.5 Mbps)	$8,000	$35,000
Total:	$14,000	$50,000
DISTRICT OFFICE COSTS		
One-time Installation Costs		
File Server	$2,000	$15,000
Router	$2,000	$5,000
District Local Area Network	$2,000	$5,000
Data line to WAN/Internet (1.5 Mbps)	$1,000	$5,000
Dialup Capabilities (50 lines)	$16,000	$80,000
Training (all teachers in school)	$55,000	$165,000
Total:	$78,000	$275,000
Annual Operating Costs		
Internet service (1.5 Mbps)	$10,000	$42,000
Dialup Lines	$20,000	$50,000
Support (4-5 staff per district)	$112,200	$255,000
Training	$16,500	$38,500
Total:	$158,700	$385,500
TOTAL U.S. ONE-TIME COSTS	$49.25 B	$112.67 B
One-Time Costs Per Student	$1,119.42	$2,560.68
TOTAL U.S. ANNUAL COSTS	$3.57 B	$10.03 B
Annual Costs Per Student	$81.15	$228.01

2.2.5 Cost Comparison of Models

Total U.S. expenditures on K-12 education in 1992-93 totaled $280 billion. Total one-time costs for the fourth model represent 3% - 7% of total national educational expenditures. The ongoing annual costs represent 0.6% - 1.6% of total national educational expenditures. For the fifth model, the costs are more significant, with one-time costs representing 18% - 41% of total national educational expenditures.

The models of advanced connectivity include significant equipment and training costs, which may be beneficial for other educational purposes in addition to networking. Looking beyond these cost items, the difference in costs between the fourth and fifth models is less significant. Table 6 summarizes the associated range of costs for the various technology models.

Table 6. Total One-Time and Ongoing Costs for Associated Models

			One-time	Ongoing
	Low	**High**	**Low**	**High**
Single PC Dialup	$0.07 B	$0.37 B	$0.11 B	$0.43 B
LAN w/Shared Modem	$2.01 B	$6.08 B	$1.18 B	$2.68 B
LAN w/ Router	$4.13 B	$10.49 B	$1.22 B	$3.38 B
LAN w/Local Server & Dedicated Line	$9.19 B	$22.05 B	$1.74 B	$4.61 B
Ubiquitous LAN w/Hi-speed Connection	$49.25 B	$112.67 B	$3.57 B	$10.03 B

2.3 POTENTIAL IMPACT OF COST REDUCTION INITIATIVES

Much more can be done by the government and the private sector to significantly mitigate the costs that schools face in developing network connectivity. This section will examine some possible programs and their impact on the costs to schools.

The baseline for NII access is model four with a LAN, local server, and dedicated line to the district hub. Table 7 provides a summary of the costs for this model.

Table 7. Total U.S. Costs (in $ Millions) for Model Four Level Connectivity

	One-time Costs		Ongoing Costs	
Component	**Low**	**High**	**Low**	**High**
Local Area Network	$1,715	$4,750	$0	$0
Personal Computers	$5,100	$10,200	$0	$0
File Server	$243	$1,500	$0	$0
Telecommunications Lines	$298	$725	$115	$500
Router and CSU/DSU	$221	$425	$0	$0
Retrofitting	$850	$2,125	$0	$0
Training	$750	$2,250	$225	$525
Internet Service	$0	$0	$150	$630
Support	$0	$0	$990	$2,250
Replacement of Equipment	$0	$0	$255	$701
Total:	**$9,176**	**$21,975**	**$1,735**	**$4,606**

Using these costs, it is apparent that various cost-saving programs will have different effects on the bottom line for schools. This section describes nine possible programs and their cost saving effects on schools. Table 8 summarizes the potential savings for each of the programs.

Table 8. Total Savings (in $ Millions) for Potential Cost Savings Programs

Type of Plan	One-time costs Low	One-time costs High	Ongoing costs Low	Ongoing costs High
Reduced Telecom Rates (30%)	$89	$218	$39	$150
Reduced Telecom Rates (60%)	$179	$435	$69	$300
Purchasing by States (30% discount)	$1,849	$4,136	$45	$189
Support from Universities	$0	$0	$792	$1,800
Train teachers on own time	$0	$1,500	$0	$300
Free labor for installing network	$1,115	$3,088	$0	$0
Donation of PCs	$5,100	$10,200	$0	$0
Donation of Routers and CSU/DSU's	$221	$425	$0	$0
Donation of Servers	$243	$1,500	$0	$0
Free Internet Connectivity	$0	$0	$150	$630

1. Preferential telecommunications tariff rates are instituted for schools.

Some state utility commissions have instituted preferential telecommunications rates for educational institutions. These rates are applicable for intrastate traffic only. For inter-state traffic, the tariffs set by the FCC are in effect. The federal Telecommunications Act of 1996 mandates unspecified preferable telecommunications rates for schools. The bill has commissioned the FCC to set the discount rate. This rate will affect the amount of money that schools will save. The following projections assume discounts of 30% and 60% respectively.

Estimated savings: **$89M - $218M (One-Time)**
(30% reduction) **$35M - $150M (Annual)**

Estimated savings: **$179M - $435M (One-Time)**
(60% reduction) **$69M - $300M (Annual)**

2. All technology purchasing is done at the state level.

State-level technology purchasing, through the state department of education or other office, provides schools with better prices due to volume discounts. North Carolina is a good example of a state that has been successful in this program. Their schools have enjoyed discounts of 20% - 50% for hardware and labor costs. The following figures assume an average of 30% discount across all fifty States.

Estimated savings: **$1.8B - $4.1B (One-Time)**

$45M - $189M (Annual)

3. Universities or other institutions provide technical support to schools.

Universities can also play a role in providing technical support to K-12 schools. Many universities have already undertaken such projects, and have provided network support to a number of K-12 schools in their areas. With this program, schools will reduce their in-house support staff budget by 80%.

Estimated savings: **$792M - $1.8B (One-Time)**

4. Teachers trained on their own time.

In the model, the training costs include costs for substitute teachers (to cover for teachers in training), and for supplemental teacher salaries (for their time in training outside school hours). If teachers were to agree to attend classes on their own time, there would be costs only for the trainer.

Estimated savings: **$0 - $1.5B (One-Time)**

$0 - $300M (Annual)

5. LAN installed by volunteers.

In the model, labor constitutes 65% of the costs for installing the LAN. If schools can do this work with volunteers, then the cost savings are significant. For example, Val Verde

Unified School District in California laid its wires with volunteers including parents and community members. If these groups offer to provide labor at no cost to schools, schools will reap significant savings.

Estimated savings: $1.1B - $3.1B (One-Time)

6. Personal Computers are donated to schools.

In the model, there is a need to purchase a significant number of PCs to provide 4-5 connections to the network in every classroom. Donations of new machines from PC manufacturers can effectively offset these significant costs. It is also possible for large corporations to donate these computers to schools. However, the schools will need fairly modern machines to run networking software. The success of a donation program is dependent on the quality of the equipment donated. Donations of obsolete or incompatible equipment may be very costly to schools.

Estimated savings: $5.1B - $10.2B (One-Time)

7. Network routing equipment are donated to schools.

The savings are lower than the similar PC program since routing equipment is less expensive.

Estimated savings: $221M - $425M (One-Time)

8. Network servers are donated to schools.

This program is similar to the PC donation and router donation programs.

Estimated savings: $243M - $1.5B (One-Time)

9. Internet connectivity is made free to schools.

Free Internet connectivity provides potential cost savings to schools. Provision would come through an Internet service provider or through a local university or community college.

Estimated savings: $150M - $630M (Annual)

2.4 SUMMARY

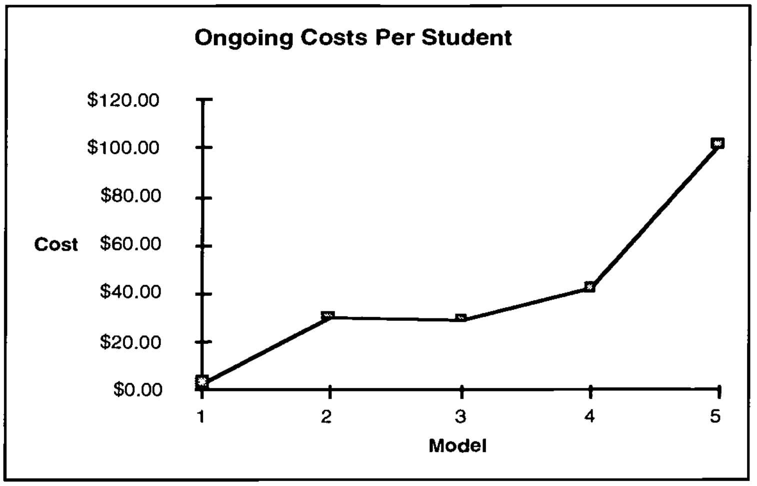
This chapter has developed a range of costs for five models of school networking. As the models increase in complexity, so do their costs and capabilities. The distribution of costs provides information about the key cost drivers for school networking.

The costs to network a school are complex. It is not simple to estimate the costs for a particular school. The costs for most schools will fall into a bounded range, but each particular school will vary greatly depending on its individual needs and characteristics. While this thesis put upper and lower bounds on the cost figures, the numbers are rough estimates at best.

The cost of the network hardware is only a small fraction of the overall networking costs. The largest one-time costs for building the network are training and retrofitting. The costs for the wiring and equipment are typically not as high. Support of the network is the largest ongoing annual cost that schools must face.

Although the five models represent a rough continuum of technological development, the transitions from model one to model two and from model four to model five are the most costly transitions, as illustrated in Figure 9. The first jump in cost arises when the school installs the LAN. At that point the school and district must pay to have the network installed and to employ full-time support staff. The second jump arises if and when the school decides to purchase computers for all students to use. Since the number of networkable PCs is inadequate for most schools, there is a significant cost to provide multiple PCs in every classroom. In addition, many schools require major electrical work, possibly exceeding $100,000, to support the increased number of PCs in the school. Between models two and three and between models three and four, as well as within each model, costs can be incremental.

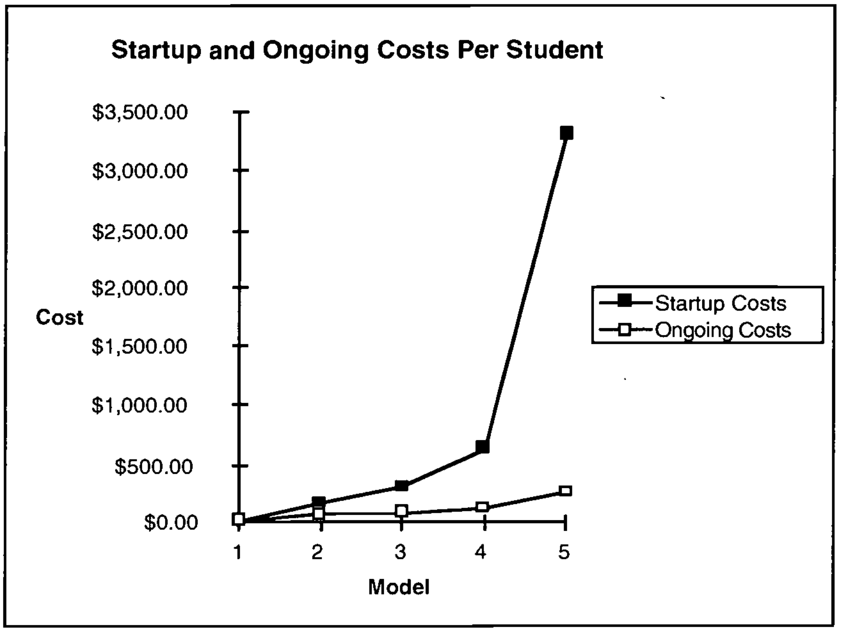
Figure 9. Ongoing Costs Per Student Per Model



SOURCE: MIT Research Program on Communications Policy, 1994

The startup cost for the network increases at a faster rate than the annual ongoing cost as the network complexity increases, as illustrated in Figure 10.

Figure 10. Startup and Ongoing Costs Per Student Per Model



SOURCE: MIT Research Program on Communications Policy, 1994

In the less complex models, the one-time startup costs are 2-3 times the annual ongoing costs of the network. However, for the more complex models (i.e., models four and five) the one-time costs are 5-15 times annual costs. The divergence indicates that the most significant hurdle that a school will face is the initial investment costs in the network and computers. Schools should be given flexibility to amortize initial costs, to spread the burden over multiple budget years.

Purchasing of technology equipment at the state and district levels can significantly reduce costs. Schools stand to save much money by pooling resources and purchasing power with other schools in the district and at the state level. When schools share a high speed data link, or support staff, the per school costs drop considerably. Schools in North Carolina and Kentucky have saved 20% - 50% by purchasing services and equipment at the state level.[16]

Further research on the costs of wireless and cable Internet access methods for schools is recommended to elucidate the costs and benefits of these approaches. In addition, the issue of software and equipment cost accounting require further analysis. It is hoped that this preliminary assessment of the costs of networking schools can provide a point of departure for analysis of these and other more detailed models of school connectivity.

[16] Phone conversations with officials at the North Carolina and Kentucky Departments of Education.

Chapter Three

Educational Networking Benefits

3.1 INTRODUCTION

The previous chapter described a series of technology models and associated costs for networking K-12 schools. For each successive model, costs increase due to increased bandwidth, equipment, training, and support. If schools were interested solely in minimizing costs, they would choose the lowest level of technology or none at all. However, schools invest in technology to take advantage of the educational, administrative, and other benefits of the technology. Since the benefits achievable through each of the five models should increase as the model increases in complexity, the purchase and implementation decisions made by a school depend on where it wants to be along the cost-benefit curve.

This chapter will briefly examine the types of networking services that schools can use for each of the five technology models developed in the previous chapter. The chapter will then describe a case study of a new networked multimedia service, Internet CNN NEWSROOM, and its use at a pilot site. The site was chosen because its advanced networking infrastructure, comparable to a model four / model five hybrid, is necessary to access multimedia services over the Internet.

3.2 EDUCATIONAL BENEFITS

A financial cost estimate in dollar terms provides a reasonably good quantitative measure of the cost for educational networking. In contrast, there are virtually no universally accepted quantitative measures of benefit in education. Education experts have argued for some time about how to measure the benefits of technology in schools.

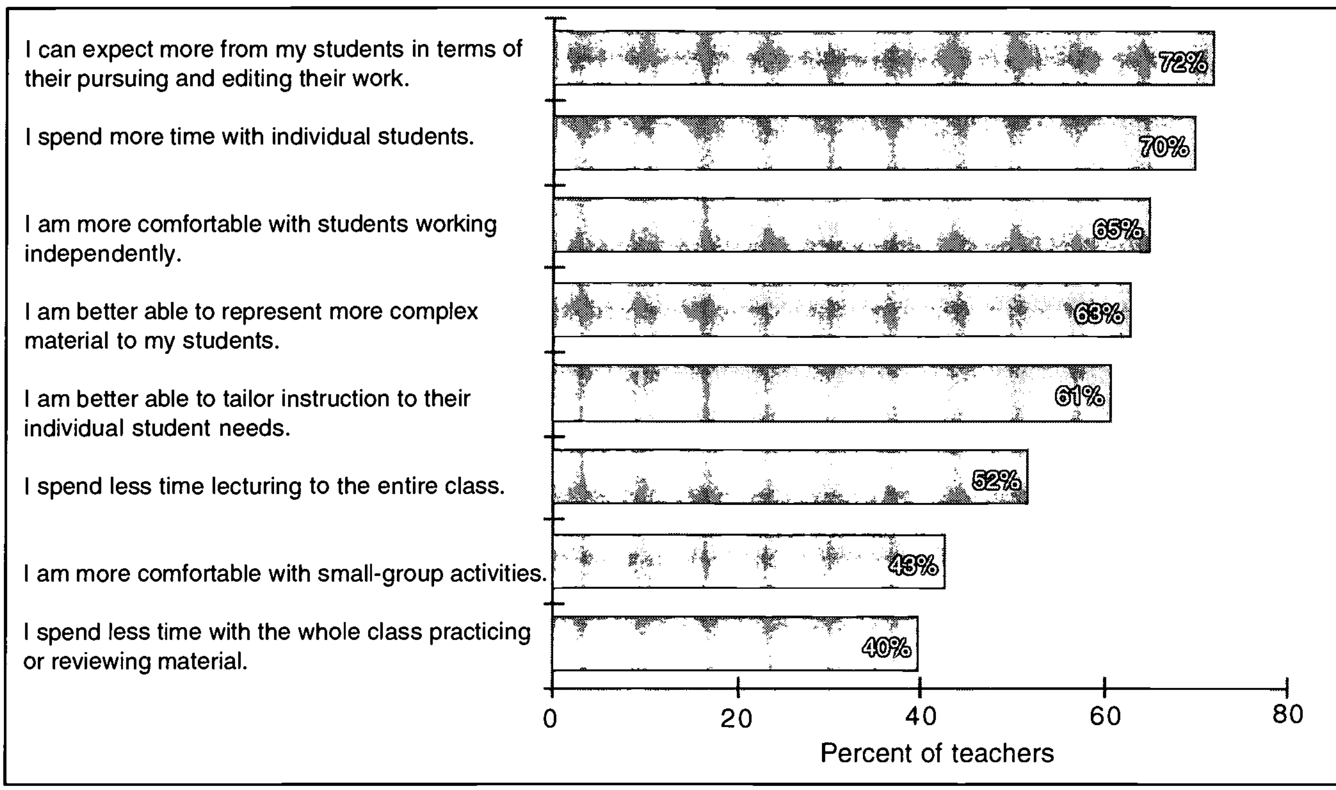
In this thesis, the benefit of a technology is viewed in terms of user acceptance of the technology. In K-12 schools, the education process occurs almost exclusively in the classroom. Inside the classroom, only the teacher and the student are in ultimate control of success or failure in the educational process. Therefore, in order for technology to have a constructive role in education, the technology must first gain acceptance from both teacher and student. User acceptance is only one way to measure technology benefits; there exists a wide body of research on the measurement of the pedagogical, instructional, and psychological benefits of technology in education.

This chapter evaluates the benefits of networking technology in schools through its use and acceptance by teachers and students. When teachers and students use technology, they implicitly assert that the technology provides them with real user benefits. It is true that use of the technology is not a sufficient indicator that it provides educational benefit, since the technology can be used for non-educational purposes. However, if the technology contains educational content and is used for educational purposes, then greater interest in and use of the technology implies that it is providing educational benefits in the classroom.

3.2.1 Benefits of Stand-Alone Computers in Education

U.S. Congress, Office of Technology Assessment (1995) describes a study where "accomplished computer-using" teachers described the advantages of computers in their classrooms. As shown in Figure 11, teachers cite student independence and greater flexibility in the classroom as the greatest benefits of computers in their classes.

Figure 11. Percentage of Accomplished Computer-Using Teachers Agreeing with the Following Statement



Source: U.S. Congress, Office of Technology Assessment (1995)

U.S. Congress, Office of Technology Assessment (1995) considered the benefits of stand-alone computing only. Since networking computers within schools is a relatively recent phenomenon, there is less research describing the benefits of networking technology in schools.

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3.2.2 Benefits of Educational Networking

A computer with a network connection, to a school LAN or to the Internet or both, has greater capabilities than a non-networked computer. The networked computer is more valuable than the particular software loaded on it, because the networked computer can be used for remote information access (to virtual libraries and educational materials) or for communication with other computer users (including other students, teachers, parents, and professionals).

Figure 12, from McKinsey (1995), describes some of the benefits that students, teachers, and other education stakeholders can gain through computer networking. Students use networks in the learning process within the classroom. Teachers use networks, for both instruction within the classroom and professional development outside of class. Administrators use networking to streamline administrative functions. Parents use networks to have greater access to the schools their children attend. Employers and the community benefit from the increased skills of school graduates in their work force. Networks also provide unique benefits for those with special educational needs or for the physically challenged. Finally, networks allow diverse communities to access and create information equally. The extent to which these stakeholders take advantage of these educational benefits depends on the amount, quality, and accessibility of technology in the classroom.

Figure 12. Computer Networking Benefits to Education Stakeholders

Students

- Promotes computer/network literacy
- Increases motivation to learn
- Increases learning/achievement
- Provides access to more resources
- Promotes communication with others

Teachers

- Enables greater individualized attention to students
- Promotes communications with other teachers, school professionals, and outside experts
- Enhances productivity

Administrators

- Increases record-keeping efficiency
- Promotes communications with other professionals and teachers

Parents

- Increases access to student information
- Promotes involvement in children's education
- Promotes life-long learning

Community / Employers

- Increase skills of work force
- Promotes community interaction

Challenged Communities / Individuals

- Levels playing field by ensuring access
- Provides opportunities to be information producers and preserve culture

Source: McKinsey (1995)

3.2.3 Review of Technology Models

For each of the models developed in the previous chapter, schools will receive a different quality of service. For the less advanced models, there will be relatively few computers per student and lower network connection speeds. As the models increase in complexity, there are more computers per student and the network connection speed increases.

Model One: Single PC Dialup – One user may use the connection at any time. Users of the system will be able to use text-based applications over the Internet. However, performance will be poor accessing graphical network applications, such as the Web.

Model Two: LAN with Shared Modem – By connecting the modem to the LAN, every computer on the network has access to the Internet. However, this model supports only a few users at a time, limited by the number of phone lines going out of the school. Just as in model one, performance is poor when accessing graphical network applications.

Model Three: LAN with Router – With the addition of a router, multiple users of the LAN may access the Internet concurrently. Performance may be better than in the first two models, but it will still be mediocre at best in accessing graphical and multimedia network applications.

Model Four: LAN with Local Server and Dedicated Line – The primary difference between this model and the former one is the existence of a file server at the school. The on-site server allows much of the information to reside locally at the school instead of at the district office. This feature provides better performance since there is less need for remote information access over the network.[17] Additionally, the local server allows school administrators to exercise greater

[17] The local server can act as a proxy/cache server used to store files that are frequently accessed over the Internet. In some schools, the local cache server has been able to service over 90% of the file requests with information in the cache. Further, the local cache can provide performance of over 1 Mbps. (Source: Presentation by Gary Warren, NASA Research Scientist, at the EPIE Institute Workshop, June 1996)

control over the information that flows in and out of the school. Higher speed links from the school enable much better performance for graphical and limited video network applications.

Model Five: Ubiquitous LAN with Local Server and High-Speed Line – In this model, there is a PC on the desktop of every student and teacher. There is a high-bandwidth connection to the school to support large numbers of concurrent users of the system. High speed links from the school enable excellent performance even for highly graphical and limited video network applications.

Table 9 provides a summary of the performance characteristics for each of the five models.

Table 9. Architecture Model Benefits

Model	Supports multiple network users?	Graphical application performance
1	No	Very poor
2	No	Very poor
3	Yes	Poor
4	Yes	Good
5	Yes	Excellent

3.3 PRODUCT BACKGROUND

Given the benefits that technology and networking can provide to schools, this thesis will examine a case study of the use of a new networked educational product in schools. Internet CNN NEWSROOM, a networked multimedia program based on the CNN NEWSROOM program, is part of the Networked Multimedia Information Services (NMIS) project at MIT.[18] It is a collaborative project between Turner Broadcasting System Inc. and MIT. A complete multimedia news program is automatically generated from CNN NEWSROOM content on a daily basis and made available on the Internet via the World Wide Web.

3.3.1 CNN NEWSROOM

CNN NEWSROOM is a thirty-minute per day commercial-free video program developed by Turner Educational Services, Inc., a division of Turner Broadcasting System Inc. The target audiences of CNN NEWSROOM are primary and secondary school classrooms as part of cable television's "Cable in the Classroom" initiative. CNN NEWSROOM's composition changes on a daily basis, but it generally consists of 8-10 segments of 2-5 minutes each. Almost 30,000 schools in the U.S. and Canada use CNN NEWSROOM.

Many teachers find CNN NEWSROOM to be of great value in their classrooms. Teachers report that students tend to show more interest in geography and in other cultures as they learn about different parts of the world via CNN NEWSROOM. Students state that they are more active in following and discussing news events. Students like the video format and the relevant and timely content of CNN NEWSROOM.[19]

[18] As described in Center for Advanced Engineering Studies (1994), "the Networked Multimedia Information Services (NMIS) is a project at MIT that conducts research on vital NII technologies. Deliverables include new software, innovative applications and services, architectural analyses of NII/Multimedia technologies, and policy recommendations." Internet CNN NEWSROOM is one of the major deliverables of the NMIS project.

[19] Burkart, Rockman and Ittleson (1991).

3.3.2 Internet CNN NEWSROOM

Internet CNN NEWSROOM is an Internet-based educational service derived from CNN NEWSROOM. As described in Compton (1995), a server at MIT generates Internet CNN NEWSROOM automatically on a daily basis from the CNN NEWSROOM broadcast. At the Center for Advanced Educational Services at MIT, a VCR automatically records the early-morning CNN NEWSROOM broadcast over the CNN cable TV channel. Then, an automated script performs two tasks – first, it translates the analog video stream into an MPEG digital file and, second, it extracts the closed caption text embedded in the video signal into a separate digital text file. A script divides the video and text files into multiple segments using the time code report received from Turner Broadcasting. Finally, the script creates a new Web page that contains links to each of the day's digital video segment files and its accompanying closed caption texts. The uniform resource locator (URL) for Internet CNN NEWSROOM is http://nmis.nmis.org/NewsInteractive/CNN/Newsroom/contents.html. Appendix One displays a typical day's Internet CNN NEWSROOM home page.

Since Internet CNN NEWSROOM is a prototype, it is not surprising that it contains a number of product design and implementation imperfections. Occasionally, the software malfunctions and the Web page must be created manually. Often the end of the video segments in Internet CNN NEWSROOM is cut off and appears at the start of the subsequent video file. This misalignment occurs because the time code file does not always exactly match the true time sequence of the CNN NEWSROOM broadcast. Layout of the Web site is not straightforward and navigation through the site can be confusing. Also, the Web site does not include any user feedback capabilities. Finally, this Internet CNN NEWSROOM prototype includes only a rudimentary search tool that does not permit complex searching.

3.4 EXPERIMENTAL PROTOCOL

3.4.1 Study and Control Groups

The pilot study group for Internet CNN NEWSROOM included two social studies classes in Lexington High School. These classes were chosen for three reasons:

- The Lexington school district has a 10 Mbps connection to the Internet through the district cable television backbone. A high-speed connection is necessary to receive a tolerable level of quality in the streaming MPEG video files of Internet CNN NEWSROOM.
- Lexington's proximity to MIT facilitated frequent study and communication with the school.
- The teacher at Lexington High School had formerly used CNN NEWSROOM as part of her regular instruction. She expressed interest in the greater use of technology in her classroom and desired to use Internet CNN NEWSROOM on a regular basis.

The Lexington study group (LEXSTUDY) consisted of a pair of tenth grade social studies classes called "Global Studies." In the classes, students learned about global civilizations and current events. The classes were not part of the school's honors track, but the class included six honors students. The teacher of these classes used Internet CNN NEWSROOM on a regular basis (2-3 times per week) throughout the study period.

There were two control groups used in the study. The first control group (LEXCONTROL), a third tenth grade Global Studies class in Lexington High School, has a curriculum similar to that of LEXSTUDY. There were approximately twenty-five students in the class. The teacher of this class used neither Internet CNN NEWSROOM nor CNN NEWSROOM in her instruction.

The second control group (BELCONTROL) was a pair of ninth grade social studies classes, called "American Studies," in Belmont High School in Belmont, Massachusetts. The teacher of these classes focused on American history interlaced with brief discussions of current events.

The teacher of these classes used neither Internet CNN NEWSROOM nor CNN NEWSROOM in his instruction. While Belmont High School has above-average resources and technology infrastructure, it has fewer resources than technology-rich Lexington High School.

3.4.2 Evaluation Methodology

Four independent focus groups of 4-5 students each from the LEXSTUDY class were conducted in January 1996 to generate verbal feedback on the use of Internet CNN NEWSROOM. The students were given the option of not participating in the focus groups and of remaining anonymous if they did participate. In the focus groups, students described their impressions of Internet CNN NEWSROOM, computing, and the Internet. The focus group protocol used in this study is described in Appendix Two.

An identical survey was distributed to the study and control group classes three times during the school year. Appendix Three contains a copy of the survey used in this study. The survey contained two parts. The first part, containing sixteen multiple choice questions and one open-ended question, probed student interest in and attitudes towards school, current events, computers, and networking. The second part, containing three multiple choice questions and two open-ended questions, elicited direct response about student usage and impressions of Internet CNN NEWSROOM. Only the LEXSTUDY group received part two since it was the only group to use Internet CNN NEWSROOM. The first survey round administered to the LEXSTUDY group did not include part two because the class had not yet used the service in class.

The surveys were administered in September 1995, January 1996, and April 1996. Table 10 lists the response rate for each of the three survey rounds.

Table 10. Survey Response Rate

	September 1995	January 1996	April 1996
LEXSTUDY	31	24	26
LEXCONTROL	24	16	17
BELCONTROL	44	40	32

The teachers for each class compiled a list of random ID numbers for each of their students (e.g., LEXA01 through LEXA20). The random ID numbers facilitated tracking of students on an individual basis. This system preserved student privacy because only the teachers used the name list, and the teacher did not have access to the survey data. When the students received the survey to complete, their assigned random ID appeared at the top of the survey. However, only the teacher possessed the table that linked the ID numbers to the names of the students. All students signed a compliance agreement to participate in the survey.

3.4.3 Demographic Factors

The towns in which this study was conducted – Lexington, Massachusetts and Belmont, Massachusetts – are similar in demographic and socioeconomic composition, but are significantly more affluent than the typical U.S. town. The per capita incomes of Lexington and Belmont in 1990 were $30,718 and $26,793 respectively, compared to $18,666 for all towns in the U.S. The ethnic profiles of Lexington (92% white, 6% Asian) and of Belmont (96% white, 3% Asian) are more homogenous than that of the U.S. (74% white, 12% black, 10% Hispanic, 3% Asian).[20,21] Lexington and Belmont schools also had greater per pupil expenditures ($6,498 and $5,856 respectively) than the average in Massachusetts ($5,235) and the U.S. ($4,407).[22,23]

[20] *Massachusetts Municipal Profiles* (1995).
[21] U.S. Department of Commerce Census Bureau (1996).
[22] Massachusetts Department of Education (1996).
[23] U. S. Department of Education (1994).

The students at the public high schools in Lexington and Belmont constitute a relatively unbiased sample of children in the towns, since only a small percentage of students attend private schools (7% in Lexington and 10% in Belmont). Therefore, the students in the study are generally representative of the towns in which they live.

3.5 PRODUCT EVALUATION FINDINGS

This section describes the findings based on the surveys, student focus groups, and teacher interviews conducted during the study. Students and the teacher were generally happy with Internet CNN NEWSROOM. The Internet product provided a number of benefits over the broadcast version. However, the initial excitement about the product in the first few months of using Internet CNN NEWSROOM greatly subsided during the latter half of the study. See Appendix Four for a compilation of all responses to the survey.

3.5.1 User Feedback

Overall, students in the LEXSTUDY group had a positive experience with Internet CNN NEWSROOM in the classroom. By the end of the study, seventy-one percent of the students expressed a desire to use it more often or just as often as is currently used in class.

The teacher said that students have more enthusiasm for Internet CNN NEWSROOM than for other class projects or materials:

> The students are asking to use it more during regular class and to be able to use it on their own...I wouldn't change a thing. I wish I could use it more.
>
> I have found that these students come in during their study halls. They can get passes to come from their study halls to use Internet CNN NEWSROOM and to look in the archive and daily news. So that if I don't have the time in the classroom – the daily periods that the students come in themselves and have access to this. And that impresses me. That they're willing to come in on their own time, be it during study halls, after school, or before school.

She attributed this enthusiasm to the direct access students have to the information:

> The students feel more ownership of the news content over the Internet even though it's the same broadcast because they can put their hands on it. I know it's the same as on a videotape, but it's different for the kids. It's a lot different than if I pushed in a tape. For some reason or other, this is more real to them.

However, statements by the students revealed that they are not absorbing the content of Internet CNN NEWSROOM fully. Before students in Lexington watch Internet CNN NEWSROOM, the teacher distributes a list of short answer questions based on the video segments she will play for the class. Since the students need to look for detailed information embedded in the news stories, they may not be able to fully concentrate on the overall significance and message of the news story. One student said:

> I like [Internet CNN NEWSROOM]. But the questions she (the teacher) gives us is the only thing that I don't like. [The teacher] makes out a list of questions and I don't like it because she turns it into homework. But we can't really get the information. It's hard to get the detail when [the video segment is] so quick.

Additionally, some students complained that the teacher has not sufficiently integrated Internet CNN NEWSROOM with the rest of the course material:

> We'll talk about something totally different and then, okay, in the back of the room. It doesn't really tie in to what we're doing all the time.

As described in the next section, frustration with usage of Internet CNN NEWSROOM in the classroom may cause students to be less interested about the technology over time.

LEXSTUDY students expressed a desire to learn how to use Internet CNN NEWSROOM features and capabilities. By the end of the study only 29% of the students said they know how to play a video news segment, while 75% expressed a desire to know how. Twenty-one percent said they know how to incorporate information from news segments into class projects, whereas 54% would like to do it. Only 17% know how to copy video, pictures or text from the news segments into a class project, yet 46% expressed a desire to learn.

Students reported that the video presentation of current events in Internet CNN NEWSROOM was much more powerful than text in a book:

> Like the Internet, it's like, I know what's really going on. I know about the people, I know, I see videos on what's happening. If I'm looking in a book, I don't see any of that.

The teacher echoed statements by the students that the video content provided extra learning value to certain students:

> It's wonderful for the visual learner. I can see some of these students trying to learn on their own; just even taking notes is difficult for them. But this way it can be organized and it looks neat and they can pick and choose what they want and I can't say enough for it. I truly believe that there were a tremendous number of students that are being saved because they are using technology. I really do.

However, some students did say that it was difficult to use the video for school projects and found text easier to work with:

> I loaded down some stuff on Mayans. It was really nice. But I didn't know how to present video.
>
> It's easier to get text than video.

Students did express a great interest in using video clips from Internet CNN NEWSROOM for their research reports:

> It would be nice if you could load the whole thing up and then save a frame on a disk for a project so I can use it on a Hypercard stack.

Despite their general affinity towards Internet CNN NEWSROOM in the classroom, not all students were eager to use it outside class:

> Maybe [I would use Internet CNN NEWSROOM on my own], if I didn't have any work to do.

However, many of the students agreed that the use of computers in the classroom was a primary motivation for getting one at home, and several of them planned to do so soon.

Part of the hesitation to use Internet CNN NEWSROOM stems from a lack of knowledge about using computers, the Internet, and the Internet CNN NEWSROOM interface. These students complained that the system is still too complex and there needs to be student training on using the technology:

> It would be nice to work with someone who understands how to use the computer.
>
> Yeah, every time we get on [the computers], somebody has to come in and set it up for us and then something happens. I guess it's just too complicated that they can't take the time to show us how to do it, although I know some of us would get it. If two people in the class would get it, imagine how many more people, but they just don't want to sit down and tell us this is how you work it.
>
> I don't know how to use the Web.

The teacher also called for greater training of the system to both teachers and students. She cited the technical instability of the product as its single drawback:

> It's easy to use when the system is up. (Laughter.) That's my only complaint.
>
> I think [more training] would be beneficial to all of us. Frequently we have difficulty with it. I think they do need more training of how we could use the on-line archives. I think we need in-service training for teachers and students.

The students noted that the system was likely to fail after an extended period of use. It was then up to the student teacher or the "computer geniuses" in the class to fix things. Most other students did not understand the technology very well. For example, in the focus groups, most students could not distinguish between Internet CNN NEWSROOM and the Internet in general.

In the surveys conducted in January and April, LEXSTUDY students answered what they liked most about Internet CNN NEWSROOM. Table 11 lists the answers received from the students.[24]

Table 11. User Responses to "What do you like most about Internet CNN NEWSROOM?"

January	April
Search capabilities (35%)	Informative (56%)
Easy to use (20%)	Search capabilities (13%)
Informative (20%)	Easy to use (13%)
Nothing/Don't know (15%)	Multimedia (13%)
Multimedia (10%)	Fast (13%)
Fast (10%)	Interesting (6%)
Interactive (5%)	Up to date (6%)
Up to date (5%)	On demand (6%)
Clear stories (5%)	
Fun (5%)	

The top three answers in both rounds cited the product's search capabilities, ease-of-use, and informative content. The search capabilities and ease-of-use are particular to the Internet version, whereas the content is identical to the broadcast CNN NEWSROOM. From January to April the students cited the networked version features less often (35% for searching and 20% for ease-of-use in January versus 13% for each in April) and the general product features more often (20% for informative content in January versus 56% in April). This trend indicates that over time the students either became less excited by the features provided by the networked version, or began to take them for granted.

In the focus groups, students lauded the product benefits of Internet CNN NEWSROOM. They found it quicker to find the desired video segment using the Internet than using a video tape:

[24] Note that the percentages do not add up to 100% because some students listed more than one feature.

> I think it's good just to be able to watch the news without having to watch the whole thing and have it in the background. You can load it right up without having to worry about it. It's there. We used to tape it and then load it and wait twenty minutes. This way you just click on a button and it goes.
>
> I know CNN repeats every thirty minutes. And then it's really hard to, like, if I'm looking for a certain topic, I might miss some, and then I have to watch it again. There's like a whole lot of other things that they're talking about that have nothing to do with what interests me.

Students also liked the archive of Internet CNN NEWSROOM stories that is available through the Web site:

> I think it's a really great tool for research for the classroom. It's really helped us out a lot. There's a lot of information that we can use.
>
> I found some news articles [for a report on Peru].

Some students took advantage of the archive search tool while others did not.

> When you watch the news, you have to wait, you have to look at everything. But you just type in a topic that you want to watch and it comes right up, and everything's right there.
>
> I didn't really use it. All I do is watch it when it's used.

While students used Internet CNN NEWSROOM for highly publicized issues, students used other sources on the Internet for research on less popular issues.

> Some reports we would go strictly just like the basic Internet, and there were a few other reports that we looked up in the Internet CNN Newsroom and tried to find some things. It just depends on the issue that you're researching and whether or not it's something that's going to make big news or not.
>
> Things that are like, more well known, something that's sort of a bigger issue like, we did some reports on Bosnia. That's something you could find on any newscast. I did another report on Somaliland. It hasn't made big news, so I didn't bother looking at the CNN.

Students liked the simple interface of Internet CNN NEWSROOM.

> I think [the Internet CNN NEWSROOM interface is] pretty straightforward. It's not very complicated to use. It's pretty easy compared to everything else.
>
> They showed it to us and it looked like something really easy to figure it out and everything, so we just did it.
>
> The Internet's confusing. I don't like it. You can't open up the files that you sometimes want because I don't know why, but it doesn't work correctly. [However,] Internet CNN Newsroom is going to come up, so all you have to do is click and it's there for you.

In interviews with the teacher, she cited that the most important benefit of using the Internet version of CNN NEWSROOM over the broadcast version is collection of all the content and accompanying material into a single location (i.e., the Web site) with minimal effort required on her part:

> I didn't use the teacher's study guide [before we started using Internet CNN NEWSROOM]. I think it might have been available but I was not quite aware where I would get it.
>
> What I like about [Internet CNN NEWSROOM] is that it's readily available. Also, I don't have to be responsible for taping it. Before this I used to tape the programs off of cable at home at three o'clock in the morning and my husband would download the daily program guide through America Online. Then, I would take the tape into school, hope I could find a VCR to play it on. [With Internet CNN NEWSROOM,] I know it's going to be there. I know that the news broadcast will be there at seven o'clock in the morning. We know that we can download it.

In the survey, students also said what they liked least about Internet CNN NEWSROOM. User responses were similar in the January and April surveys, as illustrated in Table 12. The most popular answer, coming from half of the student body, cited frustration with the pauses in the video playback. Other students cited that they did not know how to use the system or that it was boring.

Table 12. User Responses to "What do you like least about Internet CNN NEWSROOM?"

January	April
Pauses (50%)	Pauses (53%)
Not able to use it (15%)	Don't know how to use (13%)
Don't know how to use (10%)	Not enough content (13%)
Boring (10%)	Boring (7%)
No complaints (10%)	Does not always work (7%)
Not enough content (5%)	Worksheets (7%)
Cuts off end of story (5%)	Not used enough (7%)
Worksheets (5%)	Slow response (7%)

In the focus groups, students complained about the lack of performance in the system, particularly, the periodic pauses in the video playback and the improper segmentation of the video clips. However, students were willing to be patient with the technology and tolerate these technical glitches.

> It is slow at times. When it stops, it is in the middle of a sentence and you lose your whole train of thought. That's the only one little pet peeve I have with it.
> [The only problem I have is the] stopping, but that's not really that bad. That's it and that's not even a big thing.

> When you play the next report, then you get the end of the report before. I think it always happens. Then when you do the next report, it shows a little tail end part.

The teacher also cited an increased exposure to the Internet due to her experience with Internet CNN NEWSROOM:

> I am finding that by using Internet CNN NEWSROOM I have become familiar with the Internet. This is a gateway for my using it more.

Students said that they saw benefits of using the Internet in other subjects in school:

> I think we could use [the Internet] in other classes. Now we're using it instead of history books. We never did it before in history, but now we're used to it and I think if we started in the other classes, we would get used to it. If they could find programs to tie in, I think it could help.
>
> The Internet would be useful in science, debate, psychology, business, art, languages, accounting, or computers [classes].

Students debated whether the computer was a good substitute for books in school:

> I like [computers]. It's easier to get your information. You can highlight what you need and forget the rest. So books, it's like you have to read everything.
>
> You can learn a lot from computers rather than from books, but I think books go more in depth than computers. Computers are good for visual, multimedia activities rather than written activities.
>
> I don't like computers, so I use books.
>
> If you know what's good for you, you'll use both books and the Internet.

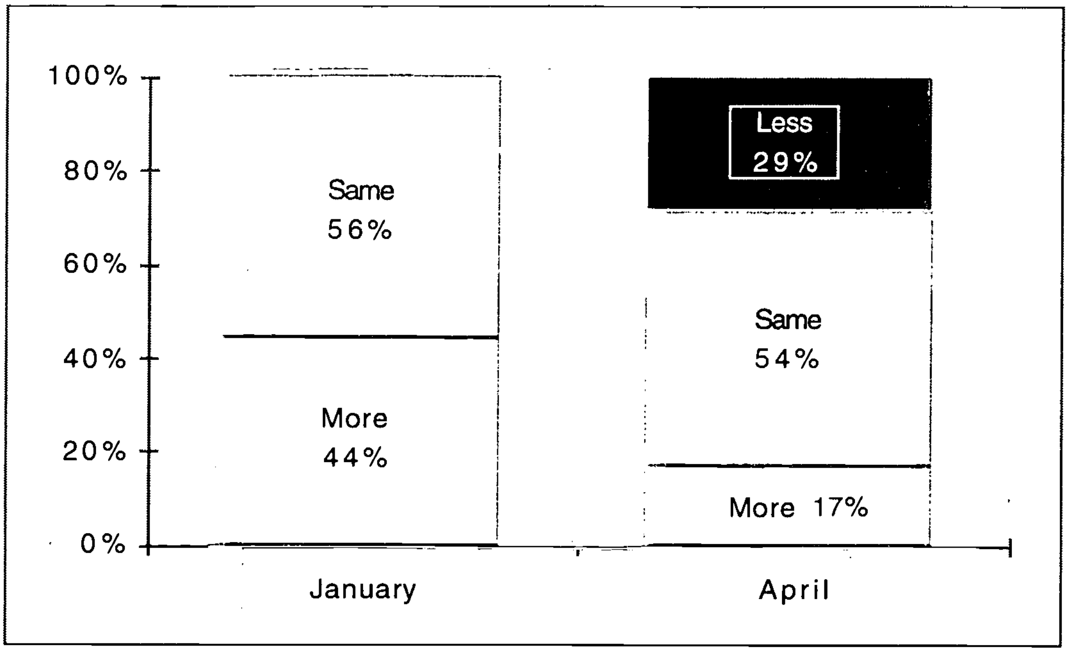
Some students said that computers and the Internet did not provide enough quality information for school research. Students said that although they used the Internet in school, they used books when they wanted to "really learn" about a subject.

3.5.2 Observed Novelty Effect

Survey data over the course of the study indicates a substantial novelty effect among users of Internet CNN NEWSROOM. While in the first half of the study users were enthusiastic about the use of the medium for learning current events, by the end of the study student enthusiasm waned considerably.

As illustrated in Figure 13, students' desire to use Internet CNN NEWSROOM in class dwindled during the study. Students were asked whether they would like the teacher to use Internet CNN NEWSROOM more often, less often or as often as is currently used. At the study's midpoint in January, 44% of the students desired to use it more often, with the remainder desiring the same level of usage. However, by the end of the study in April, 29% of the students desired that the teacher use Internet CNN NEWSROOM less often. Only 17% desired to use it more often.

Figure 13. Desired Frequency of Internet CNN NEWSROOM Usage in the Classroom

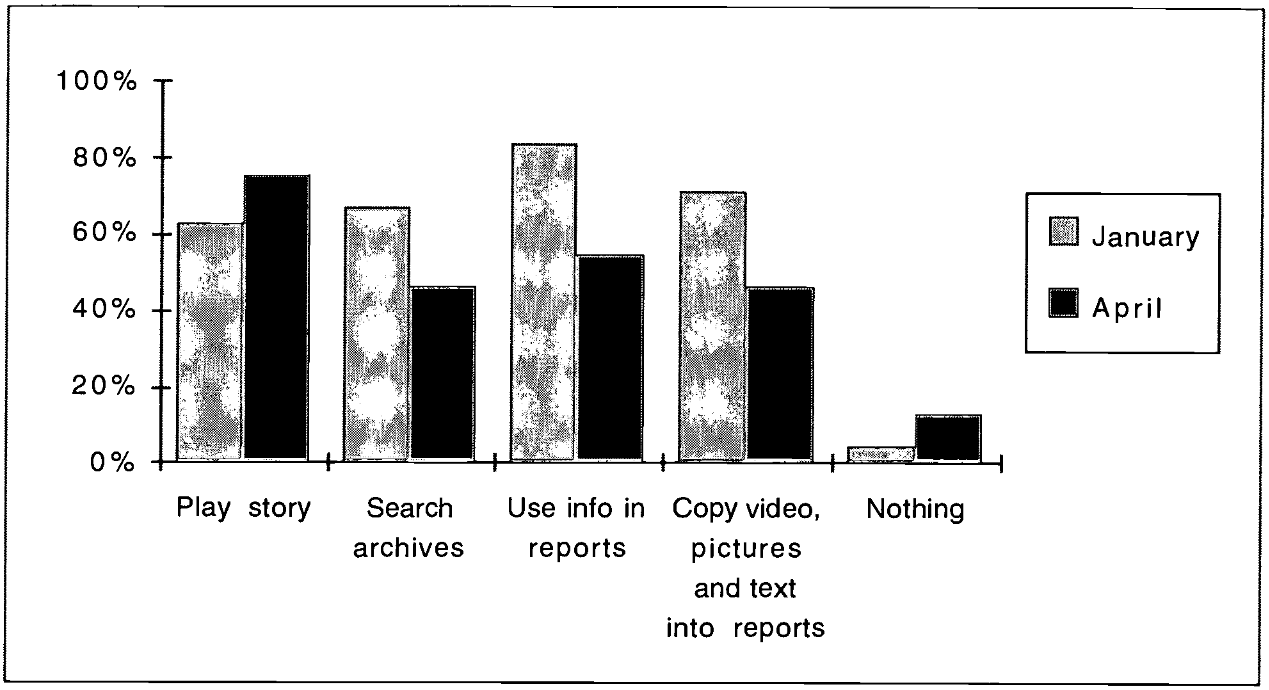


The decreased interest in Internet CNN NEWSROOM over time may be explained by a novelty effect, in which initial excitement over a new product declines after its novelty wears off. However, other factors may also account for some of the decreased interest in Internet CNN NEWSROOM. As described above, many students were critical of the product's interface, technical glitches, and accompanying quizzes. Feedback collected in this study is expected to provide recommendations for future enhancements of the service to better meet user needs.

Students' waning interest in Internet CNN NEWSROOM is confirmed by their responses to another survey question probing interest in Internet CNN NEWSROOM features. Students were asked whether they would like to know how to perform certain tasks using Internet CNN

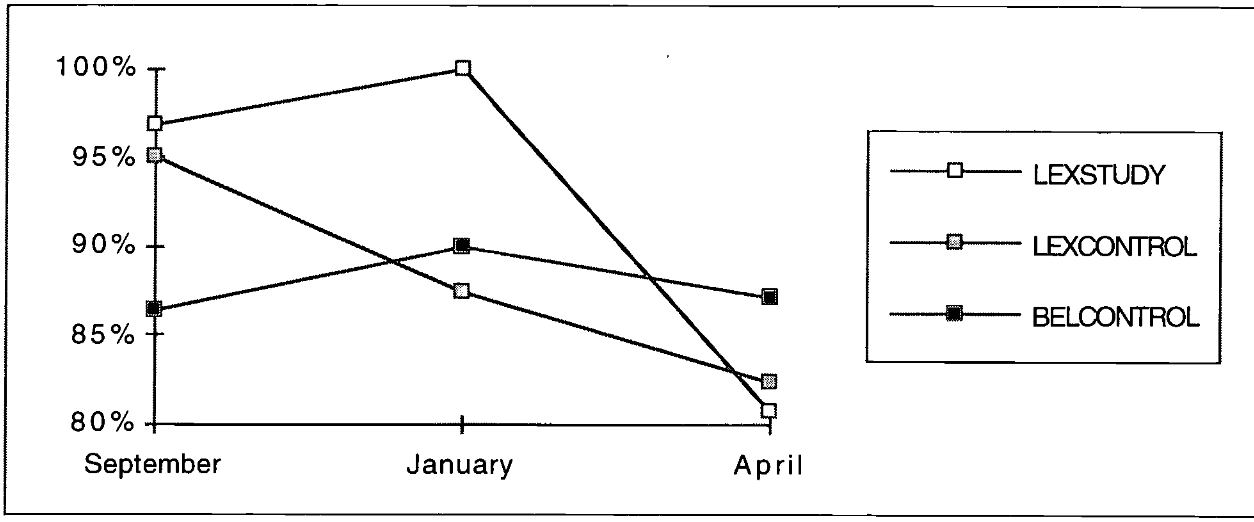
NEWSROOM. For three out of the four possible tasks, student desire to perform the tasks dropped from January to April. As illustrated in Figure 14, student interest in searching, using information, and copying information from Internet CNN NEWSROOM declined from January to April. Interest in playing a video segment story increased, albeit slightly, over the course of the study.

Figure 14. Interest in Using Internet CNN NEWSROOM Features



The novelty effect is also apparent in the attitudes of students towards the use of computers in general. As illustrated in Figure 15, the percent of students agreeing with the statement that "computers are good for work" dropped by a greater amount in the LEXSTUDY group than in either of the control groups. While in January the LEXSTUDY group universally agreed with the statement, presumably because of their excitement about the technology, by April the excitement had worn off and 19% no longer agreed. The changes were not nearly as drastic within the two control groups. LEXCONTROL students also demonstrated a drop in their favorable view of computers for work, but the decline was steady throughout the study. The fact that both Lexington groups displayed a decline indicates that students in the technology-rich Lexington High School may be turned off to the technology if they do not see it is a useful tool in their studies.

Figure 15. Percent of Students Stating Computers are Good for Work

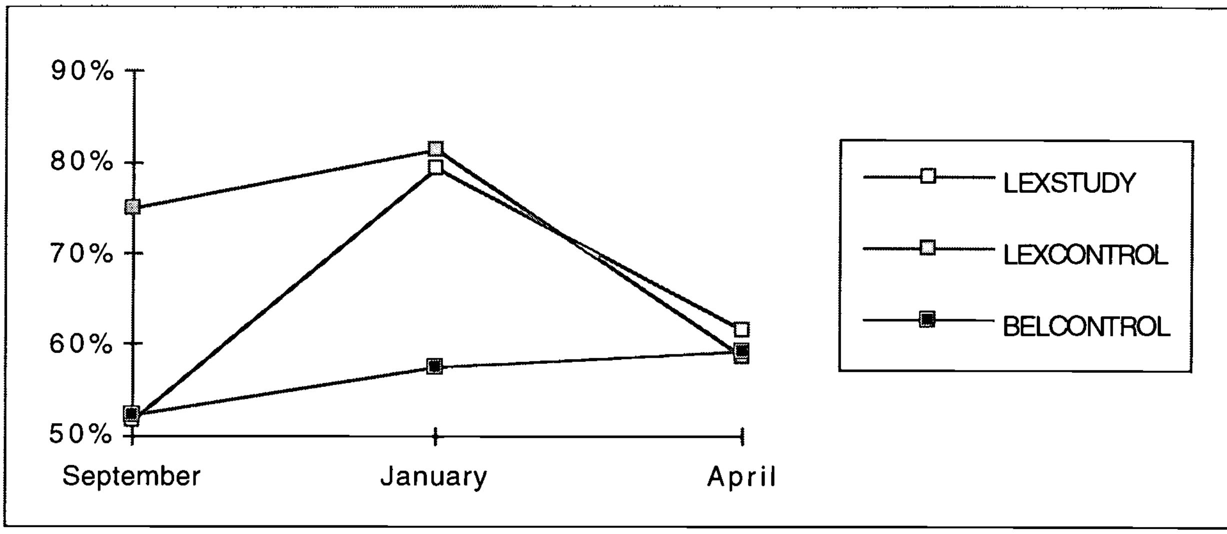


Alternatively, the decline in the number of LEXSTUDY students agreeing that computers are good for work may be attributed to a growing frustration with the prototype system. After extensive use of Internet CNN NEWSROOM, some students may come to reject computers as useful for work because of the prototype's flawed user-interface and inconsistent performance. At the beginning of the study, students were able to overlook the problems and focus on the benefits it provided them in their work. However, by the end of the study in April, an increasing number of students may have channeled their frustrations with the system into a lower opinion of the utility of computers for work.

The novelty effect has had an impact not only in student attitudes towards technology but also in student use of technology. As illustrated in Figure 16, students in LEXSTUDY increased their usage of computers significantly in the first half of the survey. The percentage of students using computers at least a few times a week increased from 52% in September to 80% in January.

However, by April the percentage dropped down to 62%. Students in LEXCONTROL also displayed a sharp drop in computer usage during the course of the year (from 75% at the beginning of the study to 58% at the end). Only the Belmont students showed increased usage throughout the study.

Figure 16. Percent of Students Using Computers at Least a Few Times a Week



Two different explanations account for the difference in trends among the three groups. The first explanation suggests that students in Lexington had over-exposure to computers without quality applications. The LEXSTUDY students turned to computers often during their initial excitement with Internet CNN NEWSROOM. However, as soon as the excitement abated, students began to shun computers. The LEXCONTROL group did not have the initial increase because it did not experience the initial excitement of Internet CNN NEWSROOM. But the group did suffer the same computer burn-out after overexposure during the course of the year.

The second explanation suggests that the students in both Lexington groups became more aware of their relative familiarity with the technology over the course of the year. In January, many Lexington students were still new to the technology and may have included any incidental or superficial contact with computers as part of their regular weekly computer usage. By April, these students were more knowledgeable about computers and excluded any superficial use from their self-assessment of weekly usage rates.

3.5.3 Effect on Technical Proficiency

Students in the study and control groups increased their self-rated proficiency with computers and the Internet in the study period. As illustrated in Figure 17 and Figure 18, the percentage of students claiming "a lot" or "some" experience with computers and the Internet increased slowly from the beginning of the study.

Figure 17. Percent of Students Claiming "a Lot" or "Some" Experience with Computers

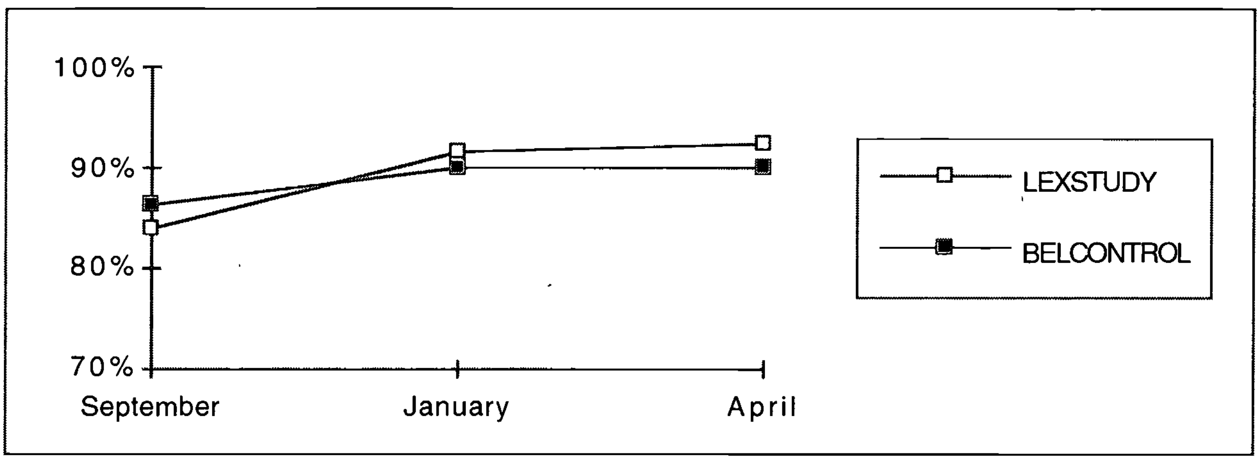
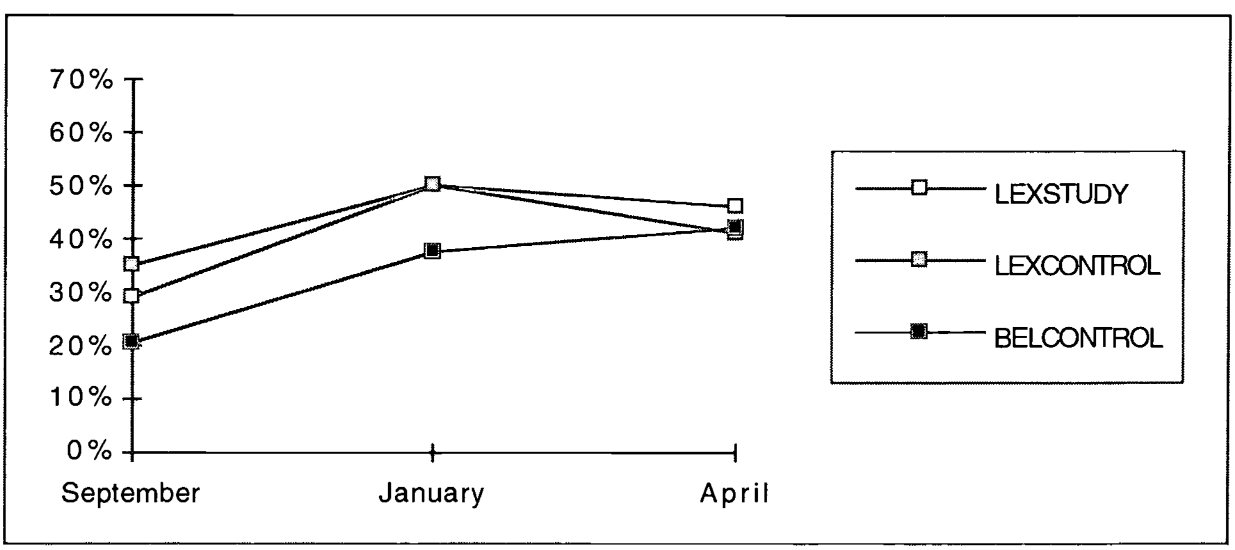
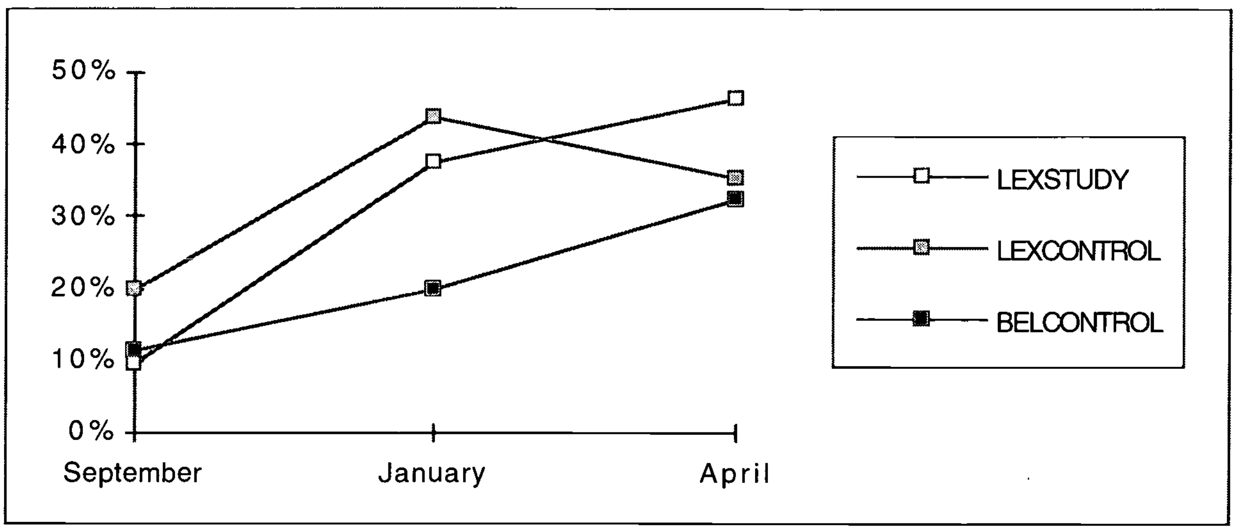


Figure 18. Percent of Students Claiming "a Lot" or "Some" Experience with the Internet



However, student experience with the Web increased at a much higher level in the LEXSTUDY group compared to the control groups. As illustrated in Figure 19, at the beginning of the study, the LEXSTUDY group had the smallest fraction of students (9% compared to 20% in LEXCONTROL and 12% in BELCONTROL) claiming a lot or some Web experience. By the end of the study, the LEXSTUDY students, having used Internet CNN NEWSROOM as part of their regular instruction, claimed the greatest experience with the Web (46% compared to 36% in LEXCONTROL and 32% in BELCONTROL).

Figure 19. Percent of Students Claiming "a Lot" or "Some" Experience with the Web



These results indicate that all students at Lexington increased their experience with the Web, but the students using Internet CNN NEWSROOM showed the greatest improvement. While these results do not indicate greater learning using the Web, they do indicate that students exposed to good Web-based applications receive greater experience with the technology.

3.5.4 Shift in View of Function of Computers

The study indicates that there is a fundamental shift in the primary use of computers by students. Students who had not used the Internet or on-line services viewed computers as having three functions – word processing, typing instruction, and game playing. On the other hand, those with more computer experience emphasized other, more powerful, uses for computers including information retrieval and communication. Student comments from the focus groups exposed the disparity between these two groups. Students without much use of computers made comments similar to these:

> [The computer is] just something that I use to type up a paper and no more than that.
>
> I have a computer [at home], but I don't really use it. I use it to type my papers.
>
> [Before high school,] all we used computers for was typing and games. We were trying to learn how to use computers, how to write papers, how to correct, how to use the fonts, and stuff like that.

On the other hand, students with more experience with computer networking had a much different impression of uses for computers. These students said that the Internet was vital for their work and research at school:

> Because all we have learned before now is how to make papers on the computer so it looks nice. That's about it. Now we know we're able to get a lot of information [off of computers].
>
> I think it is very useful having all these resources, literally the whole world at a key board.
>
> I've [used the Internet] at school. I've done it at home and at friends' homes, and it's really a great resource to use.

These experienced computer users acknowledged that before they used computers much, they saw the role of computers in the same way as the less experienced group – primarily for word processing and typing instruction.

Interviews with the teacher confirmed this trend that students were viewing computers and the Internet as serious research tools rather than game or typing machines:

> I have noticed now that when the students go into the Internet, they are going more for the news, research and so forth, rather than seeing the computers in the room and this is the place where we can have fun and play games. I'm impressed with where they're

going on the Internet. I think that Internet CNN NEWSROOM has opened up a whole new window for them. That this is not just a game machine and that they can find out about the world around them. And you see I think what they see on CNN gives them access to the world and the issues in the world today. And then I think they want to look more into these issues. I'm just impressed with how they use it in the classroom now. They're not going into games and so forth – they're looking at issues.

Some students said it was easier to access information over the Internet than in a library:

I like the Internet. I think it's much more convenient to get access to information over the Internet than by going down to the main library in Boston. I think that it is so much easier and especially to use in your own home or like right here.

It's easier to get [information off of the Internet because] instead of going through books and picking out little bits of information. It's all right there.

I want [a computer] because it's easier to [find information using the computer] than going to the library and going through books.

Other students said that the information they were seeking was available only over the Internet and not in the library:

It's become very useful for stuff that I really can't find in a library.

We wanted something on women's rights in Ghana and we couldn't find it in the school library. But a lot of other people have gotten information and put it on the Internet.

Some things you're just not going to find in the library. So when there are things that are new subjects. Like Hubble – almost all of the books in the library are from the seventies or earlier and you won't find anything about Hubble in there because it's not updated. But on the Internet you can find lots of information about Hubble.

Now we have projects on Africa, and I'm doing African music, art and masks and stuff, and we can look up things that were in the news recently, just on the Internet. It's much easier to do that instead of looking in books.

However, students feared overuse of computers and the Internet in school:

There is so much in there and after a while, I just don't like going for long periods because it bothers my eyes. And I get sick of interaction with the computer. There is no personal level of it.

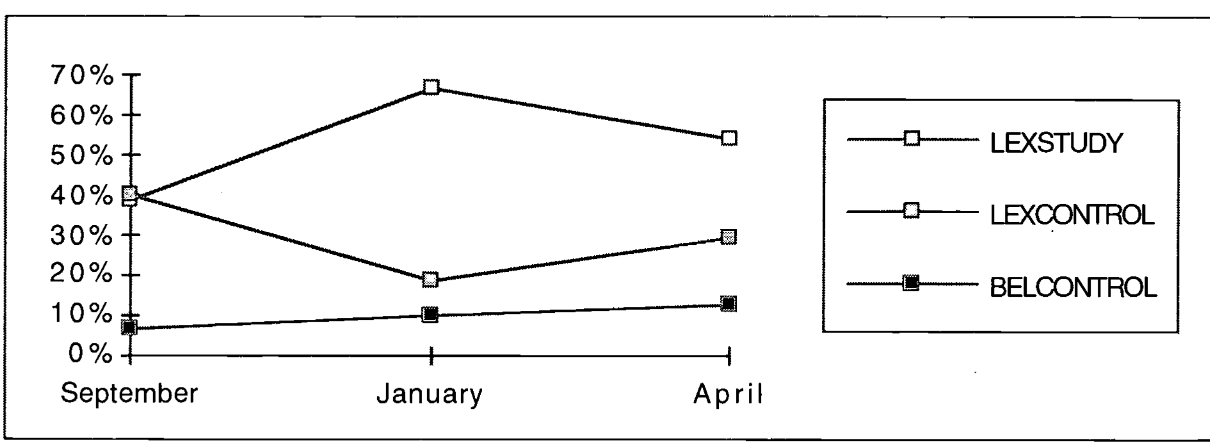
> Getting carpal tunnel syndrome before you're able to drive would be a real bummer.

Students also had a great fear of getting into trouble by stumbling upon inappropriate or restricted government information on the Internet:

> In order for us to know, we have to research. But when we research, and research too hard, we get in trouble for finding out stuff other people don't want us to know about.
>
> You can't do this (browse information over the Internet) because you'll get, I don't know, arrested.

Based on the survey data, LEXSTUDY students have placed more importance than their counterparts on the use of computers for schools projects. Students in each class were asked to name the most important source of information for school projects. As illustrated in Figure 20, the percentage of LEXSTUDY students claiming computers as their most important information source for school projects increased from 39% in September to 54% in April. Similarly, the percentage of LEXSTUDY students using print materials (e.g. books, newspapers or magazines) as their primary information source decreased from 58% to 46% over the course of the study.

Figure 20. Percent of Students Identifying Computers as Most Important Information Source



The students in BELCONTROL did not migrate nearly as much from books to computers for their information in school projects. In September, 91% claimed books, newspapers, and magazines were most important, compared to 7% for computers. By April, the percentages changed only slightly to 87% for books, newspapers, and magazines, versus 13% for computers.

The students in LEXCONTROL showed a trend contrary to that found in the LEXSTUDY group. While the LEXSTUDY students placed more reliance on computers as the year progressed, the LEXCONTROL group placed less reliance on computers over the same period. At the beginning of the study the two Lexington group profile were similar (58% print, 39% computers in LEXSTUDY and 60% print, 40% computers in LEXCONTROL). However, during the study period, behavior among the two groups diverged. In January, only 19% of the LEXCONTROL students still claimed computers as their most important information source. In April the percentage increased to 29%, but still remained below the level at the start of the study. Apparently, the LEXSTUDY group, in using Internet CNN NEWSROOM, began to view computers as valuable for class work. The LEXCONTROL group, without access to Internet CNN NEWSROOM, was not able to find good information resources for school projects using computers. Greater reliance on Internet CNN NEWSROOM does not necessarily indicate that the product is effective in education. However, it does imply that the product will receive greater student acceptance if teachers choose to use it in the classroom.

The teacher confirmed that students were learning more using Internet CNN NEWSROOM than with other computing resources. She said that the plethora of information on Internet CNN NEWSROOM and the Internet forces students to read and understand the information they browse over the network. In contrast, students using CD-ROM encyclopedias or other computer resources were simply collecting information into school projects without first reading and understanding the material:

> I would say previously that they might go to the library and they might download something from the encyclopedia CD-ROM and they would run off 9,000 pages and then not read the material, and then put it all together and hand it in. Therefore what I have found that has been most useful, and I don't even think they realize it, is that they have to select what they are going to download. They are not going to download the whole thing, so they have to read or listen to the document , and then select what they would like to download and use in their project. They have to be selective. They have to go to [Internet] CNN [NEWSROOM] or other parts of the Internet, they have to go to the archives, they have to go use the technology we have available in the room, and then select what they want to include in their project.

Other metrics did not indicate any significant difference between the study and control groups. None of the groups showed a significant difference during the study in affinity for current events, attitude towards class, class participation or collaboration with other students.

3.6 SUMMARY

This chapter examined the benefits of educational technology in K-12 schools. Education stakeholders can reap a variety of benefits from the use of technology and networking. Schools with more advanced networking infrastructure can more easily utilize high bandwidth educational services over the Internet.

Internet CNN NEWSROOM, a new networked multimedia information service, created greater enthusiasm among students because it provided them with direct access to information. Students using the product have placed more importance than their counterparts on the use of computers for schools projects. These students also showed greater use of computers and networks for school work and more experience with the Web than students without access to Internet CNN NEWSROOM.

While students using Internet CNN NEWSROOM placed more reliance on computers as the year progressed, students using technology but not Internet CNN NEWSROOM placed less reliance on computers over the same period. The former group, in using content-rich Internet CNN NEWSROOM, began to view computers as valuable for class work. The latter group, without access to Internet CNN NEWSROOM, was not able to find good information resources for school projects using computers.

Internet CNN NEWSROOM generated a considerable novelty effect among student users. In their first few months of using the product, students expressed great enthusiasm about the product and displayed a sharp increase in technology usage. However, after the novelty effect wore off student interest in Internet CNN NEWSROOM and their attitudes towards technology retreated from their former high levels.

The greatest barrier to effective use of Internet CNN NEWSROOM is the lack of knowledge in using computers, the Internet, and the Internet CNN NEWSROOM interface. User training for teachers and students is a necessary prerequisite for proper use of the technology.

The teacher and students stated that the video presentation of current events was much more powerful than text in a book. However, while students expressed a great interest in using video clips from Internet CNN NEWSROOM for their research reports, most said that video was more difficult to use than text.

Users cited Internet CNN NEWSROOM's archive search capability as its single greatest benefit over the broadcast version. Other key benefits of the Internet version include the quick access to the desired content. The greatest benefit to the teacher is the ability to access all the content and accompanying material at a single Internet site.

Students said they saw benefits of using the Internet in other subjects in school due to their positive experiences with the Internet in their social studies class. Some students said the

Internet and computers did not provide enough quality information for school research. Students said that although they used the Internet in school, they used books when they wanted to "really learn" about a subject.

There is a fundamental shift in the primary use of computers by students. Students who have not used the Internet or on-line services viewed computers as having three functions – word processing, typing instruction, and game playing. On the other hand, more experienced computer users found computers useful for information retrieval and communication.

Chapter Four

Policy and Product Recommendations

4.1 INTRODUCTION

The previous two chapters have described the costs and benefits schools face in developing networking infrastructure. This chapter offers recommendations to improve the cost-benefit ratio for schools. The first section presents recommendations for regulators, legislators, and other policy makers. These policies can make a significant impact on the networking costs for schools. The second section discusses new product development recommendations for developers of networked educational services for schools. These product recommendations can guide developers to develop network-based products and services that provide significant educational benefits to schools.

4.2 POLICY RECOMMENDATIONS

This section issues four recommendations for policy makers that will minimize the costs that schools face in developing networking infrastructure.

4.2.1 Focus on Significant Cost Items

The cost for telecommunications is only a small portion of the total networking costs to schools. As described in chapter two, the cost of telecommunications lines represents only 11% of the total networking costs for baseline NII connectivity. The costs for PCs, support, and training are much more significant. Therefore, policy makers should develop policies that concentrate on these cost items.

Chapter two developed a number of potential cost savings programs. The programs with the greatest financial impact reduced the most significant cost items – hardware, training, and support. Policy makers should take actions that will facilitate these programs:

- Free labor for installing network – State and federal officials should encourage and support grassroots volunteer programs in which technically knowledgeable volunteers help wire up schools.[25]
- Donation of PC's routers and other equipment – State and federal governments should create incentive programs for businesses (e.g., tax incentives) to donate new and used equipment to schools. It is vital that the incentives encourage donation of relatively new equipment since older equipment may have technical limitations that render it less valuable for networking schools.[26]
- Teachers trained on own time – Teachers should be given training credits or some financial compensation for spending time out of school to learn how to use computers and networks in the classroom.

Policy makers should resist the allure of focusing on lowering telecommunications costs, which represent only a small fraction of the total overall costs. Highly publicized announcements by telephone and cable companies draw attention to free and lower telecommunications rates. While low- or no-cost telecommunications reduce short-term costs, the telecommunications companies often design these programs to lock schools into a particular company and technology. Once schools are locked-in, they have less flexibility to switch to lower cost

[25] A good example is NetDay '96 in which volunteers from California helped connect schools across the state.
[26] Business donations are emphasized over individual donations since the average age of discarded equipment by individuals is much greater than that of businesses.

providers after the introductory low-cost program expires. In the long-term, total costs increase. Schools would benefit more by emphasizing the cost savings programs described above.

4.2.2 Encourage State and District Level Purchasing

Aggregating costs at the district and state levels, can significantly reduce costs for individual schools and school districts. Schools stand to save much money by pooling resources and purchasing power with other schools in the district and at the state level. When schools share a high speed data link, or support staff, the per school costs drop considerably. Schools in North Carolina and Kentucky have saved 20% - 50% by purchasing services and equipment at the state level. These volume-purchase programs should be expanded in other states and districts. State officials should develop state technology purchasing offices that will make volume purchases for most or all schools in the state.

Before implementing these programs, state officials should consider the potential drawbacks of volume purchasing. In particular, they should consider the possibility of the creation of a large, inefficient bureaucracy; conflicts with state and local procurement laws; potential political hazards; and the inability to meet the specialized needs of some school and school districts.

4.2.3 Develop Scalable Architecture

Schools should consider implementing scalable, extensible networking technology similar to models four and five from chapter two. Although these models have high per student costs, they are the only ones that are scalable for many users within a school. While models one, two, and three have lower per-student costs, these models are viable only for a small number of concurrent users. Only models four and five are viable for widespread network usage within the school.

Federal and local government officials can help schools develop plans for a scalable design by providing or encouraging the private sector to provide technical support, such as help-desks, technology guides, and technical information resources. California Department of Education (1994) and the U.S. Department of Education web site (http://www.ed.gov/) are examples of government resources that help schools learn how to design scalable, low-cost networking infrastructure.

4.2.4 Support Initial Funding Barrier

The initial investment cost is the most significant financial hurdle facing schools in developing network infrastructure. Local, state, and federal budget officials should be more flexible in their school budget allocation programs to allow schools to make a high one-time investment in networking technology. Additionally, schools should be given flexibility to amortize initial costs, in order to spread out the burden over a number of years.

4.3 NEW PRODUCT RECOMMENDATIONS

Urban and Hauser (1993) describes the process of "information acceleration" in which user feedback from pilot programs provides information about the product characteristics desired by users. Evaluation of Internet CNN NEWSROOM in chapter three described the feedback received from the pilot user group of the service – the students and teacher at Lexington High School. Their feedback provides valuable information about the important features in new Internet-based multimedia information products and services. This section uses this information to issue recommendations to software designers and developers concerning the product concept, user interface, and features of new networked educational products and services.

4.3.1 New Market Opportunity

Feedback from the study group at Lexington High School indicated that the emergence of the Internet and commercial on-line services have opened up a new market for educational products:

- Shifting user applications – New educational software should reflect the shift in thinking about the use of computers. Students are increasingly viewing computers and the Internet as research tools rather than simply typing or game machines. Therefore, there will be greater opportunity to develop new products with quality educational content and powerful research capabilities.
- Positive system feedback – Currently, few networked (as opposed to stand-alone,) educational products exist for use in the classroom. Because of the dearth of educational products and services, the Internet and computer networking is not widely viewed as a necessary classroom tool. When innovative Internet-based products begin to emerge in the marketplace, teachers will see that computer networks can be valuable in daily instruction. Increased awareness will lead to increased demand, thereby causing a positive feedback loop as companies develop new products to meet demand. Product developers must understand these market dynamics and be ready for quick increases in demand.

4.3.2 User Interface

Feedback from users indicates that product interface design is important in their experiences with the product. They desire a product that is easy-to-use, usable by students, and accompanied by good technical support:

- User-friendly interface – Products should be user-friendly and not technically complex. Many students in Lexington did not use Internet CNN NEWSROOM because they found the interface confusing.
- Student-controllable system – Students said they liked that they were in control of Internet CNN NEWSROOM. Therefore, it is important that products be developed that are to be

used by the students themselves and not just by the teacher. Students make greater use of the product when they can take ownership of it.

- Reliable technical support – Students and the teacher complained of technical problems with the product. If technical support were better, user experiences would likely have been more positive. Therefore, in future product development, technical support should be an integral part of the augmented product.

4.3.3 Product Features

Information from the students in Lexington indicates that users covet certain features of Internet CNN NEWSROOM. Their feedback indicates that users desire new educational products that contain rich multimedia content, powerful search tools, up-to-date information, and technical reliability:

- Multimedia content – The teacher and many students liked the graphical, audio, and video information in Internet CNN NEWSROOM. Many students also said that the text was the most useful part of the service. Therefore, new educational products should include multimedia information along with text-based information. The multimedia information, which students say is more stimulating and memorable, complements the more functional text-based information.
- Powerful search capabilities – Students who knew how to use Internet CNN NEWSROOM's search tool said it was an indispensable feature of the product. It addressed the student need for specific and relevant information. New educational products that provide research content should contain a search tool to maximize value to the user.
- Up-to-date information – One key advantage of using the Internet as a channel for new products and services is the ability to provide up-to-date information. Students complained that other information resources were old, inaccessible, and out-of-date. Computer networking provides the opportunity to provide schools with information that is current and relevant.

- Technical reliability – Technical bugs are still prominent in software products such as Internet CNN NEWSROOM. There was some mild disappointment with Internet CNN NEWSROOM because it did not always work. A new product will have a much greater impact on users if it is technically reliable.

4.4 SUMMARY

By the end of the century, computer networks will become a standard technology in K-12 schools. Given current trends, it is certain that a significant number of classrooms in every school will have access to a computer network by the year 2000. However, the success of networking technology in facilitating educational reform and improving schools is not at all certain. In these next few years, two elements are critical in ensuring a productive role for networking in schools – constructive policies that help schools connect properly at minimal cost and quality networked educational products that are effective educational tools.

If government and school officials develop policies that focus on the significant cost items, encourage state and district level purchasing, encourage development of scalable architecture and technologies, and support the considerable initial funding barriers, schools will successfully implement networking with the least possible drain on financial resources. Similarly, if software developers design and create new educational products with an easy and powerful user interface that take advantage of networking capabilities, then teachers will begin to regard computer networks as essential tools in the classroom. If these two conditions are met, educational technology may begin to fulfill some of the grand expectations that have accompanied it since the use of surveyor's equipment in schools in the 1920s through the use of the Internet in the 1990s.

Appendix One

Internet CNN NEWSROOM Home Page

NMIS NEWS NEWSROOM HELP

Tuesday, March 26, 1996

View today's entire CNN Newsroom Guide

View today's entire program.

(3:05) [mpeg] (cc)

Consumers boycott British beef products after "mad cow disease" disclosure.

(:30) [mpeg] (cc)

NATO EXPANDS ROLE IN BOSNIA ...

CAMPAIGN USA '96 (:40) [mpeg] (cc)

AFL-CIO endorses President Clinton's candidacy.

Appendix Two

Focus Group Protocol

NETWORKED MULTIMEDIA INFORMATION SERVICES (NMIS)
INTERNET CNN NEWSROOM EVALUATION PROJECT

FOCUS GROUP PROTOCOL

LEXINGTON HIGH SCHOOL
JANUARY 22, 1996

Interviewers: Russell Rothstein, Jae Roh and Sonia Arora

A Social Studies high school class in Lexington High School will comprise the respondent set for this study. The class will begin at 7:50am in one of the classes in the school. We will arrive shortly before the beginning of the class and walk into the classroom at the same time as the students.

After we enter the teacher will explain to the students that we will be observing them and then talking with them in group. We will then observe the teacher use Internet CNN NEWSROOM as she does on a typical day. We will take notes regarding student usage and if relevant, add questions to the question list for the focus group (see below).

After the teacher has finished using Internet CNN NEWSROOM, the teacher will instruct two sets of four students to attend the focus group for twenty minutes. Each of the two leaders will take one of the student groups into a private area and begin the focus group. At the conclusion of the focus group, the leaders and students will return to the class and the teacher will designate two more sets of students for the second round of focus groups.

Each of the sessions will be taped using a small audio tape recorder. At the start of the session, the students will be told that the conversation will be recorded. They will be asked if they would not like to participate in the session. Any students that ask to be excluded will be sent back to the classroom.

Questions will be asked of the groups relating to their experiences with Internet CNN NEWSROOM. Potential questions include:

- What do you think of this program? How would you describe it?
- What's the best thing about Internet CNN NEWSROOM?
- What's the worst thing about Internet CNN NEWSROOM?
- Do you think it's fun to use? Easy or difficult?
- What do you think would make the Internet CNN NEWSROOM better? (i.e. Kid reporters?)
- Do you enjoy learning about current events/news?

In a separate session, we will interview the teacher. This interview will take place over the phone one evening in January. The teacher will be asked to describe her experiences with Internet CNN NEWSROOM. Potential questions include:

- How often do you use the Internet CNN NEWSROOM?
- Do you use it to teach specific lessons on social studies or do you teach it as a regular current events segment during the class period?
- How attentive are students while you use the Internet CNN NEWSROOM?
- Do students refer to things they learned through Internet CNN NEWSROOM in a different context directly or indirectly?
- Do students use Internet CNN NEWSROOM for class projects/assignments?
- Do you prefer the Internet version over the broadcast version? Why?
- How does this tool help and hurt your teaching of the subject matter?
- What recommendations do you have for improvement?

Appendix Three

Survey

Survey ID No. LEXA3

Relax! This is NOT a test. It's a survey. In a survey you get to answer questions about how you think and feel about different things. There are NO wrong answers. You WON'T be graded on this and no one else, not even the teacher or the principal, will see your answers.

You don't have to fill out this survey. Also, you can skip any questions that you don't want to answer.

Please read over the survey questions carefully and be sure to ask if you are unsure of the meaning of any question.

Instructions: Check the box next to your answer for each question. Check *only one* box for each question.

1. How often do you watch the news on TV at home?
(check one answer)
❑ Every day
❑ A few times a week
❑ Once a week
❑ Once a month
❑ Never

2. How often do you read the newspaper?
(check one answer)
❑ Every day
❑ A few times a week
❑ Once a week
❑ Once a month
❑ Never

3. How often do you use computers?
(check one answer)
❑ Every day
❑ A few times a week
❑ Once a week
❑ Once a month
❑ Never

4. For school projects, the *most* important source of information I use is:
(check one answer)
❑ Books
❑ Newspapers and magazines
❑ Stories and information from my parents
❑ Television
❑ Computers
❑ Other (specify) ____________________

5. Current events are:
(check one answer)
❑ Very interesting
❑ Interesting
❑ Not interesting
❑ Boring
❑ Very boring

6. How much do you know about current events?
(check one answer)
- ❑ A lot
- ❑ Some
- ❑ Not much
- ❑ Nothing

7. The Global Studies class is :
(check one answer)
- ❑ Very interesting
- ❑ Interesting
- ❑ Not interesting
- ❑ Boring
- ❑ Very boring

8. How much do you like to do research projects and papers about current events?
(check one answer)
- ❑ I like them very much.
- ❑ I like them somewhat.
- ❑ I neither like them nor dislike them.
- ❑ I dislike them.
- ❑ I strongly dislike them.

9. In the Global Studies class, I participate in discussion:
(check one answer)
- ❑ A lot
- ❑ Some
- ❑ Not much
- ❑ Not at all

10. In my other classes, I participate in discussion:
- ❑ A lot
- ❑ Some
- ❑ Not much
- ❑ Not at all

11. In the Global Studies class, I work together with other students:
(check one answer)
- ❑ Much more often than in other classes
- ❑ More often than in other classes
- ❑ Just as often as in other classes
- ❑ Less often than in other classes
- ❑ Much less often than in other classes

Instructions: Indicate how much experience you have with each of the following technologies. (check only one box for each question)

	A lot	Some	Not Much	None
12. PC's/Macintoshes	❑	❑	❑	❑
13. The Internet	❑	❑	❑	❑
14. World Wide Web (WWW)	❑	❑	❑	❑

Instructions: For the next two questions, place a check in the box next to ***as many answers as apply.***

15. I use computers for:
(check **all** answers that apply)

❑ Learning
❑ Playing games
❑ Work
❑ Programming
❑ Other (specify)________________
❑ Nothing

16. In my opinion, computers are really good for:
(check **all** answers that apply)

❑ Learning
❑ Playing games
❑ Work
❑ Programming
❑ Other (specify) ________________
❑ Nothing
❑ I don't know

Instructions: For the last question, answer the following questions *in your own words.*

17. What are the three most important current events in the news today? For each of these three current events, where did you learn about it?

Important current event	Where you learned about it

Instructions: This final part of the survey asks you to comment on *Internet CNN NEWSROOM*, the system that you use during Global Studies class.

18. How often would you like the teacher to use *Internet CNN NEWSROOM* during Global Studies class?
(check **one** answer)

- ❑ More often than we use it now
- ❑ Just as often as we use it now
- ❑ Less often than we use it now

Instructions: In the next section, place a check in the box next to *as many answers as apply.*

19. Which of the following tasks do you know how to do on your own using *Internet CNN NEWSROOM*? (check **all** answers that apply)

- ❑ Play a news story
- ❑ Find past news stories about a particular subject
- ❑ Use the information in the news stories for your class projects and reports
- ❑ Copy video, pictures or text from the news stories into your projects and reports
- ❑ None of the above

20. Which of the following tasks would you like to be able to do on your own using*Internet CNN NEWSROOM*? (check **all** answers that apply)

- ❑ Play a news story
- ❑ Find past news stories about a particular subject
- ❑ Use the information in the news stories for your class projects and reports
- ❑ Copy video, pictures or text from the news stories into your projects and reports
- ❑ None of the above

21. What do you like *most* about Internet CNN NEWSROOM?

22. What do you like *least* about Internet CNN NEWSROOM?

Appendix Four

Survey Responses

1. How often do you watch the news on TV at home?

	Lexstudy			Lexcontrol			Belcontrol		
	September (n=31)	January (n=24)	April (n=26)	September (n=24)	January (n=16)	April (n=17)	September (n=44)	January (n=40)	April (n=32)
Every day	26%	25%	19%	40%	25%	71%	27%	33%	41%
A few times a week	35%	42%	35%	35%	50%	6%	41%	43%	22%
Once a week	23%	17%	19%	5%	13%	24%	18%	10%	16%
Once a month	6%	17%	19%	10%	13%	0%	7%	8%	19%
Never	10%	0%	8%	10%	0%	0%	7%	5%	3%

2. How often do you read the newspaper?

	Lexstudy			Lexcontrol			Belcontrol		
	September	January	April	September	January	April	September	January	April
Every day	6%	13%	4%	30%	19%	29%	14%	15%	22%
A few times a week	23%	8%	27%	40%	38%	35%	45%	48%	34%
Once a week	29%	38%	23%	15%	25%	18%	32%	28%	34%
Once a month	29%	29%	27%	10%	6%	18%	7%	8%	6%
Never	13%	13%	19%	5%	13%	0%	0%	3%	3%

3. How often do you use computers?

	Lexstudy			Lexcontrol			Belcontrol		
	September	January	April	September	January	April	September	January	April
Every day	13%	13%	27%	10%	25%	29%	20%	13%	16%
A few times a week	39%	67%	35%	65%	56%	29%	32%	45%	44%
Once a week	26%	17%	23%	15%	13%	29%	30%	23%	25%
Once a month	19%	4%	15%	10%	6%	12%	11%	13%	16%
Never	3%	0%	0%	0%	0%	0%	5%	3%	0%

4. For school projects, the *most* important source of information I use is:

	Lexstudy			Lexcontrol			Belcontrol		
	September	January	April	September	January	April	September	January	April
Books	55%	29%	42%	60%	69%	53%	91%	85%	84%
Newspapers and magazines	3%	4%	4%	0%	13%	12%	0%	3%	3%
Stories & information from my parents	0%	0%	0%	0%	0%	6%	2%	0%	0%
Television	0%	0%	0%	0%	0%	0%	0%	0%	0%
Computers	39%	67%	54%	40%	19%	29%	7%	10%	13%
Other	0%	0%	0%	0%	0%	0%	0%	0%	0%

5. Current events are:

	Lexstudy			Lexcontrol			Belcontrol		
	September	January	April	September	January	April	September	January	April
Very interesting	6%	0%	8%	10%	0%	24%	18%	13%	16%
Interesting	71%	79%	54%	70%	81%	41%	70%	80%	66%
Not interesting	13%	13%	31%	15%	13%	29%	7%	8%	19%
Boring	3%	4%	4%	5%	6%	6%	0%	0%	0%
Very boring	6%	4%	4%	0%	0%	0%	2%	0%	0%

6. How much do you know about current events?

	Lexstudy			Lexcontrol			Belcontrol		
	September	January	April	September	January	April	September	January	April
A lot	10%	4%	4%	5%	6%	29%	14%	13%	16%
Some	58%	58%	65%	65%	81%	59%	64%	68%	56%
Not much	29%	38%	23%	30%	13%	12%	18%	20%	28%
Not at all	3%	0%	8%	0%	0%	0%	2%	0%	0%

7. The Global/American Studies class is:

	Lexstudy			Lexcontrol			Belcontrol		
	September	January	April	September	January	April	September	January	April
Very interesting	19%	4%	0%	5%	6%	18%	14%	0%	0%
Interesting	58%	50%	50%	65%	25%	24%	41%	30%	16%
Not interesting	16%	29%	27%	20%	31%	41%	27%	33%	56%
Boring	3%	13%	19%	5%	19%	18%	11%	23%	13%
Very boring	3%	4%	4%	5%	19%	0%	5%	15%	16%

8. How much do you like to do research projects and papers about current events?

	Lexstudy			Lexcontrol			Belcontrol		
	September	January	April	September	January	April	September	January	April
I like them very much.	3%	4%	4%	5%	6%	12%	7%	3%	13%
I like them somewhat.	32%	29%	27%	20%	31%	41%	32%	28%	13%
I neither like them nor dislike them.	32%	29%	31%	45%	38%	29%	43%	45%	43%
I dislike them.	23%	29%	31%	10%	13%	12%	7%	13%	13%
I strongly dislike them.	10%	8%	8%	20%	13%	6%	9%	10%	17%

9. In the Global/American Studies class, I participate in discussion:

	Lexstudy			Lexcontrol			Belcontrol		
	September	January	April	September	January	April	September	January	April
A lot	10%	13%	12%	30%	31%	35%	30%	23%	28%
Some	48%	38%	46%	45%	44%	29%	32%	33%	34%
Not much	35%	42%	42%	25%	25%	35%	32%	40%	22%
Not at all	6%	8%	0%	0%	0%	0%	7%	5%	16%

10. In my other classes, I participate in discussion:

	Lexstudy			Lexcontrol			Belcontrol		
	September	January	April	September	January	April	September	January	April
A lot	10%	13%	19%	20%	50%	35%	39%	35%	41%
Some	71%	50%	50%	75%	44%	47%	48%	40%	44%
Not much	16%	38%	31%	5%	6%	18%	11%	25%	13%
Not at all	3%	0%	0%	0%	0%	0%	0%	0%	3%

11. In the Global/American Studies class, I work together with other students:

	Lexstudy			Lexcontrol			Belcontrol		
	September	January	April	September	January	April	September	January	April
Much more often than in other classes	23%	25%	12%	20%	31%	35%	0%	3%	13%
More often than in other classes	61%	42%	35%	55%	13%	41%	23%	18%	25%
Just as often as in other classes	16%	33%	46%	20%	56%	24%	50%	63%	47%
Less often than in other classes	0%	0%	8%	5%	0%	0%	23%	18%	16%
Much less often than in other classes	0%	0%	0%	0%	0%	0%	0%	0%	0%

12. How much experience do you have with PC's/Macintoshes?

	Lexstudy			Lexcontrol			Belcontrol		
	September	January	April	September	January	April	September	January	April
A lot	32%	42%	46%	30%	31%	50%	48%	43%	60%
Some	52%	50%	46%	40%	38%	44%	39%	48%	30%
Not much	13%	8%	8%	10%	13%	6%	9%	5%	7%
None	3%	0%	0%	15%	13%	0%	2%	0%	3%

13. How much experience do you have with The Internet?

	Lexstudy			Lexcontrol			Belcontrol		
	September	January	April	September	January	April	September	January	April
A lot	6%	21%	15%	25%	25%	18%	5%	18%	10%
Some	23%	29%	31%	10%	25%	24%	16%	20%	32%
Not much	29%	46%	50%	15%	31%	59%	41%	28%	29%
None	42%	4%	4%	50%	19%	0%	36%	30%	29%

14. How much experience do you have with World Wide Web (WWW)?

	Lexstudy			Lexcontrol			Belcontrol		
	September	January	April	September	January	April	September	January	April
A lot	6%	17%	15%	5%	13%	12%	5%	13%	6%
Some	3%	21%	31%	15%	31%	24%	7%	8%	26%
Not much	29%	42%	38%	10%	31%	65%	9%	20%	29%
None	61%	21%	15%	70%	25%	0%	77%	55%	39%

15. I use computers for:

	Lexstudy			Lexcontrol			Belcontrol		
	September	January	April	September	January	April	September	January	April
Learning	84%	92%	73%	75%	50%	65%	55%	65%	65%
Playing games	84%	88%	88%	95%	94%	94%	82%	85%	74%
Work	90%	92%	77%	95%	100%	88%	84%	88%	87%
Programming	19%	17%	19%	15%	13%	12%	7%	10%	13%
Other	19%	0%	15%	15%	19%	18%	30%	28%	16%
Nothing	3%	0%	0%	0%	0%	0%	7%	0%	0%

16. In my opinion, computers are really good for:

	Lexstudy			Lexcontrol			Belcontrol		
	September	January	April	September	January	April	September	January	April
Learning	77%	92%	85%	80%	56%	76%	75%	78%	77%
Playing games	81%	92%	88%	85%	75%	82%	70%	75%	71%
Work	97%	100%	81%	95%	88%	82%	86%	90%	87%
Programming	35%	42%	42%	50%	19%	29%	43%	40%	52%
Other	10%	0%	8%	10%	13%	18%	30%	23%	0%
Nothing	0%	0%	0%	0%	0%	0%	0%	0%	0%
I don't know	3%	0%	0%	0%	0%	0%	7%	3%	3%

17. What are the three most important current events in the news today? For each of these current events, where did you learn about it?*

	Lexstudy			Lexcontrol		
	September	January	April	September	January	April
Most important current event	China (48%) Bosnia (42%) Simpson trial (24%)	Bosnia (73%) Nigeria (27%) Whitewater (20%)	Unabomber is caught (50%) Ron Brown's death (45%) Mad-cow disease (30%)	Simpson trial (87%) Shootings and murders (27%) Bosnia (13%)	Not enough responses received.	7-yr. old dies in crash (73%) Ron Brown's death (45%) Unabomber is caught (18%)
Where I learned about it	TV (68%) Newspaper (43%) Class (43%)	TV (73%) Newspaper (33%) Class (33%) Computers and Internet (33%)	TV (72%) Class (39%) Newspaper (28%)	TV (80%) Newspaper (40%) Magazine (20%)	Not enough responses received.	TV (80%) Newspaper (30%) Parents (30%)

	Belcontrol		
	September	January	April
Most important current event	Simpson Trial (64%) Bosnia (52%) Shootings and murders (18%)	Bosnia (40%) Presidential election (37%) Whitewater (26%)	7-yr. old dies in crash (69%) Ron Brown's death (34%) Unabomber is caught (31%)
Where I learned about it	TV (73%) Newspaper (48%) Magazine (11%) Radio (11%)	TV (83%) Newspaper (57%) Radio (14%)	TV (82%) Newspaper (43%) Friends or other people (18%)

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* For question 17, only the three most popular answers are included.

18. How often would you like the teacher to use *Internet CNN NEWSROOM* during Global Studies class?

	Lexstudy January	Lexstudy April
More often than we use it now	42%	17%
Just as often as we use it now	54%	54%
Less often than we use it now	0%	29%

19. Which of the following tasks do you know how to do on your own using *Internet CNN NEWSROOM*?

	Lexstudy January	Lexstudy April
Play a news story	25%	29%
Find past news stories about a particular subject	29%	38%
Use the information in the news stories for your class projects and reports	38%	21%
Copy video, pictures or text from the news stories into your class projects and reports	13%	17%
None of the above	46%	46%

20. Which of the following tasks would you like to be able to do on your own using *Internet CNN NEWSROOM*?

	Lexstudy January	Lexstudy April
Play a news story	63%	75%
Find past news stories about a particular subject	67%	46%
Use the information in the news stories for your class projects and reports	83%	54%
Copy video, pictures or text from the news stories into your class projects and reports	71%	46%
None of the above	4%	13%

21. What do you like *most* about Internet CNN NEWSROOM?

Lexstudy January	Lexstudy April
Search capabilities (35%)	Informative (56%)
Easy to use (20%)	Search capabilities (13%)
Informative (20%)	Easy to use (13%)
Nothing/Don't know (15%)	Multimedia (13%)
Multimedia (10%)	Fast (13%)
Fast (10%)	Interesting (6%)
Interactive (5%)	Up to date (6%)
Up to date (5%)	On demand (6%)
Clear stories (5%)	
Fun (5%)	

22. What do you like *least* about Internet CNN NEWSROOM?

Lexstudy January	Lexstudy April
Pauses (50%)	Pauses (53%)
Not able to use it (15%)	Don't know how to use (13%)
Don't know how to use (10%)	Not enough content (13%)
Boring (10%)	Boring (7%)
No complaints (10%)	Does not always work (7%)
Not enough content (5%)	Worksheets (7%)
Cuts off end of story (5%)	Not used enough (7%)
Worksheets (5%)	Slow response (7%)

Bibliography

Anderson, Ronald E. , ed. (1993). Computers in American Schools, 1992: An Overview. Minneapolis: University of Minnesota.

Barreca, Stephen (1994). Connecting the Schools to the National Information Infrastructure. Paper prepared for the Telecommunications Technology Forecasting Group.

Bulkeley, William M. (1995). "Back to School." The Wall Street Journal. November 13, 1995: R1.

Burkart, Alice, Saul Rockman and John Ittleson (1991). Touch the World: Observations on the Use of CNN Newsroom in Schools. Chico, CA: California State University, Chico.

Burns, Pat (1994). Models and Associated Costs for Connecting K-12 to the Internet. University of Colorado. Unpublished report.

California Department of Education (1994). Building the Future: K-12 Network Technology Planning Guide. Sacramento, CA: California Department of Education. gopher://goldmine.cde.ca.gov/11/C_D_E_Info/Technology/Guide

Carlitz, Robert and E. Hastings (1994). Stages of Internet Connectivity for School Networking. Common Knowledge: Pittsburgh White Paper. http://info.ckp.edu/publications/stages/stages.html

Center for Advanced Engineering Studies (1994). Networked Multimedia Information Services Proposal. Grant proposal to the National Science Foundation. http://nmis.nmis.org/AboutNMIS/Proposal/contents.html

Compton, Charles (1995). Internet CNN Newsroom : The Design of a Digital Video News Magazine. Massachusetts Institute of Technology thesis.

Compton, Charles and Paul Bosco (1995). Internet CNN NEWSROOM: A Digital Video News Magazine and Library. Presented at 1995 ICMCS Conference. http://nmis.nmis.org/AboutNMIS/Papers/icmcs95.1/contents.html.

Glennan, Thomas K. and Arthur Melmed (1996). Fostering the Use of Educational Technology. Santa Monica, CA: RAND. http://www.rand.org/publications/MR/MR682/contents.html

Harvey, James, ed. (1995). Planning and Financing Educational Technology. RAND Critical Technologies Institute report prepared for the Office of Educational Technology, U.S. Department of Education. Report #DRU-1042-CTI.

Hezel Associates (1994). Educational Telecommunications: The State-by-State Analysis 1994 Executive Summary. Syracuse, NY: Hezel Associates.

Hunter, Beverly (1992). "Linking for Learning: Computer-and-Communications Network Support for Nationwide Innovation in Education." Journal of Science Education and Technology, 1(1):23-33.

Information Infrastructure Task Force (1994). Putting the Information Infrastructure to Work. Washington, DC: U.S. Government Printing Office NIST Special Publication 857. gopher://iitfcat.nist.gov:95/11/

Keltner, Brent and Randy Ross (1995). The Cost of High Technology Schools. RAND Critical Technologies Institute report prepared for the U.S. Department of Education. Report #DRU-1066-DoED/CTI.

Kulik, Chen-lin and James Kulik (1991). "Effectiveness of Computer-Based Instruction: An Updated Analysis." Computers in Human Behavior, 7:75-94.

Massachusetts Department of Education (1996). Commonwealth of Massachusetts Department of Education School Finance Services Web Page. http://www.doe.mass.edu/doedocs/ppesum.html

Massachusetts Municipal Profiles (1995). Palo Alto: Information Publications.

Massachusetts Telecomputing Coalition (1994). Models for Connecting K-12 Schools to the Internet: A Guide for Decisionmakers. Cambridge, MA: Massachusetts Telecomputing Coalition.

McFadden, Kay (1995). "N.C. Info Highway Toll Pricey." The Charlotte Observer. May 21, 1995: 1A.

McKinsey (1995). Connecting K-12 Schools to the Information Highway. Report prepared for the National Information Infrastructure Advisory Council. http://cavern.uark.edu/mckinsey/contents.html

Merton, Robert K., Marjoire Fiske, and Patricia L. Kendall (1990). The Focused Interview. New York: Free Press.

Milken Institute for Job and Capital Formation (1995). 1994 Survey of Chief State School Officers. Unpublished report.

Mishler, Elliot G. (1986). Research Interviewing: Context and Narrative. Cambridge: Harvard University Press.

National Center for Education Statistics, U. S. Department of Education (1993). Digest of Education Statistics. Washington, DC: U.S. Government Printing Office.

National Center for Education Statistics, U. S. Department of Education (1995). Advanced Telecommunications in U.S. Public Schools, K-12. Washington, DC: U.S. Government Printing Office. gopher://gopher.ed.gov:10000/11/publications/ majorpub/digest/94

National Research Council (1994). Realizing the Information Future: The Internet and Beyond. Washington DC: National Academy Press. Computer Science and Telecommunications Board Report. http://www.nap.edu/nap/online/rtif/

NetTeach News (1995). "Cisco Announces the Virtual Schoolhouse Grant Program." 3(6):16. http://www.chaos.com/netteach/Vol3No6.html

Newman, Dennis, Susan Bernstein and Paul Reese (1992). Local Infrastructures for School Networking: Current Models and Prospects. Bolt, Beranek and Newman Inc. Report No. 7726.

Oettinger, Anthony (1969). Run, Computer, Run: The Mythology of Educational Innovation. Cambridge, MA: Harvard University Press.

Olson, Robert, Mary Gardiner Jones and Clement Bezold (1991), 21st Century Learning and Health Care in the Home: Infrastructure Choices. Institute for Alternative Futures and Consumer Interest Research Institute.

Public School Forum of North Carolina (1994). Building the Foundation: Harnessing Technology for North Carolina Schools & Communities.

Rothstein, Russell I. (1994). Connecting K-12 Schools to the NII: Technology Models and Their Associated Costs. Discussion paper prepared for the Office of Educational Technology, U.S. Department of Education, August 1994. http://rpcp.mit.edu/People/Rir/k12costs.html

Rothstein, Russell I. and Lee McKnight (1995). "Architecture and Costs of Connecting Schools to the NII." Technical Horizons in Education Journal, 23(3): 91-96. http://www.thejournal.com/past/oct/510roth.html

San Jose Mercury News (1996). "Clinton Makes Cyberspace Connection." March 10, 1996. http://www.sjmercury.com/news/local/netday/net310b.htm

Sellers, J. and J. Robichaux (1995). Frequently Asked Questions for Schools. Internet Engineering Task Force (IETF) RFC #1578. http://www.internic.net/rfc/rfc1578.txt

Software Publishers Association (1994). SPA K-12 Education Market Report. Washington DC: Software Publishers Association.

Tejada, Carlos (1995). "Those Who Can't..." The Wall Street Journal. November 13, 1995: R6.

Telecommunications Industries Analysis Project (1995). Schools in Cyberspace: The Cost of Providing Broadband Services to Public Schools. Presented at the July 1995 NARUC meeting, San Francisco, CA.

Templin, Neal (1995). "The Bottom Line" The Wall Street Journal. November 13, 1995: R24.

Urban, Glen L. and Hauser, John R. (1993). Design and Marketing of New Products, Second Edition. Englewood Cliffs, NJ: Prentice Hall.

U.S. Congress, Office of Technology Assessment (1988). Power On! New Tools for Teaching and Learning. Washington DC: U.S. Government Printing Office.

U.S. Congress, Office of Technology Assessment (1995). Teachers & Technology: Making the Connection. Washington DC: U.S. Government Printing Office. ftp://gandalf.isu.edu/pub/ota/teachers.tech/

U.S. Department of Commerce Census Bureau (1996). Census Bureau WWW Home Page. http://www.census.gov/

U. S. Department of Education (1994). Digest of Education Statistics. Washington, DC: Government Printing Office. gopher://gopher.ed.gov:10000/11/publications/majorpub/digest/94

Weir, Sylvia (1992). Electronic Communities of Learners: Fact or Fiction. TERC working paper 3-92. gopher://gopher.hub.terc.edu/00/hub/owner/TERC/CET/electronic_txt

Whitehead, A. N. (1929). The Aims of Education. New York: Macmillan.

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