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Final Summary Report

Technology Integration in Chicago Public Elementary Schools, 1997–1998

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Executive Summary

This report presents key findings from research conducted in the Chicago public school system during the 1997–'98 school year. The goals of this research were:

- To determine how elementary schools that have chosen to invest energy and resources in making technologies an important part of their work are currently making use of those technologies.
- To identify promising practices and models currently being used in schools.
- To identify key obstacles to making use of technology.
- To explore what connections are being made, or could be made, between technology initiatives and school reform efforts in Chicago.
- To explore how teachers and administrators in this sample of schools, as well as relevant district personnel and representatives of the school reform community, understand the current and potential role that technology plays in supporting the process of strengthening Chicago's elementary schools.

Based on observations and interviews in ten schools and interviews with a wide range of education stakeholders in Chicago's central district offices, school reform organizations, and universities, we concluded that while the hurdles to successful technology integration are significant, many large- and small-scale efforts are under way to make technology a central part of the process of school improvement in Chicago. In the schools in our sample, at the district level, and in a number of innovative outreach programs, major investments are being made in infrastructure development, hardware purchasing, and support personnel. Teachers are discovering and exploring innovative applications for technology in their classrooms through alternative curriculum programs, peer coaching, and their own experimentation. Principals in these schools are making their technology programs central to their overall vision of school improvement and educational achievement.

However, serious obstacles exist that make meaningful technology use an everyday struggle in all of these schools. Strong accountability measures that discourage experimentation in favor of drills and memorization, lack of clarity in school leaders' visions of the role technology should play in their overall school program, limited opportunities for professional development, inadequate building-level technical support, and inadequate electrical wiring and aging school buildings are all major obstacles we encountered in many schools in this study.

We have found that the following set of factors interact with one another in each of the schools we studied. Taken together, they play a central role in determining how capable each school will be of capitalizing on their existing resources and moving forward from their current state of technology integration. These factors are:

- **Robust technology:** Having an infrastructure that works well enough to support the work that teachers and students are doing.
- **Freedom to innovate and experiment:** Having a shared belief within the school that it is more important to try new things and improve one's practices over time than to stick with practices that are safe but limited.
- **Diversity of application:** Having more than one kind of technology use going on in the school, so that teachers with different levels of experience and different interests can find points of entry that will allow them to get involved in technology use.
- **Depth and quality of staffing:** Having the right combination of people on the school staff to cover all the various components (teaching, planning, maintaining) of advancing technology integration in the school.
- **Professional development:** Providing a range of sustained, collegial, and immediately relevant opportunities for teachers to build their technology skills and learn about ways that technology can support their teaching.

Recommendations

1. **Enhance and coordinate support resources for developing and maintaining technology infrastructure in schools.** All schools, not only those in Chicago, have begun to face increasingly sophisticated technical choices and increasingly demanding technical support requirements. Consequently, it is crucial to establish an effective interplay between centralized technology functions and services and individual situations in local schools. Chicago should consider means to provide enhanced coordination and sharing of information between the central board and schools, and among schools themselves. This would enable enhanced coordination between those aspects of infrastructure that benefit from being centralized and those that need to be dealt with at the school level. Key issues for enhanced coordination include decisions about hardware and networking acquisition and upgrading; software choice and acquisition; and sustained, responsive technical support.

2. **Enhance and sustain school-level leadership that focuses on instructional uses of technology.** It has been repeatedly demonstrated that school-level leadership is key to successful school-wide innovation; effective technology use is no exception. Many effective leaders in schools are deploying technologies well, yet these leaders are largely isolated. Overall, few of these leaders have sufficient and sustained support for their efforts. They also have little opportunity to share their knowledge broadly with other school leaders, or to benefit from the experiences of others. These leaders are a key resource to draw on to advance the effective infusion of technology throughout Chicago's schools to improve teaching and learning. Developing means and mechanisms to systematically support and benefit from the experience of these leaders is important. This can be done in a number of mutually reinforcing ways, including use of electronic networks and the creation of a district-wide group that focuses on coordination of knowledge and effort throughout the system.
3. **Invest in and leverage the skills and knowledge of teacher-leaders.** We found a number of very dedicated, knowledgeable, and creative teachers using technology quite effectively for learning in their classrooms. These teachers largely work in isolation from others, even within their own schools. These isolated pockets of expertise need to be made more broadly available to others in the Chicago schools. A system needs to be developed that enables Chicago public school teachers to learn effectively and efficiently from one another about the infusion of technology into curriculum. This would also enable more systematic deliberation about how to shape future directions and choices in this arena. Teachers prefer to learn from one another, and Chicago now has a number of teacher-leaders in technology; a system should be developed, in part using networking technologies, that enables sharing of expertise and practice and can also facilitate appropriate deliberations with school- and district-level leaders.
4. **Expand the corps of Technology Resource Network Consultants and support their continuous professional growth.** The TRN model is a good approach to providing guidance to schools on the integration of technology. However, there are far too few TRNs to meet current demand and need in the schools. The corps needs to be substantially expanded if this model is to be a realistic solution for technical and curriculum support city-wide. In addition, all members of the corps will continue to need ongoing training that deepens their knowledge of the

integration of technology and keeps them abreast of new technological advances and new ways of using these resources in teaching and learning.

5. **Address what many schools and teachers experience as discontinuities between what they perceive to be effective uses of the new technologies and accompanying instructional practices, and the demands of the current student assessment system.** These perceived contradictions are not readily solved dilemmas. A strategy for addressing the competing demands for innovative technology-enhanced instructional practices on the one hand, and the traditional methods that are associated with performance on current assessments on the other, needs to be created.

6. **Encourage different kinds of "design experiments" using technologies to improve learning and teaching, and systematically investigate their effects.** New technologies that have become widely available to schools in the last couple of years (e.g., pervasive connectivity, greatly enhanced storage, visual and multimedia capacities, sophisticated production tools for consumers) have the potential to support new encourage teachers and leaders to conduct innovative "design experiments" with technology and curriculum. The designs should be studied so that we better understand ideas that work well and those that don't, and the conditions under which they are successful. Systematic innovation in local schools and classrooms needs to be encouraged; careful monitoring of these designs, and the formative evidence that can be gained from them, is crucial to effective decision making throughout the district.

7. **Invest in comprehensive professional development and preparation of teachers to use technologies well.** The decision to use technologies pervasively in schools is a decision to do business differently from that point forward. Professionals must learn to use the tools available to them in their work. Like businesses, school districts need to put in place programs that are intensive and sustained, so that professionals can continually develop more sophisticated knowledge about and facility with new technological resources. Coordinated programs that prepare teachers to use technologies well are needed; beyond isolated workshops, these resources should be infused into all professional development programs in the district (e.g., programs that develop enhanced expertise in reading instruction). In addition, the overwhelming majority of new teachers nation-wide are not being prepared to use technologies in their teaching. Attention to and collaboration with local teacher education programs will also be important in developing a technologically knowledgeable teaching population.

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Overview of the Project

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- To explore how teachers and administrators in this sample of schools, as well as relevant district personnel and representatives of the school reform community, understand the current and potential role that technology plays in supporting the process of strengthening Chicago's elementary schools.

School personnel participating in this study were informed that all information they provided would be kept confidential. Consequently, pseudonyms are used for all schools and school personnel discussed in this report.

How the Work Was Done

This study included two major strands of work. First, we identified a group of nine Chicago elementary schools and one middle school that had made technology acquisition and use a major priority in their school program; case studies were conducted in each of these schools. Second, we interviewed a wide range of stakeholders and policymakers working with the Chicago public school system, including district office representatives, university faculty, researchers, education advocates from nonprofit organizations, and others.

In selecting the sample for this study, we categorized candidate schools, based on initial information, as "struggling," "intermediate," or "advanced" in the process of meeting their own goals for technology integration. "Struggling" schools had a technology plan and were attempting to implement it, but were hampered by inadequate resources or other obstacles. "Intermediate" schools had some support from a full- or part-time technology coordinator as well as an investment in hardware and software, but were not fully utilizing the resources available to them. "Advanced" schools had a technology coordinator, some established professional development

practices related to technology, and some present fusion of technology into existing classrooms. Our final sample of schools included two categorized as "struggling," four "intermediate," and four "advanced." These initial categorizations are used in the discussion section of this report.

In addition to making sure that our sample included schools at various stages in the process of technology integration, we sought to diversify the sample across many variables, including school size, poverty levels, mobility rates, number of students with limited English proficiency, geographic location, race/ethnicity of students served, and whether or not the schools were involved in the Chicago Systemic Initiative.

Study Rationale

Three factors coming together over the past few years have made it more urgent and more meaningful to study the planning, implementation, and use of computer and network technologies for teaching and learning in large urban school districts like Chicago. Further, it is now possible to begin to learn from such research what next steps districts might best be advised to take in order to build on existing strategies to create systemic, equitable programs for technology implementation and integration.

First, the nature of the available technology itself has changed. Computer hardware steadily continues to become more powerful and less expensive; options for connecting to the Internet are becoming more robust, more accessible, and more reliable; and the sophistication and scope of digitally archived resources relevant to education, accessible through CD-ROMs, websites, videodiscs, and other media are expanding exponentially. Taken together, these steady improvements in the power, diversity, and ubiquity of the relevant technologies mean that they can now realistically be expected to play central roles in addressing a wide range of educational challenges.

Further, two ways of thinking about how technology should be adopted have made significant inroads into the mainstream of thinking about educational technology. Based on extensive research and the practical experiences of thousands of schools and school districts, educators are recognizing that technology can be an effective source of support or intervention in schools only when a number of other factors are in place as well. Hardware or networks deployed on their own are usually destined to obscurity—making technologies a well-used part of a school's infrastructure means introducing not only hardware and networks but sustained and appropriate professional development opportunities for teachers and administrators, adequate and reliable technical support, and a clear vision of the relation of the technology to the larger teaching and learning goals of the school.

This last point, the need for a strong connection between technology use and larger goals for school improvement, is gaining wider recognition, and this is the third change altering the outlook for the educational technology community. Educators are beginning to broadly recognize that technology is meaningful to a school or a district only to the extent that it is introduced as a contribution to solving some set of significant educational challenges. Without such a charge, adapting to technology-rich practices seems to require too many new skills, too much adaptation of practice, and too many new ideas about how communication happens among teachers, between teachers and students, and between teachers and administrators. But when a clear vision of the role technology can play in reaching a common goal or causing needed change is in place, the challenges associated with the technology itself become manageable, because they become steps taken toward a larger goal.

While these changes are unfolding, the stakes and opportunities for wasting financial resources and personal effort are also rising rapidly. Investments in networking for schools have exploded over the past five years and show no signs of slowing in the near future. Meanwhile, the factors shown to play a major role in determining the effectiveness of a school's or district's technology planning—sustained and consistent leadership, coordination among service providers and components of the educational system, and clear and specific alignment of technology and educational goals—are all factors over which individual teachers and even individual schools typically have little control. Therefore, it has become important to study these issues at a district level, especially in large urban districts, where these factors are most likely to be complex and difficult to coordinate, but where some of the biggest rewards could potentially be reaped through successful deployment and application of new technologies.

Therefore, it becomes important to look both broadly and deeply at the Chicago public schools to determine what *is* being done, what *could* be done, and what major *obstacles* stand in the way of progress. In all districts, and particularly in large ones, there are multiple pockets of activity—networks of people or schools who have managed to move ahead of the pack in developing their technology infrastructure, who have innovative and exciting visions of how technology can support their teachers and students, and who are making the effort to learn about what is happening with technology use both within and beyond the district. The work done by these often isolated groups and individuals is valuable, but there is little opportunity for it to feed into any systemic process of dissemination, experimentation, modeling, or extension across the district. This report is, in part, an effort to synthesize the knowledge and experiences of these pioneers.

Connections to School Reform

Another focus of this study is to consider how technology is serving the purposes of education reform in Chicago. In part, this means examining the connections being forged between technology use and the kinds of teaching and learning practices valued in individual classrooms. But it also means exploring whether and how technology is being used to support programmatic reform efforts in the district. Are the major education reform organizations in Chicago exploring how new technologies might support their efforts? Are reform groups that work with teachers including technological solutions in the range of methods and resources they share with teachers and administrators? We have included a consideration of these issues in this study.

What Does Effective Technology Use Look Like?

This research explores the current situations in schools with respect to the uses of technologies, particularly for purposes of contributing to educational improvement. These improvements include not only learning outcomes, but also the organization and social aspects of instruction in the schools, the professional growth of teachers, and connections with students' homes and the local community. In this project, we sought to identify the strengths and challenges of each school's situation, the resources and partnerships that support their efforts, and the relationships with the larger school system and community that help them realize effective uses of technologies.[1]

Understanding and describing what promising practices exist in the schools, and what applications of technology are occurring that seem to be effective, requires making explicit the framework that structures our interpretations of our observations. Our organization brings a particular perspective to bear. We understand technologies to be a flexible and potentially powerful set of tools that can best be used to support teachers and students in undertaking work that engages students in active negotiation with artifacts and ideas; that is resource-rich; that puts the student at the center of a process of question-asking, research, critical evaluation, and revision; and that allows the teacher to expertly deploy a flexible repertoire of strategies as appropriate to students' needs and the teaching of rigorous content. This includes, for example, the knowledge and the ability to act as a coach, supporting students in the pursuit of knowledge rather than delivering information to them to be passively absorbed.

This perspective is based on research in developmental and social psychology, cognitive science, and educational anthropology, and is consistent with the approaches advocated in the Illinois State Standards for Learning. A growing body of research

[1] It is important to note that partnerships with external organizations, including universities, community-based organizations, and grant-making organizations, are playing prominent roles in supporting technology integration in the Chicago schools. Throughout this report there will be references to a range of external organizations that have partnered with schools to provide a range of support services, often combined with research initiatives. These services include technical training, collaborative curriculum development, technical support, and access to summer programs.

provides convincing evidence that carefully designed and well-planned technology infrastructures, software, and technology-rich curricula can support teachers and students by providing rich learning environments, improved circumstances for working and communicating, and access to images, resources, and people that would not otherwise be available (Chang et al., 1998).

Current National Context

Where can technology fit into the complex process of school improvement? Experimentation is occurring all over the country as schools use technology to change patterns of communication within and beyond the school building; give students access to more complex and more up-to-date resources than ever before; give teachers ways to build and explore collegial communities extending far beyond their individual schools or districts; and challenge existing curricular frameworks with opportunities for long-distance collaboration, complex data analysis, exploration of authentic resources, and critical examination of political and cultural artifacts on a daily basis. Schools engaging in this process are discovering that it can be rewarding but also difficult—it requires balancing a whole range of demands and tensions as multiple components of the school structure undergo simultaneous shifts. Making technology central to teaching and learning in a school can be a key contribution to changing communication patterns, curriculum structures, assessment, the work that students do, and the roles students take on in their classrooms. Coordinating all of these changes so that they work together rather than compete is difficult for even the most experienced and committed educators.

Networking—connecting individual computers to one another, to peripherals, to local- and wide-area servers and to the Internet—has gained prominence over the past four years as the central goal for schools interested in improving their technology infrastructure. This rapid growth in network investment has led to a geometric increase in the complexity of the technical infrastructures that districts and individual schools are being asked to support. Schools across the country are developing new job categories, new relationships with hardware vendors and technical support providers, and new roles for parents and even students as they try to develop the expertise required to keep hardware, software, and networks running smoothly. At the same time, issues related to hardware procurement, upgrade paths, and software licensing continue to be major hurdles to equitable and efficient school technology development nationwide.

While schools are coming up with all kinds of creative short-term solutions to these challenges, school staffing structures are not yet being seriously reworked to provide the type or level of support that schools increasingly need. Also, vendors have not yet found many ways to meet schools' needs effectively—business solutions and the kinds of ongoing support available to businesses are typically the only options

offered to schools, and these are rarely the solutions that schools really need. Piecemeal networks, a diverse hardware base, aging physical plants that cannot be upgraded, idiosyncratic security requirements, and erratic funding streams can all converge to make schools into clients that discompose existing corporate models for technology purchasing and installation.

Local Context

Chicago is the third-largest district in the nation (excluding Puerto Rico), serving close to half a million students in more than 550 schools. Its schools range from brand-new buildings built with funds from the current capital improvement campaign, to buildings more than 100 years old with foot-thick walls and outdated electrical wiring. In the Chicago public schools, 83 percent of the student body is classified as low-income; there is an average 29 percent mobility rate; 89 percent of students in the district are from racial/ethnic minorities, and 15.4 percent are classified as limited-English proficient.

Poverty brings multiple, difficult challenges to bear on all educational issues, technology access included. Public schools that serve large numbers of students living in poverty provide to their students, on average, less access to computers and to the Internet, teachers who are less well-trained in using technology, and a narrower range of types of technology than wealthier schools and districts. For example, schools serving students in poverty are less likely to have Internet access: in 1996, 75 percent of schools serving wealthy student populations had Internet access, compared to 55 percent of schools serving students living in poverty (Coley, Cradler, & Engel, 1997). The challenges of providing adequate teacher training around technology use have been found to be more acute in schools in poor communities than in other, wealthier districts (Carnegie Corporation, 1996). And finally, the technology available to low-income students is more likely to be direct instruction-type technologies such as integrated learning systems, rather than a range of tools for student research or the production of original work, which are more likely to be used by their wealthier counterparts (Carnegie Corporation, 1996). These inequities in school technology use are not likely to be resolved at home, since home access to computers and to the World Wide Web has been strongly correlated with family income. For example, one study reports that while 80 percent of families with incomes of more than $100,000 a year have computers, only 25 percent of families with incomes of less than $30,000 a year have computers (Computer Intelligence, 1998).

Documenting national inequities is important, but these statistics do not tell the whole story. As we demonstrate in this report, when schools serving urban, largely impoverished populations choose to invest financial and personal resources in planning for, acquiring, and implementing a technological infrastructure, they can

succeed in making technology central to their educational program. This is a difficult process that demands flexibility, creativity, and a willingness to experiment on the part of everyone involved. This report documents the achievements of a group of schools in Chicago that have taken on this challenge. It also describes lessons learned from their experiences, challenges they continue to face, and ways other schools might best be supported in similar efforts.

The Goal

Integrating technology into teaching and learning is hard to do, but we know that some schools have taken on this challenge and that some exciting, innovative experiments are under way. What can we learn from the experiences of educators in these schools and the challenges they face, and how can we support other schools trying to do similar things?

Infrastructure Issues

This section provides an overview of how the schools in this study are navigating the process of developing their technological infrastructures, and the sources of support that are available to them. First it reviews the nature and goals of the Department of Learning Technologies at the district offices of the Chicago public schools. Then it provides a brief description of the existing hardware, software, and networking bases in the schools included in this study.

Issues discussed in this section include:

- *The Department of Learning Technologies' mission and their four key areas of work.*
- *The district's strategy for designing and building a wide-area network.*
- *The strengths and limitations of the district's TRN program, which employs former CPS teachers as roving technology consultants to the schools.*
- *The range of hardware and software being used in the schools, as well as their Internet connections and local-area networks.*
- *The funding strategies used to support the schools' technology programs.*
- *The challenges of developing adequate in-house expertise and adequate access to outside advisors to support the increasingly complex technological infrastructures these schools are implementing.*
- *The role outside organizations are playing in providing technical support to these schools through a range of volunteer and non-profit programs.*

Overview

The technological infrastructures of the schools in this sample varied widely. Every school was different in its particular configuration of classroom and lab-based computers. School networks varied from lab-only LANs with no Internet access to school-wide LANs providing access to servers and the Internet from every classroom. Several schools are experimenting with unusual technology infrastructures or applications, including one school with an extensive wireless network, one with an elaborate video production studio, and one with a school-wide video retrieval system. Eight of the ten schools are involved in external programs that are helping to support and expand their uses of technology. Finally, every school in the sample is actively engaged in expanding and updating their computer hardware and in acquiring, updating, or improving a local-area network and access to the Internet.

School-level administrators in Chicago hold a great deal of responsibility for many tasks that in other school districts would be performed by district personnel. Consequently, they have a high level of financial control over their technology investments. For example, school principals in Chicago who choose to invest in technology must negotiate their own contracts with vendors, network consultants, and professional development providers. This unusual situation exists because in 1988 many administrative and financial responsibilities for school management were devolved to the individual school level. In collaboration with locally-elected Local School Councils, individual schools were expected to shape their own curriculum, hire and fire their administrations, and manage support functions such as janitorial and cafeteria services. Since this reorganization, commonly referred to as decentralization, began, budgeting systems have been phased in that give principals and Local School Councils significant control over the planning and purchasing of school resources, including technology. In addition to receiving control over significant amounts of their state- and locally-funded budgets, these school also have local control over an average of $500,000 in annual Title I funding (Hess, 1995).[2]

The district does, however, continue to play an important role in shaping and supporting the use of technology in schools. Since 1990, the district has had a Department of Learning Technologies, which is independent from the Department of Information Technologies (which develops, implements, and supervises administrative computer systems) and exclusively focused on developing and supporting technology for the purposes of teaching and learning in the schools. The Department of Learning Technologies has developed a range of strategies and programs it uses to guide and support schools throughout the system as they plan for, acquire, implement, and make use of educational technology.

Role of the Department of Learning Technologies

The Department of Learning Technologies was created by the district in 1990, along with an administrative MIS department, through the division of the previous, larger Information Technologies Department. Thus, at a relatively early point, Chicago had in place an entire department devoted to the development of strategies for implementing technology in classrooms and labs around the city. Four areas of emphasis define the agenda of the Learning Technologies department:

- The creation of district-wide models to facilitate the adoption of technology in schools.

[2] All but one of the schools in our sample is at or about the district's average percentage of students living in poverty, which is 83%. One school is a magnet and, like many magnets in Chicago, has a significantly lower percentage of students living in poverty (about 25%). This school, consequently, received much less Title I money than the other schools in this sample. They do receive additional funds as a magnet, including the funds that they use to pay for their technology coordinator.

- The provision of services—such as technical support, help in writing technology plans, grant-writing support, and assistance with E-rate application—through the creation of the Technology Resource Network Consultant (TRN) program.
- Coordinating relationships with outside organizations that provide technology resources to some Chicago public schools—such as the Governor's State University intern program or the Chicago University Internet Program (CUIP).
- Developing and disseminating standards and specifications for technology purchasing by schools.

The Wide-Area Network Initiative

The Department of Learning Technologies has placed a high priority on increasing Internet access throughout the district. Consequently, it has invested its energy for the past two years in a major district-level effort to design a wide-area network for the district, currently planned for rollout in fall 1998. Although the Department of Learning Technologies cannot proscribe particular technology configurations for schools, it has developed recommended models for individual school networks that illustrate how this district-level initiative can interact most effectively with the individual schools (such as having a minimum of eight drops per classroom). Buying into the models recommended by the Department of Learning Technologies assures that, to the extent that the department provides technical support, it will be able to support that school. The Department has developed a template for the WAN and has negotiated with vendors to provide, to all schools that choose to buy into the model, the necessary hardware (i.e., a router) and wiring to bring Internet access (via a T-1 line) into the schools. Developing the specific local-area network remains the responsibility of the individual school.

Similarly, by providing centralized training to the TRNs (a group of technical support staff that work directly with the schools, discussed below), the district is able to develop and disseminate its own priorities for technology development in the schools. By being selective about what TRNs are most focused on in their training, the district indirectly influences the messages the individual schools receive when they work with the TRNs.

The TRN Program

The TRN program is an ambitious initiative that came out of the Learning Technologies Department in 1995. Through this initiative, a total of 24 full-time positions were created and filled by former teachers who had an interest in technology and its application in schools. Each of the six regions in Chicago is assigned a total of

four TRNs, which means each TRN is responsible for approximately 25 schools. The TRNs are available to local schools in a variety of capacities—as technical support, as a resource in writing grant applications, as a facilitator with the district for larger funding issues (i.e., E-rate), and even as a resource for professional development.

The TRN program can, in many ways, serve as a model program for other large districts struggling with issues of technology implementation. The idea behind the program is an important one: that schools need a local, accessible resource person responsive to their needs in a wide range of technology-related areas. Several features of the TRN program are particularly important to its strength. First, the TRNs bring an important perception of *legitimacy* to their jobs because they are all former Chicago teachers, so current teachers trust that they understand the contexts in which they are working. Second, the program is designed to provide TRNs with a huge amount of *flexibility*; they have offices in centrally located school buildings, but by their own report they are rarely if ever in them. Further, they are required to attend only one group meeting every two weeks at the district offices. For the rest of their time, they are free to schedule each day on their own, visiting schools as necessary, and they are provided with cell phones and pagers to facilitate their contact with school personnel. Finally, TRNs are able to offer a *real connection* to district-level resources and knowledge to the schools they support. They are regularly briefed on district-level policy decisions, new vendor contracts, and so on and are also privy to informal communication networks at the district offices that keep them "in the know." For schools able to establish significant relationships with a TRN, that person can act as an important source of locally relevant information and support.

In practice, the TRN program inevitably falls short of its own potential, for two main reasons. First, there are simply too few TRNs available to meet all of the needs of all the schools who want their help—the ratio of TRNs to Chicago schools is less than 1:24. Second, most TRNs took on their jobs with more interest than actual expertise in the technical and pedagogical issues related to educational technology. They have received extensive training over the past two years, but inevitably not all of the TRNs yet have the depth and breadth of knowledge they really need in order to serve as jacks-of-all-trades that the program tries to provide and that the schools feel they need.

The TRN program clearly has had some impact on the schools, particularly those schools the TRNs, all former Chicago teachers, have close ties to. In the schools described in this study, we were most often told that teachers and administrators were aware of the TRN program, but that TRNs were too hard to reach and spread too thin to help with problems in a timely way. In several schools with especially knowledgeable and experienced technology coordinators, the TRNs were perceived as having less

expertise than the in-house technology staff, and consequently to be of little help. This raises the possibility that TRNs may be more helpful in schools that are less far along in the infrastructure development process, and that more advanced schools with more in-house expertise may have "outgrown" this resource and should seek another level, or a different kind, of support than the TRNs can currently provide.

School Infrastructures

Hardware

The schools included in this study, which have made a concerted effort to invest in hardware, have been highly successful at leveraging Title I funds and external funding sources to build, over time, significant technological resources in their classrooms and labs. But even in these schools, much of the available hardware is outdated, and technical support is rarely adequate to daily needs.

Each school in our sample had a unique configuration of hardware, software, and networking in place at the time of our visits. It is possible, however, to make certain generalizations to understand the range of hardware investments that these schools are making. First, schools with computer labs have channeled most of their resources toward putting newer, more powerful machines into those labs. As new machines are purchased, older machines are cycled out to the classrooms, leaving teachers with classroom access to less powerful machines. Many of the schools in this sample have chosen to pursue a multi-platform purchasing strategy, which has resulted in a mixed environment of Macintosh and PC desktop machines. Several schools have recently decided to purchase new Windows PCs as opposed to newer Macintosh models, and have generally located these new PC machines in computer labs rather than classrooms.

Classrooms in the schools we visited typically had no more than two machines—the most we saw in one classroom was seven, and in this case the teacher had brought these computers in through her association with an outside partner. Two schools had four computers in all or almost all classrooms. All schools that we visited articulated having at least one computer in every classroom as a primary goal, although several have not yet achieved that target. Almost all of these schools plan to upgrade their hardware in the near future and are involved in budgetary planning toward this end. The exceptions are two schools that have made substantial recent investments in hardware—their funding focus is understandably elsewhere, specifically on stabilizing or expanding their networks, a goal that other schools are also working toward.

Because the percentage of students living below the poverty line in Chicago is so high (83 percent), federal Title I funds have a large impact on Chicago's public

schools. In seven of the ten schools we visited, significant parts of their Title I funds were dedicated to purchasing computer hardware (this was in addition to using Title I money to fund staff positions, such as technology coordinators). For example, one school we visited in Region 6 had recently outfitted two new computer labs by spending money from that year's school budget, primarily Title I funds. This translated into the purchase of 60 new Pentium-class machines and a local-area network (LAN), at a total cost close to $300,000. The school sees this as a one-time expenditure and has no plans to upgrade the computers now in classrooms.

Another school in Region 4 has spent considerable Title I funds on hardware over the course of the five years it has been in existence. Built in response to overcrowding in neighboring schools, the school had an opportunity to design and develop its technology program from the ground up. Starting with older, un-networked Apple computers, the lab underwent a major upgrade around 1996 to more modern machines. In this case, investments made with Title I funds are part of a larger technology strategy that includes funding from many sources, including state and private grants. The administration, therefore, has more flexibility with its Title I funds and uses them to pay part of the technology coordinator's salary.

All of the schools in this sample have or had both computer labs and computers in the classroom. Unlike many districts, we did not find the "labs or classrooms" debate to be intense in Chicago; we saw many different combinations of lab-based and classroom-based technology use within individual schools.

Software Purchasing

Software used in our sample fell into five main categories: basic tool-based applications (word processors, spreadsheets, graphics programs, Internet browsers); educational games; reference works (on CD-ROM); integrated learning systems; and specialized software tools related to particular curricula (such as the Collaboratory Notebook used by the school participating in the CoVis project).

All schools in this sample had at a minimum some combination of basic tool-based applications and educational games. ClarisWorks was the most commonly used suite of productivity tools, although Windows-based machines ran the Microsoft Office suite. Some schools also used the Student Writing Center. In two of the schools, Macintoshes are used in the early grades and PCs in the upper grades, so students transition from Claris to Microsoft Office in the fifth or sixth grade. Simple graphics programs like KidPix are common in those younger-grade classrooms that have computers up-to-date enough to run the program. Educational games were most prevalent in the early-grade classrooms and many in-classroom computers had a large number of them installed, including titles like MathBlaster, Sammy's Science House, StickyBear Reader, and the Carmen Sandiego series. These kinds of programs

were often distributed throughout the school through shared network arrangements that allowed school-wide access without costly site licenses (a legal arrangement endorsed by software companies). In other cases, games were available on CD-ROMs that were kept on a teacher's desk or near the computer area. Reference works such as Grolier's Encyclopedia and Encarta were often available to students on CD-ROM, both in classrooms and in computer labs.

Two schools in this sample used integrated learning systems, and two other schools had teachers using specialized software developed as part of a specific curriculum. The integrated learning systems were by WASATCH and Ideal Software—in each of these two schools, two labs were outfitted with dedicated integrated learning systems. Schools using specialized, curriculum-specific software included one school participating in CoVis and another participating in the ELDIN project, sponsored by Bill Kurtis Productions. These programs were used by only one or two teachers in each of these schools.

At least half of the schools in this sample have also implemented access-control software (e.g., AtEase) that facilitates network management and allows administrators to limit student privileges on an individual basis.

We observed a divide between classroom teachers' and technology coordinators' priorities in software acquisition. Classroom teachers who had enough computers in their classrooms for students to use them on a regular basis were likely to say that they wanted either more content-specific software or more software that would drill students on specific skills. Technology coordinators were often more focused on increasing teachers' and students' skills with tool-based software, such as spreadsheets, and improving teachers' and students' Internet skills. This divide seems to reflect the difference in the quality of the technology available in the labs and the classrooms. Typically, the more up-to-date computers and the better-quality (or only) Internet access are in the computer labs, while teachers may work in their classrooms with Apple IIe's that do not run graphics programs or Internet browsers well or at all. But some teachers do have computers and Internet access in their classrooms equal to what is available in their school's computer labs; in these cases, it may be that teachers are working from a smaller knowledge base than their technology coordinators'.

Networking

Three schools in this sample have had Internet access since 1994, and eight of the ten schools are fully engaged in wiring all of their classrooms for Internet access. These schools are unusual and ahead of the curve for Chicago schools. Important lessons for other schools can be learned from these schools' experiences with their networking initiatives thus far. The particulars vary widely, but in each case, principals, vice-principals, technology coordinators, and teachers who have taken leadership

positions around technology use have made enormous efforts to learn as much as possible about complex topics, such as negotiating with vendors, estimating costs, and deciding on network designs. They have also sought help from district personnel, friends, and vendors.

Nine of the ten schools had some kind of access to the Internet. Seven have high-speed connections, in the form of a T-1 line; funding for these lines has come through outside partners, state grants, or Title I funds. This is expected to change in the near future, however, as the district plans to begin providing Internet access to all schools through the wide-area network (discussed above). All ten schools had at least one networked computer lab with the ability to print and share files through the local-area network. The majority of the schools have in-house networks that include labs, classrooms, and administrative offices, and also provide Internet access to each computer on the network. However, in every school a considerable number of the computers—sometimes more than 50 percent—are not included on the network, usually because they are older models that are much more difficult to network in the current computing environment.

The age of the school buildings themselves has been a major challenge for several schools as they begin to build their networks. Many schools in Chicago, including the majority in this group, are more than 100 years old, and have walls more than a foot thick, which makes wiring especially labor-intensive and costly. Further, most of these schools have needed a costly electrical upgrade even to support their existing hardware base, let alone supporting the electrical demands of a server or more computers. These physical obstacles have caused some schools to delay or significantly slow down their in-school networking efforts.

Over the past two years, a major capital improvement campaign, which has built 22 new school buildings in the district, has provided more than half of the schools in the district with extra funding for capital improvements. These funds can be earmarked by the individual school for various projects, but the work is being overseen and conducted by the district. In five of the schools in this sample, the capital improvement money has paid for, or been earmarked for, necessary electrical upgrades.

The E-rate, a multimillion-dollar fund set up by Congress to support wiring and infrastructure development in schools, is anticipated to play a major role in funding both the district's wide-area network and individual schools' local networks. The process of applying for the E-rate has been a source of much confusion this year in the schools we visited. As a whole, the Chicago Public School district is pursuing a two-pronged strategy for the E-rate, a choice necessitated by the decentralization of the district. First, the district office is applying as a single entity for discounts toward

the creation and delivery of the wide-area network that is to serve all schools in the district. This plan includes the servers and centralized equipment for the WAN, and a set amount of equipment and wiring for each school in the district. The individual schools, in turn, are expected to submit individual E-rate applications directly to the Schools and Libraries Corporation for discounts on further internal wiring for their local-area network.

Scope of Need for Support and Expertise

Seven of the ten schools in our sample have a technology coordinator (technology coordinators are not included in the standard formula for staffing schools based on student population as, for example, librarians are). Often, the person serving as technology coordinator in these schools also has other duties, such as teaching computer classes or being the school librarian. In addition to teaching or supervising and planning a school's technology program, these individuals typically have significant responsibility for maintaining and implementing a technology infrastructure, performing or procuring regular maintenance, negotiating contracts with vendors, evaluating future purchases, and planning or providing staff development. It seems clear that even with some support from the district, school staff are being stretched to the limit, both in terms of available time and energy and in breadth of knowledge.

In our conversations with administrators across this sample of schools, it became clear that in addition to feeling that they do not always receive adequate support or timely information from the district, they are concerned about what they perceive as a lack of communication among school administrators and teachers around issues pertaining to technology—such as reliable vendors, support services, and curriculum strategies. Schools that might learn from one another's experiences instead make decisions in isolation because, as many principals explained to us, there is neither an effective mechanism in place for information sharing–nor, more importantly, any tradition of collaboration or informal sharing among schools.

Expanding networks increases maintenance needs, which in turn is stretching staff abilities, as technology coordinators, vice-principals, computer teachers, and others are forced to take on roles to which they bring little training or expertise. As needs become more acute, some schools are turning to individuals and institutions from the local community. In one school, a member of the Local School Council called in a contact he had at the Chicago University Internet Project, which led to the school's being wired for Internet connectivity through that organization's efforts. In another, an employee at the local Ford Motor Company plant helped the assistant principal assess bids from local vendors to revamp the school's aging computer labs.

In yet another school a vendor who helped install a video retrieval network has taken a personal interest in the school and regularly visits the technology coordinator with suggestions of new software and interactive products. In all of these cases, the support of individuals has had a real impact on the success of the school's technology programs. But many other schools told us about regrettable mistakes that they believe could be avoided if they were able to plan their purchasing more carefully and more knowledgeably.

The Role of Outside Programs

Independent organizations are also having an impact on the schools we studied. All ten schools had sought out relationships with external organizations over the years that are directly related to their technology programs. The CUIP program, mentioned above, has been active in securing Internet access for a number of schools in the Hyde Park area of Chicago, including one of the schools in this study. However, this program relies on volunteers from within the university community and is consequently limited in the scope of its goals. An intern project run through Governor's State University, which places undergraduates (usually in business, management, or computer science programs) in schools for up to 19 hours a week and pays them as work-study students, has had a positive impact on the viability of the technological infrastructures of the 18 schools it works with. For example, one school we worked in was entirely dependent on their intern to maintain the Netware server and had no plans to train other staff in this area.

In principle, CUIP, the Governor's State intern program, and other programs like them speak well for the concern of the academic community for the schools around them. Such programs are clearly making a difference in the schools they are working with and were spoken of positively in every school we visited that was involved in a collaboration with one of these programs. However, the issues facing Chicago public schools around technology implementation are of a magnitude that requires systematic and long-term solutions. One of the strengths of CUIP and of the intern program is the clarity of their goals—neither presents itself as a means of transforming the teaching practices of schools, but focuses much more on providing technical support and basic training to teachers. In the long run, this is an appropriate position and is reflected in the schools' perceptions of these programs. Teachers, principals, and technology coordinators at the schools that work with these programs were generally very appreciative of the work these organizations are doing. But at the same time, they did not view these programs as a key, transformative force in their own technology program; rather, program staff were viewed as reliable advisers, a sort of "reality check" coming into the school from another perspective and providing support, encouragement, and advice.

Use of Technology

This section describes how technology is actually being used to support student learning and teacher practices in the schools included in this study.

Issues discussed in this section include the following:

- *In-class uses of technology*
- *Uses of technology in computer labs.*

In-Class Use of Technology

In eight of the ten schools in the sample, at least some teachers other than computer lab teachers or technology coordinators are making regular use of computers in their classrooms. In some cases only one or two teachers are involved, and in other cases the majority of teachers in the building are participating. We observed that technology use fell into three general categories: technology use integral to an entire curricular unit, technology used to exhibit or explore a specific content area or topic, and technology used for skills enrichment and free-time activities.

Making Connections to Curriculum

We observed a number of individual teachers or small groups of teachers making ambitious and complex use of technology resources as an integral part of a project or curriculum unit. In these classrooms, teachers used computer capabilities to enhance components of interactive, collaborative projects in ways that would not be possible without technology.

For example, one class of second graders in a South Side elementary school was working on collecting, both from books and a CD-ROM, information about the solar system to put into a HyperStudio presentation for a school-wide language arts fair at the end of the year. The teacher in this class has strong support from a teacher across the hall who had done a similar project the year before with her own second graders and won the school-wide prize for best class project. This teacher's class did a presentation on Japanese folktales; she was taking a computer applications course as a part of her teacher certification program at the time, so she decided to make use of what she was learning. She divided her class into teams to research different aspects of their project; one team of three had worked with her to build the HyperStudio presentation (she did some of the more detailed work herself, such as connecting sound files into the presentation and timing them properly). The teacher was enthusiastic about her own experience the year before and reported that her students (whom she has again this year as third-graders) retained much more information from that project than from any other work they did in second grade: "They still

remember some of the Japanese words they learned, and they've recognized plots of stories we read this year that are similar to the folktales we learned last year."

The teacher with the solar system project was excited about her project and greatly appreciative of the help of the other teacher's help. "I've been calling her up at midnight some nights, saying, 'how do I do this? how do I do this?' And she always helps me. She's been over to my house a whole bunch of times to help me set it up."

Another teacher-driven, technology-rich project we observed was done in a school with a wireless network and a pool of "floating" laptop computers, which afforded a great deal of flexibility in technology use in the classroom. A third-grade teacher at this school was having her students generate a range of questions about the origins, behavior, and impact of El Niño. One research "station" they used was the Internet. They had posted a number of weather maps in the classroom that had been pulled off the Web, and a "question box" on one wall where students could submit questions, not necessarily related to the El Niño project. One student per week was designated the "answerer" and explored the Web for answers to the other students' questions.

A number of other technology-rich projects we observed were sponsored by outside organizations. These included classes participating in FishNet, the ELDIN project, and work with the Collaboratory Project from Northwestern University. Inviting in outside organizations that can introduce teachers to technology-rich curricula developed and tested elsewhere seems to be a promising strategy; these projects often provide support to teachers as they experiment with new materials, new content, and new classroom practices.

Content Supplement

We also observed or were told about a limited number of cases of teachers using computers to make specific connections to the content they were teaching. In one social studies class, students chose a country in the Middle East, searched for facts and pictures on the Internet, and created a webpage presenting their findings about the country. In another class we observed, a paired sixth-grade teacher and science specialist supervised a class of students as they moved through a series of stations, each one involving a different activity related to the rock cycle. One of the stations involved looking at the entry in the Grolier's Encyclopedia CD-ROM, which allowed students to see a QuickTime movie clip of a lava flow and an animation describing the movement of matter through the rock cycle. In each of these examples, the academic content of the work was not very different than it would have been without involving the computer, but the teachers were demonstrating a growing knowledge of the capacities of the technology and, perhaps, moving toward making use of the technology to afford students new kinds of learning experiences.

Enrichment and Free-Time Use

Teachers most commonly described their classroom use of computers as "enrichment" or "free-time" activities that were unstructured, not actively monitored or evaluated by the teacher and not connected to the classroom curriculum. Most of our observations of classroom use were consistent with this description, including such activities as self-monitored student use of educational games like MathBlaster, designed to provide individual reinforcement and enrichment of basic math or reading skills. This kind of use was particularly common in the early grades.

It was also common in early-grade classrooms for teachers to structure student time at computers either by restricting it to a "free-time" activity or by regularly scheduling every student for 15 minutes a day or some similar amount of time. Middle-elementary-grade teachers were more likely to leave student access more open-ended, and we often saw students who had finished an assignment early heading over to the computers to play with a favorite piece of software. Upper-elementary and middle-school students were less likely to make significant use of computers in their classrooms. They were more likely to have scheduled time in computer labs for either applications training (e.g., word processing, spreadsheets), for test-preparation drills on integrated learning systems, or conducting research on the Internet and doing writing or multimedia assignments.

Role of Computer Labs

The majority of the schools we studied have computer labs, but they are used for a wide range of purposes, and student access to them is structured very differently from school to school. Every school in this sample has gone through a process of changing the purposes of its computer labs, and differences in how schools use their labs are strongly related to how far along the schools are in the process of integrating technology into classrooms. One of the schools has an installed integrated learning system in the lab that has been used for years, and four new PCs with Internet access have just been installed. The lab supervisor in this case is a teacher aide whose only training is in administering and managing the integrated learning system, but she is gradually learning about the Internet and is allowing some students to work on the PCs during their scheduled lab time.

Lab use ranges from teaching traditional computer classes, which students attend several times a week to learn how to use various tool-based applications, to being drop-in centers where teachers can either schedule whole-class activities or send students to do research, work on a paper, or do other project work. Only two of the schools have labs equipped with integrated learning systems. In both, students at all grade levels, especially those in the gate years of third, fifth, and eighth grades (those

who take the IGAP tests), visit the labs regularly to use these systems, which are thought to raise students' test scores. Time in the labs is increased for students in the gate grades when testing weeks approach.

At the other end of the scale, two schools used to have computer labs but have entirely dismantled them. At one school, all of the hardware was redistributed into classrooms. In another, shared computer resources are in the library and considered part of the "media center," one of many resources students can use for research and writing projects. The principal at one of these schools explained that the previous principal decided to dismantle the lab because she felt teachers were using it as a holding ground for students who were struggling academically.

We observed that more elaborate project-based work—such as building webpages, creating multimedia presentations, and doing research on-line—seemed more readily accomplished in labs than in classrooms, even when classrooms had Internet access. Two contributing factors seemed to be the increased support and expertise of the computer lab teacher (teachers often reported that they relied heavily on lab teachers to take the lead in such lessons), and more sophisticated technology resources, such as faster computers and more reliable network access. An important exception to this pattern was the school that had both a traditional computer lab and a wireless network with 24 laptop computers—in this school, teachers could work extensively with Web-based student projects in their classrooms.

Summary

In all schools we visited, significant efforts at technology integration of one kind or another have been made. But even the schools making the most progress in establishing meaningful connections between technology and curriculum have had limited success so far in spreading technology use more broadly into the curriculum and into every classroom in the school. There are two important factors that appear to influence the course of technology integration:

- The relationship between goals for technology use and broader school goals for student learning.
- Teachers' perceptions of the benefits or risks of experimentation and innovation in their classrooms.

Goals, Barriers, and Perceptions

This section describes some of the major influences on how technology is being used to support student learning and teacher practices in the schools in this study.

Issues discussed in this section include the following:

- *The importance of setting and communicating clear goals for technology use*
- *Teachers' and administrators' perceptions of the risks and opportunities associated with innovation, including experimenting with new resources and teaching practices connected with making use of technology*
- *The impact of pressure to improve student performance on standardized tests on the use of technology in these schools.*

Using Technology to Meet Specific Needs

At all of the schools we studied, some individual teachers were using technology to meet their own teaching goals but there was seldom any clear connection between the interests and goals of these teachers and the interests of the larger school community. Some schools had clearly determined and evidently agreed-upon (i.e., they were stated similarly by many people interviewed in the school) goals for technology use that did not necessarily connect to an overarching vision of what the school hoped to achieve in any broader context. For example, at Warren Elementary, technology use was primarily intended to improve and enrich students' writing ability, and they seemed to use the technology toward precisely that end. But there was no school-wide focus on writing that the technology initiative fit into; rather, this was an isolated, if worthwhile, goal for technology use. At de Gaulle, teachers seemed to have no shared sense of where the administration expected technology to fit into their teaching, and they felt that they had a high degree of autonomy to pursue their own interests. In this case, technology use was dependent on teachers' individual interests and motivation rather than on any overarching goal.

Matching Technology Use to School-wide Learning Goals

Engaging in a school-wide process of discussing and defining educational goals—ones that are locally meaningful and attainable—is an important part of creating a perceived need and an agreed-upon rationale for incorporating technology throughout the teaching and learning practices of a school. Identifying, articulating, and focusing both teachers' and administrators' values and priorities can improve the implementation of initiatives meant to advance shared goals, including incorporating technology into the curriculum.

How schools make connections between their broad, school-wide goals for learning and their use of technology has implications for the kinds of technology use that occur, how varied or uniform the use of technology is throughout the school, and how easily technology use spreads among teachers. For example, at Drake Middle School, teachers experimenting with technology-rich projects were able to explain the connection between their use of technology and their curricular and pedagogical goals. They were working to provide their students with opportunities for engaged learning and interaction with up-to-date information, and saw the technology available to them as a set of resources helping them achieve that goal. At Marcus Garvey, one of the schools that made extensive use of integrated learning systems, the school-wide focus is on raising test scores through direct instruction, and the technology use in the school has been shaped to help achieve that goal. At South Kenwood, a magnet school specializing in foreign language learning, foreign language teachers found ways to use technology to expand their students' exposure to other cultures and languages through international pen pal exchanges, searching the Web for foreign-language resources, creating multilingual Web resources, and doing on-line research and multimedia presentations about other countries and cultures.

Regardless of the character of the teaching and learning goals—traditional and skills-based, student-centered and project-oriented, or focused on a particular theme or content area—we observed that schools that had built bridges between their interest in technology and their goals for teaching and learning were making important strides toward establishing technology as a central, rather than a peripheral, element of teachers' everyday practices.

Connections to Education Reform Initiatives

We found few examples of strong connections within schools between reform initiatives the school were participating in and their use of technology. More generally, we found that in schools participating in projects such as Annenberg networks or the Chicago Systemic Initiative, the teachers we spoke with were often not clear about the parameters or goals of the initiative. In conversations with representatives of education reform organizations themselves, we found most often that the organizations had not considered how technology might be used to support their work, or how technology might be useful in the models for school governance they were advocating. Their organizational investments in technology ranged from the Consortium for Chicago School Research, which has an informative website providing

access to a range of school data, to the Chicago Annenberg Challenge, which does not use e-mail to communicate with its school networks.

Some technology-focused programs working with some of the schools in this sample were also focused on reform issues, specifically in the area of curriculum reform. The most prominent was the CoVis work conducted by the Institute for the Learning Sciences at Northwestern University, and their more recent project, the Center for Learning Technologies in Urban Schools, which builds on the previous work done by CoVis, with an increased emphasis on collaborative curriculum development. These projects, unsurprisingly, had more direct ties to the technology programs of the three participating schools we visited. However, the Northwestern researchers are working with small teams of teachers, and their work had not, at this point, had an impact that we could observe on the larger technology program of these schools. This project has just completed its first year, and could have more far-reaching impact in future years.

There are at least two reasons the Chicago reform community (apart from technology-specific groups like CoVis) might not be well informed about or engaged with technology use at the elementary school level. First, some school reform organizations, such as the Small Schools Workshop, Designs for Change, and the charter schools movement in Chicago (led by Leaders for Quality Education), have focused their work for the past several years almost entirely on the high school level. Research by the Consortium has indicated quite strongly that while the elementary schools reaped some considerable benefits from the 1988 school decentralization act, the high schools benefited somewhat less. Consequently, current reform efforts are focused on finding other ways to address high school-level challenges (Sebring, Bryk, & Easton, 1995). These organizations seem to be paying less attention to elementary schools in general, and not only around technology issues. For example, we were unable to find a Small Schools elementary school making use of technology for this study, but several Small Schools high schools were recommended to us as investing in technology use in interesting ways. Second, the education reform community in Chicago has been heavily focused since the 1960s on understanding and advocating change around school governance, rather than classroom-level teaching and learning. Our focus on technology use in the context of teaching and learning, then, addresses a domain outside the area of primary expertise of much of the Chicago reform community, not only by being about technology, but also by being about teaching and learning practices in general.

Groups focused on supporting technology integration and groups supporting education reform were themselves beginning to explore ways of working together at the elementary level. For example, representatives of a sponsoring organization for a new charter school—the first elementary-level charter school in Chicago—attended

a meeting of the Chicago University Internet Project (CUIP) staff this spring to explore how their school might benefit from a partnership with CUIP.

Innovation: Risks and Opportunities

Another factor determining the overall character of technology use in the sample schools was the degree to which teachers felt they were authorized to experiment and innovate in their classrooms. This point is closely aligned with the importance, discussed earlier, of having a shared sense of school-wide educational goals. While these two factors could potentially conflict with one another, they can also find a point of productive balance when teachers are trusted enough to be allowed to work toward those shared goals in their own ways. It is possible for school leadership to be both strong and supportive, and to make room for teachers to take multiple approaches, to change their own approaches over time, and to share and learn from one another's practices. In these schools, a diversity of practice can be securely balanced with a shared agreement about *what counts*—what is most important to achieve in the educational process.

New experiences—such as participating in a technology-rich research project, or having students use the Internet as a research tool for the first time, or allowing students to create PowerPoint presentations instead of traditional research papers—are perceived as risky. They raise unpredictable logistical challenges: What if the network is too slow? What if the students lose all their work? They also change classroom dynamics and raise new assessment questions, as students work in new ways and produce new kinds of work products. Teachers who used technology extensively in their teaching often spoke about "improvising," "experimenting," or "seeing what happened" during their early years of technology integration. These teachers had already experienced changes in their classrooms, brought on in part by their use of technology, that other teachers are just beginning to explore.

Some teachers feared these kinds of change as *too* risky. They felt they could not afford to try out something new without a guarantee that the new practice would work smoothly and produce the same or better outcomes than their old practices. In part, this response can be understood as an appropriate concern about their own accountability to their students, since students can be required to attend summer school or be held back a grade, based on their test performance. This aversion to experimentation was expressed to us in different degrees by different teachers within individual schools, but there were also distinct differences across the schools in the overall sense they communicated about whether the teachers felt that they were free to innovate, or were under pressure to maintain existing practices.

Many of the teachers who were most confidently pursuing more student-centered pedagogical practices and more project-oriented curricula worked in schools

that expressed the least concern about reporting falling test scores to the district. The schools that we visited experienced different levels of pressure in relation to test scores. It is difficult to explain why, exactly, although not being at the "very top" or the "very bottom" of test score rankings seems to offer these schools a degree of freedom that the schools discussed above do not enjoy.

According to a wide range of informants in this study, the IGAPs and the Iowa tests significantly shape educational practice in Chicago. Particularly since the 1995 district reorganization, these tests have become increasingly important in measuring the success of curriculum reform based on new state standards.

Testing and Technology

Although standardized testing has been a fact of schooling for decades, it has recently taken on larger implications for the Chicago public schools because of the reforms of 1988 and 1995 and increased concern about the effectiveness and accountability of the schools. Results of the Iowa Test of Basic Skills and the IGAP (the state-mandated test) are used for multiple purposes by the district, including tracking the overall success of these reforms and assessing school quality, teacher effectiveness, and student performance. Test results have serious consequences for all parties involved, from reconstitution at the school level to repeating a grade at the student level.

In addition to the Chicago reforms, the state of Illinois has also presented the schools with new standards for student learning that attempt to incorporate learning theories and teaching methods supported by recent research in cognitive science, including collaborative, problem-based, and reality-based learning. A fundamental disconnect exists, though, between the kinds of teaching and learning emphasized in these standards and the nature of the test being used to evaluate their implementation. Staff in many of the schools we visited recognized this disconnect. Although the school district implemented "gate" testing in grades three, six, and eight to increase accountability on all levels (school, teacher, and student) and to ensure that new standards are being implemented, school reactions we observed lead us to conclude that this testing may in fact be hindering the implementation of the new state standards. Because of the emphasis in many schools on preparing students for standardized assessments, teachers have been unwilling to experiment with the more varied teaching methods and technologies included in the standards for fear they will see a drop in test scores.

In the schools in this sample, we observed a great deal of technology use to support direct instruction, including use of integrated learning systems, Accelerated Reader, and educational games to reinforce basic skills. These kinds of technology use produce student outcomes—i.e., student mastery of specific basic skills, measured

incrementally through trackable test scores—that align smoothly with the student outcomes produced on standardized tests. However, many of the schools in this sample are moving to expand and diversify their use of technology. They are beginning to invest teachers' time and energy in, for example, technology-rich research projects or student-produced multimedia or video presentations. For some schools these experiments are just beginning; for others, they have been developing for several years.

Teachers in these schools are very aware of and sensitive to what they perceive to be the districts' priorities and benchmarks for success. Consequently, many teachers express concern about the tensions they perceive between the district's expectations and the newer, technology-rich practices described above. They can see that the technology-rich, project-oriented types of curricula are unlikely to produce the kinds of student outcomes that the direct instruction models produce and that are easily justifiable in terms of the basic skills privileged on standardized tests. This perception of tension, which appeared highly legitimate to us in the context of the observations of many other informants about the city-wide emphasis on raising test scores, is one that different schools are addressing in different ways.

Professional Development

This section reviews the existing technology-related professional development practices being used in the schools in this study. We describe some of the more promising practices and identify some common challenges that the schools face. Since the schools we observed are considerably farther along in this area than are most of the Chicago elementary schools, these schools may provide a window into the range of professional development needs that are going to become more widespread over time.

Issues discussed in this section include the following:

- *The scope and urgency of the need for professional development in schools making use of technology, in order to both improve teachers' technical skills and to support them in integrating technology into the teaching and learning process.*
- *The gap we observed between available technology and the average level of teacher knowledge about how to make use of technology.*
- *The range of existing professional development practices we observed in the schools, including informal collegial training, commercial training programs, work with external partners, district-provided courses and trainers, and coursework at local universities.*
- *The significant obstacles to engaging teachers in adequate professional development, particularly the lack of time for sustained professional development work, and the expense of professional development programs, particularly for schools that have invested significant amounts of their discretionary funds in their technological infrastructure.*

Overview

There are three dimensions to the relationship between professional development for teachers and administrators and technology. First, the need for professional development for educators across the country about a range of technology-related issues is acute, and the schools we visited in Chicago were no exception. Teachers need technical training; they need to be exposed to models of how technology use might look in their classrooms, and they need to learn about existing programs, projects, and applications that they can use or participate in. Second, there is also an urgent need, both nation-wide and in Chicago, to restructure how professional development is conceptualized and delivered, including technology-related programs. A range of research has demonstrated that professional development needs to move

from a model of delivering one-time in-service workshops or courses divorced from actual classroom practice to providing sustained, long-term support to teachers that is closely tied to their work in their classrooms. Third, educators are beginning to experiment with using technology to respond to some of these obstacles and to deliver professional development opportunities to educators in new ways.

Disconnect Between Available Resources and Teacher Skills

In every school we visited, there was a clear gap between the level of technological resources available and the average level, among teachers, of both technical skill and knowledge about how to make meaningful use of the technology. Most of the school staff in this sample fell into three categories of expertise: one or two people who were very knowledgeable about technology; a small core group, which could be two teachers or 20, who had some basic knowledge of how to use the computer and were using it regularly in their teaching; and a larger group, encompassing the rest of the staff, who either had no knowledge at all about how to use computers, or knew how to use them but had made no use of them in a professional context. In every school we visited, trying to increase the skills of the core group and build up some skills among the teaching staff as a whole were challenges of primary concern to the staff most invested in the schools' technology programs.

Four of the sample schools have somewhat different professional development needs than the others because they have, for various reasons, been able to hire mostly or all new teachers in the past ten years. In each of these four schools, which have a younger-than-average teaching population, professional development was less focused on how to operate a computer and more focused on exposing teachers to potential applications of the computer in the classroom. In these schools, most teachers had already acquired basic computer skills through their college education or elsewhere. In the remaining six schools, of course, this was true for some of the teachers, but there was a much more prevalent focus on developing basic computer skills among the large number of teachers who knew nothing about how to use a computer.

Developing Teachers' Understanding of the Roles Technology Can Play in Their Classrooms

In addition to learning how to use computers and other technological tools, we saw a strong desire among teachers to learn more about how other teachers use technology, how it can fit into their teaching, and what resources can help them address the challenges they feel are important. Some teachers we spoke with were not convinced that technology could be useful to any part of their work. At one school, where it has been mandated that teachers word-process their lesson plans, a teacher who is comfortable with technology explained that other teachers were resisting

the mandate because "they don't understand why we have to do it." The teachers had been given no reason to do their lesson plans on the computer, and consequently they found the effort involved unnecessary.

Many teachers had a hard time articulating, in interviews, what kinds of professional development might be useful to them, simply because they had not been exposed to enough different kinds of technology applications to be able to imagine what they might want to learn about. One teacher, for example, when asked whether she thought any specific kind of training would be useful to her, said that training wouldn't be helpful since there were too many different types of software for the school to effectively train teachers to use all of them. Because she was unable to discriminate among the different kinds of software and the different possible uses of computers, she saw training as an endless series of "how-to" sessions with isolated software packages, which she could predict wouldn't be useful.

Existing Practices and Resources

The professional development practices we learned about in the schools we visited fell into four main categories: informal, collegial training sessions; training provided within the school by outside organizations, either commercial training programs or external partners; course or degree programs at local universities; and classes offered by the district.

Informal Collegial Training

Collegial training ranged from team-teaching to after-school "how-to" sessions to before-school breakfast meetings where teachers shared new practices and new ideas for teaching. Collegial training often focused on administrative uses of technology, such as using gradebooks and making class lists, which fit well with the emphasis several principals placed on focusing on teachers' administrative needs first, and hoping that their use of technology would then spread into their teaching.

Commercial training programs Four of the schools had had significant involvement with commercial organizations that conducted technology training for their teachers. At Marcus Garvey, teachers were required to attend a Saturday training session on using the Internet, run in the school computer labs by Midwest Visual, a vendor that provides hardware and software support to the school. This school also contracts with Josten's for their integrated learning system, and Josten's trainers show the school aides and teachers how to use the system. At Jose Marti, the computer lab supervisors are also trained in managing the integrated learning system, which is supplied by WASATCH. At Drake, Lucent trained the vice-principal and the technology coordinator in how to maintain the network and develop LotusNotes resources, but this training was not available to the larger staff. At De Gaulle, the principal contracted

with the Teachers' Academy for Math and Science to conduct a three-year professional development program addressing teacher practice in math, science, and technology for the whole school.

External Partners

Training from external partners was the most common form of professional development we learned about. Six of the schools receive some form of professional development assistance from external partners such as the Chicago University Internet Project; Northwestern's Collaboratory project; the Northwestern University-Kellogg School of Management's "Total School Quality" program; the CoVis and Center for Learning Technologies in Urban Schools projects of the Institute for the Learning Sciences, also at Northwestern; or interns from Governor's State University. The kinds of support provided vary, but typically project staff work one-on-one with teachers during prep periods on topics of interest to the teachers, help them prepare materials for classes, lead sessions with students involving technical processes that teachers are not fully comfortable with, or occasionally lead group training sessions after school or during professional development days for teachers. These kinds of external support seem to have played an important role in providing a base amount of technical training and support to teachers that is closely connected to their classrooms and based on the real resources available to them.

A limitation of these programs is that, with the exception of program staff from the Institute for the Learning Sciences, none of the trainers have expertise in the area of education. Consequently, their training tends to be limited to technical matters and to providing some exposure to resources available on the Web and different kinds of software. This support plays an important role in these schools, but it is likely to be insufficient, on its own, to spreading extensive use of technology throughout these schools.

Advanced Degrees/University Courses

Many of the teachers we met who were most involved in using technology in their teaching were involved in either teacher certification programs or master's degree programs that had exposed them to innovative uses of technology. For example, a teacher who taught several other teachers in her school to use HyperCard learned how to use the program in her educational technology course at a local university, where she is earning her teacher certification. But other teachers told us about teacher certification or master's programs that were not exposing them to technology at all. One teacher explained that she has taken 30 hours of professional development classes this year for her certification but that technology has not played a significant role in any of those classes. She reported that some of the classes had "talked about computers," but none had offered hands-on experience or explained practical ways

of using technology in the classroom. Other teachers described seeking out individual courses at local universities that could help them learn about specific technology-related subjects they were interested in, including using the Internet, general applications courses, and technology integration.

The District

Professional development offerings at the district level have focused on teaching teachers and administrators to use administrative systems, such as attendance systems and accounting systems, and to learn basic computer skills. The Department of Learning Technologies is working toward developing a "train-the-trainers" model among the TRNs; some TRNs provide workshops around specific technology skills and applications in their regions, and the Department of Learning Technologies is encouraging them to do this kind of work. However, their resources are limited, and they cannot reach every school effectively. The district is also providing a range of professional development opportunities to the schools involved in the Chicago Systemic Initiative. There seems to be a break in communications, though, between the district and schools around these opportunities, as none of the teachers we asked about district-sponsored opportunities for professional development were aware that such courses were available to them.

Obstacles to Providing Professional Development: Time and Money

Like all schools, the schools in this sample have too little time available for the professional development they would like to do around technology. School decentralization actually provides an important benefit in relation to this challenge: the teachers' union has given the schools permission to adapt their schedules with teacher approval, to accommodate their particular needs and priorities. At least four schools in the sample have elected to adjust their schedules and use many of their professional development half-days for technology training.

One reason schools rely so heavily on external nonprofit partners for professional development support is that hiring commercial organizations is expensive and must come out of individual school's budgets. The schools in this sample are investing heavily in their infrastructures and, in most cases, hiring staff to support technology use, but they are not at a point of choosing to give professional development a financial priority equal to those areas. A teaching aide at one school that uses a for-profit organization to provide teacher training explained that after paying for those sessions and for training on the integrated learning system, hardly any money is left for other kinds of professional development experiences. Another principal who uses a for-profit organization for professional development says that her schools were able to participate in the program only because she was able to negotiate a significantly reduced rate.

On a smaller financial scale, schools are able to do things like earmark portions of their own discretionary funds to pay teacher stipends for Saturday classes, which are a regular occurrence at one of the schools in this sample. We found that it was most common for schools to use these kinds of low- or no-cost solutions to meet their professional development needs. While this is in part because of their financial limitations, it seems also to fit well with the emphasis many of these schools place on creating situations where teachers can learn from one another, and on their unwillingness to risk large sums of money on unproven programs that may or may not match up well with their needs and priorities.

The Importance of Leadership

In every school in this sample, we found that the particular ways technology is being planned for, acquired, and made use of are strongly determined by the efforts of a small group of leaders—some combination of principals, technology coordinators and teachers. In this section we discuss some of the challenges encountered by two important types of leaders in the schools—principals and technology coordinators—and some of their accomplishments, some of the challenges they face, and some of the strategies they use to respond to those challenges.

Issues discussed in this section include the following:

- *The scope of tasks that need to be undertaken by school leaders with regard to implementing and promoting a substantial technology program.*
- *The challenges facing principals, including how to seek out funding for technology initiatives and sources of support and advisement, and motivating teachers to engage with new resources and new ideas. We discuss two distinct strategies that we observed being employed by various principals, one relatively more top-down, and the other relatively more bottom-up.*
- *The challenges facing technology coordinators, including training teachers, maintaining equipment and networks, writing grants, and selecting and purchasing new software and hardware.*

Who Is Taking the Lead in Technology Integration in These Schools?

We are using the words "leader" and "leadership" in this context to refer to those individuals in the school who are involved in conceptualizing and implementing the process of technology integration. This can include such tasks as defining what roles technology could or should play in the school, identifying and securing funding for technology, and seeking out external partners, grant opportunities, or professional development opportunities that could advance the school's technology integration. Of course, exactly how these different leaders carry out their roles varies widely. We distinguish technology *leadership* from hands-on, day-to-day work with technology (e.g., teaching students, coaching teachers, or doing technical maintenance). A number of individuals in these schools play both of these roles; there are also people who play one role or the other but not both.

While no two schools have precisely the same staffing situation around technology, we observed that the schools that seemed to most effectively combine

infrastructure development, teacher training, and classroom integration of technology were those that had, at a minimum, a principal and a technology coordinator working as a team to identify needs, seek out resources, and implement programs. For example, at one of the schools with both a technology coordinator and a principal acting as leaders around technology issues, the technology coordinator conducted a school-wide survey of teachers' self-reported needs for technology training and designed mini-courses to respond to those needs. She felt that she got the administrative support she needed from the principal to make the mini-courses a success. The principal arranged for Saturday access to the school building and for teacher stipends for the weekend mini-courses, and applied some pressure to let teachers know that the principal expected them to acquire these skills. Working together, the two leaders were able to combine resources and to make use of their different relationships to the teaching staff to create a new professional development opportunity. In contrast, the technology coordinator at another school oversees an extensive infrastructure and reports that her principal will support her in purchasing most of the hardware or software she wants. But, she explained, the principal is not engaged with the day-to-day challenges she faces and therefore is not aware of what the technology coordinator perceives to be an urgent need for more professional development opportunities for the staff around basic technology skills.

Principals as Leaders

Principals are particularly well-positioned to take central responsibility for two aspects of technology implementation and integration in their schools. The first is the acquisition of resources (including hardware, external partnerships, mentors, sponsors, etc.). The second is program development, that is, identifying and aligning appropriate goals for technology use that speak to the needs and interests of the various interest groups they are responsible to (teachers, students, parents, the local community, and the district).

Acquisition of Resources

The central role of the principal in planning for and acquiring technology has been discussed in the section on infrastructure, above. The principals in this sample took quite different approaches to developing technology resources for their schools. While not every principal falls fully into one or the other of these categories, they tended to use one of two approaches to resource development:

- **Relatively more top-down strategies:** These principals often became interested in technology because they saw it as a theme or specialization that could distinguish their schools in the public eye. In one case, this

specialization was actually suggested by a potential funder, and the principal agreed to the idea. These principals tend to be focused on cultivating a public perception of their school as "a technology school," by which they mean that it has more technology resources than most and that students will be sure to develop advanced technology skills. The emphasis for these principals is on bringing more technology and more programs into the school, sometimes at the expense of creating a focused or carefully planned vision for matching technology to other school-wide goals.

- **Relatively more programmatic strategies:** These principals often described having a personal experience that "opened their eyes" to the role technology could play in supporting student learning. These principals are less systematic in their approach to the acquisition of hardware and infrastructure than the other group of principals, and are more focused on encouraging their teachers to seek out involvement in technology-rich projects that match their own goals and interests. These projects often bring resources into the schools incrementally, and over time the school begins to build up a usable infrastructure. These principals are relatively more hands-off with their teachers around technology issues and view technology as an important part of a larger process of improving their schools. These principals tend to be more recently arrived at their schools than the other group. A major challenge for this group is finding ways to invite all teachers into the various technology-related programs going on in the school.

Regardless of the strategies used, all of the principals who took a leadership role around technology issues put extensive time and energy into identifying opportunities for involving the school in new programs or making the school eligible for newly available resources. These could be corporate partnerships that would support extensive technology implementation, a series of smaller donations from a member of the local community, reduced-cost services from a local business, or participation in university research projects.

Developing a Technology Program

Finding opportunities. Sometimes the principal's main role in developing a technology presence in the school happens in the political arena, by learning about and getting involved in opportunities presented in district meetings or through peer groups. Several principals explained that they had received various grants or become involved in various programs because they were "at a meeting and said yes when someone asked if I was interested," or because "so-and-so knew about this program and knew I would be interested, so he or she signed me up." These kinds of experiences

were not limited to the more top-down group of principals, as described above, but were more common among that group.

Funding for technology can also come through corporate partnerships, as was the case in two of the ten schools we looked at. One school partnered with a major technology development company to be a pilot site for wireless networking capability, and another partnered with a local cable company, again as a pilot site, and was set up with a T-1 line and two satellite dishes. These principals explained that they put a great deal of effort into networking by attending conferences and district meetings, and felt that they were "in the right place at the right time" to be chosen for a pilot study. One principal mentioned that her goal was to "keep [her school] in the conversation with those who can provide assistance." While the school that received the wireless network had a technology plan in hand at the time and was actively searching for the means to implement it when the school connected with their corporate partner, the other had to work backward once the opportunity was presented, and formed a strategy for incorporating technology after they were approached by the cable company.

Articulating a vision. In other cases, principals' main leadership around technology integration was to articulate a vision for school improvement and fit technology in as a component of that vision. This was more commonly done by principals who fell into the more "programmatic" group, described above. In these cases there was often a particular colleague, or some professional development experience, that helped the principal recognize the importance of technology to his or her educational goals and got the principal started in the process of introducing technology into the school. The principal at Prospect Park, for example, was personally inspired as she herself learned to use the Internet: "When I found out that students could go to the Louvre on the Internet and actually go *inside* of the Chinese urn [that they were looking at], not just see the outside like they would if they actually went to the museum, that was when I recognized the difference that it could really make in education." At South Kenwood Academy, the principal became interested in making technology part of the focus of her school through a teaching intern placed at the school, whose first career had been computer consulting. That person has since resumed his computing career and become an active member of the Local School Council, continuing to provide advice and inspiration.

These principals often partner with a technology coordinator or teacher to advance their vision in the school. The technology coordinator or teacher connects them to, and keeps them informed about, the needs, interests, and concerns of the teaching staff, and implements many of the training and resource development activities that need to take place. The principal focuses on allocating funding from both external and budgeted sources to the right components of the school programs

at the right times, and on seeking out professional development opportunities and other external programs that meet teachers' needs in ways that serve their overall goals.

Funding from private or nonprofit agencies is another component of technology programs, particularly in those schools building connections between their technology goals and other goals within the school. These grants, such as the Illinois State Board of Education grants, tend to be for specific educational projects and are often brought into the school by technology coordinators or teacher-leaders who are interested in the topic or in experimenting with technology in their teaching (although it may be the principal who originally becomes aware of the opportunity and passes it on to other staff).

Because technology use is growing so rapidly in the schools in this study, some principals and administrators are finding themselves responding to a range of opportunities presented to them, rather than shaping and implementing their own plan for moving their school's technology program forward. They have few mentors and are aware of few models for this process, because these schools are farther along in developing and making use of their technology resources than are most other schools in the Chicago area.

All of the principals in this sample who took leadership positions around technology integration made significant investments in acquiring technology and developing their school's technological infrastructure. We found, however, that some principals are finding themselves unprepared to take next steps, to build effectively on the groundwork they have laid for technology use in their schools. Their growth has, in some cases, begun to outstrip their vision. We saw a need in some schools to revisit old technology plans, to re-evaluate infrastructure strengths and weaknesses, to survey teacher needs, and to develop plans for new phases of technology development that will fit smoothly into the growing needs of the school. Some schools made great strides this year in addressing these needs; others seem overwhelmed by the technical burdens of the infrastructures they created, are still deeply engaged in the challenges of completing or stabilizing their infrastructures, or are too focused on other kinds of instructional goals to engage with the possibilities for further technology use in their classrooms.

The challenge for the principals, in this case, is to develop ways to monitor the growth not only of the technological infrastructure itself, but also of teachers' practices, their uses of the technology, changes and developments in other school programs, and the overall goodness-of-fit between existing technology resources and teachers' needs.

Technology Coordinators as Leaders

In this study, the majority of the schools had employed someone whose occupation fell under the general title of "technology coordinator." The titles varied somewhat: one school has an "ad-hoc math and science coordinator," another a "computer teacher," another a "media specialist," and yet another "one-half librarian, one-half technology coordinator" (see Table 1 for a summary of positions). All of the job descriptions were relatively similar and can be loosely summarized as being responsible for the following: selecting hardware and software; troubleshooting and providing support for hardware, software, and networking in classrooms and labs; writing grant proposals and technology plans; and coordinating the dissemination of new technologies. In general, the job description includes both technical and pedagogical demands. In one instance, two technology coordinators divide the job between themselves—one acts mostly as the "technologist" and one as the "curriculum coordinator." In contrast, at another school the technology coordinator felt that his job was to focus only on the installation and maintenance of the school's hardware and software.

Table 1: Technology Staff in Schools*

School	Type of staffing for technology-related issues
Juarez	Two full-time technology/curriculum integration coordinators (no computer lab)
Warren	Two full-time writing teachers staffing labs; significant planning support from school vice-principal
De Gaulle	Two full-time teachers staffing two computer labs; one full-time science specialist who is an ad hoc technology/curriculum integration coordinator
Drake	One full-time teacher/technology coordinator staffing a computer lab; significant planning support and technical support from school vice-principal
South Kenwood	One full-time teacher/technology coordinator staffing a computer lab
North Loop	One full-time teacher/technology coordinator staffing a computer lab
Christa MacAuliffe	One full-time teacher/technology coordinator staffing a computer lab
Prospect Park	One half-time librarian/half-time technology coordinator
José Martí	Two full-time aides staffing computer labs
Marcus Garvey	Two full-time aides staffing computer labs

* Note: *Teacher* indicates that the person is responsible for teaching students on a regular basis in a computer lab setting for part or all of his or her time. *Technology coordinator* indicates that the person's time is devoted to planning, implementing, training, writing grants, etc.

Maintenance of the infrastructure is one of the major responsibilities of the technology coordinator. In some schools, technology coordinators perceive this to be their main or sole concern. The expertise they bring to this part of their job varies widely, as their professional backgrounds are diverse. One is a social studies teacher; another is a math teacher. Most are self-taught "techies" with no formal training in subjects like network maintenance. Some outside resources support them in their technical work: several schools in this sample had interns from a local university who helped to maintain the technology, others had support from other university programs they worked with, and some had local volunteers who came in sporadically to help out.

At other schools, this individual is more involved in providing pedagogical support to teachers and brings less technical expertise to the job. This was true, for example, of the half-time librarian/half-time technology coordinator, who was hired with the focus on the library aspects of her job and who has taken the initiative to expand her role as a leader in technology use in her school. This was also true of the math/science coordinator at De Gaulle, whose role as a technology coordinator is explicitly focused on providing teacher support and who was previously a science teacher with self-taught technology skills.

Role of the Technology Coordinator in Technology Integration

Technology coordinators' jobs vary, but all of them do most of the following: teach students, train teachers, supervise labs, team-teach with other teachers, write proposals, advise principals, provide technical support, identify vendors, design infrastructures, supervise outside maintenance contractors, and identify and purchase software and curricular resources. Their work with teachers and their time spent planning are their most significant opportunities to influence the course of technology integration in their schools, but these aspects of their job are often overwhelmed by their other responsibilities. One technology coordinator, for example, has just short of a full class load of students and is responsible for maintaining a complex network in poor repair that, for various reasons, she inherited from a previous technology coordinator. She described plans for teacher training that had mostly fallen by the wayside this year because she simply had had no time to build up interest among the teaching staff. Among those technology coordinators who want to play a role in developing other teachers' use of technology, the ones who feel most satisfied with their accomplishments are, unsurprisingly, those able to share responsibilities with one or more other technology staff in the school.

Technology Coordinator's Role in Planning

Most technology coordinators we spoke with had spent much time during the past year writing or revising their school's technology plan and completing E-rate

applications. Some technology coordinators did this on their own; some organized voluntary staff meetings to discuss either or both documents, or conducted surveys to get input from teachers; and some had formal committees of teachers who were expected to help shape and write these documents.

During the 1997–1998 school year, schools were being encouraged by the district to write formal technology plans. Writing these plans was described as a pro forma exercise at most of these schools, and writing them motivated little or no school-wide discussion of goals, beliefs, or any of the larger issues that the technology plan template encourages schools to consider. Several technology coordinators described cutting and pasting sections from the School Improvement Plan, or from previous grant proposals, to fill in sections about visions for the future, goals, and beliefs. Some technology coordinators expressed frustration and displeasure with the template for the district-mandated technology plan, feeling it was too "generic," "bureaucratic," or "complex." In some schools, the source of the frustration seemed to be a perception that writing the technology plan was a superfluous exercise, as the schools had been working for years to determine their plans for technology use. In other schools, the problem seemed to be a perception that the task was an overwhelming burden, because the schools were primarily focused on the challenges of building their technical infrastructure and were not focused on the more programmatic aspects of the plan (such as recruiting community members to provide volunteer support and re-evaluating local assessment practices) emphasized in the template.

Providing Technical Support

One of the more challenging aspects of the technology coordinator's job is providing technical support for teachers. Day-to-day troubleshooting and maintenance demand large portions of a technology coordinator's day and sometimes test the limits of the technology coordinator's technical knowledge. We heard many technology coordinators wish for an always-available source of technical support, and express, as one teacher put it, "Frustration with a capital F" about the gap between their needs for technical support and the amount of support available from the district, the local community, or other organizations. A number of teachers and administrators expressed their belief that the district offices should find ways to provide more comprehensive support resources to help technology coordinators meet these technical challenges.

Whether or not school staff can realistically expect the district to be able to provide the level of technical maintenance help that individuals feel they need, technical problems can clearly be a serious obstacle to technology use in the classroom, not necessarily because any individual problem is serious but because even the smallest upset can become a major roadblock for a teacher with minimal computer skills. Many schools have turned to external partners, such as a corporation providing a

hardware donation or a volunteer from a local business. But this kind of support is temporary, and does not encompass all of the regular maintenance and troubleshooting these schools need.

Spreading Knowledge of Resources and Programs

Technology coordinators place a priority on using part of their work time to learn about promising and newly emerging ways to use technology in the classroom, and they use a wide range of strategies to develop this knowledge. Some have drawn on the expertise of university researchers: one technology coordinator explained that Northwestern University has been a lifeline for his school, providing people who can bring in new ideas, new materials, and technology to experiment with. Another is an Apple Distinguished Educator and spends a week per year in California learning about new developments and sharing ideas with other Apple Distinguished Educators. A third attends conferences regularly, as well as consults with outside colleagues from the business and academic worlds for information. Two schools have decided that this important aspect of their technology coordinators' jobs is so compromised by their teaching and technical maintenance responsibilities that they have dedicated funds to hiring curriculum coordinators to work alongside the technology coordinator starting in the fall.

Discussion

In this section we discuss the differences observed among the schools in this study. First we return to the classifications of the schools as "struggling," "intermediate," and "advanced" with regard to their technology programs, and compare these categorizations with other important characteristics of the schools. Then we discuss differences among the schools in terms of their potential to move forward with their technology programs. We find that a group of interrelated factors are working together to support technology integration in these schools.

Overview

As discussed at the beginning of this report, in the process of selecting the sample of schools for this study, we categorized candidate schools as being "struggling," "intermediate," or "advanced" in the process of meeting their own goals for technology integration. The schools in our final sample fell into these categories, as follows:

- **Struggling:** Marcus Garvey, José Martí
- **Intermediate:** Warren, South Kenwood, Prospect Park, Juarez
- **Advanced:** De Gaulle, Drake, North Loop, Christa MacAuliffe

In addition to making sure that our sample included schools at various stages in the process of technology integration, we sought to diversify the sample across a range of demographic and structural variables.

Two important questions were implicitly raised by our sample selection process. First, did the classifications of "struggling," "intermediate" and "advanced" accurately reflect the degree of progress we saw in the schools when we visited, talked to people, and observed classes? And second, if the categories did prove to be useful, which if any of the demographic and structural variables corresponded to the categories of "struggling," "intermediate," and "advanced," and what did that correspondence tell us about the challenges of technology integration?

The Significance of the Classifications

The "struggling," "intermediate," and "advanced" categories did correspond fairly accurately to the breadth and depth of technology use in the schools we studied. The two schools we designated as "struggling" were the two using technology primarily for drill and practice on integrated learning systems. The four schools designated as "intermediate" were quite different from one another but were all struggling with an existing range of dominant practices that were relatively superficial and other, more promising and ambitious resources that were accessible to the school but still

marginalized in the school as a whole. The "advanced" schools were also quite different from one another, but in each case had a more diverse repertoire of technology uses and a more fully developed technical infrastructure than the "intermediate" schools; further, in three out of four cases, they had begun to seriously address the professional development needs of the staff.

Demographic and Structural Variables

Although this sample is too small to draw any strong conclusions about these issues, it is important to note that, in this exploratory study, with one exception we saw no obvious interactions between level of technology integration, or major hurdles to technology integration, and school size, student race/ethnicity, poverty levels, number of students with limited English proficiency, or mobility rates. The exception is that the two schools making extensive use of integrated learning systems are the two schools serving almost entirely African American students.

The only other prominent association we found was that two regions—1 and 4—were over-represented throughout our search for schools to include in the sample and are over-represented in our final group. In part, this overrepresentation seems to reflect the prevalence of externally sponsored projects that focus on these regions. It may also reflect the quality of the TRNs that serve these districts—we were informed several times that the TRNs vary widely in their depth of knowledge, and that several of the strongest ones serve these regions. It seems likely that other systemic differences among the regions account for the low number of schools from regions 2, 3, 5, and 6. For example, when we mentioned the absence of any Region 3 schools to one educator, she responded that she was "not surprised—Region 3 principals never seem willing to participate in things or want to get involved in outside projects."

Limitations of the Categories

What these three categories did not capture were important differences, in our judgment, in the potential of each school to move *forward* from its existing practices. For example, Jose Marti, one of the two schools classified as "struggling," has small but very promising pockets of experimentation going on in the lower grades. With an absolute minimum of equipment, one enthusiastic teacher who has been exposed to some innovative uses of technologies in a graduate school class has informally recruited and trained other teachers who are excited by work she is doing with her students and would like to do similar projects in their own classrooms.

By contrast, one of the "advanced" schools, with one of the most extensive networking infrastructures in the sample, is doing little to build up teachers' capacity to use the technology in their classrooms. This is largely because the one full-time technology coordinator in the school has an almost full-time teaching load, in addition to being responsible for troubleshooting a network installed by a former technology

coordinator, which she does not have adequate technical training to maintain. She has little time left to do one-on-one training with teachers or to plan other kinds of programs that might stimulate teachers to experiment more extensively with the technology available to them.

Overarching Themes

We have found that a central set of closely interlocked factors are determining the capability of these schools to capitalize on their existing resources and move forward from their current state of technology integration. These factors are:

- **Robust technology.** Having an infrastructure that works well enough to support the work that teachers and students are doing.
- **Freedom to innovate and experiment.** Having a shared belief within the school that it is more important to try new things and improve one's practices over time than to stick with practices that are safe but limited.
- **Diversity of application.** Having more than one kind of technology use going on in the school, so that teachers with different levels of experience and different interests can find points of entry that will allow them to get involved.
- **Depth and quality of staffing.** Having the right combination of people on the school staff to cover all the various components (teaching, planning, and maintaining) of advancing technology integration in the school.
- **Professional development.** Providing a range of sustained, collegial, and immediately relevant opportunities for teachers to build their technology skills and learn about ways that technology can support their teaching.

These factors are not freestanding variables that add up by neat increments into an ideal whole. Rather, they are present in different combinations in different schools, and in different combinations they can produce different results, each with their own strengths and weaknesses. Their impact on schools is situational—each one is changed by the degree to which the others are present.

Additionally, these factors can produce implicit tensions in relation to one another, particularly when any one of them is expressed rigidly or becomes the exclusive domain of any one staff member or a small group of staff members. For example, one school in the sample has a particularly extensive staff available to support teachers in their use of technology; at this phase in their development, however, only specific

cohorts of teachers are receiving additional professional development around technology from outside organizations. We found that in this school some of the teachers not receiving training from external groups are disinclined to seek out the support of the technology coordinators and seem to feel that the school's technology resources are really only meant for teachers involved in "special" programs.

Schools that seem well-prepared to move their technology programs forward have struck an effective balance among some subset of these factors and continually review and adapt the "fit" among them. For example, one of the schools has been investing in the professional development of a very small group of teachers in the school for a number of years. But as their infrastructure has grown, the technology coordinator has begun to reconceptualize the kinds of in-house professional development she is offering, and is adjusting and diversifying these offerings to reach a larger group of the school's teachers.

The remainder of this section will discuss these factors and provide examples of how they can, in different combinations, produce different outcomes.

Robust Technology

Although it has been emphasized throughout this report that technology cannot have an impact on a school on its own, it is nonetheless true that the accessibility and reliability of the technology itself plays an important role in shaping a school's progress toward technology integration. In the schools we visited, a combination of a basic level of classroom access (such as having four networked, relatively up-to-date Macintoshes in a classroom of 30 students) and flexible access to a networked computer lab with enough computers for all students in the class seemed to be the baseline that made teachers feel that it was "realistic" to make regular use of technology for anything other than "free-time" or "reward" activities with their students. Having minimal in-classroom access to computers (such as schools that had one or two Apple IIe's in most classrooms) and to the network had distinctly dampened teachers' willingness to experiment. Additionally, unreliable or excessively slow network access was very discouraging for teachers and could easily put many of them off the idea of further exploring the Internet.

It is important to note that a number of the most innovative and creative uses of technology we saw in the schools occurred in classrooms with very limited access to computers. We saw examples of teachers making excellent use of a single computer in a class of 30 students, and we saw many classrooms with four or more computers available that were never or rarely used. Access to technology clearly did not *determine,* for this group of schools, how or whether teachers used the technology. But when other conditions came together in ways that made teachers want to experiment with technology in their classrooms, adequate access to both classroom

and lab configurations made teachers feel that it was logistically *possible* to succeed and create a positive experience for their students.

Freedom to Innovate and Experiment

On the level of the individual classroom teacher, this is possibly the single most important factor in determining whether a teacher engages with a new professional development program, participates in a new project, tries a new kind of activity with her students, or makes the effort to learn to use a new piece of software.

Throughout our school visits, teachers clearly explained the priorities of the schools they worked in, and where they and their work fit into those priorities. In one school, teachers explained that they were expected to come up with new curricula on a regular basis and to increase the interdisciplinary nature of their work with students. In the context of these development efforts, experimentation was acknowledged to be necessary and inevitable. Consequently, many teachers at this school felt comfortable integrating technology components into new curricular units, even when they were not entirely sure of how the unit might work or knew they would need support from another teacher to make the unit run smoothly. In another school, teachers clearly understood that they were expected to produce high test scores, and that any teaching practices that were not sure to raise scores on the next round of tests would not be accepted by their principal or peers. Consequently, these teachers perceived any kind of innovation in their classroom practices or materials as risky and potentially damaging to their own professional standing.

It is important to note that the culture of experimentation that seemed to support expanding technology use in the schools we studied was not limited to experimentation with technology per se. Instead, we observed that some school staffs shared an overall sense that teachers were expected to take initiative, to learn new skills and ideas (from one another, from graduate courses, or from other colleagues), and to act on what they learned in their classrooms. When this kind of professional culture was in place, experimenting with technology became a natural and non-threatening piece of the larger project of constantly adapting and improving teaching practice.

Diversity of Application

Some of the most interesting and innovative uses of technology we observed took place in schools where multiple uses of technology occurred within a single building. Based on a small number of examples, it seems likely that the emergence of multiple types of technology use within a school is a key step in moving schools forward from their earliest technology applications.

For example, one school's main emphasis for technology use was an integrated learning system used to prepare students for standardized tests, but individual teachers

in that school were also supported and encouraged in their experiments with using multimedia production tools for student presentations. At another school, different small groups of teachers were participating in a range of technology-rich curriculum projects that were quite different from one another and involved quite different uses of the technology. In each of these schools, teachers were able to find various points of entry into technology use that were comfortable for them, and to learn from other teachers about other possible uses of technology over time. Allowing multiple technology components to coexist in a school and encouraging diverse types of technology use aligned with a range of types of instruction seem to be promising strategies for encouraging all teachers to use technology.

Depth and Quality of Staffing

The technology coordinators interviewed for this study varied enormously in the skills and interests they brought to their jobs. They were also often overwhelmed by the diversity of skills expected of them, from network design to teaching students to training teachers to grant writing. The district TRNs could potentially play an important role in alleviating the burden the technology coordinators felt they were carrying, but the TRNs were not seen as a reliable resource by this group, mainly because there are simply too few of them. We were told about some cases of TRNs providing valuable assistance and guidance to technology coordinators, but in many other cases we were told that TRNs took too long to respond to be of help, or that they were too unfamiliar with the individual schools to understand their particular needs and priorities. This is unfortunate, because no matter how well-trained the TRNs become or how well they do their jobs, their inability to become substantively involved with every school they work with will persist as long as they are few in number. Schools like the ones in this study, which have already made so much progress toward substantive technology use, urgently need the support and expertise that well-qualified TRNs could provide if this well-conceived program were expanded.

We found that the schools that were most effectively building and expanding their technology use had technology coordinators with a clear vision of how technology can support teaching, and a deep knowledge of existing programs, software, and technology-rich teaching practices. These technology coordinators had seen or learned about a wide range of model projects, had visited many other schools, or had a wide community of colleagues from other schools or from academia who kept them up to date on new developments and new projects they could draw on as they built up technology use in their own schools.

These technology coordinators were able to build a bridge between the nuts and bolts of learning to use technology and the real, felt needs of the teachers in

their schools. They were able to bring their teacheers into contact with technology applications the teachers recognized as being immediately useful or as exciting for their students. They helped teachers feel that they could be successful using technology in their teaching. These were the technology coordinators who engaged with teachers, who understood and supported teaching, and who were genuinely excited about the potential of technological tools to support good teaching.

Professional Development

The schools in this sample that seemed most prepared to move forward and improve on their existing uses of technology were the schools that encouraged and accommodated sustained collegial professional development. Many teachers were enthusiastic about learning from other teachers; they explained that when another teacher told them about something done in class, they trusted that it was something they could do successfully in their own classrooms. Individuals or small groups of teachers are acquiring skills and learning about new practices and new programs from a wide range of sources—and when they are encouraged to share their knowledge, and when other teachers are willing to learn from them rather than compete with them, the benefit of their experience is multiplied.

Two schools in the sample were supporting major, relatively sustained collegial professional development. In one, the practice was much more institutionalized—sessions were referred to as "seminars," and after-school and Saturday sessions were regularly scheduled. Although individual workshops were sometimes one-session reviews of specific skills, the sessions occurred frequently enough and among a coherent enough group that teachers were able to provide ongoing support to one another and to build up their learning over time within a consistent community. In the other school, a single two-week course had "sprung up" because a group of teachers was interested in the work that two other teachers had done in an intensive collaboration that had been going on for several months. Although this school has not institutionalized this structure, it provides a promising model of how the knowledge of a small group can be spread within a school.

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Glossary of Terms

CUIP (Chicago University Internet Project): CUIP is an all-volunteer effort by faculty and students at the University of Chicago to improve the technology infrastructures of schools in Chicago's Hyde Park neighborhood. Since 1994, CUIP has helped eleven schools get connected to the Internet, and provided technical support and training to teachers.

E-rate: The E-rate is a program administered by the Libraries and Schools Corporation, an NGO that administers and distributes funds earmarked by the U.S. Congress to subsidize the costs of networking libraries and public schools. The E-rate is designed to provide schools who apply for funding with financial resources to defray the costs of wiring school buildings and maintaining Internet connections.

IGAP (The Illinois Goal Assessment Program): The IGAP is one of two standardized tests administered to students in the Chicago public schools each year. It is designed and administered by the state of Illinois and is intended to measure students' achievement in relation to the Illinois State Learning Goals.

ITBS (Iowa Test of Basic Skills): The ITBS is one of two standardized tests administered to students in the Chicago public schools each year. It is a basic skills test intended to measure students' mastery of fundamental academic tasks.

LAN (local-area-network): A LAN is two or more computers within a single building that are connected by wires so they can share printers, Internet access, access to data on a central server, and/or other technological resources.

Local School Council: All schools in the Chicago public school system are governed by a Local School Council, whose membership includes the school principal, three teachers, two parents, and two members of the local community. The Local School Councils control the schools' discretionary budgets, the focus and structure of the school curriculum and schedule, and the hiring and firing of teachers and principals. Local School Council members are elected annually by the school community and usually meet biweekly or monthly.

T-1: A T-1 line is a type of connection to the Internet. It is relatively fast and is the highest-quality type of connection to be found in almost any K–12 school building.

TRN (Technology Resource Network): The TRNs are a group of 24 former Chicago public school teachers who now work full-time for the district as floating technology experts. They work directly with the schools to provide guidance in technology planning, technical support, professional development, and other

forms of support to maximize a school's success in using technology in instructional contexts.

WAN (wide-area-network): A WAN is a group of computers in multiple locations that are all connected by wires and by one or more centralized computers (called servers) so that they can share access to the Internet, centralized information, and other resources.

Appendix

Interviews with Stakeholders and Site Selection

Interviews with Stakeholders

Interviews were conducted with a wide range of individuals involved in one way or another with the Chicago public schools. With assistance from the Joyce Foundation and others, we began contacting people from school reform organizations, Chicago-area universities, and district personnel. Meetings and interviews began in September and continued until late in the school year.

Interviews focused primarily on understanding the recent history of the Chicago public schools and gaining insight into the primary challenges facing the system in the present and near future. We developed a wide range of perspectives on these issues by speaking with individuals and organizations who play widely varying roles in the school system. We also asked everyone we met with what they knew about the role technology was playing in the Chicago schools, and whether they knew of specific schools that were doing interesting things with technology.

In addition to interviews, we sat in on meetings of some of these organizations to learn more about the roles they play in supporting the schools. We also made presentations to two organizations to explain our work and seek input.

Notes from all meetings and interviews were written up and shared among the research team.

Site Selection

During interviews and meetings with people involved in the Chicago public schools, we consistently asked for recommendations of K–8 schools that were "making interesting uses of technology." Responses ranged from "I wouldn't know," to detailed lists of schools and their activities. Gradually, we accumulated a list of more than 40 schools.

The other major source of school recommendations was a group of TRNs who met with Frank Nardine in January (a member of the research team was to be at this meeting but was unable to attend). At this meeting, the TRNs articulated their criteria for defining "advanced," "intermediate," and "struggling" schools (with regard to technology integration), and recommended 17 schools that ranged across these three levels. Five were already on our list; eventually, seven of the schools recommended by TRNs were included in the study.

The final list of close to 60 possible schools was reviewed and narrowed down according to the following criteria.

- **By region:** Region 1 and Region 4 were disproportionately represented in the recommendations we received (particularly Region 4). This seems to be related to the important role that various university outreach programs are playing in supporting technology use in schools in these regions. This sample reflects the emphasis on these regions: four of the schools in the sample are from Region 4, and four are in Region 1 (the remaining two schools are from Regions 5 and 6). A positive aspect of this weighting is that it allowed us to look at differences in funding, application of technology, leadership, etc. in schools that are geographically close but quite different in their student population and size.
- **By poverty level:** In order to understand the range of implementation situations in Chicago, it was important to look at schools with high, medium, and low student poverty levels. Schools with higher rates of student poverty are challenged to meet the academic and personal needs of students who may have few resources to draw on at home, which may inform their choices in their uses of technology. Further, schools with high rates of student poverty receive higher levels of Title I funding, which can be spent on technology and which may also relate to differences in school infrastructures. However, because poverty levels are so overwhelmingly high in Chicago, we defined "medium" as meaning at or about the average, which is 83 percent, and "high" as meaning above 90 percent. There are very few schools in Chicago with 40–70 percent poverty levels; instead, there are a few schools with very low poverty levels balance out the large majority of schools with 95% or greater poverty levels, bringing the average down to 83 percent. Therefore, we included only one school with a very low poverty level in the sample, along with four schools at a medium level and five schools at a high level. Additionally, the school with a low poverty level is in a region where we are looking at several other schools, which allowed us to understand that school's financial situation in the context of other nearby schools.
- **By racial/ethnic makeup of the student body:** It was important to include schools reflecting the racial/ethnic makeup of the Chicago school district's student body. This sample includes two schools with all or almost all African American students; two schools with all or almost all Hispanic students; and six schools serving students with a range of racial/ethnic backgrounds. Additionally, two of the schools in the sample serve a student body that is more than 50 percent limited English proficiency, and another four serve more than 25 percent limited English proficiency.

- **By size of student body and grade levels served:** This sample includes large and small schools, ranging in student population from 260 to 1,421; this is an important variable that plays a large role in infrastructure and purchasing concerns, and also has an impact on the processes of school change and school management. Although we are concentrating on the K–8 schools that are most typical of the Chicago public school system, we have also included a 6–8 middle school in this sample to look at how the grade levels served by the schools may relate to differences in issues such as curricular concerns around technology use, views about most appropriate student uses of technology, and distribution of technology in classrooms.
- **By participation in the Chicago Systemic Initiative:** We chose to strike a balance in this sample between schools that are and are not part of the CSI. Five of these schools are CSI participants and five are not; this allowed us to consider whether or not the CSI plays a significant role in driving or supporting schools' technology use.

- **By relationships with other relevant programs or institutions.** It was important to have a sense of the different impacts of various programs on schools' experiences with technology, so we paid particular attention to including schools in the sample that are working with a wide range of outside partners. Eight of the ten schools work with outside organizations around technology issues; these schools vary in the number of programs they are involved with, which helped us gain a sense of how the overlap of multiple programs in single schools may or may not be useful to the school. School reform and technology programs playing a significant role in the schools in this study include the following.
    - CUIP: The Chicago University Internet Project, an initiative sponsored by the University of Chicago that works to bring Internet access to schools in the Hyde Park area and to support teachers in technology integration.
    - CoVis: The Collaborative Visualization Project, a research and development project run by Northwestern University's Institute for the Learning Sciences; CoVis involved a number of Chicago schools in on-line science collaborations.
    - Governor's State Interns: Undergraduate students from a local university work as technical support in schools across the district and provide technical training to teachers.

- Illinois State Department of Education grants: The Illinois State Department of Education has sponsored several types of curriculum grants to schools across the state over the past three years, which provide Internet access, partnerships with scientists, and other support for technology-rich curricula.
- Annenberg Challenge: The Chicago Annenberg Challenge supports networks of schools and their external partners to foster the creation of smaller learning communities and to address problems of isolation and time management; the past school year was the third in the five-year life of this program.

- **By type of technology emphasis:** This sample represents a range of technology infrastructures. Particularly interesting or unusual cases include schools with a very strong emphasis on integrated learning systems, wireless networking, use of mixed models (both integrated learning systems and tool-based software), video distribution systems, and video production systems.

By reviewing our initial list of schools and coming up with a distribution that represented an appropriate range over all of these factors, we narrowed down the field of schools considerably. This process left us with 15 to 18 possible schools, which we began contacting. As some schools were not willing to participate or could not be successfully contacted after numerous attempts, we ended up with ten schools that satisfactorily represented the range of factors we were interested in.