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Introduction

Technology, Equity, and School Reform

The head of the math department guides us through the halls of an urban high school, known for its high academic standards and focus on preparing minority students for competitive colleges and universities. We stop in at an environmental science class, where the veteran teacher enthusiastically describes their participation in the Rouge River Project. Her students, like those in dozens of other schools in the Detroit area, collected water samples and computed a water quality index during the second week of May. She describes how students at multiple schools have been working with university scientists to monitor all branches of the Rouge River since 1989. Unlike students at other schools, however, her class will not be posting their data on the World Wide Web and examining the data other schools have displayed there. "We don't have the Internet connection."

A few hundred miles away, in a well-to-do Chicago suburb, high school students peruse the home page for their physics class. It invites them to check out the on-line "physics classroom" of instructional pages written in easy-to-understand terms or the multimedia physics studios, with GIF animations and QuickTime movies illustrating physics principles. The virtual "Quiz Room" features quizzes given in the course in past years as well as tips for studying for this year's quizzes. The on-line "Laboratory" features makeup labs for anyone who missed a class lab, and the "Refrigerator" Web page features exemplary student problem solutions.

Data gathered by the U.S. Department of Education and others have documented what has come to be known as the "digital divide." As far back as 1983, observers noted with alarm that technology appeared to be on a road toward doing more to exacerbate differences in educational opportunity than to overcome them (Anderson, Welch, & Harris, 1984). The proportion of wealthy schools with microcomputers was four times that of poor schools with such equipment. By 1994–95, strides toward narrowing the gap in computer access had been made. The average number of students per computer was 11 in schools serving predominantly low-income students compared with 9.5 in those serving the most economically privileged student bodies. More recently, the density of computers in schools serving low-income students appears to be quite similar to that of schools serving average and high-income students (Anderson & Ronnkvist, 1999).

Differences persist in the quality of most of the computers in the two sets of schools, however, and in the amount and diversity of software present. For example, Quality Education Data (QED) technology inventory data for the 1996–97 school year indicated that more than three-quarters of computers in Detroit public schools and nearly half of those in Chicago public school classrooms were older models, most of which could not run current versions of spreadsheet or database programs (Education Writers of America, 1999).

Even larger differences are found in Internet access. In 1998 only 39 percent of classrooms serving the poorest students had Internet access compared with 62 percent of classrooms in schools with the most economically privileged students (National Center for Education Statistics [NCES], 2000). Moreover, students attending schools in middle- or upper-income zip code areas are twice as likely as those in low-income zip codes to have high-speed access to the Internet at school, according to a 1998 survey (Anderson & Ronnkvist, 1999). Becker (2000) has examined the proportion of schools that meet various criteria for a strong technology infrastructure (e.g., 50 percent of computers local area network (LAN)-connected; fewer than twelve students per Internet-connected computer; high-speed Internet access). Schools with more than 40 percent of their students eligible for compensatory education funds were less likely than other schools to meet these criteria. Similarly, the most recent NCES data on Internet access indicate that in 1999 there were seven students per computer with Internet access in the lowest-poverty schools compared with sixteen students per Internet-accessible computer in the highest-poverty schools (NCES, 2000). Thus, no matter which data source or criterion for Internet access we examine, there are significant differences between schools serving students from low-income versus higher-income families.

Finally, even when an adequate technology infrastructure is in place, available survey data suggest that teachers in low-income and urban schools do not use it in the same way teachers do in more affluent settings. In his 1998 national survey Becker (2000) found that teachers in high-poverty elementary and middle schools are more likely to report "remediation of skills" and "mastering skills just taught" as the purposes for which they have their students use computers. By high school, teachers in high-poverty schools view technology as an opportunity for their students to work independently. Becker contrasts the technology uses of teachers in schools with many low-income students with those of teachers with more affluent students: "teachers in high-SES schools [in contrast to those in low-SES schools] were more likely to use computers to teach students skills such as written expression, making presentations to an audience, and analyzing information" (p. 55). Becker attributes these differences in practice to differences in teacher beliefs: "Computer use in low-SES schools often involved very traditional practices and beliefs about student learning, whereas computer use in high-SES schools often reflected more constructivist and innovative teaching strategies" (p. 55).

Federal compensatory education programs have had *mixed* effects with respect to equity. On the one hand, an estimated $2 billion of Title I funds have supported educational technology within schools serving low-income students over the last decade (President's Committee of Advisors on Science and Technology, 1997). On the other hand, compensatory education dollars going to technology at the local level tend to be used for drill and practice in basic skills to the exclusion of the kinds of activities Becker refers to as "more constructivist, intellectual purposes."

Conceptual Framework: Student-Empowering Uses of Technology

In schools serving mostly middle-class students, there is an emphasis on teaching students to think and create *with* technology rather than on simply learning *from* technology. Instruction for middle-class students is geared toward putting the students in control, whereas instruction for low-income students is more likely to put the technology in control (through uses such as delivering information or basic skills practice sessions).

The student-controlled activities more typical in middle-class schools include such things as having students gather and analyze information, produce on-line reports and multimedia presentations of their research findings, manipulate computer models and simulations (or even produce their own models) as they develop and refine their understanding of systems and concepts, and interact with distant scientists as they participate in real scientific expeditions and investigations.

This is not to say that teachers working with low-income students in urban settings never have their students use technology in these ways, and we set out to look for examples of this kind of technology-supported teaching and learning at our urban case study school sites. More specifically, we selected those classes to observe most frequently that contained elements of what we have come to call *student-empowering technology use*. Our concept of student-empowering technology use contains the following six features. It

- emulates the ways in which professionals use technology,
- involves complex tasks,
- requires significant amounts of time for completion,
- gives students latitude in designing their own products and in determining when and how to use technology,
- involves multiple academic disciplines, and
- provides opportunities for student collaboration with peers and outside experts.

Unlike the technology-controlled experiences of learning factual knowledge through computer tutorials or practicing discrete skills on a computer, student-empowering technology uses put the student in a decision-making role, much as professional designers, scientists, journalists, and e-traders use technologies that serve their ends. Because the tasks that students accomplish with technology supports are complex and realistic, they typically call upon knowledge and skill from more than one academic discipline (e.g., scientific understanding, statistical analysis, and writing skills) as well as the ability to use technology skills. The multifaceted nature and high level of challenge posed by these tasks also encourage collaboration among students (who may produce a joint product or simply advise each other or share resources) and with individuals outside the school, who may provide information, suggest interesting problems to solve, act as coaches, or simply serve as an external audience for student work.

Such uses of technology are consistent with contemporary learning theory (see National Research Council, 1999) and with the qualities promoted by educational reformers (see Means, 1994). They foreshadow the environments that knowledge workers will encounter in the next century.

Survey statistics provide an outline of the differences in technology use in different kinds of schools. Wenglinsky (1998), for example, reports that eighth graders who attend urban public schools or who are eligible for free or reduced-priced school lunches are less likely than other eighth graders to have math teachers who use computers primarily for simulations and applications. In this book, we seek to paint the picture behind the numbers. Beyond mere counts of self-reported types of software use, what does the teaching and learning supported by technology look like in urban schools? How is it different from that in more affluent suburban schools? Is technology inevitably a magnifier of educational inequality? What barriers do urban schools have to overcome? Are there urban schools using technology in ways that empower students? If so, how do they do it? What would it take for other urban schools to emulate their strategies?

The Joyce Foundation funded SRI International's Center for Technology in Learning to address these questions through case studies of selected urban high schools' use of technology. This volume presents selected findings from fieldwork conducted primarily during 1998 and 1999 in the Chicago Public Schools (CPS) and the Detroit Public Schools (DPS).

Study Context: Chicago and Detroit Public Schools

Both the Detroit and the Chicago districts serve student populations with significant educational needs. The proportion of the student body eligible for free or subsidized lunches is 83 percent in Chicago and 84 percent in Detroit. In Chicago 54 percent of students are African American and 33 percent Latino; in Detroit 86 percent are African American and 9 percent other racial or ethnic minorities. Just under one-third of Detroit's eleventh-grade students met or exceeded state standards in reading, and 19 percent met or exceeded standards in math in 1998. Among CPS high school students, just 29 percent were reading at or above the national norm and just 31 percent were performing at or above the national norm in mathematics in 1997–98. In Chicago the graduation rate, computed as the number of high school graduates divided by the number of students who entered high school four years earlier (thus including "late graduates" in the numerator), is 65 percent. Coming predominantly from low-income, minority families, CPS and DPS students are much less likely than students in more affluent settings to have significant experience with, and access to, technology in their homes.

With 585 schools and more than 430,000 students, Chicago is the third largest school district in the United States and site of one of the country's most far-reaching efforts in school reform. Passed in 1988, the Chicago School Reform Act gave local school councils unprecedented control over local budgets and hiring and firing in return for accountability—requirements for bringing student achievement test scores in line with state averages under threat of "takeover" by outside organizations. In Chicago, local school councils not only hire principals but also evaluate their performance and have decision-making power over whether or not to renew their contracts. Principals, in turn, can hire teachers as they see fit, without respect to seniority within the district. Another unusual feature of the Chicago Reform is that principals and school councils control significant discretionary budgets, an average of $850,000 at the high school level (Hess, 1999). In 1996 a second piece of state legislation aimed at Chicago schools put the schools under the control of Chicago's mayor, who in turn appointed a chief executive officer (CEO) to run the schools. Under the current plan, schools where fewer than 15 percent of students perform at or above national norms on state-mandated tests are put on probation and then reconstituted with a new staff if improvement is not forthcoming.

Compared with Chicago, Detroit is a somewhat smaller school district seeking to get on the reform path that Chicago pioneered. In the year immediately preceding our case studies, the DPS came under increasing criticism for poor performance and excessive bureaucracy. A 1998 report from an outside consulting firm cited costly and ineffective services and an excess of staff at the district level. The district moved to transfer functions and employees from the central office to twenty "constellations," each composed of a comprehensive high school and its feeder middle and elementary schools along with associated adult and alternative programs (Keller, 1998). The district moves did not satisfy Michigan's governor, however, who pushed state lawmakers to pass a bill early in 1999 putting the city's schools under direct control of the mayor, as part of a "Chicago-style reform."

The emphasis on site-based control within these two districts has implications for the way in which technology gets introduced and supported within their schools. At the time of our research, the Chicago and Detroit district offices had neither the budget, nor the staff, nor the mandate to institute technology planning, purchasing, and support in these reorganized districts in the way districts have in some other parts of the country (e.g., Honey, Carrigg, & Hawkins, 1998). Geraldine Carroll, the head of Detroit's Educational Technology Office describes the shift in positive terms, "The old paradigm of every school receiving uniform support and direction from the central office has been replaced with a more customized presentation of services to fit the unique needs of each school." Under this new paradigm technology does or does not get introduced into individual schools at the option of that school's principal and local council. The commitment, technology savvy, and organizational skills of the principal are even more than usual critical factors in determining the success of technology introduction under site-based management.

A second major characteristic affecting technology implementation in these districts is the strong emphasis on accountability as measured through performance on statewide tests. Although schools have been feeling pressure to modernize their programs and introduce technology, their first requirement is to ensure that their students demonstrate an acceptable level of performance on these state and district examinations. Given the focus of many standardized tests on basic skills and knowledge of discrete facts, accountability programs can reduce administrator and teacher willingness to invest time and effort in student-centered uses of technology to develop advanced skills and conceptual understanding that are not measured on the high-stakes tests.

Technology Infrastructure in the Two Districts

In terms of technology implementation the two districts were at different stages at the time of our study. The CPS established a Department of Learning Technologies independent of the Department of Information Technology Services (ITS) early in 1996. (Previously, ITS was responsible for both administrative and academic computing.) The reorganization gave greater visibility to academic issues surrounding the use of technology. In 1999 Learning Technologies was promoted to "office" status within CPS, with Richard White, the Learning Technologies Officer, reporting directly to Cozette Buckney, the district's Chief Education Officer.

Starting in 1996, the district undertook several major efforts to support technology implementation in Chicago schools. First, a major effort to provide training and technical support around the use of technology was launched. A Technology Resource Network (TRN), consisting of twenty-six individuals designated to act as technology coordinators and teacher trainers, was established. Each school was assigned to a TRN coordinator who could provide training at the site, help the school develop a technology plan, and provide an additional communications link between the school and CPS Learning Technologies. Teacher training offered by the TRNs is supplemented by other forms and sources of professional development. A districtwide technology training day held each October has been characterized as the largest teacher technology training session in the world. An Instructional Intranet offers resources for teachers, including information about standards and detailed lesson plans (Greene, David, & Young, 2000). A summer institute fosters development of technology-supported curriculum units for teachers from twenty-nine pilot schools participating in the Technology Infusion Planning (TIP) program. CPS also supports the University of Chicago's summer Web Institute for Teachers, offered as part of the Chicago University Internet Project (CUIP) for schools in the Hyde Park area. In summarizing these activities, CPS Learning Technologies Officer Richard White asserts that Chicago's professional development with respect to technology integration is ahead of its infrastructure. By providing the teacher training early, the district fostered interest in technology use at the school level.

A second thrust in the CPS technology effort was districtwide planning for a uniform technology structure that would be implemented in all schools. The school board made a commitment to providing all CPS schools with high-speed T-1 access to the Internet plus a router, server, and uninterrupted power supply. Schools would connect to the district's wide area network (WAN) through five administrative drops placed in each school. The CPS technology plan calls for this "Short Scope" phase to be followed by a second stage in which each school would receive connections for their library, computer lab, and ten classrooms. The first stage of this infrastructure plan was completed in the fall of 1999. CPS plans to install the local area network configuration in every school by 2004.

Finally, CPS aggressively pursued maximization of the district's ability to take advantage of the E-rate discounts. The federal Telecommunications Act of 1996 provides for discounts of 20–90 percent (depending on the proportion of low-income students in a school or district) on Internet and intranet connectivity, classroom data cabling, and telecommunications services. While E-rate subsidies cannot be applied to teacher training costs or hardware and software purchases, the CPS viewed the federal program as an opportunity to support a technology infrastructure development that had lagged behind much of the country because of the high costs of upgrading electrical wiring and providing a technology backbone within the district's aging school buildings. In addition to the E-rate application submitted through the district, individual schools were encouraged to get state-approved technology plans so that they could make their own school-level applications and receive subsidies through the program. In a spring 1999 survey of Chicago high schools by The Chicago Panel, half of the schools reported having submitted individual E-rate applications (The Chicago Panel, 1999). In the first year of E-rate funding, Chicago received $49 million, the third largest allocation in the nation. (This figure includes the allocations for 117 Chicago schools that made their own E-rate applications.) These funds supported completion of the Short Scope phase of the district's technology plan in the fall of 1999. In the second round of funding, Chicago garnered $85 million in discounts, the largest allocation to any school district in the nation (The Chicago Panel, 1999).

Although it would not qualify as one of the first districts in the United States to push educational technology implementation, the CPS actions since 1996 have been vigorous and demonstrate a strong commitment to promoting technology use. Nevertheless, from the school perspective, district support only goes so far. With each TRN coordinator assigned to cover twenty-three schools, no single school can expect extensive on-site assistance or training for the district. Similarly, although the district undertook a significant expense in taking on the bill for installing T-1 connections to the schools, individual schools still faced responsibility for connecting the data cabling from the main distribution frame (MDF) room to their computer labs or classrooms with the associated costs of asbestos abatement, electrical upgrades, and within-school wiring as well as the expense of computers and software. In the case of many of Chicago's older, decaying school buildings (nearly half of the district's schools are over fifty years old), these costs were daunting. Recognizing these problems, CPS has established a Local School Education Network program to help schools pay for internal wiring and local area networks. This $57 million fund is intended to ensure that all CPS schools meet a minimum technology standard, with libraries, computer labs, and at least ten instructional classrooms connected to the school network (Honey & Culp, 2000). The CPS Financial Support Services (FINSS) program, a partnership between CPS Learning Technologies and Finance Departments, provides an option to pool five years of allowable discretionary funds to purchase hardware and software (The Chicago Panel, 1999).

Detroit has faced similar challenges of decaying buildings, inadequate wiring, and uncertainties regarding the best organizational home for instructional technology. Up until 1996, only a small minority of Detroit schools had Internet connections of any kind; the district's administrative network supported only dial-up modem access, and few classrooms had connections to the Internet (Honey & Culp, 2000). The district's share of the settlement of a Michigan State lawsuit against Ameritech, received in 1996, enabled DPS to build networks in several high schools. With the advent of E-rate funds, Detroit was able to commit to wiring all of the district's schools, beginning with high schools and middle schools in 1998. Wiring efforts have been complicated, however, by asbestos abatement requirements and by the fact that the telephone cabling in some schools was too old to carry computer signals (Education Writers of America, 1999). A state-level fund has provided $12 million dollars for electrical upgrades in Detroit schools (Honey & Culp, 2000).

As in Chicago, the DPS have reorganized the way in which the district supports technology use in schools. District-level educational technology services began as part of the Division of Educational Services and have maintained a strong emphasis on curriculum integration. At one time, the DPS maintained a Software Department that approved all instructional software. Schools could not use a piece of software until it had been vetted by this office. As the number of computers in schools grew, however, and the need for technical support and computer repair and maintenance rose, educational technology was made part of Information Services. By 1998 the professional development and curriculum integration functions related to technology had once again been made a part of Educational Services, with purchasing and repair of computers remaining with Information Services. In school year 1998–99 Detroit's Educational Technology

Office within Educational Services had twelve technology consultants responsible for providing professional development related to technology use for 280 schools. Information Services had fourteen technicians available to respond to schools' needs for technology maintenance. In 2000 the district announced its intention to outsource technology maintenance entirely. As in Chicago, individual schools in Detroit have had to cover the costs for computer equipment, maintenance, and upgrades out of their own discretionary budgets. With little certainty concerning school budgets from year to year, the ongoing investment required for technology was regarded by many principals as a risky undertaking.

The 1998 DPS E-rate application stated that only one out of eight classrooms in the district was connected to the Internet. Detroit received $15 million from the first round of E-rate funding and about the same amount in the second round. Detroit's E-rate application was managed by the Office of Information Services but required coordination with the Educational Technology Office. A former DPS Director of Information Technology has been quoted as referring to Detroit's early E-rate subsidies as "a godsend" (Honey & Culp, 2000), but they were considerably less than those received by other comparably sized urban districts (Education Writers of America, 1999).

Prior to the E-rate, the DPS approach was to put technology into a school's office, labs, and library, "usually based on school or district politics," according to a former Information Services administrator. The E-rate is making it possible for Detroit schools to bring technology into instructional classrooms, and the E-rate discount formula means that schools serving more low-income students are getting technology first. In all cases, schools still face the problem of finding resources to pay for computers and software. Schools are largely left to fend for themselves in this regard, by using their own discretionary funds or finding corporate donors or securing grants.

The academic side of technology in DPS is the responsibility not of Information Technology but of the Educational Technology

Office within Educational Services. A distinctive feature of the DPS Educational Technology Office is its emphasis on integrating technology use with curriculum. In-service courses cover topics such as “Software in Social Studies” or “Spreadsheets in Science,” rather than the more generic technology training (e.g., “Building Web Pages”) emphasized in many districts. Similarly, technology use is integrated into the district’s core curriculum across subject areas and grade levels rather than called out as a separate curriculum topic or set of learning outcomes. This approach has advantages in terms of helping teachers see the applicability of technology to the particular subject areas they teach (and we will describe its advantages at greater length in Chapter Eight), but it is hampered in Detroit by the very limited professional development time available. The contract negotiated with the teachers’ union calls for only two professional development days per year. Substitutes to cover additional days are difficult to come by in this urban district, and there are limits to what can be achieved through voluntary weekend or summer programs. Detroit schools vary markedly in the inclination of their teachers to devote uncompensated time to their own or others’ professional development. The factors associated with teachers’ willingness to devote such time were among the issues addressed in our case study research.

Both DPS and CPS participate in a National Science Foundation project, along with the University of Michigan and Northwestern University, aimed at infusing exemplary technology-supported science inquiry curriculum into their schools. In Detroit, efforts related to this Learning Technology for Urban Schools (LeTUS) project have been concentrated at the middle school level. Juanita Clay-Chambers, the Associate Superintendent for Educational Services, explains that the middle schools were seen as the greatest challenge, on the assumptions that at the high school level there were department heads who could help carry the message about the integration of technology with math and science content back to their schools.

Case Study Approach

Within each district, the study team queried district staff, researchers at local universities, and educational technology experts concerning high schools making interesting uses of educational technology. Descriptions of school technology use on the Internet and in national publications dealing with educational technology were consulted as well. In Chicago we made exploratory visits to a number of high schools in addition to conducting telephone interviews with technology coordinators and school principals to help narrow the field of potential sites. A more-limited preliminary appraisal was conducted in Detroit, in keeping with district procedures for reviewing and approving proposals to conduct research in the city's schools.

The schools we selected for study represent a range of educational purposes and characteristics as well as different histories of technology use. Some have long been considered "early adopters" of new technologies within their districts, others are in midcourse or trying to "catch up."

Our Chicago schools comprise a traditionally organized college preparatory school with a mathematics and science focus; a vocational/technical magnet school emphasizing computer technology; and a small, progressive high school stressing student-centered interdisciplinary studies. None of these schools has selective admissions, although the college preparatory high school began a scholars program, admitting 100 students per year on the basis of test scores starting in 1998–99.

In Detroit we conducted fieldwork at a selective college preparatory school, a technology demonstration school, and a general high school located in an economically strapped Empowerment Zone. The broad range of school sizes and missions enabled us to examine technology use in the service of different educational goals.

Once a school was selected as a case study site, we undertook a series of site visits, observations, and interviews over a period of nine months or more. Most of the visits to Chicago schools occurred during school year 1998–99, whereas those to schools in Detroit began in the spring of 1999 and continued through the spring of 2000. Each school was visited by a core team of two researchers with less frequent visits by the study's principal investigator (Means). Interview guides were used to structure initial interviews with principals, technology coordinators, and teachers. These early conversations and associated brief classroom visits provided a basis for selecting two to three particularly interesting uses of technology on which to focus at each school. Subsequent observation sessions were supplemented with opportunistic conversations with students and teachers. Key interviews were transcribed for subsequent analysis. All this information was used in completing a structured debriefing form for each case study school. The school's liaison with the research team was given the opportunity to review the debriefing form and make additions, corrections, or comments.

To provide perspective on the nature of the challenges urban schools face in implementing technology, the study team also visited several suburban high schools in the same regions. Effective implementation of technology is a challenge for any school, and many observers judge that only a minority of U.S. schools in any economic circumstances are meeting this challenge. Nevertheless, urban schools must deal not only with limitations on resources but also with constraints of size, politics, and perceived mission that dwarf the challenges faced in the typical suburban district. Contrasting the experiences of the urban case study schools with those of their suburban counterparts helps to clarify the ramifications of these constraints. By looking carefully at the contexts in which these urban case study schools operate and at the strategies they have used, we can gain a fuller understanding of just what it means for them to try to implement technology-supported "twenty-first-century" learning environments and of the special blend of vision, dedication, and pragmatism it takes to make such environments work.