Information Technology in Childhood Education Annual (2002), 147-179

School Change with Technology: Crossing the Digital Divide

MARGARET RIEL AND JENNIFER SCHWARZ
Center for Collaborative Research in Education
University of California, Irvine
Irvine, CA USA
mriel@uci.edu

AMY HITT
Anaheim City School District
Anaheim, CA USA

Closing the digital divide requires much more than buying equipment, it requires increasing the knowledge and skills of teachers using the technology, and access to digital tools in the community. In such a larger system of change, technology can serve as a catalyst for increasing teacher and student learning.

The Anaheim City School District (ACSD) tackled the problem of closing the digital divide by creating the Technology Learning Community. This community approach to school change engaged students, teachers, and principals of two schools, researchers from two universities, school and local librarians, and members of the Hispanic community in a process of continual learning centered on the use of technology.

In this article, we explore the process of school change documenting the school and community efforts to close the technical, cultural, and structural dimensions of the digital divide. These changes are evident on test scores but even more so in changes in the way teachers relate to their own learning and to that of their students.

Computer skills and Internet access are increasingly required for participation in learning opportunities (Dede, 1998) and are baseline requirements for employment (Rifkin, 2000). Unfortunately, people from different social classes and ethnic backgrounds do not have equal access to this technology. The digital divide has consequences that extend beyond the school. If the digital divide was only a matter of unequal access to equipment, closing it would simply involve duplicating the resources of wealthy schools in poorer schools. Unfortunately, educational needs of the students in urban schools are more complex. The professional background and training of teachers is often not well matched to this complexity and the employment of resources in these environments is very different. School districts often find it easier to acquire computers than to develop the culture of learning necessary to incorporate them into effective learning environments.

There are also forces beyond the school that shape the digital divide. Students as well as teachers bring computer skills to the classroom. The gap in home ownership and Internet access between Caucasian and African Americans and Hispanic groups has increased not decreased over the past few years (National Telecommunications and Information Administration (NTIA), 1999). As a result, teachers in upper income neighborhoods do not have to invest valuable classroom time in teaching students how to use computers; moreover, they can even rely on students for their own technical support. These student resources are missing in urban schools.

Lacking the resources of teachers who understand technology and without computer learning in the homes, students in urban schools are more likely to be controlled by technology while their peers in affluent schools are learning how to control the technology. Recognizing the technical, cultural, and structural dimensions of the digital divide, the Anaheim City School District (ACSD) sought to augment student computer literacy skills and to form a technology learning community for integrating technology into the curriculum. Their goal was to increase teacher and student learning both *with and without* technology. Learning to integrate technology with teaching practice opened up the possibility of school change as a means to provide new opportunities for both student and teacher learning. They designed a program that placed students, teachers, parents, principals, researchers, librarians, technology experts, and the superintendent in a Technology Learning Community (TLC) with the goal of increasing technology use throughout the school and community. Margaret Riel and Jennifer Schwarz, from the Center for Collaborative Research in Education at the University of California, Irvine provided both formative and summative evaluations of the process of school change with technology. Amy Hitt assumed coordination of the Technology Literacy Challenge Grant that funded this program half way through the project.

TECHNICAL, CULTURAL, AND STRUCTURE DIMENSIONS OF THE DIGITAL DIVIDE

The digital divide is characterized in terms of its width, slope, and depth. The width represents differential access to technology resources in schools. The slope represents differences in the cultural context of use—how and why teachers choose to use computers to support their teaching. The depth represents structural differences in access to, and knowledge about, these evolving tools based on an individual's or a group's socio-economic and cultural location in society. Taken together these three dimensions produce massive differences in student skill level, learning, and future economic opportunities. The article begins with the national and local context of the divide and then the ACSD-TLC plans for, and success in, closing the divide for students in two elementary schools is presented (Figure 1).

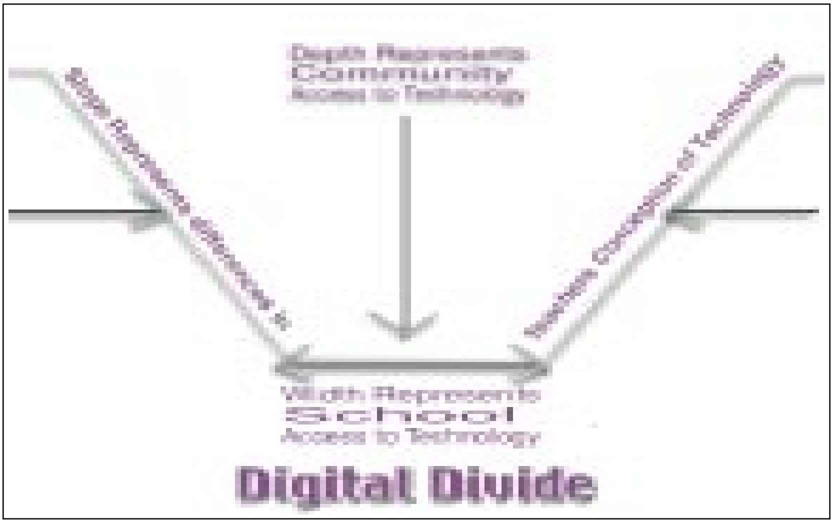

Figure 1. Characteristics of the digital divide

WIDTH OF THE DIVIDE: DIFFERENTIAL ACCESS TO TECHNOLOGY IN SCHOOLS

National Context

In 1997, the President's Committee of Advisors on Science and Technology reported that most experts find a ratio of four to five students per computer is needed for effective use of computers (U.S. Department of Education, 2000). In 1997-98, the year this project began, schools with minority enrollment greater than 90% had a student to computer ratio of 17 to 1, compared to the national average of 10 to 1. For computers with advanced graphics and interactive video capabilities (multimedia computers), the discrepancies were even greater (Coley, Cradler, & Engel, 1997). Socio-economic disparities exist in computer connectivity as well. In 1998, 90% of the nation's schools were connected to the Internet; but the schools in the richest communities were more than twice as likely to have high-speed lines as those in the poorest communities (Anderson & Ronnkvist, 1999).

In the last few years most schools have obtained access to both computers and the Internet, but the digital divide remains. *Technology in Education 2000* (2000) reported that schools with more than 50% minority enrollments had a 9.4 to 1 ratio of students per multimedia computer compared to a ratio of 6.9 to 1 for schools with fewer than 5% minority enrollments. Schools with 50% or more minority enrollments averaged 10.5 students per Internet-connected computer compared to 6.4 students for schools with fewer than 5% minority enrollments. A survey of elementary schools in the spring of 2001 places the average ratio of elementary student to multimedia computers in California as 9.5 to 1 (California Department of Education and the California Technology Assistance Project (CDOE-CTAP), 2001).

Local Context

The two elementary schools involved in the TLC project have a combined annual enrollment of approximately 2,000 students; 94.1% are Hispanic, with 67% designated as English language learners. Almost all of the students (about 93.7% across both schools) qualify for free and reduced price lunch.

Not only did the 50 year-old buildings lack sufficient computers for Internet access, but they even lacked the electrical wiring to plug them in. If Internet resources were to be part of the instructional plan in these classrooms, an enormous effort at many different levels including classroom, school, district, and local communities would be necessary. The baseline information indicated a ratio of about 13 students to 1 computer for both schools when all computers of any age were counted. The number of students per computer doubles if only multimedia computers are considered. Only one fourth of the classrooms had printers. The staff or principals did not commonly use computers.

SLOPE OF THE DIVIDE: DIFFERENCES IN TEACHER CONCEPTIONS AND THE CULTURE OF TECHNOLOGY USE

National Context

The educational background of the teacher is a significant factor in shaping the use of computers in the classroom. A national study of more than 4,000 teachers suggested that teachers who received higher grades in college, attended more select universities, and continued their academic work were more likely to value the use of computer technology in schools and, when available, use them to promote student problem-solving, writing, and collaboration (Riel & Becker, 2000). Also, teachers who reported a number of leadership practices (mentoring, presenting, and publishing; and informal and formal professional peer relationships with other teachers) were 10 times as likely to use computers for inquiry and idea sharing as were teachers who were less professionally engaged. Teachers involved in a "private practice," isolated from their peers (Riel & Becker, 2000), and teachers of low-achieving students were substantially more likely to have their students play games to practice skills than were teachers of high-achieving students (Becker, 2001).

Among the fourth through sixth grade teachers in this sample who used computers for instruction, teachers in predominately minority, poorer schools (N=120) showed no real difference in the use of skill/game software than teachers teaching in wealthier schools (N=189). The use of word processing was much more prevalent in privileged schools. They were also more likely to use simulations, reference materials, spreadsheets/databases, multimedia, and World Wide Web (WWW or Web) browsers than were teachers who taught minority students in low SES schools.

The difference in cultural climate of computer use was made clear in a recent PBS television broadcast, *The Digital Divide* (Public Broadcasting Service, 2000). A teacher, who worked with diverse students in an urban setting, spoke passionately about her students' needs to understand their real world, to interact with each other, and to attend to the important goals of education. This led her to argue that her students did not need more computers to isolate and disconnect them. The next segment showed a teacher working in a suburban school with a homogenous group of students. She illustrated how technology helps students record, analyze, and understand what they observed in their natural environments working in collaborative teams and how sharing these observations with students in other countries is enriching the lives of her students.

These two teachers expressed the same educational goals, but viewed the role of technology in fundamentally different ways. Teachers on the far side of the digital divide are skeptical about the value of digital technologies, rejecting them as impersonal settings for drill and practice. Their cultural assumptions of technology are quite different from teachers on the other side of the divide who view technology as part of the learning landscape employed to increase access to human and informational resources beyond the classroom.

Local Context

Before TLC, only a few of the teachers had experimented with Internet projects or used computers to engage their students in innovative learning tasks. The staff, teachers, and principal had minimal computer literacy skills and e-mail was not used regularly in either school. Over a third of the teachers (35%) reported that they never or rarely discussed computers, software, or the Internet with other teachers. A classroom computer was most often used for software games to practice skills and to access reference material stored on CD-ROMs. The absence of printers indicated that writing was not a common use for the technology.

DEPTH OF THE DIVIDE: DIFFERENCES IN ACCESS TO TECHNOLOGY OUTSIDE SCHOOL

National Context

It is difficult, if not impossible, for schools to close the digital divide without reaching beyond the school. Analyzing 1998 data from U. S. Census Bureau Current Population Study, Becker (2000) found that students from Caucasian families were more than twice as likely to have a computer at home than students from African American or Hispanic families. In terms of access to the Web, students from a Caucasian background were three times more likely to have an Internet connection in the home than students from either African American or Hispanic families. Education and social-economic status are also strong forces dividing students into groups with and without access to technology. However, even among families with *similar* incomes and parent education levels, most African American and Hispanic children had at least 10% less access to home computers and the Internet than white non-Hispanics or Asian American children. The differences in ownership are only partially related to income and education levels. Among those living in households without computers, and with a minimum education (elementary school), 66% said they did not need a computer, 58% reported that they didn't know how to use a computer, and 42% said it would be difficult to learn (NTIA, 2000). The lack of knowledge and skill in using computers and negative attitudes about the Internet also appeared to be significant factors contributing to the depth of the digital divide.

The U.S. Department of Education reported that students spend only 9% of the year in the classroom. When students come to school with a deep knowledge of technology, teachers can use this expertise in complex learning tasks. Without this resource in urban schools, the teacher is forced to devote valuable instructional time to teaching mechanical skills and cannot rely on students to deal with minor technology problems.

Local Context

Most of the working-class parents who send their children to these two schools in Anaheim do not use computers in their workplace. With little personal knowledge and limited income, few students had access to computers in the home and even less had any experience with the Internet. Without a way for parents and students to develop conceptual tools, even families that might be able to afford computers, are unlikely to buy them.

ACSD TLC PLAN TO CLOSE THE DIGITAL DIVIDE

The ACSD developed a plan to close the digital divide that involved: (a) increasing access to technology, (b) developing a culture of teacher learning to support innovative use, and (c) increasing community access to technology.

Increase Technology Access

Classroom access to computers necessitated electrical rewiring and wiring for classroom, school and district networks. A goal was to place four to six multimedia computers and two scanner/printers in every classroom, upgrade the computer lab, and create a class, school, and district network. Other technology, such as portable keyboards, digital cameras, video systems, would be made available based on teacher requests.

Develop a Culture to Support Innovative Computer Use

The TLC project wanted to build whole school capacity to learn and teach with technology in a way that encouraged inquiry, problem solving, and meaningful work rather than drill and practice. Four major initiatives were developed to build the capacity of teachers to learn, think and teach with technology.

1. *Teacher leadership*. A teacher on "special assignment" directed the TLC project and coordinated the work of all of the partners. A Technology Steering Committee of 10 teachers from each school represented the teachers in the decision-making. Underlying these leadership decisions was the desire to have teachers view this change as one that was under their control—one in which they were the agents, not objects, of school reform.
2. *Self-directed program of professional development.* The choice of a single computer platform was made at the district level for economic reasons—to facilitate staff development and technical support. This decision caused concern among some teachers and necessitated increased learning as most teachers has some experience with Apple™ computers. Teachers have little time in the school day for experimentation with technology; usually those who use computers extensively at school also have them at home. To enable all TLC teachers to have access to similar technology in the home, the project paid teachers for the extra time they would spend in professional development activities at the beginning of the project as an advance with the condition that it be spent on technology (for more details see Riel, Schwarz, Peterson, & Henricks, 2000). A computer store, a member of the TLC partnership, offered ACSD teachers significant educational discounts to extend their stipends. The stipends were designed to involve teachers in mak-

ing choices for their own use of technology and to encourage everyday use of technology in the home and with the family.

The $1400 stipend committed a teacher to invest 140 hours of professional development time outside of normal school hours on learning how to teach with technology. The Technology Steering Committee determined that teachers would be given TLC credit for workshops, committee work, courses, conferences, and projects that contributed to their learning. The grant covered the cost of providing workshops "on demand" by any group of more than five teachers. Independent learning was documented with a written report. Teachers earned credit for time spent designing new lessons with technology if they shared in writing or presentations with other teachers. This system also provided a way to track the different choices that teachers made as they participated in the design of their own personal programs of professional development.

3. *Teacher mentors.* Changing the culture of technology use involves going beyond learning *about* technology to learning with technology. The TLC project increased conceptual understanding by identifying teachers who developed skills in integrating the computers with the curriculum and asking them to serve as project coaches. Teachers were invited to model lessons and/or work on skills with peers during their four-week breaks (in their year-round teaching schedule).
4. *Community commitment to teaching and learning.* Finally, and perhaps most importantly, the teachers at these two schools agreed to learn in order to teach their peers. The TLC project began with a presentation to the teachers at both schools of the project plans. They were given the option of relocation to another school in the district. While a few teachers took this option, most teachers agreed to actively participate and to share what they learn with other teachers in the district through presentations at workshops and technology fairs.

Increasing Community Access to Technology

The TLC project addressed out-of-school learning by forming a partnership with the public library, creating parent courses for basic computer literacy, and developing after-school programs for students. The partnership with the public library and a San Jose State University Library Science Department gave students access to the same technology used in schools at several branches of the public library. The TLC project added computer literacy courses for parents to increasing learning in the home and availability of parent technical assistance in the classroom. Students had increased technology-learning opportunities after school through a program designed to teach them to become “Technology Ambassadors.” After completing the program, these students provided immediate in-class assistance for low-level problems, freeing the district technical support personnel to handle more serious problems.

Summary of the ACSD’s Technology Learning Community Plan

The three-part plan to close the digital divide for the students at these two large urban elementary schools and increase student learning, thus, involved the following:

- increase access to technology and basic technical literacy of students and teachers;
- develop teachers’ abilities to use technology to reach important curricular goals; and
- use out-of-school resources to increase student expertise with technology.

DATA COLLECTION

Riel and Schwarz documented the process of change from 1998 to 2001, focusing on how changes in teacher learning effect changes in student learning. The relationship between sustained teacher learning and measurable changes in student learning was explored. While these changes are likely to take longer than the three-year period of the TLC project, the trends should be visible by the end of the project. Project planning occurred from April 1998 through September 1998 during which baseline surveys were collected and detailed assessments were made of electrical/wiring needs. From this point forward, the project data collection and evaluation took place in three phases linked with the school year:

- Planning/Baseline Period (Apr. 1998 - Sep. 1998);
- Phase 1 (Oct. 1998 - Sep. 1999): Computer Literacy and Wiring;
- Phase 2 (Oct. 1999 - Sep. 2000): Developing the Networking Infrastructure; and
- Phase 3 (Oct. 2000 - Sep. 2001): Computer and Internet Integration.

Data collected included: teacher and principal annual surveys, scheduled classroom observations, project and school administrator interviews, school visits (Technology Fairs and Open House), teacher professional learning programs, and student achievement test results.

In July 1998, baseline data from the TLC project teachers was collected using a survey adapted from the national 1998 Teaching, Learning, and Computing Study (Center for Research on Information Technology and Organizations (CRITO), 1999). This enabled the comparison of the TLC teacher responses to those of a representative sample of 792 US elementary teachers and with a sample of 69 elementary teachers who were involved in school reform programs emphasizing technology. All teachers at both schools (*N*=90) completed the baseline survey. The Phase 1 survey was similar to the baseline survey with a few questions added or modified to evaluate new changes taking place in the schools. The survey return rate for Phase 1 was 92% (*N*=81). Phase 2 involved the integration of the technology with the curriculum. The Technology Integration Survey was created, which included previous questions about technology, with new questions organized in three parts: (a) Technology and the Writing Process, (b) Technology and the Curriculum, and (c) Professional Development with Technology with return rates between 85%-90%, *N*=80-85). The final Teacher Survey was distributed in July and August 2001. This online survey included the three-part technology integration survey and a three-part practice and philosophy survey. The return rate was 90% (*N*=67). The principals at the project schools also completed annual questionnaires pertaining to school demographics, technology access, and school policies related to technology, as well as issues of school reform/restructuring.

Classroom observations were conducted at three points during the study (summer 1998, fall 1999, and spring 2001) at the two project schools as well as at a nonproject district school with similar school demographics, in 1998 and 2001. Thirty to 40 minute observations took place in all TLC classrooms and nine classrooms at the comparison site (one teacher from each grade level, plus one special day class, and one GATE class). Two types of data were collected: (a) ethnographic descriptions of the social organization of the classroom and teacher-student interaction and, (b) quantitative information including class size, structure of learning context, characteristics of the students' work, types and occurrences of teacher/student questions and statements, and teacher/student computer use. The data collected were used to create an extensive report of the strategies observed in teaching and in the introduction and use of technology. This information was shared with the TLC project staff and a shortened version was submitted to the California Department of Education as part of the year-end evaluation.

Visits were also made to classrooms during both schools' Open House (in April and May each year) as a way of monitoring the changes in the display of student work with technology. The researchers also attended three "technology fairs" in which teachers shared technology integration ideas with other teachers in the district.

In Phase 2, mid-project interviews of TLC project leaders and school leaders were conducted to obtain the administrators' perspectives on project goals, learning communities, their roles in the project, challenges they had encountered, and outcomes. In Phase 3, leading administrators and teachers wrote reflective essays about their participation in the project.

Technology stipends committed teachers to invest time in professional development activities and classroom projects. TLC staff kept records of teacher participation in all forms of professional development (i.e. classes, meetings, conferences, special projects).

Stanford Achievement Test (SAT 9) student test result data were collected prior to the project (1997-1998 baseline/pretechnology integration), Phase 1 (1998-1999 school year), and Phase 2 (1999-2000 school year). While fully aware of the limitations of test scores to document learning especially with technology, these data are used to help explore the relationship between teacher and student learning.

FINDINGS

The findings are reported in three parts that reflect the width, slope, and depth of the digital divide. First, how increasing access to the equipment and developing the technical capacity to use it reduced the width of the divide is examined. Second, the focus is on the culture of teacher learning and how the teachers sought to use technology to increase student learning. Third, efforts to reduce the depth of the divide by increasing out-of-school learning for students and parents are examined. And finally effects of these changes on student achievement are discussed.

Closing the Width of the Digital Divide: Increasing Access to Technology

Building a technical and communication infrastructure at aging schools was a complex process. The changes that took place according to the project phases previously listed are reported.

Planning Period (1998): Evaluating Access to Technology

Prior to the TLC project, most classrooms had a single Macintosh PowerMac™ computer, some had no computers, and only a few had two to four additional computers, (typically Apple IIe™s and early Windows™ computers). Only 11% of classrooms were observed using their computers during scheduled classroom visits.[1] The baseline survey indicated that 50% of the teachers had little or no experience with computers. Most of the other teachers reported a moderate level with only one teacher reporting expertise.

Phase 1 (1998-1999): Providing Teachers, and then Students, Access to Technology

The first year involved increasing teachers' general familiarity and comfort with the technology intended for their classrooms. Rewiring the classrooms—for both electricity and computer networking—took longer than anticipated. When the first shipment of computers arrived, the classrooms were not ready. This proved fortunate, as the teachers were sent home with their classroom computer, after some initial instruction on setting up a computer. They had several months to experiment with the technology in the comfort and privacy of their homes with no pressure to begin using them with students. In December of 1998, the computers were returned to the classrooms and connected to color printers/scanners. The second computer and connections to the Internet were added at the end of this phase.

TLC viewed teacher access and ownership of technology as an important precondition for integrative classroom use. When the electrical and wiring was complete and loaned computers were to be returned to the classrooms, teachers received their technology stipends making it possible to purchase hardware and/or software to continue home access to technology. Half of the teachers used the stipend to buy a new computer, but the stipend was also used to buy printers, fax machines, digital cameras, and scanners.

While a majority of the teachers began the TLC project with a rudimentary understanding of basic file management skills, it became clear that basic computer literacy (displaying, saving, printing files) and communication skills (sending e-mail and using the Web) were mastered as a result of increased access to technology at home and school. The school principals modeled this learning process by creating school bulletins as digital documents and sending them as e-mail attachments. Their actions greatly increased professional use of e-mail because teachers had to be able to access e-mail to respond to important school business.

Increased student access to computers was achieved through the use of AlphaSmart™ portable keyboards. Classroom sets of 30 portable keyboards were provided on carts to be shared among a number of classrooms. TVs and VCRs were installed in all classrooms with one computer connected so that a teacher could display the information from the computer on an overhead monitor. A 10-station research lab was installed at each school, with a projector and a SmartBoard™ for presenting lessons. Digital and video cameras were also made available in response to teacher requests.

Phase 2 (1999-2000): Increasing Student and Teacher Access to the Internet

Phase 2 marked the beginning of access to the Internet and use of district, school, and classroom networks. Classrooms gained two computers and a printer giving them a total of four computers and two printers. A network server was added for each school. And, in response to teacher requests, more classroom sets of AlphaSmart™ portable keyboards, a MacG3™ video editing workstation for teacher use, laptop computers for teacher checkout, and more digital and video cameras for classroom use were purchased.

Although teacher access to the Internet was available during this period, student use required parent signatures on “responsible use” forms. The creation, translation, distribution, and collection of these forms further delayed instructional use of the Internet. The survey given at the end of this phase (August 2000) indicated that about a third of the teachers (37%) moved quickly to incorporate student use of the Internet with classroom work.

At this point, most of the teachers were comfortable with using computers and had mastered file management. Most of them (93%) also knew how to send/receive e-mail and attachments (70%) and use websites for professionally development (56%).

During this phase, each school decided to purchase reading assessment programs, *Reading Counts*,™ and *Accelerated Reader*.™ Teachers felt that giving students practice in reading and taking tests on the computer, a task they appeared to enjoy, would help prepare them for the more stressful SAT 9 testing regimen.

Phase 3 (2000-2001): Connected Access to Multimedia Tools

During Phase 3, the TLC goal of school-wide connectivity was finally reached. In October 2000, the two schools began full-school networking using four network servers and two CD towers. A fifth computer was added in primary classrooms with 20 students and a sixth computer in intermediate grades with 30 students or more. In addition, both schools had computer labs equipped with 30 networked computers.

Purchases based on special requests of teachers, which showed teacher initiative in the use of new technology, appeared in Phase 3. The TLC project purchased portable computers (iBook™ laptops with iMovie™), digital video cameras, software, and digital microscopes for teachers who provided leadership in exploring learning contexts using these tools.

The gradual process introducing this level of technology into classrooms was important. Neither teachers nor students were initially ready to move from the sporadic use of a single computer to full utilization of four to six computers connected to the Internet. The gradual purchase and installation of equipment gave the teachers more opportunity to experiment with classroom management, and created a staggered plan for replacement. In 1998 only 64% of teachers had used a computer for instruction, while in January 2000, 95% reported regular instructional use.

Summary

Over the three years of the project, the ratio of students to multimedia computers decreased from 19 to 1 to 4.8 to 1 which matches the ration that researchers recommend for effective instructional use (US Department of Education, 2000). These schools have twice the number of computers available than the average elementary schools in California (CDOE-CTAP, 2001). They also join the 53% of schools in California that have Internet access in all classrooms. If AlphaSmart™ keyboards are counted as computers, then the overall ratio of students to computers decreases even further to 2.8 to 1. Their access to these, and other digital resources, places these schools on par with most technology-rich schools in the country. The access to technology at these two schools has closed the width of the digital divide. In addition, the clear increase in teachers' technical skills makes it possible for them to use this technology in their classrooms, the topic of the next section.

DECREASING THE SLOPE OF THE DIGITAL DIVIDE: DEVELOPING THE CULTURE OF COMPUTER USE

Reducing the width of the digital divide (increased access to technology), does not necessarily affect the slope of the divide (differential uses of the technology). Data on professional development, interviews, survey data, classroom and school visits, and teacher reflections were used to describe the culture that developed around technology learning and use.

Professional Development Program

At the beginning of the project, teachers accepted a technology stipend for which they agreed to design a personal program of professional development. The 58 teachers who have been in the TLC project from the beginning have invested an average of 138 hours (*SD*=35) of out-of-school time in professional development activities. While there were wide differences in the way teachers structured their personal programs, an average teacher spent 56% of the time in classes (*SD*=28), 17% attending conferences (*SD*=25), and 19% of the time submitting projects and participating in other activities (*SD*=15.5). The TLC teachers have submitted more than 100 classroom projects to document professional development—a number that has increased substantially over each year of the TLC project.

Mid-way through the project and again at the end of the project, teachers were asked to rate themselves on a scale developed by the Apple Classrooms of Tomorrow (ACOT) research studies (Sandholtz, Ringstaff, & Dwyer, 1997). The teachers placed themselves on a scale from entry level to "inventive" in their use of technology by selecting a statement that most fit their current attitude toward their instructional use of technology (Table 1). The change on this scale closely mirrors differences seen in classroom observations. Most of the teacher change has been in the movement from entry to intermediate levels. While this question was not in the baseline survey, teachers were asked to rate their expertise with computers and only 9% listed themselves as experts. Many of the teachers who selected inventive uses of technology were members of the Technology Steering Committee.

Table 1

Instructional Expertise Scale (ACOT)

Level	Phase 1 (1999) *N* = 81	Phase 3 (2001) *N* = 67
Entry: I use the textbooks, workbooks, overhead projectors and sometimes computers. I have set up new procedures for the use of technology by students in my classroom with an effective rotation schedule. My students are just becoming comfortable with technology.	30%	10%
Adoption: I have developed computer-based activities helping students to use the technology; particularly keyboarding, word processing, and help students learn how to save, store and organize work. My students use computers to write.	16%	8%
Adaptation: I use technology as a productivity tool with my students and for myself. I have found that computers make compositions more presentable to others, thus encouraging writing, and that students write more and better as a function of the accessibility of computers. I am developing new strategies in instruction, feedback and evaluation with technology.	20%	42%
Appropriation: My personal attitude toward technology has changed, as I reach a level of personal mastery. I have replaced old teaching strategies with new; e.g., I am experimenting with interdisciplinary project-based instruction, team teaching, student grouping and different ways of organizing my instructional day.	10%	18%
Invention: I have experimented with new instructional patterns and new ways of communicating with students and peers. I have found that I am reflecting on teaching to a greater degree than I had in the past, questioning old patterns and speculating about the causes behind changes that I have seen in my students. I view knowledge as something that children must construct for themselves and less as something that can be transferred intact and I see how technology can help in this process.	21%	20%

Note. We included an additional response for teacher to indicate technology mastery without increased use: “I have become skilled in the use of technology and I use it where appropriate, but I don’t believe that technology plays a significant role in educational change. There are other more important ways to improve education.” (3%—1999). (2%—2001).

Professional Uses of Technology

In 1998, 55% of the teachers used computers regularly (at least weekly) to make handouts for students to use in class or at home (Table 2). The next most commonly reported instructional use of computers was to write lesson plans or notes. The number of teachers who did this regularly more than doubled over the course of the project.

Table 2
Professional Use of Computers

Technology is used to: (either weekly or daily)	Baseline *N*=90 (1998)	Phase 1 *N*=81 (1999)	Phase 2 *N*=80 (2000)	Phase 3 *N*=67 (2001)
make handouts for students	55%	58%	77%	74%
write lesson plans or notes	30%	45%	62%	54%
get information or images from the Internet	14%	22%	—	46%
correspond with parents	32%	35%	39%	44%
collaborate with other teachers	—	15%	52%	31%
record or calculate grades	11%	17%	16%	28%
exchange computer files with other teachers	4%	8%	34%	17%
post student work or share ideas or lessons on the web	3%	8%	13%	3%

With the addition of teacher mentors, in the second year of the project, teacher communication increased. This is seen in the number of teachers exchanging files and using computers to communicate with other teachers on a weekly basis. These mentor teachers returned to the classroom at the end of the project and because new teachers have joined the faculty, the frequency of computer-based communication among teachers has dropped from 52% to 31% weekly.

Teacher Technology Skills for Classroom Use of Technology

Perhaps the most visible change in the classrooms was the widespread use of digital images to personalize the classrooms. By the third year, almost all teachers (98%) knew how to use digital cameras and how to add graphics to word processing documents (90%). Teachers took digital pictures of classroom activities, experiments, school activities, and field trips and used them in essays, reports, and multimedia presentations (Table 3). Other significant gains included ability to use presentation software and cable television in the classroom.

Table 3
Technology Skills for Teaching with Technology

I know how to:	**Baseline (1998) *N*=90**	**Phase 1 (1999) *N*=81**	**Phase 3 (2001) *N*=67**
prepare a slide show using presentation software	10%	33%	82%
use a World Wide Web search engine	26%	70%	88%
send/receive e-mail	47%	81%	100%
add graphics into a word-processing document	38%	61%	90%
access cable television in the classroom	33%	57%	79%
send an attachment	—	38%	82%
use AlphaSmarts	—	63%	95%
project computer on TV display	—	51%	90%
use a video camera	55%	72%	90%
create a classroom video	—	40%	64%
design a web-based lesson linked to the standards	—	7%	25%
create a word processing file	76%	84%	93%
create a new database, establish fields & layouts	15%	26%	33%
create a video for parents	—	38%	54%
create a spreadsheet	42%	55%	50%

Instructional Use of Computers

Survey responses were used from two groups of elementary students who were part of the Teaching, Learning, and Computing, 1998 National Survey as a comparative context for the baseline data collected on the instructional use of computers. The first comparison group consists of 560 elementary teachers (fourth to sixth grade) from the national sample, and the second comparison group is made up of 69 elementary teachers who taught at schools engaged in school reform with technology (see Tables 4 and 5). Both these samples were drawn from the Teaching, Learning, and Computing, 1998 National Survey (CRITO, 1999).

Before the TLC project, only 15% of the teachers in the two Anaheim schools reported using multimedia in instruction and less than 4% had their classes involved in multi-school projects (Table 4). By Phase 3, over half of the TLC teachers had students creating multimedia presentations (58%) and using graphic tools (55%), and more than four times as many teachers had students involved in creating multimedia reports and cross-school projects. Participation in multi-school projects and publishing on the Web also increased.

Table 4
Computer Use—Instruction

	National		TLC	
Students Use Software in the Following Ways[2]	**U.S. Elem (1998) *N*=570**	**Tech Reform (1998) *N*=70**	**Baseline (1998) *N*=90**	**Phase 3 (2001) *N*=67**
Create a multimedia report (for example a Hyperstudio stack)	20%	40%	15%	58%
Collect data into computers & present it using graphic tools	16%	22%	4%	55%
Participate in a multi-school project using the computer	7%	22%	3%	17%
Publish materials on the Web	3%	6%	3%	17%

In comparison with the national survey results, the number of teachers who have learned to use the computers in these more innovative ways is impressive.

Technology Integration with the Curriculum

Data from classroom observations indicate frequent use of digital cameras and scanners. Pictures of the students accompanied student work on classroom displays, and the “student of the week” was sometimes displayed on screen savers. Digital images were also used to involve students in the design of instructional materials. Intermediate level teachers created math lessons in which students used a digital camera to find pictures of geometric shapes on the school campus, and then wrote essays discussing them. In one primary classroom, the teacher took pictures of 2-3 students whose bodies were positioned to form alphabet letters. The whole alphabet was displayed in this “personal” format for students. In addition, a teacher with special education students took pictures of them holding a toy dinosaur in different positions (above, under, over, etc.), laminated them as cards to teach these concepts. Class books and student books were published with personal images. A primary grade teacher created videotapes containing students practicing sound-letter correspondence. This is now sent home to all families with entering students as way of extending second language learning. A number of teachers are currently learning how to make instructional movies with and for students.

The increasing use of technology in the classrooms is also evident in survey results over time. We again provide a national context for the baseline results. In 1998 (before the TLC project) learning games and word processing programs were used at a high rate, 84% and 67%, respectively (Table 5). In this use, TLC teachers were similar to teachers across the nation. In fact, they were even more likely than the national average to use computers for drill and practice educational games, and just about as likely to use them for writing.

Table 5

Software Used with Students

	National		**TLC**	
Use of Software in Three or More Lessons	**U.S. Elem (1998) *N*=570**	**Tech Reform (1998) *N*=70**	**Baseline (1998) *N*=90**	**Phase 3 (2001) *N*=67**
Reference materials (encyclopedia; CD-Rom)	54%	61%	22%	86%
Graphic oriented publishing (*Printshop*)	27%	33%	8%	66%
Multimedia (*Hyperstudio*)	13%	21%	3%	43%
Web browser (Netscape or Explorer)	26%	43%	3%	36%
Presentation software (*PowerPoint*)	8%	22%	3%	30%
Spreadsheets or database (*Excel, Filemaker*)	10%	13%	2%	26%
Word processing (*Claris* or *Word*)	66%	70%	67%	75%
Simulations or exploratory environments	32%	31%	22%	44%
E-mail (Eudora or Mail Express)	7%	16%	0%	7%
Games for practicing skills (*Jump Start*)	62%	60%	84%	62%
Electronic reading programs	—	—	—	93%

Teachers reported and the researchers observed a dramatic increase in student use of multimedia programs to present ideas and projects over the project years. The use of graphic-oriented publishing programs by students climbed from 8% in 1998 to 66% in 2001, and multimedia tools for presentations of information increased from 3% in 1998 to 43% in 2001. Use of encyclopedias or CD reference materials increased from 22% to 86%. Each school made a commitment to augment reading skills and, as a result, student use of electronic reading resources showed a marked increase from 23% in 1999 to 93% in 2001.

The use of software in the classroom with students by TLC teachers has increased dramatically in all areas but one—students are not using computers to communicate with peers. While there is some increase in student use of e-mail, this is not yet a common use of technology in these schools.

Collaborative Planning and Technology Integration

The spirit of collaborative work is seen in the increased hours set aside for both grade level planning and school level professional development. Phase 3 marked the beginning of regular, weekly instructional planning for teachers to meet with grade level teams, a 200% increase from the 1999-2000 school year in which one optional hour of planning time was provided to teachers each month. According to administrator interviews, there has been a substantial increase in the amount of time spent discussing classroom technology use and professional development at whole-school staff meetings.

Teaching Teachers: Technology Fairs

The teachers at both project schools have accepted leadership roles in the district. They have held three technology fairs to celebrate their success and to share what they have learned with each other and with the other teachers in the district. These fairs have included presentations by the teachers and the principal on how to use hardware (Palm Pilots™, Smartboard™, digital cameras) and software (spreadsheets, multimedia tools, graphing, communication) in instructional context. The teachers have shared projects such as using the computer to create “big books” and other teaching materials, publishing of student work in newsletter and book formats, and how to participate in international partnerships. For each of these three fairs 15-18 teachers volunteered to teach. They provided teacher produced materials on CD-Rom and distributed throughout the district.

Summary

The ACSD-TLC project has succeeded in creating a culture of learning with technology that is pervasive throughout the schools. While it is not the case that every teacher is enthusiastic about learning how to teach with technology, as a collective these two schools have taken on the task of learning how to integrate technology and instruction with an impressive dedication. The technology stipends brought computers into the homes of teachers and established a commitment of 140 hours of professional development time. These were critical factors in creating a strong learning community.

Teacher proficiency with technology within these school communities is much higher than what is found at other schools in the district based on classroom observations in a similar school. At the state level, in spring of 2001, about 13% of the teachers reported proficiency at selecting and implement technology resources appropriately into a lesson design. An additional 35% of the teachers reported an intermediate level described as “actively manages the desktop, competently uses word processing and spreadsheet software, uses search engines, downloads and opens files from the Web, custom configures browser software” (CDOE-CTAP, 2001). By using items from the TLC survey that were similar to those on the CTAP survey and using information from classroom observations, researchers conservatively placed about 30% of the teachers at each project school in the technology proficient level, with almost all of the other teachers at the intermediate level defined in the CTAP survey.

The teachers in this study have, to a large extent, embarked on a process of collaborative teaching and learning. One teacher described how her experience as a learner helped shape her teaching. She noted how many times, and in how many contexts, her technology mentor needed to repeat the same information before she “owned” it. This observation helped her understand the important role of repetition in learning—that when students ask for repetition of information it may not signal inattention. She says she teaches with more patience now.

The teachers’ sense of ownership over the change process was an important part of the success of the project. There is, however somewhat of an insular quality that is reinforced by the structure of teaching in schools that works against the continual development of a learning community. The competitiveness created by standardized testing tensions and the external pressure to dictate classroom practices work against fostering a strong sense of local control. The project has helped many teachers move beyond the use of drill and practice software towards creating powerful contexts to support continual learning of both teachers and students. During classroom visits, one month prior to state testing, the researchers observed a strong shift towards test preparation and tension over students' performance was clearly evident. The high stakes testing in California encourages a narrow definition of learning as raising test scores; supports the development of receptive skills rather than fostering expressive ones; and rewards speed over thoughtful inquiry. This pressure caused some teachers to look for computer software drills to prepare students to practice for testing. Other teachers found creative ways to embed test preparation drills within larger learning contexts using computer tools. For example, a math teacher used students practice tests as "data sets" and helped her students use computer tools to learn about measures of central tendency. The students' interest in seeing the graph rise helped them understand how small changes by the whole class led to higher average scores than a larger change by only a few students.

When student learning is equated with high scores on timed tests, and school success is determined by comparative rankings on these tests, teachers' focus on extensive test practice is a predictable and unfortunate outcome. Until better measures of learning are developed, the concern of low-level accountability may actually result in a move away from students' development of problem-solving and critical thinking skills (Becker & Lovitts, in press).

Developing innovative uses of technology from within a community places a high value on sharing evolving knowledge. Fostering learning communities to work collaboratively on projects and activities and evaluating their progress is far more challenging than fostering computer literacy skills. The current structure of teaching (one teacher to a class of students for one year) does not support it. Even with increased time for group planning, teachers remained reluctant to engage in critical analysis of one another's teaching practices. They were more comfortable sharing reports of their successful projects than they were analyzing the factors that led to more or less successful learning contexts. The classrooms where we observed some of the most engaged teacher community and changes in teaching both on and off the computer had teacher teams sharing a classroom during double sessions. In these over-crowded year-round schools, the only way to reduce class size was to structure a double session with a 90-minute overlapping period. In many of these classrooms the teachers worked closely as a team planning, watching, and adjusting their teaching with constant feedback. The uses of technology, the development of new teaching practices, and the sense of collaboration in these classrooms were impressive.

DECREASING THE DEPTH OF THE DIVIDE: INCREASING STUDENT TECHNOLOGY EXPERTISE OUTSIDE OF SCHOOL

Student learning outside of the classroom is a critical component of school experience. If the only time students encounter technology is in the school, then there are not enough hours for them to develop the basic literacy necessary to use it effectively for learning. Students in higher socio-economic neighborhoods have many hours to play with technology, which helps them develop a deep understanding—a valuable classroom asset. Neither the TLC grant, nor the teachers at these schools can effectively address the deep inequities that exist in society. However, the TLC project realized that out-of-school partners could help reduce the depth of the divide. TLC addressed out-of-school learning by increasing the technology knowledge of the family, increasing access to technology in the community, and designing after school programs.

Parent Technology Literacy

The TLC teachers, project staff, and a local community college formed a partnership in Phase 2 of the project to provide parent technology classes in Spanish and English. Each course consisted of 10 two-hour classes. The total enrollment of 200 parents was drawn from the two project schools and 10 other schools in the district. The waiting list with over 100 parents indicates the strong interest. The initial program, started by TLC, has been expanded to include technology with English language classes. Additionally, approximately 20 parents benefited from out-of-school hours assistance and onsite training with a TLC teacher. Parents have benefited from learning how to use technology both to support their own professional learning and to help children learn at home and in the classroom.

Community Technology Literacy

Three branches of the local public library have received support through TLC, resulting in increased student and parent use, as well as extending the reach of the project into the general community. Six or more AlphaSmarts™, one computer, and one printer were provided to each of the three branch libraries. Library records indicate that more than 3,000 students, parents, and community members used the AlphaSmarts™ and computers at these three locations. As use increased, resources were increased. Students have come from more than 15 local schools, including the two TLC schools and local junior high and high schools, to use the AlphaSmarts™ and computers provided at the libraries. An additional set of 30 AlphaSmarts™ was purchased by the grant for each school to be used for home checkout.

Student Technology Literacy (out-of-school experiences)

The TLC project provided students additional learning experiences outside of the classrooms. After-school programs are giving students the chance to develop expertise and leadership skills. Student participation has shown increased interest in technology and an increase in classroom skills. The Technology Ambassador program is a 10-week after-school program to train fourth- and fifth-grade students to be peer tutors and teacher assistants. Annually, about 20 students per grade level attend the program, which includes instruction and exploration of computer hardware (including digital and video camera), Windows-based applications, and the Internet. Approximately 60 students have been trained as Technology Ambassadors at the two schools. The goal of this program is to have technology-literate students in the classrooms who can help with simple computer problems that arise throughout the day. All teachers are provided with the names and room numbers of Technology Ambassadors.

The after-school literacy program is another student-based program that had served more than 30 students in Phase 2 and TLC continues to provide these opportunities. The availability of after-school classes increased in direct response to student interest. Begun as a partnership with San Jose State University, these information literacy programs are now led by TLC teachers at both schools. These students return to the classroom with increased skill in reading and information literacy and often become leaders of literacy circles, book talk presenters or mentors for younger children.

San Jose State interns were also responsible for the creation of a comprehensive literacy/library web resource called the “TLC Library Connection” available to students and parents and the general public.

The changes in the school have extended into the homes of the students. This has resulted in a whole-community effort to provide technology resources/training and an overall increase in the participation in education by outside sources and adults.

Community Support for Technology Literacy

A local company donated numerous technology instructional manuals in Spanish for parent classes and general information purposes. These materials have been especially useful in the project’s collaborative effort with a local nonprofit organization, the Community Development Council (CDC) that collects donated technology and redistributes it to the community. In Phase 2, CDC received more than 20 Pentium II computers from a local business as well as $3,000 to purchase technology resources for the school library. As a result, 20 families received donated computer systems and family training from CDC. Leveraging school and community resources, efforts continue to support learning outside of the school.

STUDENT ACHIEVEMENT

The Stanford Achievement Test (SAT 9) data for the TLC schools suggests that students are benefiting from the increased expertise with technology and classroom use of word processing and multimedia tools. There is an evident increase in language scores that reflects the literacy goals of the TLC project. The test results suggest that the sixth grade classes are leaving these project schools with stronger skills than they have in the past (Table 6). Both schools reached their target growth on the state’s Academic Performance Index qualifying the teacher for bonuses, while the comparison school did not.

Table 6

SAT 9 PAC 50[3] Scores—Grade Level Comparison (6th Grade): 1998-2001[4]

School	Year	PAC50: Reading	Language	Math	Spelling
TLC School 1	1998	12%	33%	18%	17%
	1999	14%	32%	18%	17%
	2000	17%	45%	32%	29%
	2001	28%	46%	43%	29%
TLC School 2	1998	29%	45%	40%	38%
	1999	33%	55%	47%	31%
	2000	42%	58%	62%	43%
	2001	34%	58%	56%	44%
District	1998	31%	41%	41%	35%
	1999	29%	43%	42%	31%
	2000	32%	47%	47%	37%
	2001	32%	48%	52%	38%

However, "high stakes" standardized testing often misses much of the learning that occurs among immigrant students and others from nonEuropean cultures. For students in wealthy, European-American communities, school is a predictable extension of home-life; their parents talk like teachers and their teachers act like parents. This continuity makes it easier for both teachers and students to make steady progress on school tasks. Students in these high-density Hispanic communities cross a different threshold when they enter the school; many walk into a new culture and a second language. In some cases, they encounter teachers who have minimal understanding of either their home language or culture; and each year one in five of these students faces a teacher who is new to the school and perhaps new to teaching. These students face a much steeper learning curve. Standardized tests use a narrow set of indicators and often word questions in ways that are particularly misleading for nonnative speakers. The result is that most of the learning that these students are engaged in is ignored and they are labeled as "low" or "slow performers." This label carries with it unfortunate motivational effects on future learning. Schools need to recognize the societal value of the complexity of skills that students are learning (Cummins & Sayers, 1995).

The integration of technology in these schools created a palpable sense of pride in student achievement. The students gained control of a technology that, while not always extensive, was impressive (Table 7). They learned these technical skills during school time and while working on all of their school subjects, learning a language, and understanding a different culture.

Table 7
Use of Computer Technology for Instruction—Student Use

Student Use of Computers over the past three years	National U.S. Elem (1998) *N*=570	National Tech Reform (1998) *N*=70	TLC Baseline (1998) *N*=90	TLC Phase 3 (2001) *N*=67
Collect data into computers & present it using graphic tools	27%	33%	4%	55%
Create a multi-media report for example a Hyperstudio stack	13%	21%	15%	58%
Participate in a multi-school project using the computer	7%	22%	3%	17%
Publish materials on the Web	3%	6%	3%	17%
Work with *AlphaSmarts*		—	—	90%
Create a presentation	8%	22%	—	63%
Use a digital camera		—	—	44%
Make a video		—	—	32%

The extent to which these new skills will help them in their learning in the coming years and prepare them for learning in their middle and high school years is yet to be seen.

DISCUSSION AND CONCLUSIONS

The visual metaphor of the width (access to technology in the school), slope (conceptual knowledge of the teacher), and depth (societal opportunities and access) of the digital divide helps illustrate why it is not possible to close the digital divide with a single intervention. If access to equipment is provided, then *the width* of the divide is narrowed, but with a long slope and deep divide, the journey to equal opportunity remains. If teacher knowledge is increased, *the slope* decreases. But, without regular access to technology in either the home or the schools, a deep, wide chasm separating students still remains. If the structural inequalities outside of the school are addressed and students have good home access to technology, *the depth* of the divide is reduced. But without school access and knowledgeable teachers the large slope and width of the divide make for a long, but less difficult path, to equality.

A significant change in any two dimensions will help close the digital divide. Given the difficulties in addressing societal inequities, it makes sense for educators to focus on change in the schools. When schools provide access to technology and teachers are engaged in a culture of learning concerning how to integrate technology with instructional goals, the digital gap narrows, the slope decreases, and with some effort, students can leap across the remaining divide.

The goal of the TLC project has been to contribute, in their local context, to the closing of the national digital divide. In terms of that goal, Anaheim educators have successfully increased access to technology for their severely underserved clientele and have created a system that is helping teachers and their students develop the technology and pedagogical skills for effective computer use. The project developed many innovative strategies to avoid the problem of teacher entrenchment and resistance that often accompanies new programs. The entire staff at two schools has incorporated technology in their classroom teaching, and many are using computers in and beyond their homes, extending the reach of the project into the community.

In this technology driven educational reform, a team of teachers has engaged in a process of whole school change. At the heart of this school reform was the effort to develop a rich learning community experience with technology for teachers. By actively engaging teachers in the choice and design of the changes, the project made teaching more communal and less atomized. Teachers became a part of a collective effort to learn new skills and employ them in the service of student learning. When change is imposed on teachers from the outside, a culture of resistance can develop (McNeil 2000; Datnow, Hubbard, & Mehan, 2002). To avoid this opposition, the TLC project was designed to promote both individual and community engagement and control over professional change.

Framed in this way, the TLC project is an important experiment in whole-school change directed by teacher community leadership. While ideas from outside experts and partners have played an important role in the process of change, there was no specific outside agent or reform model directing the change. Instead, teachers at each of these schools engaged in a program of continual professional development designed by their colleagues and implemented independently. While some teachers started the project with unrealistic beliefs about the changes that technology would bring, there were also teachers who were skeptical about investing so much time and energy in learning to use technology. Most of the participants were aware that technology, by itself, would not change schools. Learning to use technology did serve as a catalyst encouraging teacher leadership and professional engagement, and in some cases led to dramatic shifts. More often, the technology was subsumed into the current teaching philosophy and practices and only slowly led to experimentation with new ideas and teaching strategies.

Frequently, schools in urban settings experience a high rate of turnover in teachers and school leaders. This presents a challenge to "learning community" models (Honey, Carrigg, & Hawkins, 1998; Riel & Fulton, 2001). During the three and one-half years of this project, the superintendent, the technology director at the district, the TLC project director, the principals and vice principals at both schools, and approximately 20% of the teaching staff each year changed. It is a testament to the TLC teachers that the project continued to operate to the end despite a change in every leadership position. However, it remains an open question if this process of designing new learning opportunities will continue beyond the period of external funding. The next five years at these schools will provide the answer. It will define the project either as a burst of learning that accomplished a specified goal of bringing technology into the schools, or as the institutionalization of a culture of learning that evolves and adapts technology to new forms of teacher and student learning.

References

Anderson, R., & Ronnkvist, *A*. (1999). *The presence of computers in American schools. Teaching, learning & computing: 1998 national survey*. Retrieved from the World Wide Web on April 2, 2002, from: www.crito.uci.edu/tlc/findings/computers_in_american_schools/

Becker, H.J. (2000). Who's wired and who's not: Children's assess to and use of the computer technology. *The Future of Children: Children and Computer Technology, 10*(2), 44-75.

Becker, H.J. (2001). *How are teachers using computers in instruction?* Paper presented at the conference for the American Educational Research Association. Seattle, WA. Retrieved from the World Wide Web on April 10, 2002, from: http://www.crito.uci.edu/tlc/findings/conferences-pdf/how_are_teachers_using.pdf

Becker, H.J., & Lovitts, B.E. (in press). A project-based assessment model for judging the effects of technology use in comparison group studies. In G. Haertel & B. Means (Eds.), *New approaches to evaluating the impact of educational technology*. New York: Teachers College Press.

California Department of Education and the California Technology Assistance Project (CDOE-CTAP) (2001). *California School Technology Survey*. Sacramento, CA: California Department of Education. Retrieved from the World Wide Web on April 2, 2002, from: http://www.cde.ca.gov/edtechsurvey/catechsurvey01.pdf

Center for Research on Information Technology and Organizations (CRITO) (1999). *Teaching, learning, and computing: 1998 National Survey.* Survey results, reports, papers, snapshot tables, and complete questionnaires. Retrieved from the World Wide Web on April 2, 2002, from: http://www.crito.uci.edu/tlc/html/questionnaires.html

Coley, R., Cradler, J., & Engel, P. (1997). Computers and classrooms: The status of technology in U.S. schools. *ETS Policy Information Report*. Princeton, NJ: ETS Policy Information Center. Retrieved from the World Wide Web April 10, 2002, from: ftp://ftp.ets.org/pub/res/compclss.pdf

Cummins, J., & Sayers, D. (1995). *Brave new schools: Challenging cultural illiteracy through global learning networks*. Toronto, Ontario, Canada: OISE Press.

Dede, C. (Ed.) (1998). *Learning with technology: The 1998 yearbook of the Association for Supervision and Curriculum Development*. Alexandria, VA: ASCD.

Datnow, A., Hubbard, L., & Mehan, H., (2002). *Scaling school reform: From one school to many*. New York: Routledge Falmer.

Honey, M., Carrigg, F., & Hawkins, J. (1998). Union City online: An architecture for networking and reform. In C. Dede (Ed.), *Learning with technology: The 1998 yearbook of the Association for Supervision and Curriculum Development*. Alexandria, VA: ASCD.

McNeil, L. (2000). *The contradictions of school reform*. New York: Routledge.

National Telecommunications and Information Administration (NTIA) (1999). *Falling through the net III: Defining the digital divide*. Retrieved from the World Wide Web on April 2, 2002, from: http://www.benton.org/Library/Schools

National Telecommunications and Information Administration (NTIA) (2000). *Falling through the net: Toward digital inclusion*. Washington, DC: Author. Retrieved from the World Wide Web on April 2, 2002, from: http://search.ntia.doc.gov/pdf/fttn00.pdf

Public Broadcast Service (2000). *Digital divide: Technology in our future*. Broadcast on KCET/KDOC, January 28, 2000. Retrieved from the World Wide Web on April 2, 2002, from: http://www.pbs.org/digitaldivide

Riel, M., & Becker, J.H. (2000). *The beliefs, practices, and computer use of teacher leaders*. Paper presented at the conference for the American Educational Research Association, New Orleans, LA. Retrieved from the World Wide Web on April 2, 2002 from: http://www.crito.uci.edu/tlc/findings/aera/

Riel, M., & Fulton, K. (2001). Technology's role in supporting learning communities for the new millennium. *Kappan, 82*(7), 518-523.

Riel, M., Schwarz, J., Peterson, H., & Henricks, J. (2000). The power of owning the technology. *Educational Leadership, 57*(8), 58-60.

Rifkin, J. (2000). The age of access: The new culture of hypercapitalism where all of life is a paid-for experience. New York: J.P. Tarcher.

Sandholtz, J.H., Ringstaff, C., & Dwyer, D. (1997). *Teaching with technology: Creating student-centered classrooms*. New York: Teachers College Press.

Technology in Education 2000 report (2000). Market Data Retrieval. Retrieved from the World Wide Web on April 2, 2002, from: www.schooldata.com

U.S. Department of Education (2000). *Stats in brief: Internet access in U.S. public schools and classrooms: 1994-99*. Washington, DC: National Center for Education Statistics. Retrieved from the World Wide Web on April 2, 2002, from: http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2000086

Notes

1. We told teachers that, although we were interested in their current use of technology, we did not want them to alter their teaching schedule for our benefit. Teachers knew the times and dates of the visit, but they were encouraged to continue their teaching as planned. We examined examples of student work with technology which teachers provided.

2. In the national survey, the teachers were instructed to reflect back over the last five years; in the TLC surveys, they were asked over the past three years.

3. PAC 50=percent of students scoring at or above the 50th national percentile.