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Technology and Equity in Schooling: Deconstructing the Digital Divide

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This qualitative study compared the availability of, access to, and use of new technologies in a group of low– and high–socioeconomic status (SES) California high schools. Although student-computer ratios in the schools were similar, the social contexts of computer use differed, with low-SES schools affected by uneven human support networks, irregular home access to computers by students, and pressure to raise school test scores while addressing the needs of large numbers of English learners. These differences were expressed within three main patterns of technology access and use, labeled performativity, workability, and complexity, each of which shaped schools' efforts to deploy new technologies for academic preparation.

Keywords: *technology; equity*

INEQUALITY IN EDUCATION, and how to overcome it, has been a critical social issue facing the United States for more than 100 years. Today, huge gaps continue to exist in academic achievement in the United States, whether measured by standardized test scores, graduation rates, or admittance to

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universities by race and socioeconomic status (Cheng, 2001; Noguera, 2001). With the rapid increase of Latinos in many states, most notably California, New York, and Texas, and their corresponding general low rates of academic achievement (see U.S. Census Bureau, 2002), inequality of educational inputs and outputs threatens to create an increasingly larger body of undereducated and underserved Latinos, expanding social and economic stratification within the United States even further.

The rapid diffusion of information and communication technology (ICT) in the past decade has added an important new element to the issue of education inequality. New technologies are widely viewed as having the potential to either alleviate or exacerbate existing inequalities (see discussions in Warschauer, 2000, 2003). On one hand, if computers and the Internet are distributed equally and used well, they are viewed as powerful tools to increase learning among marginalized students and provide greater access to a broader information society (see Cummins & Sayers, 1995). On the other hand, many fear that unequal access to new technologies, both at school and at home, will serve to heighten educational and social stratification, thereby creating a new digital divide (Bolt & Crawford, 2000). This article reports on a qualitative study of technology access and use in eight California high schools, including those in both low socioeconomic status (SES) and high-SES neighborhoods. The study sought to explore the issue of technology and equity by documenting the ways in which ICT was used to enhance students' academic preparation in diverse socioeconomic contexts.

RESEARCH TO DATE

Research on technology and equity originally focused on unequal physical access to computers and the Internet in home and work settings. A series of studies by the U.S. National Telecommunications and Information Administration (1999, 2000, 2002), for example, has called attention to how computer and Internet access is distributed unequally by race, income, and education. This research has also demonstrated how these gaps are gradually decreasing as a higher percentage of people in the United States purchase home computers or obtain access elsewhere.

Although home access to computers has long been regarded as important for supporting students' academic achievement, research suggests that home ownership of computers alone does not level out inequalities in terms of technology's contribution to student learning. For example, one study revealed that high-SES students with home computers are much more likely to use them to complete school assignments than are low-SES students with home computers (Becker, 2000), whereas another showed that home computer access raises the academic achievement of high-SES students more than it does for low-SES students (Attewell & Battle, 1999). These studies suggest that how technology is used is as important as who has access to it.

Research in schools similarly has focused predominantly on documenting unequal distribution of computer and Internet resources. Although inequalities still exist with regard to quantity and quality of computer equipment in schools (cf. Cuban, 2001), these gaps are gradually being narrowed. For example, in 1998, the ratio of students to instructional computers with Internet access in U.S. schools was 17.2 in schools with large numbers of minority students enrolled (those schools with 50% or greater of ethnic minorities) and only 10.1 in low-minority schools (those with 6% or less of ethnic minority students enrolled; see Kleiner & Farris, 2002). Three years later, in 2001, the ratios were on average 6.4 students per computer in high-minority schools to 4.7 students per computer in low-minority schools. This still represents a significant gap where physical access to computers at school is concerned, but a noticeably smaller one than in the past. Looked at another way, the ratio of 6.4 students per computer in high-minority schools in 2001 was better than the average ratio of 6.6 students per computer in all public schools just 1 year earlier. This narrowing of differences by demographic categories of schools (whether comparing high- and low-minority schools or high- and low-SES schools) is occurring in most other areas of infrastructure as well, including students per computer, students per multimedia computer, students per networked computer, schools with high-speed Internet access, schools where the majority of teachers are using the Internet, and schools with laptop computer programs (Kleiner & Farris, 2002).

More recent research has investigated how computers are used by different groups of students. Schofield and Davidson's (2004) qualitative study of Internet use in schools documented how online access is often provided as a privilege or reward to the most advanced students, thus amplifying other forms of inequality in schools. Becker's (2000) national survey analyzed school use by subject area, showing that low-SES students actually use computers more than high-SES students in math and English courses, where computer-based drills are common, but high-SES students are the main users of technology in science courses, where computers are often used for simulations and research. An emphasis on remedial or vocational uses of new technology by low-SES or Black and Hispanic students and more academic uses of technology by high-SES or White and Asian students was similarly found by Wenglinsky (1998) and Warschauer (2000).

What emerges from this research is not a single construct of a digital divide but rather a number of factors that shape technology's amplification of existing inequalities in school and society. A review article in *Education Week* (Dividing Lines, 2001) neatly summarizes this issue:

> Inequities in the availability of computer technology and Internet access still exist. But rather than one single, gaping divide, what the nation's schools are grappling with is more a set of divides, cutting in different directions like the tributaries of a river. And, increasingly, those inequalities involve not so much access to computers, but the way computers are used to educate children. (p. 10)

It is in this spirit of exploring the many tributaries of technology access and use in school and home settings, and their relationship to equality in education, that the current study was conducted. Most of the prior research on this topic (e.g., Attewell & Battle, 1999; Becker, 2000; Wenglinsky, 1998) was conducted via survey methods. The few qualitative studies available are either quite small in scale (e.g., Warschauer's 2000 study comparing one public and one private school) or limited in scope (e.g., Schofield and Davidson's 2004 study that focuses on who accesses the Internet in schools). This study, by qualitatively investigating a broad array of school and home technology access and use issues in eight California high schools, was designed to broaden and deepen our understanding of technology and equity in schooling.

METHOD

The study sought to investigate the availability of, access to, and use of new technologies within selected California public high schools, and the variation among these dimensions by school, community, and student population in relation to students' academic preparation for entry into universities.

The overall methodological approach in the study was that of a qualitative survey (Knobel & Lankshear, 1999). This approach involves *surveying*, or comprehensively examining, a context or person and can include field-based observations, interviews, questionnaires, artifact collection, and numerical aggregates of equipment or demographic characteristics. Qualitative survey designs maximize data collection within a minimum amount of time and thus allow qualitative data to be efficiently gathered and compared from multiple sites (Marsland, Wilson, Abeyasekera, & Kleth, 1999). The approach enabled a team of four researchers to gather data from 64 classrooms in eight schools over a 7-month period in the 2001-2002 academic year.

There were two units of analysis in the study: (a) each teacher and class, and (b) each school. On one hand, focusing on particular teachers and their classes enabled us to more directly observe how technology was being used at the instructional level and to compare relevant sources of data (e.g., we surveyed and interviewed students from the same classes that we observed). On the other hand, by aggregating and analyzing classroom data at the school level, and also examining additional schoolwide data (e.g., school technology policies), we were able to identify significant patterns of access and use within and across schools.

Sites and Participants

A sample of schools in low- and high-SES neighborhoods was selected to provide comparative data. Five low-SES schools were chosen from a broader list of partnership schools between the University of California and local school districts. There is no precise formula for determining what qualifies as a University of California partnership school; the principal criterion is that the schools have large numbers of students from groups that are underrepresented in University of California enrollments, particularly Latino students, and nearly all partnership schools are in low-SES neighborhoods. Approximately 12 partnership schools were contacted and invited to participate in the study. Five of them agreed and were included in the study.

A comparison group was chosen among high schools in higher SES neighborhoods in California. Five schools were contacted based on proximity and accessibility to the research team. Three of the schools agreed to participate. More low-SES than high-SES schools were included in the study because the funding agencies that supported the study had a particular focus of learning about access and use of new technology in low-SES underserved communities, as did the researchers.

Table 1 lists the eight schools that formed the sites for the study (school names have been changed for the purpose of anonymity). Each of the five schools that we have labeled low-SES had 40% or more of their students on free or reduced price lunch programs. The three schools that we have labeled high-SES each had fewer than 13% of their students in these programs. In addition, each of the low-SES schools had at least 44% Hispanic students, whereas the three high-SES schools each had fewer than 13% Hispanic students. (There were few African American students in any of the eight schools, which reflects trends in the California districts we studied.) Also, the low-SES schools had an average of 31.4% English language learners, whereas the high-SES schools had an average of 10.3% English language learners. All five of the low-SES schools fell in the bottom 40% of California schools on the state's Academic Performance Index (based on students' standardized test scores), whereas the three high-SES schools all fell in the top 20% in the state on this measure. Finally, there were important differences among the teaching populations at the two schools, with teachers in the low-

Table 1
Participating Schools

High School	*% Free/ Reduced Meals*	*% Principal Ethnic Groups*	*% English Language Learners*	*API Index (Decile)*	*Average Years of Teacher Experience*	*% Teachers Fully Credentialed*
Low-SES schools						
Bergenia	74.8	97.2 Hispanic	38.8	460 (1)	17	78
Erica	68.1	94.4 Hispanic	29.8	524 (2)	15	80
Escallonia	55.8	61.2 Hispanic 31.5 Caucasian	41.2	568 (4)	12	95
Kalmia	46.5	60.9 Hispanic 27.2 Caucasian	28.4	582 (4)	14	98
Salix	40.7	44.3 Hispanic 31.9 Caucasian 12.6 Asian	18.9	599 (4)	12	92
High-SES schools						
Cassia	12.7	74.8 Caucasian 16.8 Hispanic	14.0	751 (9)	18	97
Dalea	10.6	80.2 Caucasian 14.6 Hispanic	7.9	761 (10)	18	98
Vallota	6.5	49.7 Caucasian 41.9 Asian	9.1	850 (10)	18	98

Note: API = Academic Performance Index; SES = socioeconomic status.

SES schools having, on average, 4 fewer years of teaching experience (14 vs. 18, unweighted average) and with low-SES schools employing nearly five times as many teachers without full credentials (11.4% vs. 2.3%, unweighted average).

Participants

Because the study sought to focus on the relationship between technology and academic preparation, teachers from the main California subject areas of science, mathematics, language arts, and social studies were chosen as target participants. A total of 64 teachers participated in the study, with a minimum of 4 (i.e., at least 1 from each of these four subject areas) from each of the eight schools. The criteria for selection included that the teachers were using technology in their instruction and were willing and available to participate in the study. Selection was based on consultation with school administrators and participation by teachers was voluntary. Students in the teachers' classrooms also participated in the study by completing surveys and joining focus group discussions (see further details below).

Data Collection

Data collection took place over 5 to 15 days at each school. In some cases, these days were consecutive, and in other cases, they were spread out, depending on the wishes of school administrators and availability of the teachers. The following sources of data were collected.

Observations. Classes were observed for an average of two 50-minute periods of instruction per teacher for a total of 115 hours of observation overall. Observations were negotiated with each teacher and took place during times when technology was being used in teaching and learning. Detailed field notes were taken.

Adult interviews. Teachers were interviewed either once or twice, with total interview time per teacher generally ranging from 50 to 90 minutes. These semistructured interviews included questions concerning teaching biography, the teachers' personal experiences with using computers, their thoughts about technology and equality, and their thoughts about the role of new technologies in enhancing student learning and academic preparation. One to two administrators at each school were interviewed as well, usually those most directly responsible for developing and implementing instructional technology policy. All interviews were audiotaped. In addition, informal discussions were held with teachers before or after observed classes, with field notes taken, and occasional follow-up discussion was carried out with teachers or administrators via e-mail.

Student questionnaires. Students in one of each participating teacher's classes were asked to fill out a brief questionnaire made up of 15 questions. Twelve of these were discrete item questions and addressed specific demographic information (e.g., grade level, ethnicity, home language) or the types of technology that students had access to at school and home. Three of the questions were open-ended and solicited students' comments about how technology is used in their school.

Student interviews. Small group interviews were held with students at six of the eight participating schools (time constraints prevented us from completing interviews at the remaining two schools). These semistructured interviews included questions concerning what students did with computers outside school, whether they thought computers enhanced their learning and grades, and what they planned on doing after graduating from high school. These interviews usually took about a half hour during lunchtime and were audiotaped.

Artifacts. We also collected artifacts and texts related to technology policy and use in each school. These documents included technology policies, school-conducted technology inventories and surveys, school technology grant proposals, school and teacher Web sites, samples of student work during observed lessons, teachers' lesson handouts and assessment rubrics, and statistic and survey data with regard to the schools from the California Department of Education and the California Technology Assistance Project.

Data Analysis

Data analysis techniques were drawn from ethnography, sociolinguistics, and histiography and included pattern matching, domain and taxonomic analysis, I-statement analysis, and content analysis. Pattern matching is a formal and systematic process of identifying patterned action across time that can be used to construct broadly sketched comparisons across large and diverse data sets (LeCompte & Schensul, 1999). We used pattern matching as a first pass through the data to generate broad patterns that we could then follow up on in more detail, using more finely honed analysis techniques.

Domain analysis refers to the process of organizing data into culturally defined categories such as "classroom," "lesson," or "PowerPoint presentation" in a way that establishes a semantic and cultural relationship between the category label, or "domain," and the items that define it (Spradley, 1980). Within this study, domain analysis was used to identify the ways in which teachers and students defined particular social practices involving new technology use. For example, according to the technology coordinator and the media specialist we interviewed at a school, academic preparation includes student mastery of a range of computer skills and software applications, being able to conduct effective Internet-based research, being familiar with working in educational contexts, and enrolling in appropriate classes (see Figure 1). Constructing domain analyses using other teachers and our field notes made for useful dimensions of comparisons across each participating school.

We applied taxonomic analysis to the items within the domains to show relationships between included terms within a domain (see Spradley, 1980). When like terms were analyzed using different data sets (e.g., academic preparation, technology use), taxonomies greatly facilitated comparisons across our data.

The linguistic choices people make when presenting themselves in an interview carry significant information about representations of self. For example, with regard to technology, we were interested in seeing whether teachers presented themselves as active users, passive users, or users beset by constraints. We examined the interview data using a technique called I-statement analysis, which examines the ways in which people speak as an "I" and thus fashion themselves as a person of a particular sort or type through language (Gee, 2000).

Content analysis, as we have employed it in this study, is "a research method that uses a set of procedures to make valid inferences from text" (Weber, 1990, p. 9). Content analysis was employed in our study to make justified inferences from student questionnaire responses, as well as from school policy and other documents pertaining to new technologies within the school.

To ensure interrater reliability, the researchers independently analyzed the same set of transcripts, field notes, and documents, meeting approximately every 2 weeks for 2 months to compare and make decisions in identifying and coding I-statements and constructing domain analyses. The next phase of interrater reliability involved the researchers in working on separate data sets but continuing to bring their analyses to regular meetings to present for comment and evaluation. The guide for coding I-statements was refined throughout this period and served well as a final arbiter when there was a question concerning how to code an item. The bulk of the analysis was completed by two researchers who met regularly to double-check their coding and categorizing decisions. In addition, judicious triangulation between questionnaires,

. . . students' academic preparation at this school	Domain
↑ is a feature of ↑	Semantic Relationship
• learning computer skills • becoming familiar with certain types of software (e.g., Word, PowerPoint) • word processing papers • being able to obtain a range of information from the Internet related to the subject under study, instead of teachers giving it all to students • becoming comfortable in educational settings • enrolling in academic classes	Included terms

Figure 1. A Domain Analysis of Two Teachers' Construction of What Counts as Academic Preparation in Their School

individual and group interviews, and observed lessons during and after data collection enabled us to cross-check analyses and interpretations.

Finally, it should be mentioned that the relatively small number of schools, and the fact that they are all located in southern California, restricts the generalizability of this study to other contexts. California is facing many special educational challenges, including a funding crisis and the presence of large numbers of immigrant students, that may or may not be present in other states. Nevertheless, we expect that much of what we found will resonate with other similar contexts of financially pressed urban schools with a large number of immigrant students.

FINDINGS

The high-SES and low-SES schools in the study had, on average, relatively comparable numbers of computers and of Internet-connected computers per student (see Table 2). This is consistent with national data that report

Table 2
Computer and Internet Availability

School	*Computers for Instruction*	*Students per Computer*	*Internet Connected Computers*	*Students per Internet-Connected Computer*
Low-SES schools				
Bergenia	680	4.5	321	9.5
Erica	506	5.7	506	5.7
Escallonia	327	3.7	327	3.7
Kalmia	541	4.0	357	3.9
Salix	600	3.3	600	3.3
Mean rates		4.2		5.2
High-SES schools				
Cassia	667	3.7	453	3.7
Dalea	688	4.2	459	6.3
Vallota	300	7.8	300	7.8
Mean rates		5.2		5.9

Note: SES = socioeconomic status.

earlier gaps in amount of computer equipment in low- and high-SES schools are narrowing. In fact, in this small sample, the low-SES schools had a slightly better student-computer ratio on average than the high-SES schools.

For us, the more important question was how technology was integrated into the curriculum in the schools. An overview of the main uses of technology in the low- and high-SES schools is found in Table 3. Uses were most similar in science, where teachers in both low- and high-SES schools used computers for a combination of simulations, data analysis, and PowerPoint presentations. Students in the low-SES schools occasionally used computers for Internet-based research during lessons but in ways that were perfunctory (e.g., looking up definitions of the word *biology*).

There were greater differences in the other three subject areas. Students in high-SES schools used computers to carry out statistical analyses, whereas students in low-SES schools used computers for individualized instruction and for a visualization program (in geometry). In language arts, students in both low-SES and high-SES schools used computers to make Microsoft PowerPoint presentations and to write essays. However, students in the high-SES schools also used computers to plan, edit, and analyze essays and to conduct research on the Internet. In social studies, students in both low- and high-SES schools carried out Internet-based research, but students in low-SES schools also created PowerPoint presentations and video presentations.

Table 3

Computer Uses in Main Subject Areas

	Science	*Mathematics*	*Language Arts*	*Social Studies*
Low-SES schools	simulations data analysis PowerPoint presentations Internet-based research	visualization software individual instruction and drill	PowerPoint presentations essay writing	PowerPoint presentations Internet-based research video presentations
High-SES schools	simulations data analysis PowerPoint presentations	statistical analysis	PowerPoint presentation Internet-based research planning, writing, editing, and analyzing essays	Internet-based research

Note: SES = socioeconomic status.

In summary, subject area differences included greater amounts of research and analysis in mathematics and language arts by students in the high-SES schools and greater amount of visual presentations (using PowerPoint and video) in social studies by students in the low-SES schools. This reflected in part a difference in the courses most frequently offered at the low- and high-SES schools. For example, we witnessed students using computers for statistical analysis in an advanced placement statistics course at a high-SES school; the course is rarely offered in low-SES schools in California. In contrast, students in a low-SES school in this study used computers for individualized prealgebra instruction. The majority of students in the high-SES schools were in more advanced mathematics courses and presumably deemed less in need of individualized remedial work.

The evidence of greater emphasis on research and analysis in the high-SES schools was backed up by the summaries of 2002 survey data from the California Technology Assistance Project provided by the schools. According to this survey data, roughly similar numbers of teachers at the low- and high-SES schools reported that their students did word processing, corresponded with experts, accessed content-specific resources, or graphically presented materials. However, on average, greater percentages of teachers at the high-SES schools reported that their students analyzed data, carried out research, created projects, or created demonstrations (see Table 4).

To better understand some of the similarities and differences between the low- and high-SES schools, we now turn to three overall patterns of technology access and use we identified in the study, which we have labeled "performativity," "workability," and "complexity." These patterns resonated with extant research literature (e.g., Cuban, 2001; Lankshear & Snyder, 2000) and, at the same time, had a life of their own particular to the contexts in which data were collected for the study reported here and served to indicate the particular challenges low-SES schools face in relation to the effective integration of technology into classroom teaching.

Performativity

The concept of performativity comes from the work of Jean-Francois Lyotard (1984), who used the term to describe the state of affairs in postindustrial societies, such as the United States, that has brought about the legitimization of anything that contributes to maximizing the optimal performance of a system. In plain words, measurable performance becomes a justifiable end in itself. Thus, in educational contexts, performativity refers to situations in which teachers are going through the motions or ticking off checklists of skills without paying due attention to larger issues of knowledge

Table 4

Reported Student Uses of Technology in Participating Schools

	Low-SES Schools					*High-SES Schools*		
Student Use	*Bergenia %*	*Erica %*	*Escallonia %*	*Kalmia %*	*Salix %*	*Cassia %*	*Dalea %*	*Vallota %*
Word processing	75-100	75-100	75-100	75-100	75-100	75-100	75-100	75-100
Analyze data	1-24	1-24	1-24	1-24	25-49	25-49	1-24	50-74
Research	50-74	75-100	75-100	75-100	25-49	75-100	75-100	75-100
Create projects	50-74	50-74	75-100	50-74	50-74	50-74	75-100	75-100
Create demonstrations	25-49	25-49	1-24	1-24	1-24	50-74	25-49	25-49
Access content-specific resources	1-24	75-100	1-24	25-49	75-100	50-74	50-74	75-100
Correspond with experts	0	25-49	1-24	1-24	25-49	25-49	1-24	1-24
Graphically present materials	25-49	1-24	75-100	1-24	25-49	50-74	1-24	50-74

Note: SES = socioeconomic status.

construction and purposeful learning (Lankshear & Knobel, 2003; Lankshear & Snyder, 2000).

We found a common pattern of performativity in technology use at almost all the schools, regardless of SES. Many teachers we observed focused on the completion of technology tasks as an end in themselves, without attention to the relationship of these tasks to relevant learning goals. More emphasis was frequently put on mastery of hardware or software functions rather than on underlying learning outcomes. This can be illustrated through two examples: one from a low-SES school, and one from a high-SES school.

At a low-SES school, a class with many English language learners was completing an Internet-based research assignment. To complete the assignment, students simply input the name of the country they were researching into a popular Internet search engine and worked their way aimlessly through the list of sites returned by the search, starting with the first search return and on to the next, without any apparent consideration of the relevance of any of the sites listed. They then cut and pasted text from the Web pages they visited into a Word document, as they had been instructed to do by their teacher. Although the students could be said to be performing the task of searching for material on the Web, they were not developing any of the cognitive or information literacy skills that such a task would normally involve (cf. Lankshear & Knobel, 2003). Such skills include selecting the right search engine, determining the best search terms, scanning search results for appropriateness and relevance, and interpreting and synthesizing information on the located Web pages. The teacher did not intervene in any way in these students' searches, at least in the lessons that we observed, to help students develop these skills.

At a high-SES school, a science teacher assigned students the task of creating a PowerPoint presentation with grades based, in part, on how many fonts, sounds, slide transition types, and animations a student used. In the real world, of course, the use of multiple fonts and animations is usually the sign of a bad PowerPoint presentation rather than an effective one. It appeared that the purpose of this assignment and grading rubric, as well as other PowerPoint assignments we witnessed across the schools, was not to teach students to develop an effective presentation but rather to check off that they had mastered the various features of the PowerPoint software program.

This general emphasis on performativity was well noted by students. In focus group discussions at several schools, students told us that using computers improved their grades—not because it improved their learning or academic performance but simply because teachers allotted extra points to the final grade for papers that had been word processed.

Although we found some examples of excellent practices at both the low-SES and high-SES schools, the above examples of performativity were representative of school technology practices in many classrooms. Although performativity was unfortunately common in all the schools in our study, this problem appears to have a special effect on students in low-SES schools. First, performativity intersects with and is reinforced by other trends already noted in the low-SES schools, such as the greater tendency to teach basic computer tasks in class due to teachers' uncertainty about students' home computer access. Second, because low-SES students face far greater challenges than do high-SES students in preparing for higher education, these disadvantaged students can least afford to be distracted from real and efficacious learning opportunities. And distracted they appear to be: In survey responses, nearly twice as many students in the low-SES schools indicated that PowerPoint was something they especially liked about using computers in education, as compared with students in the high-SES schools. Becoming fluent users of particular software applications is rarely identified by researchers interested in globalization and the future world of work as being important (cf. Baumann, 1992; Gee, 2003).

Workability

The second consistent pattern that we noted in the study was that of workability. Simply put, teachers, administrators, and students in both low- and high-SES schools had concerns about whether and to what extent the existing digital networks actually functioned for teaching and learning, that is, whether they could be accessed and used easily. This was in contrast to other, older technologies in the schools, such as blackboards, books, or overhead projectors, which were integrated more seamlessly into classroom life.

The most pressing workability issues concerned the robustness of the new technologies and hardwired networks in the school. Many teachers reported that they could not always rely on new technologies to work when they needed them. As a teacher in one of the high-SES schools put it, "Teachers can't use something if they can't count on it." Teachers regularly recounted how using new technologies often doubled their workload because they had to develop a back-up lesson and materials in case the network was down or the Web sites could not be accessed. Workability extended to design flaws as well. In one library, for example, the power cord for a set of computers grouped in the center of the lab space is at floor level and is regularly kicked out of its socket by accident, which causes all six computers connected to this power source to immediately lose power. At Salix, a low-SES school, the majority of computer labs are actually classrooms dedicated to business studies courses and to Grade 9 introduction to computer courses. Based on teacher interviews, we were left with the impression that the location of these computers has established an association of technology as belonging principally to business studies rather than to an open culture of computing that includes all subject areas.

Although workability issues were found throughout the study, there were differences between how these issues played out in the low- and high-SES schools. In general, the three high-SES schools in the study tended to invest more in professional development, hiring full-time technical support staff and developing lines of communication among teachers, office staff, media specialists, technical staff, and administration that promoted robust digital networks. This, in turn, encouraged more widespread teacher use of new technologies. The low-SES schools had achieved less success in creating the kinds of support networks that made technology workable. These differences are illustrated by a comparison of Dalea and Bergenia High Schools.

Workability at Dalea. Dalea High is located in a wealthy suburb. Some 80% of the student population is Caucasian and more than 98% of the teachers have full teaching credentials. Dalea has worked hard at establishing mini computer centers in classrooms throughout the school. Every classroom has at least two computers in it, and several have enough to accommodate every student in the classroom. Within the school, 12 technology facilitators have been selected from the teaching staff. As the school's media specialist explained,

> Those teachers are in the various different [subject area] departments and they're available for the other teachers to come to as a kind of mentor. So if they get stuck on something, they don't just come to me or they don't just have their students. They've got another teacher that can help them in the classroom, someone that teaches the same subjects as they do and maybe have some ideas about how the technology can be used to teach.

These 12 technology facilitators have undergone extensive in-service training in using a range of office and educational software. In addition to these teacher facilitators, the school has a broad-based technology committee and employs a full-time media specialist. The school has made a conscious decision to free up specialists within the teaching staff to provide technical and pedagogical support to other teachers, and students have been recruited for maintenance, installation, and other technology-related work as well. The school's media specialist describes how this works:

> [One teacher] teaches our CISCO class, which is a network wiring and design class, and we hired him for one period to be free to help facilitating teachers with their lesson plans and integrating technology. He has a crew of kids that have been through his CISCO class that are helping us wire our [classroom-based] mini-centers because we

did not have our mini-centers up and running when we walked in the door. We got a lot of computers this summer. Four hundred computers this summer, and to get the mini-labs up and wired, he's got a crew. He has two or three students helping him I think. And I have aides, as well. I have four aides that I use during the morning—student aides. And they help me so much. We get a lot done with students, and the students are very good. I mean, you have to trust them, but they just get a lot done.

In addition, another teacher oversees the development and maintenance of the school's Web site. In turn, this support network is facilitated by clear channels of cross-communication and coordinated effort. The system does not rely solely on a single expert, who could be transferred to another school or whose position may no longer be funded. Indeed, a key finding of a large-scale investigation of new technology use in classrooms across Australia emphasized the fragility of technology initiatives when schools overinvest in and overrely on the expertise of a single teacher, instead of aiming at a more distributed model of expertise and responsibility (Lankshear & Snyder, 2000). In the case of Dalea, however, the school has established a robust, distributed, but interconnected human network that parallels the new technologies' hardware, software, and cable network in the school.

Taxonomically mapping access to new technologies in this school, as represented in teachers' interview responses and our observation field notes, suggests that the human network at Dalea, and access to it, is regarded by participating teachers as having equal, if not greater, importance as access to hardware and software. The taxonomy presented in Figure 2 represents the semantic relationship, where "*X* is a characteristic of access to new technologies in this school according to interviewed teachers."

Taxonomies are only partial representations of how participants within a given context see their world (Knobel & Lankshear, 1999). Nevertheless, the salient features singled out for discussion by participants within the context of our interviews, or captured in the course of our observations, provide us with insight into the ways in which access is construed within a school. In this particular case, funding was not presented as an issue but rather as a series of opportunities and options. These teachers present themselves as accountable to the district, as well as needing to be accountable to parents in relation to students. New technologies are seen as being more than simply computers and Internet connections, and it is understood that there is a range of options available for accessing and using them.

Workability at Bergenia. The organization of computer access at Dalea contrasts markedly with that at Bergenia, a low-SES school in an urban neighborhood where 97% of the students are Hispanic and only 78% of the teachers have full teaching credentials. Although Bergenia has a comparable

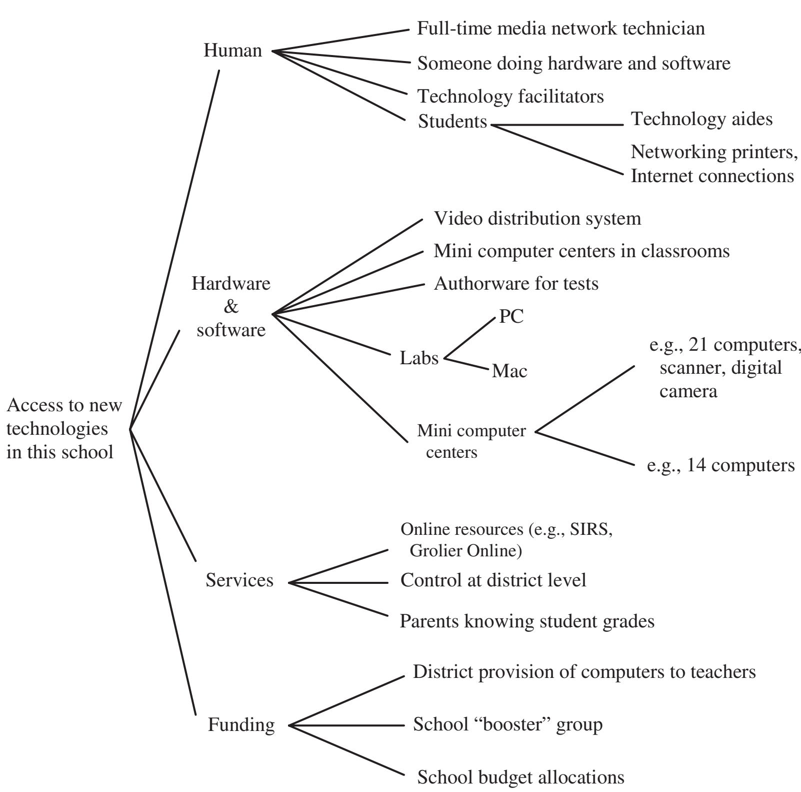

Figure 2.
Taxonomy of Access to New Technologies as Represented in the Talk and Teaching of Four Dalea High School Teachers

student-computer ratio to Dalea (4.5 to 1 at Bergenia compared with 4.2 to 1 at Dalea), teachers at Bergenia indicated much greater difficulty in being able to use the computers for instruction than did teachers at Dalia. Bergenia's computer labs are managed by diverse groups who at the time of the study appeared to be in poor communication with each other. As a result, two computer labs had Internet connections installed for more than 5 months before teachers were told students could go online, and lab monitors (nonteaching staff hired to oversee the welfare of computer labs during class use) did not seem to be familiar with what software had been loaded onto the computers in each lab, which led to scheduling frustrations for many teachers at the school. The assistant principal at Bergenia commented on some of these lab management problems:

The Internet's been sitting there [hooked up to all computers in two labs] for the five months that we've been in school, not being accessed. Nobody really knew why or wherefore, it was kind of: "Nobody gave us [the lab monitors] the directive that we could do that" [i.e., let teachers and students use the Internet while in the labs]. . . . It's a communication problem. When we had a Mac lab that was the word processing lab and then the PC lab was multimedia only originally [and neither were connected to the Internet], and then they both became PC labs. [The lab assistants] just assumed now they're both multimedia and you couldn't word process [in either lab]. It's just that kind of stuff that happens.

An example recounted to us by one teacher at Bergenia succinctly captures the difficulties associated with teaching in rapidly changing urban schools that, even despite the presence of a well-planned system for deploying and using technology, were thwarted in their attempts to implement it seamlessly throughout the school due to an extensive but slow-moving school building renovation and construction program. This program meant that many teachers were housed in temporary buildings or were periodically shifted from classroom to classroom. This teacher recounted how she has recently moved from one classroom to another classroom. In the first classroom, she had an Internet connection for an entire year but no computer to use it with. Now she reports having a computer in her classroom but no Internet connection. She is currently waiting to move into a classroom in the new building, where she hopes to have both an Internet connection and a computer.

Finally, at the time of our study, there was no network of facilitators to offer pedagogical support to teachers. Compared with Dalea, teachers at Bergenia were at a distinct disadvantage when it came to learning how to best use new technologies confidently for effective pedagogical purposes.

Bergenia demonstrated the greatest problems with workability in the study and Dalea demonstrated the fewest. Nevertheless, the differences between them were mirrored in the other low-SES and high-SES schools, albeit less dramatically. In general, the high-SES schools demonstrated smoother computer management throughout the school and more robust support systems, and thus fewer problems appeared to be encountered by teachers and students in working with ICT in these schools.

Complexity

A third pattern found within the eight schools, and one that overlapped with workability issues, was that of complexity. Even in situations when the machines were accessible and useable (i.e., "workable"), many teachers still found it a complex undertaking to actually integrate computers in their teaching. There were several factors that contributed to this complexity, and all of them were thrown into sharp relief in the low-SES schools.

High-stakes testing. One important element in the successful or unsuccessful use of ICT in classrooms concerned the pressure of high-stakes testing. Teachers in all the participating schools, and especially in the low-SES schools where student test scores are lower, told us that they feel a great deal of pressure to focus instruction on covering standard curriculum material and raising test scores. Teachers repeatedly reported feeling torn between needing to prepare students for testing and wanting to engage in innovative instruction that made good use of new technologies. Less experienced teachers, in particular, appeared to feel these pressures more so than experienced teachers.

The following comment from a teacher at a low-SES school was typical of those that were heard:

> Time is probably the biggest [problem]. Now it's even worse. Now that we're changing our curriculum big time to make it a standards-based curriculum—I know the United States has always been a mile wide and an inch deep—and we're pushed, I feel, in that direction, that we really have to be efficient to cover the stuff that's in the standards in one academic quarter. There's not much time for other stuff. And so now it's almost that way even more. Before, if somebody pushed the computer lab, great. I could drop something that we were doing. It's not that critical, you know, it's an assignment we like, but, okay, let's drop it and let's go into the computer lab. And now we're dropping something that's on the [California state] exam at the end of the year and our API score that goes in the [news]paper then could go down because of having more emphasis on computers. So, that is, to me, time is an even bigger obstacle now than it was the first couple of years.

For this teacher, and many others in our data like him, the push to technologize his teaching loses out repeatedly to stronger pressures to raise the school's overall Academic Performance Index. The pressure to teach to the test has important implications in low-SES schools, where school may be the primary point of access to innovative new technology uses for students. In short, classes in these schools that focus on test preparation could well eat into time that otherwise could be spent using new technologies in meaningful ways. Research to date indicates that low-SES schools tend in the main to devote substantially more classroom time to explicit test-taking preparation than do high-SES schools (McNeil, 2000).

Differential home computer access. A second important factor contributing to complexity in the partnership schools in our study is uneven student access to home computers. In the three high-SES schools in our study, an average of 99% of the students we surveyed had home access to computers, with 97% having access to the Internet as well. Quite separately from these survey data, teachers in these schools explained in their interviews that because their students could learn and practice a range of computer applications at home, the teachers did not feel the need to cover basic computer skills during class time and thus could save class time for addressing more important academic material. Teachers in these schools more readily assigned homework that involved computer use. For example, a teacher at Cassia has extra credit assignments whose descriptions and assessment criteria are only available online. A teacher at Dalea has students do all their text input at home and then work on multimedia production in class, using those texts. A teacher at Vallota puts all his homework assignments and outline notes online and then has students copy them out at home.

In contrast, in the low-SES schools, an average of 84% of the students we surveyed had home computer access and 72% had home Internet access. Teachers in these schools were keenly aware that many of their students lacked home computers; in fact, in our interviews, these teachers tended to underestimate how many of their students had home computers. As a result, teachers in these schools were almost unanimous in shying away from assigning homework that involved the use of computers, and indeed, this appeared in several schools to be an unwritten school policy (i.e., to avoid assigning homework involving computer use so as not to disadvantage students without home computers). By default, they subsequently spent more nonacademic computer time (e.g., having students input text) during class hours than did teachers in the more affluent schools we studied.

English language learners. A third factor contributing to complexity, and once again disproportionately within the low-SES schools, was the challenge of teaching English language learners. The low-SES schools in our study had an average of about 30% English language learners, or roughly three times the percentage in the high-SES schools, and many classes in the low-SES schools included students of mixed English language ability. This complicated all aspects of schooling, including technology use. Teachers explained that the types of research and writing activities they engaged in with English proficient students could simply not be carried out with limited-English speakers, due to the latter students' difficulties with spelling, vocabulary, or grammar. Several teachers pointed out the difficulties of teaching limited-English speakers to use the Internet because they were regularly unable to key in URLs and search terms correctly or interpret the results of online searches. One teacher at a low-SES school complained that English learners' incorrect use of the grammar checker in Microsoft Word interfered with students' meaning making. He described how many English language learners would simply accept the grammar checker's suggestions without any evidence of understanding what was being suggested and why, such that, in the end, the papers these students submitted were almost unintelligible.

DISCUSSION

This study contributes to a growing body of research that suggests there is no single digital divide in education but rather a host of complex factors that shape technology use in ways that serve to exacerbate existing education inequalities. We found effective and less effective uses of information and communication technologies for academic preparation in all eight schools. At the same time, we found no evidence to suggest that technology is serving to overcome or minimize educational inequities within or across the eight schools we examined. Rather, the evidence suggests the opposite: that the introduction of information and communication technologies in the eight schools serves to amplify existing forms of inequality. Differences in human support systems for technology use, homework assignment patterns, and emphases on preparation for testing all mitigated the extent to which technology could be used effectively for academic preparation in low-SES schools.

The findings from our study may also add useful explanatory power to previous but related studies. For example, Becker's (2000) finding that high-SES students with computers use them more for school assignments is likely explained in part by the fact that teachers in high-SES schools may be more willing to assign computer-based homework to their students, confident that they have home computers. This same phenomenon can help to explain Attewell and Battle's (1999) finding that high-SES students benefit more academically from having home computers than do low-SES students. Similarly, Warschauer's (2000) case study illustrating how low-SES students were drawn into perfunctory uses of the Internet is better understood in light of the category of performativity that was noted in this study.

The study strengthened our view that the concept of a digital divide, although once useful for drawing attention to the important issue of technology access and inequality, has now perhaps outlived its value, at least when referring to a single construct focusing on physical access (Warschauer, 2002, 2003). As Rob Kling explains (Warschauer, 2002),

> [The] big problem with "the digital divide" framing is that it tends to connote "digital solutions," i.e., computers and telecommunications, without engaging the important

set of complementary resources and complex interventions to support social inclusion, of which informational technology applications may be enabling elements, but are certainly insufficient when simply added to the status quo mix of resources and relationships. (paragraph 26)

As this study helps demonstrate, placing computers and Internet connections in low-SES schools, in and of itself, does little to address the serious educational challenges faced by these schools. To the extent that an emphasis on provision of equipment draws attention away from other important resources and interventions, such an emphasis can in fact be counterproductive.

A more important concept for us, highlighted by this study, is that of the social embeddedness of technology. This concept suggests that technology does not exist outside of a social structure, exerting an independent force on it, but rather that the technological and social realms are highly intertwined and continuously cocreate each other in myriad ways (Warschauer, 2003). In the schools that we studied, specific features of the social context (e.g., the difference in organizational systems at Dalea and Bergenia) shaped how computers were deployed and used, and the placement and use of computers helped shape broader social systems (e.g., the location of Salix's computer labs in the business department, reinforcing a vocational emphasis in the school).

CONCLUSION

The social realm of U.S. education, and in no place more so than California, is largely defined by the vast economic, cultural, and linguistic differences that exist among students, neighborhoods, and schools. The use of technology in education cannot be viewed in isolation from these broader contexts. Nearly five times as many teachers in the low-SES schools in our study lacked full credentials as compared with the high-SES schools. Faculty, staff, and administrators at the low-SES schools in our study had, on average, fewer years of experience. Student absenteeism was much greater in the low-SES schools than in the high-SES schools in this study, too. Greater numbers of students in the low-SES schools in our study were assessed as being below grade-level in English and mathematics in comparison with students in the high-SES schools we studied. Teachers in the low-SES schools assumed that only about 50% of their students had access to computers at home, whereas our survey data suggest that the figure was more than 80%. All these elements meant that the administration, faculty, and staff, with less experience and fewer professional credentials, were devoting much of their attention to remedial literacy and numeracy and computer basics. This left less time and energy that could be devoted to enhancing instruction through academically rigorous uses of technology in the classroom.

One of the most salient differences affecting instruction was the much larger number of English language learners in low-SES schools than in high-SES schools. Referring to this, one administrator in our study succinctly described the challenge of needing to offer both an academic "university track" and a survival/vocational "California track." The latter was aimed at equipping large numbers of immigrant students, who enter secondary school with little knowledge of English and limited reading and writing skills in any language, with operational understandings that will, at the very least, help them get by in California as adults.

In our study, issues of workability, complexity, and performativity were evident in all the schools we examined, although the way those issues played out differed between the high-SES and low-SES schools, largely due to the broader social realms making up those schools rather than to student-computer ratios and school Internet access. To help meet these challenges, educational policy makers need a three-pronged approach.

First, they need to address broad issues of educational inequity by creating mechanisms that ensure that low- and high-SES schools have higher numbers of well-trained and experienced teachers, staff, and administrators. In addition, funding mechanisms need to be in place to ensure that schools with large numbers of English language learners receive the additional financial resources required to meet the needs of these students.

Second, teachers need to turn their attention away from mastery of software programs, such as PowerPoint or Internet Explorer, as an end in itself, and instead pay greater attention to using technology for scholarship, research, and inquiry. To encourage this, funds can be provided for release times for teacher mentors at school sites to assist other teachers in more effective academic uses of digital technology. Every school we visited had some teachers who were creatively making use of technology to help realize the full potential of their students; such teachers can play an invaluable role in providing support and assistance to their colleagues, if offered the chance.

Third, schools need a better approach for addressing unequal access to home computers. Students can be encouraged to make use of publicly available computers, such as those in libraries or community centers. Schools can also make laptops available on a check-out basis. Lack of access by some students to home computers should be viewed as a challenge to be overcome rather than a rationale for lowering expectations.

The narrowing gap in numbers of computers in high- and low-SES schools, both in our sample and in the nation at large, is an important first step toward helping overcome a digital divide in education. However, there is much work that remains to be done. Greater attention to technology use for academic purposes rather than for mastery of software programs is an important next step. This requires increased peer mentoring among teachers and better support for students who lack home computers, while we continue to work more generally for sufficient financial and human resources in low-SES schools.

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