The Presence of Computers in American Schools

Ronald E. Anderson and Amy Ronnkvist

Teaching, Learning, and Computing: 1998 National Survey

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INTRODUCTION

During the last decade, as the Internet and multimedia technology became widespread, enthusiasm for the use of computers in schools also became more evident across the United States. Attendance at educational technology conferences rose sharply; hundreds of businesses started up to offer hardware, software and related services to education; and thousands of teachers took courses to help them utilize newer technology in their classrooms. Outside the school system enthusiasm grew as well despite the publication in newspapers and magazines of several articles critical of the growing reliance on computers in schools. An MCI nationwide poll in 1998 found that nearly 60% of the public answered "a great amount" when asked "How much do you think computers have helped improve student learning?" (Trotter 1998).

Despite this enthusiasm, the schools have had difficulty keeping up with the opportunities provided by new technologies. In a context of rapid technological and social change, the educational system has faced huge challenges in planning and implementing new policies and procedures that integrate computing technology into instruction. Many districts and schools have not been able to afford the costs of installing the new technology that they would like to use. Others have weighed the advantages and disadvantages and found contradictory claims and little evidence on the extent to which learning is enhanced from different ways of applying information technology. It is therefore extremely difficult to predict how rapidly teachers, schools, and districts will appropriate into their routines, the newer technologies and methods for using them.

In April 1995, for the first time a Presidential panel on educational technology was commissioned to advise the President on how computer technology could be used to strengthen K-12 education in the United States (PCAST 1997). This Panel on Educational Technology concluded that the amount of computing and networking equipment available for instruction in the schools remains "suboptimal" and a large share is "obsolete and of very limited utility." Importantly, the report also argued that the problem is not just in the infrastructure but in the lack of adequate staff preparation and support.

In order to assess the current presence of computing technology in American schools, a national survey of schools was conducted in 1998. This survey makes it possible to evaluate whether or not the conclusions of the President’s Panel remain true.

SAMPLE

The information gathered by the Teaching, Learning and Computing - 1998 survey derives from a national probability sample of elementary and secondary principals and technology coordinators in U.S. public and private schools conducted in the Spring of 1998. Initial contact letters along with roster forms were sent to 1,215 public, private and parochial school principals selected from a national database of 109,000 schools supplied by the firm of Quality Education Data (QED) of Denver, CO, a marketing information division of Peterson’s Guides. Schools were sampled according to their size (estimated number of full-time teachers of grades 4 through 12) and according to how much computer technology they had (using an index incorporating per-capita technology presence).

The attained sample consisted of 655 schools whose principals agreed to participate in the survey (a 74% response rate at the Roster stage) with 488 principals (a 75 % individual response rate) and 467 technology coordinators (a 71% individual response rate) actually completing surveys. (Principals were asked to roster 3 to 5 teachers at their schools as well, however teacher level data was not evaluated for this report.)

COMPUTER DENSITY

During the 1980's and even into this decade, surveys found that schools had relatively little computer equipment, particularly up-to-date technology, compared to the number of potential student and teacher users (Becker 1986; Becker 1991; Anderson 1993). In Becker's 1983 school survey only 250,000 computers were found in schools for instructional purposes, although this had increased to a little over one million by 1985 (see Table 1). Many teachers and administrators were excited then about the possibilities of using computers, but with so few computers for the nearly 45 million students, technology had relatively little impact on day-to-day teaching and learning.

TABLE 1: TOTAL INSTRUCTIONAL COMPUTERS AND STUDENT-COMPUTER RATIO IN K-12 SCHOOLS, USA IN LAST 15 YEARS

Total Number of Instructional Computers in 1,000s	250	1,000	2,400	3,500	5,400	8,600
Overall Student-Computer Ratio	168	39.1	19.2	13.7	9.2	6.0
Year	1983	1985	1989	1992	1995	1998

Source: Teaching, Learning and Computing-1998, "The Presence of Computers in American Schools," http://www.crito.uci.edu/TLC.

Even in 1992, research conducted under the auspices of International Association for the Evaluation of Educational Achievement (IEA), found that U. S. schools had an inventory of only 3.5 million computers (Anderson 1993; Pelgrum 1993). However, as shown by our "Teaching, Learning and Computing - 1998" survey, in the six years that followed, the number of instructional computers grew to about 8.6 million, which is an increase of more than 150%. During this decade the number of instructional computers in elementary and secondary schools in the United States has increased by about 15% per year. However, the annual increase in the last three years has risen slightly above that.

This pattern of growth is likely to escalate in the next year for two main reasons. One is falling prices and the other is increased interest and funding of telecommunications. During the 1998 calendar year, the annual growth of computers in the home market nearly doubled. This seems to have been driven by interest in new Internet applications but also by the increased affordability of desktop computers. It is expected that these same two forces will spur acquisitions of new computer units by schools during the 1998-99 school year. The rising interest in the Internet is currently fueled by the funds from the Telecommunications Act of 1996. Under the new "E-rate" programs established by this act, the SLD (Schools and Libraries Division) of the USAC (Universal Service Administration Company), which administers this fund, has committed as of February 1999, over $1.08 billion to about 16,000 schools or districts. While these funds can not be used for buying computers, it is expected that schools will add more computers to take advantage of expanded Internet access. Thus, a 20% growth in new instructional computers would not be surprising, with the total of computers for instruction rising well above 10 million by the end of the 1998-99 school year.

Actual numbers of computers are not nearly as meaningful as measures of computer density that take into account the number of students. Lower density levels make it impossible for students to spend much time engaged in learning with the use of computing tools. Student-computer ratios (the number of students enrolled divided by the number of computers available for students and teachers) measure how likely students are to have to share a school computer. The smaller a ratio, the more computer units a school possesses relative to its student body. For example, a student-computer ratio of 10 means that there is one computer for every 10 students while a school with a student-computer ratio of 50 has only one computer per 50 students. Table 1 shows that in the past 15 years, the overall student-computer ratio in K-12 schools has dropped from about 168.0 to 6.0, which means there are 6 students for every computer.

But the overall student-computer ratio is calculated at the population or system level and so does not represent how many students actually share a computer. The overall student-computer ratio is simply the division of the total students in all USA schools by the total number of instructional computers. Somewhat better measures, which are given in Table 2 and subsequent tables, are the average and median student-computer ratios taken across all schools. As Table 2 shows, the average (mean) ratio is higher (7.3) than the overall ratio, but the median (6.0) is the same as the overall ratio. When a median is less than a mean, it means that there are some extremely large ratios that skew the distribution away from a normal curve. The median better represents a typical school, but even the median doesn't show that there are many students in schools with very high ratios and many in schools with very low ratios.

TABLE 2: INDICATORS OF COMPUTER DENSITY IN USA ELEMENTARY AND SECONDARY SCHOOLS[a], 1998

		Elementary	Middle	High School	Total
Mean and Median	Mean	75	109	174	100
Number of Instructional					
Computers per School	Median	69	98	122	79
Mean and Median	Mean	7.6	6.8	6.8	7.3
Number of Students					
per Computer	Median	6.3	5.2	5.2	6.0
Total Number of					
Computers (in thousands)		(4,026)	(1,806)	(2,762)	(8,595)

Source: Teaching, Learning, and Computing Survey of K-12 Schools in USA, 1998 http://www.crito.uci.edu/TLC.
[a]Elementary schools were defined as those schools with a median grade range of 5.5 or lower; high schools as those with a median grade of 9.5 or higher; and those in between as middle schools.

Another measure of computer density is the mean and median number of instructional computers per school and this is given in Table 2 also. The median number of computers per school is 80, and the mean is 100. While this is interesting, these statistics are dependent upon school size (i.e.; larger schools tend to have more computers). So, the most meaningful comparisons of computer density across years and types of schools use the student-computer ratio.

The typical or median student-computer ratio in U.S. elementary schools is 6.3, and in middle schools and high schools is 5.2. These are not large differences, but what is most interesting about this comparison is that the differences among school levels are much less than 6 years ago when the elementary school ratio was 50% higher than the high school (Anderson 1993). This means that schools with younger students have been acquiring computers at a higher rate than have high schools.

COMPUTER CAPACITY

In the 1980's to early 1990's, Apple II computers dominated school computer inventories. The 1992 IEA survey found that about 50% of all instructional computers in schools were Apple IIs. However, six years later that percent had dropped sharply to only 9% (See Table 3). And while 68% of computers in elementary schools were Apple IIs, now they comprise only 15%.

This most dramatic change has occurred since the 1992 IEA survey which concluded that the schools' computers were largely obsolete.

This shift toward a more modern inventory of computers is evidenced by the fact that 24% of all school computers are Pentiums and 21% are Power Macintoshes. Another indication is that 70% of the computers are now capable of running Windows or Mac OS. This capacity has reached 90% in high schools.

A more pessimistic view also can be supported by the statistics in Table 3. To run multimedia applications efficiently, a Pentium or Power Macintosh is needed, but only 45% of the school inventory consist of those computers. This percentage is 39% for elementary schools and 46% for middle schools. So, using contemporary standards for home and office computers, over half of the computers are out of date. And in elementary schools almost two-thirds are of limited capacity.

TABLE 3: PERCENT[a] OF COMPUTERS IN U.S. K-12 SCHOOLS BY PROCESSOR TYPE AND SCHOOL LEVEL[b], 1998.

	Level							
Processor Type	Elementary		Middle		High School		Total	
Pentiums	18%	(708)	23%	(420)	33%	(919)	24%	(2,048)
386 or 486	12%	(482)	20%	(369)	24%	(672)	18%	(1,523)
286 or earlier	7%	(276)	5%	(95)	7%	(183)	6%	(555)
Windows & DOS Subtotal	36%	(1,467)	49%	(884)	64%	(1,775)	48%	(4,126)
Power Macs	21%	(840)	23%	(421)	20%	(548)	21%	(1,809)
Older Macs (68xxx)	21%	(849)	16%	(293)	12%	(327)	17%	(1,469)
Macintosh Subtotal	42%	(1,689)	39%	(713)	32%	(875)	38%	(3,277)
Apple II Series	15%	(595)	8%	(143)	3%	(70)	9%	(809)
Other	7%	(275)	4%	(66)	2%	(42)	4%	(383)
Total Computers	100%	(4,026)	100%	(1,806)	100%	(2,762)	100%	(8,595)

Source: Teaching, Learning and Computing Survey of K-12 Schools in USA, 1998 http://www.crito.uci.edu/TLC.
[a]These are percents of the estimated computers available for instructional use in K-12 schools in the U.S. as of Spring, 1998. The cells contain the number of computers divided by column sum.
[b]Elementary schools were defined as those schools with a median grade range of 5.5 or lower; high schools as those with a median grade range of 9.5 or higher; and those in between as middle schools.

Both Macintosh and Windows based computers hold strong positions in the schools. Forty-eight percent of all computers were designed for DOS or Windows platforms, while 38% were built for Mac OS. But this pattern is reversed for elementary schools where there are only 36% for Windows or DOS but 42% Macintosh.

This dramatic contrast between computers in elementary schools and those in high schools is revealed by another indicator, the percent of computers that were acquired by schools since July of 1996. The technology coordinators reported that overall 30% had been acquired in the previous two years. However, while 37% of high school computers had been acquired in the last two years, only 25% had been acquired by elementary schools in that same period of time. So, the relative obsolescence of computers in elementary schools may result in part from the tendency of schools at the higher levels to pass on their replaced computers to the elementary schools. While elementary schools in general do not stay as up to date as higher level schools, it is very impressive that the percentage of Macintosh computers in elementary schools increased from 4 to 42 percent between 1992 and 1998.

COMPUTER RENEWAL

In 1992, the schools had about 2 million Apple II series computers, but this number has dropped to less than half that number, approximately 824,000. During this last decade, it has not been possible to purchase new Apple II computers, so this inventory drop means that the schools disposed of over 1 million Apple II computers; a step which most technology specialists would consider progress because newer computers are necessary for multimedia and Internet applications.

Looking at the inventory of higher end computer models yields another interesting view of how school computing has changed in the past 6 years. In 1992 only 22% (about 750,000) of the computer models were less than 10 years old. This included the Macintosh and the Intel 80286, -386, and –486 models, which had all been first released in 1982 or later. Only 6 years later, in 1998, over 50% of instructional computer models were less than 10 years old. In fact by 1998, almost half (45%) of the computers had been first shipped within the previous 5 years. This included Power Macintoshes, Pentiums, and their clones.

Not only are schools buying a lot more computers, but they are adjusting to the increasingly short replacement demands of current computer technology. The useful life cycle of computers now sold for home and business has been shrinking down to as few as 3 to 4 years, and our survey data indicate that schools have recognized this renewal challenge.

Given that the average desktop computer now is obsolete in 4 years or less, and given that the typical (median) school has 79 computers, this implies that the typical school acquires roughly 20 or more computers per year on the average. It is impossible to predict the future, but it is likely that the average or typical useful life of desktop computers will get even shorter.

The schools have shown their capacity to adapt to this rapidly accelerating context of machine obsolescence. Only six years ago, the obsolete equipment made it seem doubtful that U. S. schools could keep up with the rapid pace of computing technology. The latest data suggest that schools are doing an impressive job of catching up.

PERIPHERALS

The quality of computing depends partly on the auxiliary devices and connections attached to computer units. Table 4 gives the percent of all computers that have each of the peripherals or connections listed. Nearly half (46%) of all school computers have a CD-ROM drive while 59% have a direct access to a printer. While only 8% have a modem attached, nearly half (48%) have a connection to a Local Area Network (LAN). Comparable statistics are not available from the 1992 survey for CD-ROMs, printers, and modems. But in 1992 only one-sixth of elementary schools had a laser printer. In 1998, 55% of all computers in elementary schools had direct access to a printer; so printing capability seems to have improved substantially in elementary schools. Also, in 1998 about half of the computers are connected to a LAN, whereas in 1992 it was only 20%. While computers in high schools are over 20 percentage points more likely to be connected to a LAN than are schools at lower levels, for the other attached peripherals the differences are relatively minor.

TABLE 4: PERCENT[a] OF COMPUTERS WITH SELECTED ATTACHED PERIPHERALS WITHIN EACH LEVEL[b], 1998

	School Level							
Attached Peripheral	Elementary		Middle		High School		All Schools	
CD-ROM drive	46%	(1,861)	44%	(804)	46%	(1,269)	46%	(3,935)
connection to LAN	41%	(1,688)	47%	(851)	58%	(1,578)	48%	(4,116)
direct access to printer	55%	(2,217)	55%	(1,004)	68%	(1,857)	59%	(5,078)
attached modem	9%	(372)	8%	(152)	7%	(199)	8%	(722)

Source: Teaching, Learning and Computing Survey of K-12 Schools in USA, 1998 http://www.crito.uci.edu/TLC.

[a]These are percents of the instructional computers with the attached peripheral within each level of school in U.S. K-12 schools as of Spring, 1998.

[b]Elementary schools were defined as those schools with a median grade range of 5.5 or lower; high schools as those with a median grade of 9.5 or higher; and those in between as middle schools.

The presence of video production studios is another indication of the currency of schools' capacity for utilizing information technology, since video production operations tend to rely heavily upon computer hardware and software. Overall, about 9% of schools report that they have a video production studio. About one quarter of high schools have such video facilities, but only 8% of middle schools and 3% of elementary schools have them.

COMPUTER LOCATION

The mere presence of computers in a school building does not mean that teachers and students have access in the sense of opportunities to actually use the computers. If computers are not located in a particular classroom, then the teacher and the students in that classroom may not be able to utilize the schools' computers effectively for learning. When schools aggregate computers and place them in a shared place, such as a computer laboratory, they do so to insure these scarce resources are available to more teachers and students. However, placing a resource outside of the normal working space of teachers and students means that it will be more difficult to integrate computer activities with the other instructional and learning activities going on in the classroom (Becker 1998). Computer use in a lab must be planned in advance and occupy a discrete period of class time. On the other hand, integration of computer activities may also be problematic when the computers are located in each teacher's classroom. Each classroom may be limited to having a single computer and having too few computers in one place makes it difficult to orchestrate activities for an entire class of students.

Table 5 provides the percent of computers located in classrooms, labs, and "other places" by school level. Overall, 48% of the computers are found in classrooms and 43% in computer labs. This is a noteworthy change from 1992 where overall there were about 10% fewer computers located in classrooms. In high schools, this shift was mostly from "other places," primarily media centers, whereas in middle and elementary schools the shift was mostly from computer labs. This may result from a greater need in high schools for computer labs for business education classes.

TABLE 5: PERCENT[a] OF COMPUTERS IN U.S. K-12 SCHOOLS IN DIFFERENT LOCATIONS BY SCHOOL LEVEL[b], 1998.

	Level							
Location	Elementary		Middle		High School		Total	
Computer labs	37%	(1,501)	44%	(799)	49%	(1,360)	43%	(3,660)
Classrooms	56%	(2,273)	40%	(725)	42%	(1,159)	48%	(4,157)
Other places	6%	(252)	16%	(283)	9%	(244)	9%	(778)
Total	100%	(4,026)	100%	(1,806)	100%	(2,762)	100%	(8,595)

Source: Teaching, Learning, and Computing Survey of K-12 Schools in USA, 1998 http://www.crito.uci.edu/TLC.
[a]These are percents of the estimated computers available for instructional use in each of these levels of schools in U.S. as of Spring, 1998.
[b]Elementary schools were defined as those schools with a median grade range of 5.5 or lower; high schools as those with a median grade of 9.5 or higher; and those in between as middle schools.

In elementary schools 56% of the computers were in classrooms, but in middle schools, that share was 40% and in high schools, 42%. In 1992 this difference across levels was about the same even though at each school level the concentration of computers has shifted since then somewhat more into classrooms.

TECHNOLOGY-INTENSIVE SCHOOLS

For the purpose of identifying high-end technology schools that had invested substantially in fairly up-to-date computing and networking hardware, an index of technology intensity was designed for schools in our sample. Technology-intensive schools were defined as those having all three of the following: (1) a student-computer ratio of 6 or less, (2) at least 25% of their computers equipped with CD-ROMs for multimedia, and (3) a moderate or high speed Internet access, that is, a bandwidth higher than current modem technology, which would include ISDN, T1, and other such technologies. Those schools that did not supply this type of information to us were treated as "missing" and not included in the comparisons.

Even though these criteria for technology-intensity were not very demanding, only 25% of all US K-12 schools qualified as "technology- intensive" (Table 6). There was a greater tendency for high schools to be technology-intensive (31%) compared to middle schools (29%) and elementary schools (22%). It is noteworthy that technology-intensive schools are more common among private as compared to public schools, in smaller schools, and in higher income schools as measured both by chapter 1 eligibility and by the average household income within the schools' zip code area.

TABLE 6: PERCENT TECHNOLOGY-INTENSIVE BY SCHOOL LEVEL

	Elementary	Middle	High School	All Schools
Technology-Intensive Schools	22	29	31	25
Not Technology Intensive	78	71	69	75

Source: Teaching, Learning, and Computing Survey of K-12 Schools in USA, 1998 http://www.crito.uci.edu/TLC.

SOFTWARE

Software and hardware are equally essential for teachers and students to benefit from information technology in their teaching and learning. Several indicators were constructed to measure the level of software resources available for instruction within schools. These measures were all based upon answers to the question asked of technology coordinators about the percent of instructional computers in their schools. The question asked about each of 20 types of software. These software types are listed in Table

7, which also gives the mean percent of schools' computers with access to these types of software. Taking the average of these 20 averages yields an indicator of the total amount of software available in schools which we call "software saturation." As can be seen on the last row of Table 7, the overall software saturation for elementary and middle schools was 41, but was 38 for high schools.

TABLE 7: SOFTWARE SATURATION: AVERAGE PERCENT OF SCHOOLS' INSTRUCTIONAL COMPUTERS WITH ACCESS TO EACH TYPE OF SOFTWARE BY SCHOOL LEVEL

	Elementary	Middle	High School	Total
Word Processing*	96	97	95	96
Spreadsheet*	79	91	88	83
Database*	79	87	86	81
Drawing or Painting Software*	81	82	72	80
Desktop Publishing, Presentation Software*	55	56	57	56
Image-Editing Software (e.g., Photoshop)	10	15	16	12
Multimedia Development (e.g., Hyperstudio)	30	35	23	30
Reference Information on CD-ROM	51	54	51	51
Interactive Laserdisc Software	4	5	6	7
Internet (e.g., Netscape, e-mail software)	37	52	55	43
Web Development Tools	11	24	25	16
Programming Languages	6	10	13	8
Math-specific Programs	62	39	22	50
Science-specific Programs	35	29	21	31
English-specific Programs	56	29	23	45
Social Studies-specifics Programs	44	28	18	36
Foreign Language-specific Programs	11	13	15	12
Typing Tutors	59	51	30	52
Business Education-specific Programs	4	13	34	11
CAD-CAM, Industrial Arts Programs	3	6	10	3
Average	41	41	38	40

Source: Teaching, Learning, and Computing Survey of K-12 Schools in USA, 1998 http://www.crito.uci.edu/TLC.

Another dimension of software presence considers the availability of specialized software. We call this "software diversity" and it is operationalized by counting the number of specialized types of software present at a school. Six types of software were considered general and excluded from the measure of software diversity. The six general types of software not counted in the diversity index were word processing, spreadsheet, database, drawing/painting software, desktop publishing, and Internet software. The software diversity index consisted of the count of the remaining 14 software types that a school had accessible on one or more computers. The overall average number of software types was 9.5 out of 14, which is shown in Table 8. The elementary school software diversity average was 8.7, while the middle school average was 9.9, and for high schools it was 11.8.

TABLE 8: SOFTWARE DIVERSITY AND DENSITY BY SCHOOL LEVEL

	Elementary	Middle	High School	All Schools
Software Diversity	8.7	9.9	11.8	9.5
Software Density (Units Per Student)	1.6	2.3	1.9	1.8

Source: Teaching, Learning, and Computing Survey of K-12 Schools in USA, 1998 http://www.crito.uci.edu/TLC.

High schools had higher software diversity, but lower software saturation than the schools for younger students. This probably reflects the greater variety of specialized coursework in the secondary school curriculum and their tendency to have computer labs targeted for specialized course work such as business or computer science. The elementary and middle schools have less software diversity, but greater saturation. Thus, the typical computer in an elementary or middle school has more software loaded onto it or accessible to it from a local server.

A third indicator of software presence, software density, is the average number of software units per student. As show in Table 8, the average number of software units was 1.6 in elementary schools, 2.3 in middle schools, and 1.9 in high schools. Greater software diversity in the high school seems to yield a relatively high software density compared to elementary schools. The even higher software density in middle schools may be a consequence of the smaller enrollments in middle schools.

INTERNET ACCESS

The Internet is arguably the most rapidly spreading communication technology in history. What makes this diffusion so remarkable is that its adoption and use demands considerable expense and skill. While several decades old, in the early 1990's a large number of organizations and individuals became users. A TIME/CNN poll in April, 1999 surveyed USA teenagers (age 13 to 17) and found that 82% said they "use the Internet for things like e-mail, chat rooms or visiting websites" (TIME, May 10, 1999; p. 40).

Meanwhile schools have also been linking up to and using the Internet. From the technology coordinators or specialists in our survey conducted in the Spring of 1998, we found that 90% of all U.S. schools have some kind of access to the Internet. What is so remarkable about this statistic is that most schools, which historically change so slowly, have made this connection within just 5 years. In 1992, when the IEA conducted its survey, the word "Internet" had not yet become commonplace. However, the survey did find that nearly one third of the schools claimed to have some access to external networks, such as Compuserve, AOL, or to databases such as Dialog through remote telephone links (Anderson and Magnan,1996). In 1994 the NCES began an annual Fast Response survey of "Advanced Telecommunications" in schools and found that 35% of the schools had some kind of access to the Internet. This number more than doubled by 1997 to 78% (NCES 1998).

Type of Access

The Internet has become an essential tool for many to find, share, or disseminate information and resources, and it is impressive that so many schools have considered it essential to make some kind of connection. Nonetheless, there is great variation in the type and quality of access among schools. At the large bandwidth, or fastest access level, are wideband cable or wire connections at speeds of 1 megabits per second (T1) or greater. We found that 30% of the schools reported having such connections (Table 9). An additional 27% reported having a slower broadband connection such as ISDN service. Thirty-three percent of the schools had no broadband service but did have a modem connection to the Internet. Ten percent had no connection at all. The significance of these different types of connections is that some Web and Internet applications are not feasible at slower access speeds, and many that are feasible at slower speeds waste considerable time of the users as they wait for graphics and other media to download.

TABLE 9: PERCENT WITH EACH TYPE OF INTERNET ACCESS BY SCHOOL LEVEL

	Elementary	Middle	High School	All Schools
T1 or faster	24	35	45	30
Medium speed	26	28	29	27
Modem only	37	31	24	33
No Internet	13	6	2	10

Source: Teaching, Learning, and Computing Survey of K-12 Schools in USA, 1998 http://www.crito.uci.edu/TLC.

High speed (T1 or higher bandwidth) access is considerably more common in high schools than in elementary and middle schools, where 45% rather than 24% of the elementary schools and 35% of the middle schools reported the fastest type of connection (Table 9).

Public schools tend to have more advanced, faster Internet connections than do private schools. While 60% of the public schools had higher speed (broadband) connections, only 47% of the private schools had this service. In addition, 30% of the public schools had only modem connections to the Internet, while 46% of private schools depended upon modems alone for access. The advantage that public schools have in Internet bandwidth may be a consequence of numerous programs like Net-Day that help schools get connected to the Internet.

Internet Penetration

The extent to which the Internet has penetrated the schools and classrooms can be evaluated by the percent of instructional rooms that have Internet connections. An even better indicator can be derived from the percent of instructional rooms that have a broadband connection to the Internet. To measure this we first got an estimate of the number of instructional rooms, which includes labs and media centers as well as classrooms. Then we asked how many of these rooms had a connection to the Internet through a LAN (local area network). The average of that percentage is given in Table 10. An average of 18% of instructional rooms were reported to have a connection to the Internet through a LAN. This percent was essentially the same for all three school levels. While this may not seem like a large share of the rooms, it is a surprisingly large number given that such connections require not only expensive technology and expertise, but many labs and classrooms require extensive remodeling including new conduits and new wiring.

Another important indicator of the quality and amount of Internet access is the average number of computers that have simultaneous Internet connectivity or access. Overall, the average share of computers that could connect with the Internet at the same time was 26% (Table 10). In high schools 37% of the computers on the average could have simultaneous Internet access, while in elementary and middle schools it was 21% and 33% respectively.

TABLE 10: INTERNET PENETRATION INDICATORS BY SCHOOL LEVEL

	Elementary	Middle	High School	All Schools
Percent of Instructional Rooms with LAN Internet Connection	18	18	21	18
Percent of Computers with Simultaneous Access to the Internet	21	33	37	26
Percent of Schools with Web or E-mail Server	37	50	59	43

Source: Teaching, Learning, and Computing Survey of K-12 Schools in USA, 1998 http://www.crito.uci.edu/TLC.

A third indicator of Internet penetration or presence is whether or not schools have either a Web or an E-mail server, a computer that is set up to manage electronic mail or dispatch Web pages. Our technology survey found that 43% of the schools had such a server or servers, although some of these servers may have been limited to administration rather than instructional tasks. High schools were much more likely to have such servers (59%), but 50% of the middle schools had this technology as did 37% of the elementary schools.

DISTRIBUTIONS AND DISPARITIES

Previous sections supplied the statistics to allow comparisons of various technology presence indicators across the three school levels, and this section discusses the differences of these indicators across a number of background categories. Most of these categories are based upon school demographics, making it possible to assess the extent to which there may be disparities among various social categories or groupings.

The background categories are defined in Table 11, which also gives the number (and percents) of schools in our U.S. sample for each category. These statistics are weighted to adjust for the sampling design. In addition, those schools without complete data on both school enrollment and total number of instructional computers are excluded. Due to non-response to certain questions, the actual counts for these background tables varies from indicator to indicator. The counts and percentages apply to the student-computer ratio, but these counts vary slightly for other indicators. A separate chart for each of the eleven indicators is given in the appendix, where each indicator is broken down by all eight background factors. Table 12 summaries these comparisons by a matrix crossing each indicator with each background variable. A "+" indicates a small but significant gap or difference between two or more categories for each background variable. A "++" marks a larger and more significant gap or difference between categories. The determination of a small or large difference was based upon a combination of statistical inference and substantive significance. A small and a large gap correspond roughly to a probability of the difference occurring by chance of .05 or .01 respectively. The charts in the appendix contain error bars making it possible to visualize which categories have small or large gaps between them. The gaps are discussed for each background variable below.

TABLE 11: NUMBER OF SAMPLED SCHOOLS BY BACKGROUND CATEGORIES*

	Categories	Count	Percent of Schools
School Level			
	elementary	286	62
	middle	88	19
	high school	85	19
Public or Private			
	public	367	80
	private	92	20
Size of Enrollment			
	small	107	23
	medium	253	55
	large	100	22
Percent Minority Enrollment			
	0 to 1%	120	28
	2 to 8%	94	22
	9 to 38%	107	25
	39 to 100%	115	25
Percent Eligible for Chapter 1			
	0 to 10%	92	25
	11 to 22%	95	26
	23 to 40%	91	25
	41 to 100%	90	24
Income (Average in Zip Code)			
	low SES	47	11
	average SES	195	47
	high SES	177	42
Metropolitan Status			
	city	125	28
	suburb	138	32
	town	64	15
	rural	109	25
Region			
	east	82	18
	south	139	30
	midwest	159	33
	west	88	19
All Schools		459	100

Source: Teaching, Learning, and Computing Survey of K-12 Schools in USA, 1998
http://www.crito.uci.edu/TLC.
*Note: These counts (N=459) include only those schools in the sample with data for enrollment and for total number of computers. There were an additional 13 schools for which we had background information but lacked either estimates of enrollment or the counts of computers.

TABLE 12: SUMMARY OF INDICATOR GAPS AMONG BACKGROUND CATEGORIES*

	School Level	*Public / Private*	*Enroll-ment*	*Percent Minority*	*Chapter 1 Elig.*	*Comm. Income*	*Metro Status*	*Region*
Students per Computer			++	+	+		+	+
Percent Computers with CD-ROM		+		++	++	+		+
Percent Pentium or PowerMac Computers	+			++	++	+		+
Percent with Printer Access	+		+		++	++		+
Percent Computers in Classrooms	++	++	+					
Software Saturation				+	++	++	+	+
Software Diversity	+				++	++		+
Percent of Schools with Broadband Internet Access	++			+	+	++		+
Percent of Simultaneously Internet-connected Computers	++	+		+	++	++	+	+
Percent of Schools with Web or Email Server	+	+	+		++	+	+	+
Technology-Intensive Schools	+		+	+	+	+	+	+

Source: Teaching, Learning, and Computing Survey of K-12 Schools in USA, 1998 http://www.crito.uci.edu/TLC.
+ Small but significant gap or difference among one or more categories.
++ Large gap or difference among one or more categories.

School Level

For sampling purposes the three types or levels of school were defined in this study as follows. 'Elementary schools' were those having a median grade range of 5.5 or below; 'middle schools' had median grade ranges of 5.6 to 9.4; and 'high schools' had median grade ranges of 9.5 or above. This definition made it possible to group schools into fairly homogeneous categories on the basis of grades served, even though there is great diversity in how grades are grouped in the United States.

The predominate pattern in the findings is that the high schools (and sometimes the middle schools as well) demonstrate greater technological presence than do the elementary schools. The important exception is the percentage of computers located in classrooms, which is higher among elementary schools. In general, the gaps in technology by school level seem to be a function largely of differences in school levels in how they are organized and what the nature of their curricula. For instance, the upper grades tend to have more specialized courses, including more business computing and computer science courses, thus they also tend to have greater diversity in software and faster access to the Internet.

Public vs. Private Schools

Surprisingly few differences are evident between public and private schools. Where a gap does exist, the public sector is favored in terms of access to technology, with one exception - the average percent of computers with CD-ROMs. The most salient differences are in Internet presence, where the public schools probably benefit from a number of federal and local programs targeting Internet connectivity.

The comparison of public to all private schools masks a rather large gap between Catholic and other private schools. Many Catholic schools lack any access to the Internet and few have high speed access, whereas just the opposite is true for non-Catholic private schools. In fact, when only non-Catholic private schools are compared to public schools, they tend to rank higher in terms of Internet presence.

Size of Enrollment

High school enrollments tend to be much larger than those of elementary schools, but our size of enrollment categories adjust for that by dividing each school level separately into low, medium, and large size schools. Smaller schools have lower student-computer ratios, larger percents of computers with printer access, are more likely to have an Internet server, and more likely to be technology-intensive. On the other hand, larger schools have more computers in classrooms. The greater concentration in classrooms may be an artifact of there being many more elementary schools than secondary schools in general.

The structural difficulties of large schools in getting technological resources is elaborated by the Education Writers Association (1999) report on urban schools. There is a tendency in large schools to underestimate the amount of resources and support services needed to support the larger numbers of students. In addition, they often have difficulty in acquiring the funding for such resources and services as well. For these, and perhaps other reasons, the larger schools definitely tend to have a technology deficit relative to smaller schools.

Percent Minority Enrollment

A question often asked is whether or not schools with larger numbers of racial minorities have less technology presence than do those with less. The results reveal that schools with higher concentrations of racial minority enrollments do have less technology presence on many indicators of computer and Internet presence. However, the patterns are uneven and the relationships are generally not linear or even monotonic. Overall, the associations are not as nearly as great as are the associations with the income measures described in the next two sections.

One problem with such comparisons nationally is that the percent minority tends to be confounded with other background factors like region or metropolitan status. Thus, differences that appear due to minority concentration may actually result from these other factors.

Student Poverty (Chapter 1 Eligible)

Schools with larger numbers of students living in poverty (or very low income) conditions gain eligibility for special federal Chapter 1 funding. Thus, it is possible to use this eligibility standard as a proxy for the socio-economic status of the school.

With the exception of the percent of computers in the classroom, on every indicator of technology presence there is a disadvantage associated with more student poverty. But on quite a few indicators the gap is rather small and uneven (e.g., students per computer, percent with high-speed access, and percent with an Internet server).

The most significant finding is that the computer density gap has narrowed since 5 to 10 years ago. While computer density has become more equalized across income categories during the past decade, there still are large gaps in both the quality of the computer equipment available and in access to the Internet. Schools have had about two decades to institutionalize their organization and use of instructional computing, yet they have had only a few years to adapt to new multimedia and Internet technology.

Community Income (Zip Code Based)

Using the average household income of the zip code within which the school resides, we obtain a measure of 'community income.' Because some zip codes contain great heterogeneity in income levels, it is not always a valid measure. Nonetheless, the pattern of differences coincides quite closely with the previous measure using percent eligible for Chapter 1 funding.

The largest gaps can be found with Internet access. With regard to Internet access, only 16% of the schools in low income communities have high speed (T1 lines or faster), whereas 37% of the schools in the higher income communities have the T1 plus bandwidth. Thus, the schools in the richest communities are more than twice as likely to have very high lines as those in the poorest communities. A similar disparity is found for the indicator of the percent of the schools' computers with simultaneous Internet access.

For a variety of reasons having to do with tax policies and larger costs of low-income schools, the schools in lower income communities tend to have less funding and other resources to acquire recent technologies. The schools in the poorer communities tend to lack access to recent technologies, not because they want it that way, but because they don't have the means to acquire it.

Metropolitan Status

School communities were classified in terms of city, suburban, town, and rural areas. While a few small gaps were found across these categories, the pattern is not consistent nor strong. Towns and more rural places tend to have an advantage in terms of computer density and percent of computers with simultaneous Internet connections; these differences appear to be a consequence of the smaller schools within these communities.

Region

Regional differences tend to be uneven like those due to metropolitan status. However, there is one consistent pattern and that is that the schools in the South tend to be lower on most indicators of technology presence. On most indicators the schools in the Midwest and West show greater technology presence. Because such gaps are due to a variety of different factors, rather than claim that certain regions are ahead, it is more appropriate to conclude that these data offer more evidence that serious disparities still exist across important social, economic and geographic boundaries.

CONCLUSIONS

Without a doubt the state of computing capacity for instruction in the nation's schools has improved dramatically in the past 6 years. However, these findings also point out some major deficiencies. Most of the computers in schools do not have the capability to run the large variety of multimedia software currently on the shelves in local computer stores. This means that these computers are also severely limited in how they can access graphical information on the Internet. The findings thus do not contradict the conclusion about the state of computer obsolescence in K-12 schools quoted earlier from the President's Panel on Educational Technology.

Many school technology specialists, administrators and teachers have been working very hard to keep their schools current with progress in information technologies, but ways and means need to be found to bring schools up to the norms of computing typical in the home and workplace. It is most impressive that American schools have in the past few years institutionalized a pattern of computer renewal, upgrading their equipment much more frequently and acquiring new technologies soon after they emerge.

The rapid connection of schools to the Internet has also been most impressive. But while nearly all schools have an access point to the Internet, there are many schools where the access is minimal and few of the students in these schools can use the Internet for their school work.

While systematic comparison of technology presence indicators across school demographic categories has demonstrated that computer density gaps have narrowed, the 'digital divide' remains. There are new technologies, especially access and use of the Internet, that have been out of the reach for many types of schools. These data provide evidence that serious disparities still exist across important social, economic and geographic boundaries.

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