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The Mid-Atlantic Equity Center
5454 Wisconsin Avenue, Suite 655
Chevy Chase, MD 20815
phone: 301-657-7741
www.maec.org

Technology in K-12 Public Schools: What Are the Equity Issues?

By Ray Yau

I. Introduction

In recent years, the investment in technology for K-12 public schools in the United States has grown astronomically. In 1998, the level of spending on educational technology at the national level was estimated at over $5 billion (Archer, 1998). This grand shift towards a technology-driven model for education has raised many new questions and concerns for educational equity advocates. These include:

(1) Are traditionally underserved students receiving a fair or adequate share of technological resources in comparison with mainstream populations?

(2) Are the teachers of these students receiving adequate training on the effective uses of educational technology?

(3) Are there specific uses of educational technology which are particularly effective for teaching traditionally underserved populations? If so, are they actually being employed for these students?

(4) Do these students have sufficient access to computers at home to aid their learning?

This article summarizes the current state of research pertaining to the above questions and is intended as a guide for administrative decisions as well as a call for further research and analysis. The current state of knowledge about the distribution and the effectiveness of educational technology is very weak, due to lack of funding for research and poor research techniques, among other factors. The collective data that we have so far does not justify any strong and far-reaching conclusions. The aim, thus, is not to seek such conclusions but to scout out the existing terrain, to inform some of the decisions that educators are currently making, and to see where research has to *go* in order to *acquire* a better understanding of the issues involved. Educators must consider what policies and practices they can adopt in the interim to ensure that students of all races and backgrounds are receiving access to technology in a way that benefits their learning.

To begin, it is important to acknowledge that *access* to technology is considered and measured in a variety of ways. Below are some of the different operative definitions for "technology access" that appear in the existing literature:

(a) The ratio between the number of students at a school and the number of computers owned by the school. (This definition does not distinguish between computers available for actual use and computers wrapped in boxes.)

(b) The ratio between the number of students at a school and the number of computers that are operational in the school's classrooms. (This definition is indifferent as to whether any students are actually assigned to work on computers.)

c) The amount of time that students work on computers in school.

(d) The type and range of computer learning tasks that students are assigned at school.

(e) The availability of a computer for use at home or after regular school hours.

Distinguishing among these definitions is crucial because some are more useful than others in gauging the *effectiveness* of computers as teaching tools, and in determining whether current practices for using computers in the classroom are *equitable* — in that they improve the achievement of minority students as much as they benefit mainstream students.

II. Statistical Overview of Computer and Internet Access

Computer Access

The available statistics show that the number of computers in U.S. public schools has increased at a very steep rate over the past decade or so. According to a report published by the Rand Corporation, the number of computers available per student increased from a ratio of 1:125 in 1983 to a ratio of 1:9 in 1995 (Glennan & Melmed, 1996). A more recent study by Market Data Retrieval (MDR) found that in 1998 the number of computers available per student was 1:6 (Market Data Retrieval, unpublished). Data from the same study indicated that — in the course of a single year — the number of students for every *multimedia* computer (viz: a computer equipped with a CD-ROM and a soundcard) dropped more than a third, from 21 in 1997 to 13 in 1998.

Internet Access

Schools are also being connected to the internet at an ever-increasing rate. The National Center for Educational Statistics (NCES) reported that, as of 1997, 78% of U.S. public schools had Internet access and that 20% of all classrooms had Internet access. Survey data collected by MDR showed that the percentage of schools with Internet access climbed sharply from 54% in 1994 to 90% in 1997.

III. Equity Issues: The Digital Divide

Disparities Between Poor and Wealthy Schools

No shortage of technology resources is apparent at the aggregate level, but the *distribution* of these resources across different populations is a cause for concern. A report by the Educational Testing Service concluded that Title I funds had been effective in keeping the poorest schools on par with other schools technologically at some earlier stage of the technology "boom", but that they were no longer sufficient as of 1997 (Coley et al, 1997). Furthermore, data compiled by NCES in 1997 indicated that the level of Internet access is significantly lower for the poorest schools in comparison with other schools. Specifically, among public schools with 71% or more of its students eligible for the federal lunch program, only 63% had access to the Internet — in contrast to the aggregate figure of 78% for all schools across the United States. The inequalities in technology funding between the poorest schools and other schools most probably indicate unequal computers-per-student ratios between schools with predominantly White populations and schools with predominantly Black and/or Latino populations — since significantly higher percentages of Black families and Latino families live at or below the poverty level as compared with White families.

Disparities Between Mainstream and Traditionally Disadvantaged Racial/Ethnic Groups

The above statistics are based on a notion of "access" defined by a ratio of the number of students to the number of computers. Where "technology access" is defined by frequency of use of a school computer, s*ome* data shows that traditionally disadvantaged groups such as Blacks and Latinos are *not* lagging behind the "mainstream" population. For instance, among fourth graders who took the 1996 National Assessment of Educational Progress (NAEP) in Mathematics, 41.9% of Black students reported using school computers at least once a week to learn math, as compared with 33% of Asian students, 32.3% of Latino students, and 31.7% of White students. Thus, students of color actually spend *more* time working with school computers than White students who are part of the cultural mainstream (Wenglinsky, 1998). Among *eighth* graders who took the 1996 NAEP: 33% of Black students, 30% of Asian students, 28% of White students, and 26 % of Latino students reported using

school computers at least once a week to learn math (Wenglinsky, 1998). In this case, Latino students were at the bottom of the distribution curve, but, as the numbers show, the differences between groups are relatively small.

However, where "access" is defined according to the types of computer-learning tasks assigned, Black students and Latino students lag significantly behind in access to tasks involving "simulations and applications" -- which exercise higher-order thinking skills and correlate with higher achievement — as opposed to "drill and practice" tasks, which do not correlate with higher achievement. Thus, as explained by one researcher, "[d]isadvantaged groups seem to lag behind in access to those aspects of technology that do affect educational outcomes, but not in access to those aspects of technology that do not affect educational outcomes" (Wenglinsky, 1998). This type of bias has also been reported in a number of other studies over the years (Becker, 1983; Winkler et al., 1984; Sutton, 1991).

Percentage of Fourth Graders Whose Teachers Report Learning Games as the Primary Computer Use, Separated by Race & Ethnicity

Race/Ethnicity	Percentage
Asian	57%
White	57%
Latino	56%
Black	48%
Overall	55%

(Source: Wenglinsky, H. *Does It Compute? The Relationship Between Educational Technology and Student Achievement in Mathematics.* Princeton, N.J.: Educational Testing Service, 1998. Based on 1998 NAEP Achievement Data)

Percentage of Eighth Graders Whose Teachers Report Simulations/Applications as the Primary Computer Use, Separated by Race & Ethnicity

Race/Ethnicity	Percentage
Asian	43%
White	31%
Latino	25%
Black	14%
Overall	27%

(Source: Wenglinsky, H. *Does It Compute? The Relationship Between Educational Technology and Student Achievement in Mathematics.* Princeton, N.J.: Educational Testing Service, 1998. Based on 1998 NAEP Achievement Data)

Percentage of Fourth Graders Whose Teachers Report Drill/Practice as the Primary Computer Use, Disaggregated by Race & Ethnicity

Race/Ethnicity	Percentage
Asian	35%
White	35%
Latino	35%
Black	42%
overall	35%

(Source: Wenglinsky, H. *Does It Compute? The Relationship Between Educational Technology and Student Achievement in Mathematics.* Princeton, N.J.: Educational Testing Service, 1998. Based on 1998 NAEP Achievement Data)

Teacher Training

A possibly related statistic is that teachers of Black and Latino students (who were part of the NAEP data pool) had, on average, slightly less technology training than teachers of White students (Wenglinsky, 1998).

Percentage of Fourth Graders Whose Teachers Report Any Professional Development in Technology Use in the Past Five Years

Race/Ethnicity	Percentage
White	82%
Latino	81%
Asian	80%
Black	78%
Overal	81%

(Source: Wenglinsky, H. *Does It Compute? The Relationship Between Educational Technology and Student Achievement in Mathematics.* Princeton, N.J.: Educational Testing Service, 1998. Based on 1998 NAEP Achievement Data)

Percentage of Eighth Graders Whose Teachers Report Any Professional Development in Technology Use in the Past Five Years

Race/Ethnicity	Percentage
Asian	77%
White	77%
Latino	76%
Black	76%
Overall	76%

(Source: Wenglinsky, H. *Does It Compute? The Relationship Between Educational Technology and Student Achievement in Mathematics.* Princeton, N.J.: Educational Testing Service, 1998. Based on 1998 NAEP Achievement Data)

Computer and Internet Access in the Home

A number of studies have concluded that having access to computers at home correlates positively with student achievement. For instance, the study employing NAEP data found that the eighth graders who use computers frequently at home demonstrated higher levels of academic achievement than those who did not (Wenglinsky, 1998). Another study conducted by the Stanton/Heiskell Center for Public Policy in Telecommunications and Information Systems at the City University of New York produced a similar finding. At the beginning of this research project, which spanned seven years, personal computers and training on their use were given to 125 underachieving minority 6th graders in the New York City Public Schools and their academic achievement was measured across time. Below is a summary of the key research results:

> At the time they received their computers in 1990, all the students were considered at risk of dropping out. By the end of eighth grade, all were still in school, as compared with only 75% of a 125 student control group that did not receive computers.
>
> 46% of the students who received computers finished high school in four years, as compared with the systemwide graduation rate of 41% for minority students.
>
> 40% of the students who received computers in the study are now in college, with more planning to attend next year. (Sandham, 1998)

The current data show that Black and Latino students have significantly less access to computers at home in comparison with White students. Among the fourth graders sampled in the NAEP-based study, 68% of Asian students and 64% of White students had access to computers at home. In contrast, only 45% of Black students and 44% of Latino students had home access. Among the eighth graders sampled, 69% of White students and 68% of Asian students had access to computers at home. For Black students and Latino students, the figures were much lower, 51% and 50%, respectively (Wenglinsky, 1998).

Furthermore, a 1998 report by the National Telecommunications and Information Administration, titled *Falling Through the NET II: New Data on the Digital Divide*, conveyed that the "digital divide" has increased from 1994 to 1997, such that percentages of Blacks and Latinos who own personal computers and have home Internet access are *shrinking* as compared with Whites. The main findings are:

> White households are more than twice as likely (40.8%) to own a computer than Black (19.3%) or Latino (19.4%) households.
>
> Even at income levels greater than $75,000, Whites are more likely to have PCs (76.3%) than are Blacks (64%). The rates for internet access are nearly three times as high for Whites (76.3%) as for Blacks (7.7%) or Latinos (8.7%).
>
> Those groups with the lowest percentages of PC-ownership are: Blacks in rural areas (14.9%), Latinos in central cities (16.2%) and Blacks in central cities (17.1%). Those with the lowest percentages of Internet access are: Black households in rural areas (5.5%) and central cities (5.8%), followed by Latino households in central cities (7.0%) and rural areas (7.3%). (McConnaughey et al., 1998)

A 1997 survey study on the Internet usage had also found similar disparities. According to the published report,

> "A disproportionate number of Black and Latino respondents [in the study] reported not being aware of the Internet (21 percent were Black, and 10 percent were Latino). In addition, this group was more likely to be female (64 percent of our sample were female); older (41 percent were 50 and over); less well-educated, and less well off (58% had a household income below $25,000)" (Katz & Aspden, 1997).

Percent of U.S. Households with a Computer By Race/Origin, 1997

White Not Latino	40.8
Black Not Latino	19.3
Other Not Latino	47.0
Latino	19.4
U.S.	36.6

(Source: National Telecommunications and Information Administration, 1998)

Percent of U.S. Households with a Computer
By Race/Origin, 1997

Race/ Ethnicity	U.S. 1994	U.S. 1997	Rural	Urban	Central City
White Not Latino	27.1	40.8	36.7	42.5	41.5
Black Not Latino	10.3	19.3	14.9	19.9	17.1
Other Not Latino	32.6	47.0	35.8	48.4	43.5
Latino	12.3	19.4	19.2	19.4	16.2

(Source: National Telecommunications and Information Administration, 1998)

Percent of U.S. Households with a Computer
By Race/Origin and Income, 1997

Race/ Ethnicity	Under $15,000	$15,000 - $34,999	$35,000 - $74,999	$75,000+
White Not Latino	15.4	28.0	55.1	76.3
Black Not Latino	6.3	18.2	40.2	64.1
Other Not Latino	19.1	38.5	62.6	81.0
Latino	7.8	16.6	36.8	72.8

(Source: National Telecommunications and Information Administration, 1998)

U.S. Household Computer Penetration Gap
By Race/Origin & Income, 1994 vs. 1997

Income Level	Under $15,000		$15,000 - $34,999		$35,000 - $74,999		$75,000+	
Year	1994	1997	1994	1997	1994	1997	1994	1997
White Not Latino	9.2	15.4	18.1	28	40.5	55.1	61	76.3
Black Not Latino	2.9	6.3	10	18.2	24.8	40.2	52.6	64.1
Latino	3.6	7.8	9.4	16.6	30.6	36.8	60.7	72.8

(Source: National Telecommunications and Information Administration,1998)

Percent of U.S. Households with On-Line Service
By Race/Origin & Area Type, 1997

Race/ Ethnicity	U.S.	Rural	Urban	Central City
White Not Latino	21.2	15.6	23.5	23.3
Black Not Latino	7.7	5.5	7.9	5.8
Other Not Latino	25.2	16.1	26.4	23.5
Latino	8.7	7.3	8.9	7.0

(Source: National Telecommunications and Information Administration, 1998)

IV. Research Limitations

As stated earlier, the current state of research on the availability and effectiveness of educational technology is very weak — particularly as it pertains to equity issues. This is due to a variety of factors, including: (a) lack of funding, (b) inadequate data collection methods, (c) poor research design and/or scope and (d) unfocused research priorities.

Funding for Research on Educational Technology

Compared to the amount of investment in technological resources, the level of funding for research on effective uses of educational technology is virtually non-existent. According to a White House Advisory Panel, the amount of funds spent on researching educational techniques -- which includes research on effective uses of technology in the classroom -- is no more than one-tenth of one percent of the total spending on education (Trotter, 1998). At the current time, the federal government does not collect any data for evaluating the use of technology and for gauging its effectiveness in increasing student achievement (Wenglinsky, 1998). Some data collection for these purposes have been initiated at the state level. However, as of July 1999, only two states -- Idaho and West Virginia — have completed evaluation studies on the effects of technology on learning (Mendels, 1999).

Criticisms of Data Collection Methods

Most of the available statistics on student-to-computer have been compiled from data collected by firms such as Market Data Retrieval (MDR) and Quality Educational Data (QEM), described in one article as "commercial marketing firms that collect information on technology and sell it to technology companies." As a for-profit enterprise, these companies collect data from each school and sell it to technology companies for use in directing their sales efforts. For lack of any other available data, the statistics gathered by MDR and QEM have been used to tally unofficial state-by-state "report cards" on technology access (Trotter, 1997). Unfortunately, this data has a number of flaws and deficiencies, including:

- The "census survey" method employed is prone to undercounting.
- Schools are not under any compulsion to report data to the companies. Consequently, many schools do not reply to the surveys conducted.
- In many cases, the schools do not take the surveys seriously and make little effort to respond to the questions accurately.
- Since the survey instruments are designed mainly for profit-making interests, they do not even attempt to gauge how *effective* the available technology resources are in aiding student achievement and do not collect information on relative effectiveness of different instructional practices using computers -- along with other information of importance to *educators.*

Criticisms of Research Designs and Analyses

Since solid conclusions can be derived only from good data, the general lack of good data, due to factors like the above, limits the depth of findings. In some instances, researchers have also been tempted to interpret more than the data warrants. A good example appears is the ETS study by Harold Wenglinsky, which is cited often in the literature (as well as several times in this article). In reviewing the data from the 1996 NAEP, Wenglinsky found that students who were given "applications and simulations" tasks on the computer achieved better math scores than students who were given only "drill and practice" tasks. In assigning significance to this finding, he effectively implies that "applications and simulations" tasks *cause or produce* the likelihood of improved math achievement. But, in fact, no particular *direction* of causality can be determined from the existing data. Since there were no control measures, the above correlation could just as well indicate that students who perform well in math tend to be given "applications and simulations" tasks — in which case "applications and simulations" do not play any obvious causal role in creating higher achievement.

With respect to smaller-scale research studies designed around model programs, most do not provide practical information that would be helpful to policymakers interested in creating programs based on the models. Elliot Soloway, a computer scientist and educational software developer at the University of Michigan, has expressed: "Researchers typically omit information — such as a project's costs and the level of teacher training — of immense value to anyone who would replicate the project or even compare the results of different studies" (Trotter, 1998).

V. The Need to Advocate for Better Research

Now that we have a broad sketch of the current research on educational technology and its limitations, we can ask: What role can educational equity advocates play within the current scenario to help traditionally disadvantaged groups?

Since the research on the effectiveness of educational technology is severely limited at this point, equity advocates cannot truly make *informed* policy decisions concerning specific practices that will work or not work for traditionally disadvantaged groups. However, we know for certain that they need to advocate better research — specifically, research that is sensitive to the factors which affect the educational opportunities for targeted populations (i.e., Blacks, Latinos and women). As part of that task, they need to assess their priorities and maintain focus on the *important* factors that need to be measured. Instead of focusing on student-to-computer ratios as a measure, for instance, they should be concerned about those factors which are more directly related to student achievement outcomes (such as teacher training).

Below is a sampling of questions they should consider in ordering priorities and assessing the types of research to advocate:

(1) For the sake of improving basic skills (i.e., math & reading) among underachieving minority populations, what can computer technology provide, if anything, above and beyond what teachers can accomplish with the tools they had previously?

(2) Relative to achievement outcomes, what is the cost efficiency of technology investment as opposed to investment in more and/or better trained teachers to educate traditionally underserved student populations? (For example, do projected achievement outcomes based on empirical data warrant the investment of, say, $25,000 in computer equipment and software for an ESL class, as opposed to the hiring of an additional ESL teacher for the same amount? Also, is the investment cost-efficient given that computer equipment becomes obsolete in a short time and requires constant upgrades?)

(3) What are better ways of defining and measuring "technology access" relative to student achievement outcomes?

(4) What are some ways to ensure that superintendents and school principals maintain their focus on achievement outcomes for targeted populations foremost, where the role of technology is placed in a relative context?

(5) Do the answers to the above questions vary when the focus in on long-term effects versus short-term effects?

(6) What measures can be instituted to compensate for unequal access to home computers between the rich and the poor (i.e., access to computer labs after regular school hours)?

(7) In evaluating different computer-based curricula for reading and math, are there special variables to consider for children of color, children of different cultures, and children whose home language is not English?

(8) In using computers for instruction, how can we accommodate and support different learning styles and "multiple intelligences"?

Since the shift towards a computer-based paradigm of teaching is a reality and we have legitimate reasons to believe that newly-developed uses of educational technology and better teacher training *will* increase student achievement to the level where the investment *is* cost-effective, the issue of technology access in schools is not a "red herring" for equity advocates to simply ignore. Nevertheless, the overarching goal should always be improved achievement outcomes. In this respect, poor districts should not compete with rich districts in purchasing technology for its own sake, without assessing the achievement outcomes relative to other investment options (i.e., more teachers, better teacher training) -- precisely because they have fewer money resources available and can less afford to waste them.

VI. What Policies and Practices Should Educators Adopt in the Interim to Support Equity, Given the Limits of Current Research?

Apart from the research question of how technology access, by all its definitions, correlates with student achievement, there is the *practical* question of what educators should do *currently* to provide equal access and benefits for all students. Below are some recommendations which appear often in the literature on the subject:

At the District Level

1. Provide the same equipment and course offerings to schools serving mostly lower-income children as are provided to schools serving mostly higher-income children.

2. Provide the same equipment to schools serving mostly children of color as is provided to schools serving mostly White children.

3. Ensure that students in schools with high numbers of students of color or low-income students have an opportunity to use computers in the same way as students in schools with high numbers of White students or high income students.

4. Ensure that those who screen and purchase software are trained in evaluating bias issues.

5. Seek out instructional software that meets the needs and interests of limited English speaking, ethnic minority, differently-abled and female students, namely -- software that (1) shows both boys and girls from varying ethnic backgrounds in diverse roles, (2) is available in more than one language, (3) allows for different learning styles, (4) accommodates varying ability levels and (5) addresses the needs of differently-abled students.

At the School Level

1. Provide opportunities for all students — including lower-income, lower-achieving and ethnic minority students — to use computers for high-level cognitive tasks (simulations and applications) as well as low-level cognitive tasks (drill and practice).

2. Allow all groups equitable access to the computer facilities before and after school and during other free times.

3. Encourage all groups to use computers before and after school and during other free times.

4. Educate all parents and guardians about the importance of technology skills for their children.

5. Ensure an equitable representation of all groups of students in computer clubs.

6. Require all students to demonstrate proficiency with computers and other technology.

7. Ensure that no particular group of students is allowed to dominate computer use.

8. Provide students with female and diverse racial and cultural role models in technology-based careers.

9. Make efforts to counter negative labels like "computer nerd" or negative attitudes about computers like "it's not cool."

10. Take measures to accommodate students who do not have access to a computer or to the Internet at home.

(Warren-Sams, 1997; Jones et al, 1998)

Given the already wide disparities in achievement between mainstream students and students of color, the issue of equity in technology use needs to be addressed *currently*, as technology is being infused into school curricula, so that the basic *policies* and *structures* governing technology access and use are equitable for all students.

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Additional Resources

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B. Organizations and Projects

Community Technology Centers' Network (CTCNet)

Consisting of over 250 affiliate centers, CTCNet advocates equity in access to technology and promotes non-profit, community-based efforts to provide computer access and learning opportunities to the general public.
contact: Dr. Holly Carter
address: 230 Third Street, 4th Floor, Waltham, MA 02451
phone: 781-684-0380 fax: 781-684-0052
website: www.ctcnet.org

ET^3 Educational Technology Think Thank

A national collaborative of business, civic, and government sector representatives committed to harnessing technology and telecommunications for economic and educational empowerment of traditionally underserved communities.
contact: Dr. Ronnie B. Lowenstein
address: 1800 Old Meadow Road, Suite 1417, McLean, Virginia 22102
phone: 703-448-6022 fax: 703-506-3636
e-mail: RBL50@aol.com
website: www.nettech.org

Helping Educate, Activate, Volunteer and Empower Via the Net (HEAVEN)

A national non-profit dedicated to using technology and new media to benefit society and bridge the digital divide.
contact: Wendy Dubit
phone: 212-873-2043 fax: 212-873-7417
e-mail: WDubit@aol.com
website: www.heavens.org

Northeast Regional Technology in Education Consortium (NetTech)

A partnership funded by the U.S. Department of Education's Office of Educational Research and Improvement to promote the effective use of computer and telecommunications technology in primary and secondary education.
contact: Bonnie Brownstein
phone: 212-541-0972 fax: 212-541-0357
e-mail: blbbh@cunyvm.cuny.edu2

TechForce Initiative

A two-year School-to-Work Office-funded project administered by the Informational Technology Association of America (ITAA), the National Alliance of Business (NAB) and Education Development Center (EDC), whose goal is to highlight and expand IT employer involvement in School-to-Careers (STC) nationwide.
contact: John Donaldson, ITAA
phone: 703-284-5323
website: www.techworkforce.org/programs/stw.htm

C. Website Links on Educational Technology

California Instructional Technology Clearinghouse
description: database of evaluated educational software, with rating criteria
website : http://clearinghouse.k12.ca.us

Closing the Equity Gap in Technology Access and Use: A Practical Guide For K-12 Educators
description: tips on how to ensure equity in educational technology
website : http://www.netc.org/equity/index.html

Internet Connections: Technology in Education
description: assessment instruments for evaluating software and websites
website : http://www.mcrel.org/connect/techined.html

LEARNNET
description: the Federal Communications Commission's informal education page
website : http://www.fcc.gov/learnnet

NETDAY
description: a volunteer program to get all schools across the country wired to the Internet
website : http://www.netday.org

Schools and Libraries Corporation (SLC)
description: questions and answers on the implementation of the Universal Service Program ("e-rate") for schools and libraries
website : http://www.neca.org/funds/slfaq.htm

U.S. Department of Education Technology Initiatives
description: technology projects initiated under the Improving America's Schools Act
website : http://www.ed.gov/Technology