Computers and Test Scores:
Does the "Digital Divide" Really Matter?

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I. Introduction

The use of educational software and Internet resources in public schools has emerged as a popular issue in recent years. Discussion of the role of computers in education occurs at the federal, state, and local levels among administrators, teachers, and parents. As vice president, Al Gore stressed the importance of wiring every classroom in the United States for Internet access, claiming that it was essential to the way children learn (Gore 1998). However, less than three years later, the new Bush administration has shown much less enthusiasm about eliminating the "digital divide" between those who have computers and Internet access and those who do not. The Commerce Department has proposed cutting the Technology Opportunities Program by 65 per cent, and new FCC Chairman Michael Powell has dismissed the idea of a digital divide altogether, comparing it to "A Mercedes divide – I'd like to have one, I can't afford one" (Bridis 2001).

Questioning the importance of the digital divide and, more generally, the effectiveness of using computers as instructional tools has put some educators in a defensive position, prompting one to ask, "Since when are we publicly and across the board assessing the efficiency of any particular current pedagogical approach?" (Tuinman 2000). But such questioning has also led some reporters to conclude that at least one manifestation of the digital divide is the reverse of what most people would expect. Looking at elementary schools nationwide, he reports that low-income students were more likely than their affluent peers to use calculators in their classrooms – and that their test scores on a standardized exam were lower even though calculators could be used to take the test (Golden 2000). Given the range of claims about computers as instructional tools, the related issues of their effectiveness and of the importance of the digital divide remain unsettled.

II. Background

The use of computers as educational tools dates to the early 1960s, when the machines taught students in a fill-in-the-blanks format. Since then, the pedagogical uses have come to encompass drill and practice; tutoring; computer-managed teaching (i.e., the computer is used to evaluate student performance and diagnose weaknesses); simulation; programming in order to solve problems; and, most recently, project-oriented teaching.

Many studies have considered the effectiveness of the computer as an educational tool. The literature includes studies of educational outcomes for individual courses and programs, as well as meta-analyses of those studies. Meta-analyses aggregate the findings in the studies of individual courses, in order to come to more general conclusions about the effectiveness of computer aided instruction (CAI). When examining the effectiveness of CAI, the relevant areas to consider include final examination performance and retention.

Final examination performance

Kulik et al. (1983) analyzed 48 studies of individual CAI programs with results from final examinations, and found that in 39 of the studies students from CAI classes received better scores on final examinations than students from conventional classes. In 23 of the 39 studies favoring CAI classes, the difference in exam performance between CAI and conventional classes was statistically significant. Using an index of Effect Size developed by Glass, McGaw, and Smith in 1981, Kulik et al. determined that the performance of CAI students was raised by .32 standard deviations relative to non-CAI students.

In another meta-analysis restricted to CAI in mathematics instruction, Burns and Bozeman (1981) find that traditional instruction supplemented by CAI is more effective than traditional instruction alone for highly achieving students and for disadvantaged students at both the elementary and secondary levels. They found no significant enhancement among average-level students.

Finally, Lewis et al. (1985) report that seven experiments using CAI in economics instruction all show positive results for the effectiveness of CAI on student achievement. They point out that this is consistent with the broader research done by Kulik et al., as well as with studies by Dean Jamison in 1976 and Denyse Forman in 1982.

In general, research over the past 25 years has usually shown that students in courses using CAI perform at least as well, and frequently better, on final examinations compared to students receiving only traditional instruction. However, these studies have measured performance on tests directly related to the material taught with the aid of computers. They did not test performance on examinations that assess general skills.

Retention

While studies and meta-analyses typically show an increase in student performance on final examinations in CAI classrooms, the impact of computers on retention of learning is less favorable. Kulik et al. (1983) report that, of five studies with follow-up examinations measuring retention over 2 to 6 months, one reports significantly higher exam scores in non-CAI classrooms while four studies report higher, but not statistically significant, scores by students from CAI classes. Similarly, Edwards et al.

(1975) find that there is evidence that CAI students may not retain as much as traditionally taught students. Of the three studies they reviewed that measured retention, one showed no difference between the two groups of students, and 2 showed greater retention by traditionally educated students.

III. Data Set

The data for this study are taken from the 1999 Report Card on the Schools published by the *Philadelphia Inquirer*, and from a separate report on suburban crime also by the *Inquirer*. Information was available for junior and senior high schools in 52 school districts from five counties (Bucks, Chester, Delaware, Montgomery, and Philadelphia) in the Philadelphia area.

Scores on Pennsylvania System of School Assessment (PSSA) tests from 1998 provided a measure of educational outcome. The PSSA tests reading and math skills at the fifth, eighth, and 11th grade levels. It was chosen for use in this study instead of other standardized tests, such as the Scholastic Aptitude Test, because participation by Pennsylvania public school districts is mandatory. With mandatory testing, students who do not expect to do well on the tests cannot opt not to take the tests. PSSA scores are scaled scores, and fall within a range of 1000 to 1600. For each school, the average score on the reading and math tests was reported.

Three important aspects of using computers as educational tools are the quality and availability of computers, and teachers' ability to use the technology effectively in the classroom. Because the 1999 Report Card focused on technology in education, it provided a way to measure each of the three aspects. Computer quality is reflected by the percentage of each school district's computers that are either Pentiums or PowerMacs.

There were two possible measures of computer availability: the number of students per computer, and the percentage of classrooms with computers. As the Report Card noted, some schools had low percentages because they chose to put their computers in labs rather than in the classrooms. As a result, the number of students per computer was used in this study, because it was a more accurate description of computer availability. Finally, teacher preparation was measured by the percentage of teachers who were trained to use the Internet or specialized software as part of the curriculum.

In addition to the use of technology in education, other economic and demographic factors also influence educational outcomes. This study includes data on instructional spending per pupil, the percentage of low-income students, the percentage of white students, and the crime rate in each school district. For regional school districts, the crime rate used is a composite of the crime rates of the municipalities the district serves.

IV. Analysis and Results

During the course of this study, two sets of models were constructed. In the first set, the models were multiple regressions of instructional spending (SPEND), the percentage of low-income eighth grade (LOWINC8) or 11th grade (LOWINC11) students, the percentage of Pentiums or PowerMacs (PENTIUM), the number of students per computer (SPERC), and the percentage of trained teachers (TEACH) on each of the districts' PSSA scores (math and reading in eighth and 11th grade). Computer availability and quality and teacher training were not significant variables in any of the multiple regressions. Per-pupil instructional spending and the percentage of low income students were significant for each of the PSSA tests.

Table 1

Eighth grade reading:

$$\mathbf{PSSAR8} = 1437.169 - \underset{(-9.34)\ ^{*}}{4.189\ \mathbf{LOWINC8}} + \underset{(0.24)}{0.116\ \mathbf{RESID}} + \underset{(0.99)}{0.006\ \mathbf{SPEND}} - \underset{(-1.71)\ ^{***}}{0.536\ \mathbf{PENTIUM}}$$

$$+ \underset{(0.85)}{2.091\ \mathbf{SPERC}} - \underset{(-1.14)}{0.299\ \mathbf{TEACH}}$$

$R^2 = 0.67$

11th grade reading:

$$\mathbf{PSSA11} = 1339.233 - \underset{(-6.13)\ ^{*}}{3.595\ \mathbf{LOWINC11}} - \underset{(-0.01)}{0.006\ \mathbf{RESID1}} + \underset{(1.06)}{0.008\ \mathbf{SPEND}} - \underset{(-0.81)}{0.307\ \mathbf{PENTIUM}}$$

$$- \underset{(-0.13)}{0.390\ \mathbf{SPERC}} + \underset{(0.52)}{0.161\ \mathbf{TEACH}}$$

$R^2 = 0.47$

Eighth grade math:

$$\mathbf{PSSAM8} = 1368.045 - \underset{(-8.00)\ ^{*}}{4.096\ \mathbf{LOWINC8}} - \underset{(-1.32)}{0.717\ \mathbf{RESID}} + \underset{(2.40)\ ^{**}}{0.018\ \mathbf{SPEND}} - \underset{(-1.57)}{0.562\ \mathbf{PENTIUM}}$$

$$+ \underset{(0.85)}{2.377\ \mathbf{SPERC}} - \underset{(-0.76)}{0.228\ \mathbf{TEACH}}$$

$R^2 = 0.64$

11th grade math:

$$\mathbf{PSSAM11} = 1260.533 - \underset{(-6.44)\ ^{*}}{4.914\ \mathbf{LOWINC11}} - \underset{(-0.85)}{0.607\ \mathbf{RESID1}} + \underset{(2.60)\ ^{*}}{0.025\ \mathbf{SPEND}} - \underset{(-0.82)}{0.403\ \mathbf{PENTIUM}}$$

$$+ \underset{(1.04)}{4.021\ \mathbf{SPERC}} + \underset{(0.11)}{0.044\ \mathbf{TEACH}}$$

$R^2 = 0.52$

* = significant at the 0.01 level ** = significant at the 0.05 level *** = significant at the 0.1 level

But Paraan (2000) found that the crime rate negatively influenced student performance on the SAT and the New Jersey High School Proficiency Test. With Paraan's results in mind, a second set of models was constructed using the two-stage least squares method. Because there was a high correlation between the crime rate and the percentage of low income eighth and 11th grade students, LOWINC8 and LOWINC11 were each regressed separately on the crime rate. The residuals for each regression (RESID for eighth grade and RESID1 for 11th grade) were then used along with SPEND, PENTIUM, SPERC, TEACH, and LOWINC8 or LOWINC11 in regressions on each of the four test scores. Regression estimates and t-statistics for the second set of models are shown in Table 1.

In this set of models, the percentage of low-income students is significant for all PSSA tests. Instructional spending is still significant for the middle and high school math tests, but it is not significant for the reading tests. The number of students per computer and the percentage of teachers trained to incorporate computers into their curricula remained insignificant.

The estimates for the percentage of Pentiums or PowerMacs (summarized in Table 2) are the most interesting result of the models that account for the crime rate. While insignificant at the 11th grade level, computer quality appears to be more important for the middle schools. The PENTIUM variable was significant at the 0.1 level for the eighth grade reading PSSA, and almost significant at the 0.1 level for the math test. Because the percentage of PowerMacs and Pentiums was measured for each district rather than for each school, the significance of the PENTIUM variable in middle schools but not in high school could indicate that middle schools are receiving more of a district's new computers than high schools are. However, the PENTIUM variable also had an unexpected negative coefficient, indicating that PSSA test scores fall as computer quality rises.

Table 2

Coefficients and significance of PENTIUM variable		
	PSSA reading	PSSA math
Grade 8	-0.536 significant at 0.1 level	-0.562 almost significant at 0.1 level
Grade 11	-0.390 not significant	-0.403 not significant

V. Conclusion

Spending on technology, as measured by increased quality and quantity of computers and by special teacher training, does not translate into higher scores on the PSSA, a general test of math and reading skills. In most cases the inclusion of computers into junior and senior high school curricula had no significant effect on PSSA test scores. In the single model that did show an effect on test scores due to computer quality, that effect was negative rather than positive. Factors such as per-pupil spending and income level continue to explain much of the variation in test scores among school districts. Together, these results indicate that a transfer of funds from computer-related to other areas of a district's educational budget may be appropriate.

While earlier studies have shown improvement of test scores in individual subject areas when computers are used to teach those subjects, this study does not find similar results for scores on tests of general skills. This might reflect earlier findings about reduced retention rates in classrooms that emphasize computer use. It may also be the case that students demonstrate increased learning that is subject- or assignment-specific, but that the knowledge and skills they acquire are not retained and transformed into the sort of general skills that tests like the PSSA assess. In terms of test scores, the "digital divide" does not appear to be detrimental to student achievement.

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