

THE DIGITAL HORSERACE:
AN ANALYSIS OF DIFFERENCES IN STUDENT COMPUTER USE
ACROSS THE STATES AND ACROSS THE YEARS

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Introduction

Given the billions of dollars of federal and state funds that have been earmarked for educational technology expenditures over the last decade or so, it makes sense that there have been numerous attempts to document computer access and computer use in schools. Access has been explored a number of different ways, though it is mostly “measured” by installed base statistics such as student:computer ratios. Computer use in schools has been examined mainly from two perspectives: types of use and frequency of use.

This article adds to the body of literature on the latter category, the frequency of computer use in schools. To this point, there has been no systematic and integrated analysis of student computer use across the states and across the years. Most of the empirical work in the area has been cross-sectional and/or has used the student as the unit of analysis. Thus, the purpose of this study is to analyze state-level data on student computer use across multiple time periods. The goal is to investigate trends and to consider implications of and for past and future state-level education technology policy. Accordingly, the review of the literature includes two sections. The first section is a survey of the empirically-based literature on the frequency of student computer use in schools, organized chronologically. The second section considers states as units of analysis in educational technology studies.

Review of the Literature

Frequency of Student Computer Use in Schools

Though the language changes over time, data on computer use in schools date back over two decades. The data used for the analyses reported from this study date back to 1996, so that is where this chronological review of the data begins.

As part of a validity study of the National Assessment of Educational Progress, Hedges, Konstantopolous and Thoreson (2000) examined patterns of teacher and student-reported computer use in schools. The data were from students in grades 4, 8 and 12. According to the 4th grade data from the 1996 main NAEP in mathematics (see Table 1), over 56% of students reported never or hardly ever using a computer in mathematics class. Over 13% of 4th grade students reported using computers for math every day.

According to data from the 1998 main NAEP assessment in reading and writing (see Table 2), 58.5 percent of 4th grade teachers reported never or hardly ever using computer software for reading instruction. That estimate is considerably higher than the 78.5% of 8th grade teachers who reported never or hardly ever using computer software for reading instruction. In that same year, only 28.2% of 4th grade students reported never or hardly ever using a computer for writing drafts or final versions of stories or reports. There was not much difference in frequency of such computer use amongst 8th or 12th graders.

Table 1. Student Reported School Computer Use for Mathematics in 1996

	Student Reported School Computer Use in Mathematics Class				
	Mean Mathematics Achievement	Never or Hardly Ever	Once or Twice a Month	Once or Twice a Week	Every Day
U.S. Population					
Grade 4	224	56.3	10.5	19.6	13.6
Grade 8	272	56.5	15.2	15.6	12.7
Grade 12	304	58.3	15.4	12.5	13.9

Source:

Table 2. Teacher Reported Computer Software Use for Reading and Writing Instruction in 1998

	Teacher Reported Computer Software Use for Reading Instruction				
	Mean Reading Achievement	Never or Hardly Ever	Once or Twice a Month	Once or Twice a Week	Every Day
U.S. Population					
Grade 4	217	58.5	17.4	15.8	8.3
Grade 8	264	78.5	14.3	4.5	2.8

	Student Reported Computer Use for Writing Drafts or Final Versions of Stories or Reports				
	Mean Writing Achievement	Never or Hardly Ever	Once or Twice a Month	Once or Twice a Week	Everyday
U.S. Population					
Grade 4	150	28.2	35.3	23.6	12.9
Grade 8	150	25.6	39.0	23.6	11.8
Grade 12	150	22.6	42.1	23.5	11.8

Source: Hedges, Konstantopolous and Thoreson (2000)

The Teaching, Learning and Computing (TLC) survey of over 4,000 teachers nationwide was conducted in 1998. The data from that survey showed that 43% of elementary (self-contained) teachers reported “that a typical student in one of their classes used computers on more than 20 occasions during class over roughly a 30-week period” (Becker, 2000). The other 57% of teachers reported less frequent student use of computers. Becker (2000) writes that

frequency of computer use at the secondary school level is subject-specific and largely dependent on the availability of computers. However, at the elementary level, computer use is generally more consistent. “The obvious explanation is that elementary teachers have their students for most of a school day rather than 50 minutes at a time. Thus, they have a greater opportunity to provide frequent computer experiences for each student” (Becker, 2000).

Using data from the Early Childhood Longitudinal Study, Kindergarten Class 1998-99 (ECLS-K), Judge, Puckett and Cabuk (2004) examine computer use among kindergarten and first grade students in 1998 and 1999. From a subsample of 9,840 students in 669 public schools across the country, they document that over 2/3 of students in high poverty schools reported weekly use of instructional software for reading, writing and/or spelling. In low poverty schools, the percentages for that sort of use were 64.1 in kindergarten and 61.2 for low poverty first grade students. Figure 3 shows the data across different subject areas.

Norris et al. (2003) surveyed 3,665 teachers in geographically diverse areas within four states in late 2000 and early 2001. The researchers did not disaggregate by grade level, but they do tell a general story of computer use in schools. Across their sample of K-12 teachers, “fully 14%...make no use whatsoever of computers for instructional purposes, and nearly half (45%) use it with their students less than 15 minutes per week—*equivalent to just 3 minutes per day!*” (pp. 17-18). On the other end of the use spectrum, 18% of respondents report at least 45 minutes of computer use per week. Internet use,

according to Norris et al. (2003), is even less frequent. Over ¼ of all respondents report never using the Internet, and 2/3 of the respondents have students use Internet technologies less than 15 minutes per week.

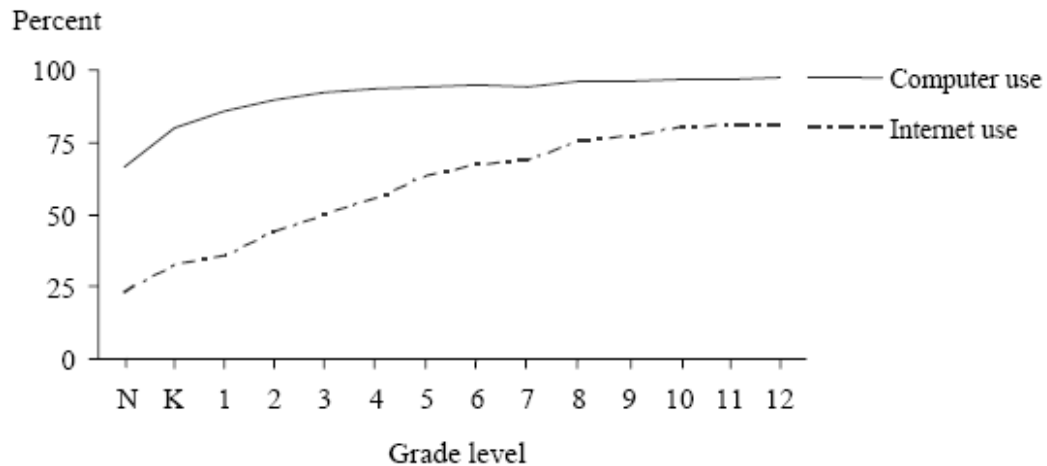
Table 3. Percent of kindergartners and first grade children that used computers in their classrooms on a weekly basis for various instructional purposes

	Kindergarten		First Grade	
	<i>High Poverty</i>	<i>Low Poverty</i>	<i>High Poverty</i>	<i>Low Poverty</i>
Instructional Software	%	%	%	%
Read/write/spell	67.2	64.1	67.2	61.2
Math	62.9	60.6	57.4	53.7
Social studies	17.4	16.5	14.5	13.2
Science concepts	19.2	18.9	14.7	13.3
Keyboard skills	42.3	35.1	40.4	32.7
Create art	34.6	34.3	27.8	24.1
Games	59.8	60.1	50.8	51.4

SOURCE: Judge, Puckett and Cabuk (2004)

The United States Census Bureau conducted the Current Population Survey (CPS) in 2003. According to that survey, 85% of all students in grades one through five reported using a computer in school. Sixty-seven percent of kindergartners reported using a computer in school. Those percentages vary according to student characteristics. Somewhat surprisingly, of all groups of students, private school students were the least likely (71%) to report using computers at school. Figure one shows how computer and Internet use in schools varied by grade level in 2003.

Figure 1. Percentage of children in nursery school and students in grades K-12 using computer or the Internet by grade level: 2003



NOTE: "N" is nursery school. "K" is kindergarten. Population is limited to age 3 and older.
SOURCE: U.S. Census Bureau, Current Population Survey (CPS), October 2003.

The multiple cross-sectional looks at computer use in schools over the last decade or so are each useful. From those analyses, we learned that, among other things, computer use is generally higher in the elementary grades and that the so-called digital divide does not necessarily exist with respect to computer use in schools. Those consistent findings are informative. However, largely due to the differences in wording of survey items, it is very difficult to get a complete longitudinal understand of the frequency of computer use in schools across the years. Furthermore, there has been no consistent surveying of any one grade level or even any one configuration of grade levels, making comparisons over time even more complicated. The study reported herein is not a true longitudinal analysis, but it does utilize data from a single grade level (4th grade) and from the same questions asked of teachers and students over multiple time periods.

Education Technology as a Domain of State-Level Educational Policy

This study uses states as the unit of analysis. Prior to the last decade or so, education technology policy, like most other aspects of education, was very much a local matter. Any district or school or even classroom teacher that implemented or used educational technology did so as part of a local initiative or an individual commitment. While state education agencies began to explore the use of computers in the teaching and learning process as early as the late 1970s and early 1980s, states did not formally develop or adopt statewide master technology plans until the 1990s.

States and Education Technology: Early Days

The formal relationship between state education agencies and educational technology can be traced back to the late 1960's, but the strength of the association did not reach significance until the last 10 years. The earliest documented involvement of states with learning technology dates back to 1966 (Southeastern Regional Council for Educational Improvement [SERCI], 1983). In that year, Delaware, recognized as one of the pioneering states with respect to educational technology, used Title III funds to back an "Educational Technology" project. In 1971, the state established the "Data Information Center for Education," a consortium of school districts. During that time, the state of North Dakota began studying the potential values of instructional technology (SERCI, 1983).

In 1977, legislation in Alaska supported a multi-year project called “Educational Telecommunications for Alaska” (ETA). ETA covered a broad range of educational technologies in Alaska, including a satellite-fed television network, microcomputer-based methods of instruction, and electronic mail. That same year, Florida established the Florida Educational Computing Project (FECF) “to provide technical services in the administration and technical use of computers” (SERCI, 1983, p. 1).

In 1981 and again in 1983, *Electronic Learning* magazine conducted the first ever surveys of state-level initiatives on educational technology. Also in 1983, the Southeastern Regional Council for Educational Improvement (SERCI) conducted a nearly identical survey across the states to “gather information concerning state policies relating to the use of technology in public education” (foreword). Both the *Electronic Learning* and SERCI surveys revealed increased activity on the part of states in the promotion of instructional computing between 1981 and 1983. However, the major conclusion to be drawn from the surveys is that with only a few exceptions, as of 1983, state education agencies had primarily assumed the role of facilitator rather than initiator. That is, in the arena of educational technology policy circa 1983, state education agencies were following their then traditional pattern of providing technical assistance, curriculum development, and other guidance. All other computer-related instructional activities were locally generated matters (SERCI, 1983).

The Centralization of Education Technology Policy: The Technology Literacy Challenge

The impetus for full-scale, state-level educational technology planning and activity was the federal government's arrival into the arena of education technology policy. On February 15, 1996, President Clinton and Vice President Gore announced the Technology Literacy Challenge. This first national technology plan¹ focused private, federal, state, and local attention on educational technology. At the core of the Technology Literacy Challenge were four concrete goals, or as they were called, the four pillars: (1) All teachers in the nation will have the training and support they need to help students learn using computers and the information superhighway; (2) All teachers and students will have modern multimedia computers in the classroom; (3) Every classroom will be connected to the information superhighway; and (4) Effective software and on-line learning resources will be an integral part of every school's curriculum. (U.S. Department of Education, 1999).

Since 1997, the federal government implemented a number of programs to help further the goals of the first national educational technology plan. In fiscal year 2002, in conjunction with the then newly passed No Child Left Behind Act, the total funding earmarked for educational technology increased slightly. However, more importantly, a few individual programs were completely eliminated, and three major technology programs were combined into a single block grant to the states. That change signaled an end to a large competitive

¹ The full name of the national educational technology plan was, *Getting America's Students Ready for the 21st Century: Meeting the Technology Literacy Challenge*.

grant program and a greater commitment to the states in the form of a block grant. In other words, the federal government turned more to the states to be the levers for educational technology policy.

The Contemporary State of the States

To provide insight into the education technology policies of the 50 states, the Milken Exchange on Educational Technology (MEET) conducted a state-by-state education technology policy survey in the summer of 1998. By surveying and interviewing the state education technology director² (or their designated representative) in each of the 50 states, MEET produced a profile of in-depth information on state legislation and projects, funding, standards, support structures, etc. all around the issue of learning technology. The survey consisted of a 75-minute telephone interview and a nine-page questionnaire.

The survey data ranged from rich descriptions of education technology-related state legislation to finely grained funding data. Similarly, the data painted a picture of great range. With respect to funding, from 1995 to 1999, the states earmarked a five-year total of nearly \$4 billion for K-12 education technology, and, on average, state appropriations for education technology increased each year since 1995. However, no state was spending more than 1.9% of its total education budget on education technology. In terms of credentialing, 22 states had established or were in the process of establishing technology-related requirements for pre-service teachers. Conversely, as of 1998, 22 states did not

² According to Lemke & Shaw (1999), “[t]he state technology director is an individual who has been identified by the state superintendent of education as the chief manager of state education technology programs in the public schools.”

require any educators to meet any technology-related requirements to receive or obtain their credentials. Finally, as of the summer of 1998, almost all of the states (90%) had officially adopted a state technology master plan. Federal and state legislation were most frequently cited as providing the impetus for developing state technology plans. Moreover, of the 44 states that had state-funded technology initiatives for school districts, 34 (68%) required districts to submit technology plans for state approval for the districts to participate in state-funded educational technology initiatives (Lemke & Shaw, 1999).

Zhao and Conway (2001) found a few commonalities in their examination of those state technology plans. First, state technology plans seemed to favor “new” technologies over “old” technologies. Furthermore, the portrayal of the inevitability of change as a result of technology adoption was a pervasive theme throughout technology plans. Second, the plans more often than not focused on technology’s capacity to improve student test scores, paying little attention to important epistemological assumptions about student learning. Third, the technology plans acknowledged the importance of teachers in technology adoption, but do not go as far as to identify ways in which teachers can be resourceful, knowledgeable, and purposeful designers of educational technology. Fourth, the plans privilege the goal of economic progress or social efficiency over democratic equality (Zhao & Conway, 2001).

Those commonalities notwithstanding, and while most states have recently developed and implemented statewide master technology plans which increasingly include focused statewide technology initiatives, states still differ

greatly in the extent to which they invest in learning technology as a key policy lever. As detailed above, and as documented annually in the *Education Week* special report “Technology Counts”, state departments of education have differentially approached technology funding, professional development, and infrastructure development. In every category of possible investment in learning technology, there are still substantial differences in the policies employed by states.

Study Methods

Clearly, then, there are differences in educational technology policy across states. However, there is little evidence of whether or not there are differences in educational technology practices across states. To address that knowledge gap, it is necessary to have comparable data across states. Fortunately, the state National Assessment of Educational Progress (NAEP) has included several questionnaire items on computer use. Like the national assessment, state NAEP generates results about subject-matter achievement across the states. In addition to the cognitive items, background questionnaires are administered within the sampled schools to assess instructional experiences and school environment factors.

The state NAEP has been administered in grades four, eight and twelve in various subject matters since 1990. The first three such assessments (1990, 1992 and 1994) were considered trial assessments and evaluated thoroughly. The 1996 assessment was the first state NAEP not considered a trial. When the

“No Child Left Behind” legislation reauthorized the Elementary and Secondary Education Act in 2001, states that received Title I funding were required to participate in state NAEP in reading and mathematics in grades 4 and 8 every two years. Table four lists the state NAEP years and subjects that were administered to samples of 4th grade students since 1990.

Since the Trial State Assessment (TSA) in 1994, the state NAEP has generated useful data on computer use by students in schools. The number of computer-related background questions in each assessment year and for each assessment subject varies from year to year, and from grade to grade. Furthermore, the background questions included in each of those assessments have changed over time, though some are repeated across assessments.

Table 4. State NAEP by year and subject

YEAR	SUBJECT TESTED	NUMBER OF STATES PARTICIPATING
1990 (trial)	Math	40/58
1992 (trial)	Reading, Math	44/58
1994 (trial)	Reading	44/58
1996	Math	48/58
1998	Reading	45/58
2000	Math, Science	47/58
2002	Reading, Writing	51/58
2003	Reading, Math	53/53
2005	Reading, Math, Science	52/52
2007	Reading, Math, Writing ³	52/52

For this analysis, the focus was on computer use in 4th grade only. It can be stated with relative certainty that all of the 4th grade students in the NAEP database are in an elementary school setting. The 8th and 12th grade students

³ Eighth grade only

could be served in a school with a number of different configurations, conditions and practices. Additionally, it is often the case that secondary school students are educated in departmentalized schools which would raise a number of confounds for this research including making the subject matter more relevant. Finally, past research indicates that teacher-directed student use of computers is highest in the elementary setting. Thus, the focus for this research is the 4th grade students.

The NAEP Data Explorer (NDE) is an online⁴ data analysis system that provides Tables of detailed results from NAEP's national and state assessments. Every cognitive item and background question is included in the NAEP data tool. For this study, multiple keyword searches of the NDE across all administrations of the national and state NAEP included the word "computer" or "computers" in the stem. Hundreds of items were located. Those were narrowed down to only those items administered to the 4th grade samples in state NAEP assessments since 1996⁵. The questions listed in Table five became the items for analysis in this study.

⁴ The NAEP Data Explorer can be found at: <http://nces.ed.gov/nationsreportcard/nde/>

⁵ Questionnaire items from the trial state assessments were not included in this analysis. Also, starting with the 2005 administration, a considerable number of very specific computer-related questions were added to the student and teacher background questionnaires. Since the purpose of this analysis is to not only compare results across states, but also over time, those items are not included in this analysis.

Table 5. State NAEP items included in the analyses

YEAR	SUBJECT TESTED	QUESTION
GENERAL COMPUTER USE		
1996	MATH	How often do the students in this class do each of the following? Use a computer (teacher-reported)
1998	READING	How often do you use a computer for schoolwork? (student-reported)
2003	MATH	For this school year, how often do you use a computer? (student-reported)
COMPUTER USE FOR MATH		
1996, 2000,	MATH	How often do you use a computer for math? (student-reported)
2005, 2007	MATH	When you do mathematics in school, how often do you use a computer? (student-reported)
COMPUTER USE FOR READING		
1998	READING	How often do you use the following resources to teach reading in this class? Computer software for reading instruction (teacher-reported)
1998	READING	How often do you ask students in this class to do the following on a computer? Read stories or do work related to reading instruction (teacher-reported)
1998	READING	How often do you ask students in this class to do the following on a computer? Do spelling, punctuation, or grammar exercises (teacher-reported)
COMPUTER USE FOR WRITING		
2002	WRITING	Evidence of computer use for writing (based on student responses to two background questions ⁶) (student-reported)
2005	READING	Use computer for word processing [T088705]

The NDE can be used to run descriptive and inferential statistics on NAEP data, including numerous statistical tests of difference on any of the instructional experience or school environment factor items. Those tests of difference can be run across years or, for example, within years and between demographic subgroups or any number of participating jurisdictions. However, where

⁶ The two questions are: (1) How often do you use a computer from the beginning to write the story or report (for example, use a computer to write the first draft)?, and (2) How often do you use a computer to make changes to the story or report (for example, spell-check, cut and paste)? (student-reported)

questionnaire items have categorical response sets, the NAEP data tool only allows tests of difference within each category (though still between subgroups or jurisdictions, for example).

For all items (with the exception of the item from the 2002 writing assessment) listed in Table five, the categorical response set included: “almost every day”, “1-2 times per week”, “1-2 times per month”, and “never or hardly ever.” Thus, for the sake of painting a picture of the differences that exist in student computer use between the states, the results for the highest (“almost every day”) and lowest (“never or hardly ever”) of the ordered response categories are presented below. In all cases, for the listed states, the difference between the estimate for the state and the national (public schools only) estimate is statistically significant ($p < .05$). In other words, the students in the states listed on the left side of the Tables reported greater computer use than students in the national sample, i.e. the students in those states were statistically more likely than students in the national sample to report using computers “almost every day” or “a lot.” The students in states listed on the right side of the Tables reported less frequent computer use than students in the national sample ; i.e. the students in those states were statistically more likely than students in the national sample to report using computers “never or hardly ever.”

In addition to the data Tables, for the most recent data in each subsection below, a Scalable Vector Graphic (SVG) generated by the NDE graphically depicts the differences across states on the highest (“almost every day” or “a lot”) response category.

Findings

Computer Use in general

On the 1996 state math NAEP, the teachers of the 4th grade students in the sample were asked how often the students use computers. In the national sample, teachers of 14% of the students reported student computer use almost every day, while teachers of 21% of the students reported students never or hardly ever using computers. The most striking finding from Table 7 is the frequency of computer use for 4th grade students in West Virginia. Over half of the teachers of the students in the sample reported students using computers almost every day. The next closest states are Florida and Georgia at 32%. On the opposite end of the spectrum from West Virginia is New Jersey where 40% of the teachers reported students never or hardly ever using computers.

Table 7. How often do the students in this class do each of the following? Use a computer (teacher-reported) (1996)

ALMOST EVERY DAY			NEVER OR HARDLY EVER		
Jurisdiction	Row %	(S.E.)	Jurisdiction	Row %	(S.E.)
West Virginia	51%	(3.8)			
Florida	32%	(3.0)			
Georgia	32%	(3.9)			
South Carolina	26%	(3.4)			
Tennessee	25%	(3.1)			
Alabama	22%	(2.8)			
National Public	14%	(1.8)	National Public	21%	(2.4)
			Hawaii	35%	(2.8)
			Delaware	39%	(1.2)
			New Jersey	40%	(4.4)

In 2003, for the mathematics state NAEP, the general computer use question was switched from the teacher background questionnaire to the student questionnaire. Instead of teachers reporting student computer use, the students

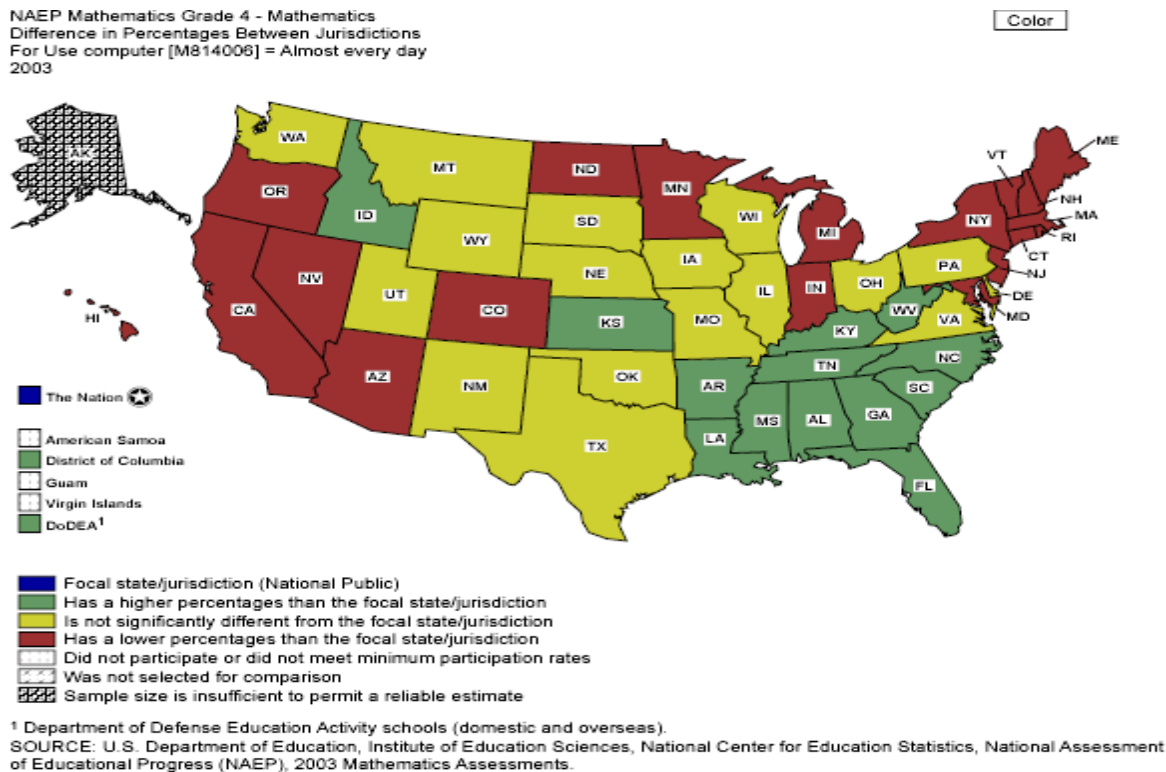
self reported. In a validity study of the National Assessment of Educational Progress, Hedges, Konstantopolous and Thoreson (2000) concluded that there is a very small correlation between teacher and student reports of computer use ($\gamma = 0.16, \tau = 0.10$). It is unclear, therefore, how comparable the results from 2003 are to those from 1996. However, all six states that were on the left side of the Table in 1996 are still there in 2003; they are joined by seven new states. Also, Hawaii and Delaware are on the right side of both Tables 7 and 8. Finally, while the percentage of students in the national sample never or hardly ever using computers went from 21% in 1996 to 20% in 2003, the percentage of students reporting daily computer use went up considerably from 14% to 22%.

Table 8. For this school year, how often do you use a computer? (student-reported) (2003)

ALMOST EVERY DAY			NEVER OR HARDLY EVER		
Jurisdiction	Row %	(S.E.)	Jurisdiction	Row %	(S.E.)
West Virginia	34%	-2.3			
Tennessee	32%	-1.9			
Mississippi	32%	-1.8			
Florida	32%	-1.7			
Kentucky	31%	-1.8			
Georgia	30%	-1.6			
Louisiana	30%	-1.7			
South Carolina	30%	-1.7			
Kansas	28%	-1.9			
Arkansas	28%	-1.5			
Alabama	28%	-1.4			
Idaho	28%	-1.7			
North Carolina	26%	-1.3			
National Public	22%	-0.3	National Public	20%	-0.3
			Delaware	24%	-0.7
			New York	24%	-1.3
			California	25%	-1.4
			New Hampshire	26%	-1.6
			Hawaii	27%	-1.1
			Rhode Island	28%	-1.5
			Ohio	29%	-2.2
			Oregon	29%	-1.9

Figure one is a graphical representation of the data on computer use “almost every day.” The states in green had a higher percentage of students than the national sample using computers almost every day. The states in red had a lower percentage. There is no statistically significant difference between the students in the national sample and the students in the states in yellow. All similar figures throughout this analysis use the same color scheme. The figure depicts a regional trend to computer use in schools. Above average use took place largely in southeastern states while below average amounts of use occurred in the West and in New England states.

Figure 1. Differences in computer use “almost every day” (2003)



On the 1998 state reading NAEP, the 4th grade students in the sample were asked about computer use, but the question specified computer use for schoolwork (as opposed to, for example, personal uses). Thus, this is a more specific or targeted question than the general computer use questions. And, in fact, as seen in Table nine, the percentages of students reporting daily use are much lower than in 1996 and 2003, and the percentages of students reporting never or hardly ever using computers for schoolwork are considerably higher than in 1996 and 2003. Specificity notwithstanding, of the nine states on the left side of Table nine, eight were on the left side of Table eight containing data from 2003. In other words, with the exception of Wyoming, the states where students were more likely than students in the national sample to report daily computer use for schoolwork in 1998 were also more likely than students in the national sample to report computer use in 2003. In other words, over the period of 1998 to 2003, there was a core group of states that were consistently ahead of the national average with respect to computer use in schools.

Table 9. How often do you use a computer for schoolwork? (student-reported) (1998)

ALMOST EVERY DAY			NEVER OR HARDLY EVER		
Jurisdiction	Row %	(S.E.)	Jurisdiction	Row %	(S.E.)
Kansas	19%	(2.8)			
Arkansas	19%	(2)			
Kentucky	19%	(2.3)			
West Virginia	17%	(1.6)			
Mississippi	17%	(2)			
Louisiana	17%	(2.3)			
Georgia	16%	(1.8)			
South Carolina	15%	(2)			
Wyoming	15%	(1.9)			
National Public	9%	(0.7)	National Public	55%	(1.2)
			Nevada	65%	(1.8)

Computer Use for math

During four different administrations (1996, 2000, 2005 and 2007), as part of the background questionnaire for the mathematics state NAEP, the students in the 4th grade sample were asked how often they used a computer for mathematics. However, during the 1996 and 2000 administrations, the question was worded, “when you do mathematics in school, how often do you use a computer?” For the 2005 and 2007 administrations, the language was changed to: “How often do you use a computer for math at school?” As demonstrated below, that slight change of wording may have rendered the data incomparable. However, it is still possible to compare the 1996 data to the 2000 data and the 2005 data to the 2007 data..

As per Table 10, in the 1996 national sample, 14% of the students reported using computers for math almost every day, and 56% of the students reported never or hardly ever using computers for math. Students in four states (West Virginia, Connecticut, Georgia and Florida) were significantly more likely than students in the national sample to report regular (“almost every day”) use of computers for math.

By 2000, as shown in Table 11, the amount of daily computer use for math had not changed much, and 57% of the nation’s 4th graders still reported never or hardly ever using computers for math. West Virginia was the only state where the percentage of students reporting almost daily use of computers for math remained above the national average from 1996 to 2000. On the other hand, in

2000, students in 15 states reported using computers for math almost every day significantly less frequently than students in the national sample.

Table 10. When you do mathematics in school, how often do you use a computer? (student-reported) (1996)

ALMOST EVERY DAY			NEVER OR HARDLY EVER		
Jurisdiction	Row %	(S.E.)	Jurisdiction	Row %	(S.E.)
West Virginia	22%	(1.6)			
Connecticut	19%	(1.4)			
Georgia	18%	(1.5)			
National Public	14%	(0.8)	National Public	56%	(1)
			Virginia	61%	-1.7
			Maryland	61%	-1.6
			Montana	63%	-1.7
			New Jersey	63%	-1.8
			Louisiana	64%	-1.5
			Missouri	64%	-1.5
			North Dakota	64%	-1.5
			Alabama	65%	-1.7
			Arizona	65%	-1.2
			Nevada	65%	-1.3
			Hawaii	65%	-1.2
			Delaware	68%	-1.1
			New Mexico	68%	-1.3

Table 11. When you do mathematics in school, how often do you use a computer? (student-reported) (2000)

ALMOST EVERY DAY			NEVER OR HARDLY EVER		
Jurisdiction	Row %	(S.E.)	Jurisdiction	Row %	(S.E.)
West Virginia	19%	(1.0)			
National Public	16%	(0.5)	National Public	57%	(0.9)
			Nevada	60%	-1.2
			Mississippi	62%	-1.5
			Alabama	62%	-1.6
			Tennessee	62%	-1.3
			Missouri	62%	-1.6
			Arizona	62%	-1.4
			Kentucky	63%	-1.7
			Montana	63%	-1.8
			New Mexico	63%	-1.5
			North Dakota	63%	-1.1
			Maryland	64%	-1.4
			Arkansas	65%	-1.7
			Oklahoma	67%	-1.3
			Nebraska	67%	-1.8
			Hawaii	68%	-1.3

Unless frequency of computer use for math changed dramatically between 2000 and 2005, the effects of the change in wording of the student background questionnaire item are apparent when comparing Table 11 and Table 12. By 2005 the percentage of 4th grade students in the nation that reported using computers when they do math in school “almost every day” dropped to 6% (from 16% in 2000). Furthermore, the percentage of 4th grade students reporting never or hardly ever using computers when doing math in school rose to 68% from 57% in 2000. Finally, the configuration of states on either side of the Tables changed considerably between 2000 and 2005.

Table 12. How often do you use a computer for math at school? (student-reported) (2005)

ALMOST EVERY DAY			NEVER OR HARDLY EVER		
Jurisdiction	Row %	(S.E.)	Jurisdiction	Row %	(S.E.)
Mississippi	11%	(0.9)			
Louisiana	10%	(0.7)			
Florida	10%	(0.9)			
Oklahoma	8%	(0.7)			
National Public	6%	(0.1)	National Public	68%	(0.2)
			California	70%	(0.8)
			Indiana	71%	(1.1)
			Washington	72%	(1.3)
			South Dakota	72%	(0.8)
			Oregon	72%	(1.1)
			Nevada	72%	(1.2)
			Michigan	72%	(1.3)
			Massachusetts	72%	(1.3)
			Illinois	72%	(1.3)
			Idaho	72%	(1.2)
			Kentucky	73%	(1.2)
			Nebraska	74%	(1.1)
			Hawaii	74%	(1.2)
			Wisconsin	74%	(1.3)
			Montana	75%	(1.2)
			Iowa	75%	(1.5)
			Maine	75%	(1.4)
			Vermont	76%	(0.8)
			Rhode Island	77%	(1.0)
			North Dakota	77%	(0.9)
			New Hampshire	79%	(0.9)

The data from 2007 are certainly more comparable to those from 2005, and in that two year span, not much changed. The national averages were not much different, though the percentage of students who reported never or hardly ever using computers for math dropped to 64% from 68%. Also, three of the four states (Louisiana, Florida and Mississippi) remained above the national average with respect to daily (or almost daily) computer use for math.

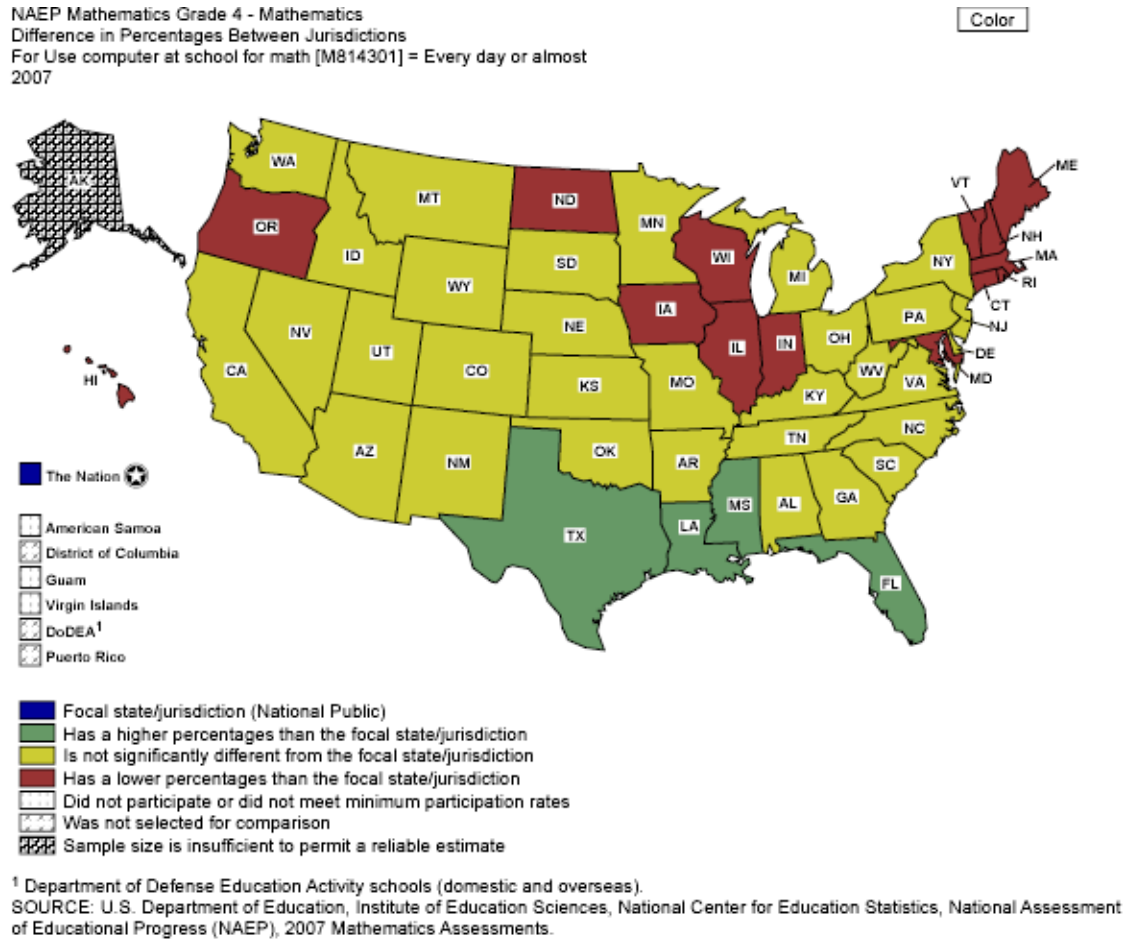
Table 13. How often do you use a computer for math at school? (student-reported) (2007)

ALMOST EVERY DAY			NEVER OR HARDLY EVER		
Jurisdiction	Row %	(S.E.)	Jurisdiction	Row %	(S.E.)
Louisiana	10%	(1.0)			
Florida	9%	(0.7)			
Mississippi	8%	(0.7)			
Texas	8%	(0.6)			
National Public	6%	(0.2)	National Public	64%	(0.2)
			Wisconsin	67%	(1.3)
			New Mexico	67%	(1.1)
			Tennessee	68%	(1.5)
			California	68%	(0.8)
			Idaho	68%	(1.4)
			Nebraska	68%	(1.7)
			Indiana	69%	(1.6)
			Michigan	69%	(1.4)
			Massachusetts	70%	(1.4)
			Oregon	70%	(1.1)
			Montana	70%	(1.4)
			Iowa	70%	(1.5)
			Maine	70%	(1.5)
			Vermont	73%	(0.9)
			Rhode Island	74%	(1.2)
			North Dakota	74%	(0.9)
			New Hampshire	79%	(1.1)

Figure two paints an interesting picture of the frequency of student computer use for math relative to the national average. The clustering of states is again notable. Specifically, the four states that are higher than the national average on daily computer use are all Gulf Coast states. The states that are lower than the national average mainly fall into two clusters. There is the Midwestern cluster (Illinois, Minnesota, Iowa and Indiana) and the New England

cluster; students in all of the New England states were more likely to report never or hardly ever using computers for math than the nation as a whole.

Figure 2. Differences in computer use for math “almost every day” (2003)



Computer Use for reading

The data on student computer use in reading are reported by the teachers and have only been asked, to this point, during the 1998 administration. One of the questionnaire items from the 1998 reading state NAEP asked teachers how often they asked students to read stories or do work related to reading instruction on a computer. Teachers in six states were more likely than teachers in the

national sample to respond with “almost every day” and teachers in teachers in four states were more likely than teachers across the country to respond with “never or hardly ever.” Here again, West Virginia, Florida and Mississippi show up on the left side of Table 14, and three of the four states on the right side are New England states.

Table 14. How often do you ask students in this class to do the following on a computer? Read stories or do work related to reading instruction (teacher-reported) (1998)

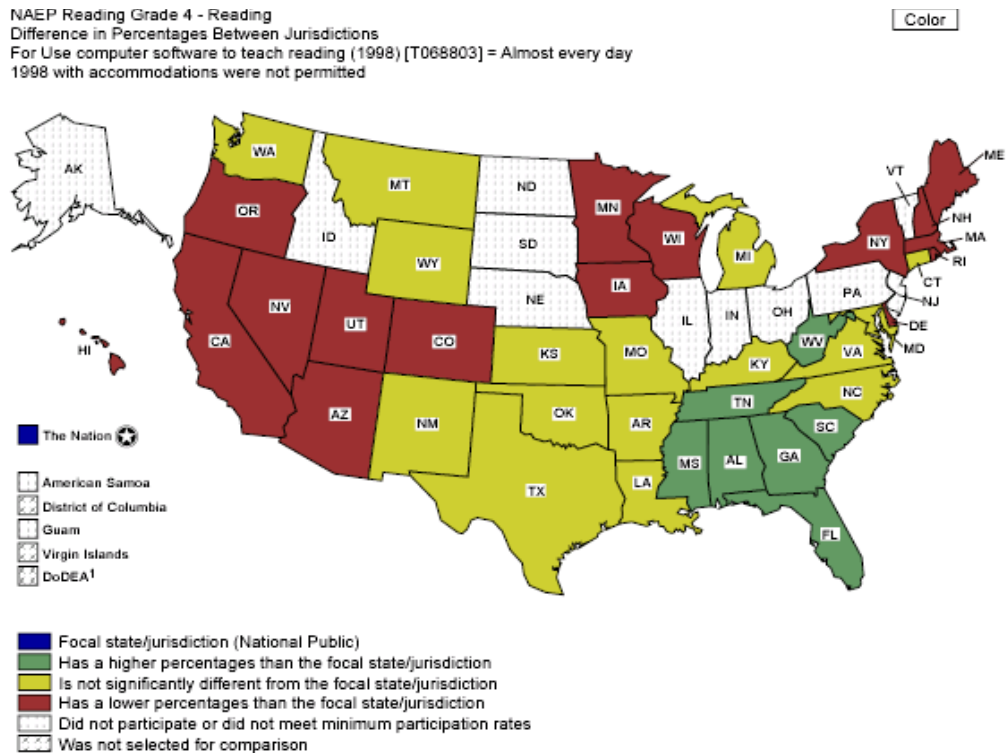
ALMOST EVERY DAY			NEVER OR HARDLY EVER		
Jurisdiction	Row %	(S.E.)	Jurisdiction	Row %	(S.E.)
West Virginia	37%	(4.1)			
Alabama	29%	(3.1)			
Georgia	28%	(3)			
Florida	28%	(2.9)			
Mississippi	27%	(3.4)			
Texas	24%	(2.7)			
National Public	16%	(1.3)	National Public	48%	(2.1)
			Delaware	55%	(1)
			Rhode Island	55%	(2.2)
			New Hampshire	60%	(3.3)
			Maine	68%	(2.9)

Another questionnaire item from the 1998 reading state NAEP asked teachers how often they used computer software to teach reading. Here, there are more states on either side of the Table with nine of the same ten showing up in Table 14 and Table 15 (only Texas does not appear in both). Nationally, it is worth noting, more teachers reported asking students to read stories on computers than using computers for reading instruction. It might be said that teachers were less willing to turn instruction over to the computers than they were to use the computers as a content delivery tool. Or, alternately, it might be said that teachers are able to imagine how reading stories on the computer is a simple replacement for reading stories in traditional print, whereas it is more difficult to imagine actually doing reading instruction with a computer.

**Table 15. How often do you use the following resources to teach reading in this class?
Computer software for reading instruction (teacher-reported) (1998)**

ALMOST EVERY DAY			NEVER OR HARDLY EVER		
Jurisdiction	Row %	(S.E.)	Jurisdiction	Row %	(S.E.)
West Virginia	34%	(3.3)			
Georgia	21%	(2.9)			
Florida	21%	(3.1)			
Mississippi	21%	(3.2)			
Alabama	19%	(3)			
South Carolina	17%	(3.1)			
Tennessee	17%	(3.2)			
National Public	9%	(1.3)	National Public	56%	(2.5)
			Minnesota	66%	(3.6)
			Washington	66%	(3.2)
			Oregon	66%	(3.3)
			Delaware	69%	(1)
			New Hampshire	71%	(2.7)
			Rhode Island	72%	(2.3)
			Hawaii	74%	(2.3)
			Maine	78%	(2.8)

Figure 3. Differences in computer use for reading instruction “almost every day” (1998)



¹ Department of Defense Education Activity schools (domestic and overseas).
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 1998 Reading Assessments.

Computer Use for writing

The first (and only, to this point) time the state NAEP included a 4th grade writing assessment was 2002. On the student background questionnaire for that assessment, the teachers in the sample were asked how often they asked students to use a computer to do spelling, punctuation or grammar exercises. Those data are displayed in Table 16 which looks nearly identical to the Table containing the data for teacher-reports of directing students to use computers to read stories or do work related to reading instruction (Table 14); we see essentially the same states represented as above the national average with respect to regular (“almost every day”) computer use for these tasks. West Virginia is way out in front, but is again joined by some other southeastern states.

Table 16. How often do you ask students in this class to do the following on a computer? Do spelling, punctuation, or grammar exercises (teacher-reported) (1998)

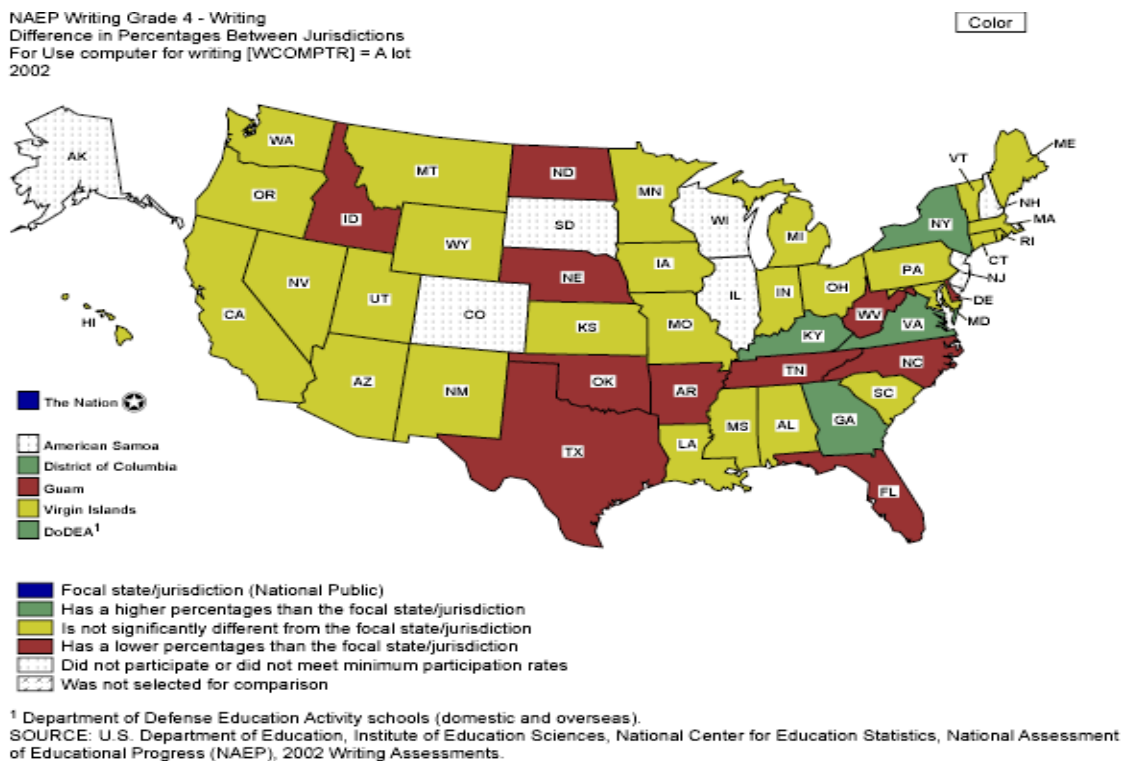
ALMOST EVERY DAY			NEVER OR HARDLY EVER		
Jurisdiction	Row %	(S.E.)	Jurisdiction	Row %	(S.E.)
West Virginia	28%	(3.2)			
Mississippi	20%	(2.8)			
Arkansas	18%	(2.7)			
Georgia	18%	(2.4)			
Alabama	18%	(2.6)			
National Public	9%	(1.3)	National Public	49%	(2.2)
			Delaware	60%	(1.1)
			Rhode Island	61%	(2.7)
			Maine	65%	(3.4)

Also included on the student background questionnaire for that 2002 writing assessment were two questions: (1) How often do you use a computer from the beginning to write the story or report (for example, use a computer to write the first draft)?, and (2) How often do you use a computer to make changes to the story or report (for example, spell-check, cut and paste)? For analytic purposes, NCES combined the responses to those two questions to form a single

variable, “Evidence of computer use for writing.” The response set for this variable, unlike those previously reported, was: “a lot,” “some” and “little or no.”

As displayed in Table 17, only 7% of students in the national sample reported using computers a lot for writing; 32% reported little or no computer use for writing. Students in five states offered evidence of a lot of computer use for writing more frequently than students in the national sample. Other than California, those states are all East Coast states.

Figure 4. Differences in evidence of computer use for writing “a lot” (2002)



As part of the background questionnaire for the 2005 NAEP reading assessment, teachers were asked the degree to which their students used computers for word processing. Nationally, only 1% of teachers responded

“almost every day”; no state’s teachers reported “almost every day” at a rate higher than 2% and most states had too few teachers report student use of word processors “almost every day” to meet reporting criteria. However, on the other end of the spectrum, there are enough data to report differences across the states. Nationally, 87% of teachers report that their students never or hardly ever use computers for word processing. Teachers in 12 states exceeded that rate. This indicates very low levels of computer use for word processing among 4th graders in 2005. In Iowa, for example, 96% of all 4th grade students never or hardly ever used computers for word processing in 2005. Since there are no states that were higher than the national average in word processing use, rather than displaying the data in a Table, they are presented only in Figure five which shows differences between the states within the category of never or hardly ever using computers for word processing.

Table 17. Evidence of computer use for writing (based on student responses to two background questions) (student-reported) (2002)

A LOT			LITTLE OR NO		
Jurisdiction	Row %	(S.E.)	Jurisdiction	Row %	(S.E.)
Kentucky	13%	(0.9)			
New York	10%	(1.0)			
California	9%	(0.8)			
Virginia	9%	(0.6)			
Georgia	8%	(0.5)			
National Public	7%	(0.2)	National Public	32%	(0.4)
			Oregon	35%	(1.6)
			Ohio	36%	(1.6)
			Missouri	36%	(1.6)
			Mississippi	37%	(1.4)
			Idaho	38%	(1.6)
			Florida	39%	(1.3)
			West Virginia	39%	(1.4)
			North Carolina	40%	(1.3)
			Tennessee	43%	(1.7)
			Oklahoma	44%	(1.4)
			Texas	44%	(1.7)
			Arkansas	48%	(1.4)

Discussion

National Trends

In general, the data do not support the claims of those who suggest that funding earmarked for technology has gone to waste (e.g. Cuban, 2001; Stoll, 1999). According to results of the Fast Response Survey System (FRSS) of the National Center for Education Statistics (NCES), as of 2003, the ratio of students to instructional computers (with Internet access) was 4.4:1, down from 12.1:1 five years earlier. So, assuming a relationship between computer access and computer use (see e.g. Norris et al., 2003), we would expect growth in computer use to correspond to that growth in access. Sure enough, in 1998, only 9% of the 4th grade students reported using computers for schoolwork almost every day. However, that changed to 22% in 2003. Additionally, 55% of the students in 1998 reported never or hardly ever using computers for schoolwork compared to only 20% in 2003.

Thus, assuming the data generated from the general computer use for schoolwork questions utilized in 1998 and 2003 can be treated as comparable, and with the necessary cautions about comparing cross-sectional data, the data show that the overall use of computers in elementary schools grew substantially in that five year period. As access improved, so did levels of use.

Furthermore, there is good reason to believe that student computer use across the states will continue to increase. In particular, where large-scale statewide initiatives are taking hold, student computer use should dramatically rise. For instance, the state of Maine is now heading into the fifth year of its well-

documented statewide laptop initiative, the Maine Learning Technology Initiative (<http://www.state.me.us/mlte/index.htm>). The early success of that endeavor (Silvernail & Lane, 2004) helped convince states such as Michigan and Connecticut to consider similar programs. These statewide projects and other regional or district-wide ubiquitous computing projects are certain to generate increased student use of computers across the states.

The Primacy of West Virginia

The one state that consistently shows up on the positive side of the ledger with respect to regular (“almost every day”) student computer use is West Virginia. Particularly with respect to frequency of computer use for reading and mathematics, elementary school students in the state of West Virginia continually exceed the national average. While statewide policies do not always translate into changes in practice at the school or classroom level (Cohen & Hill, ???), there are clear reasons for West Virginia’s prominence with respect to student computer use.

In 1989 the West Virginia Legislature passed a proposal to fund a statewide basic skills development project using personal computers in West Virginia schools (Section 7, Article 2E, Chapter 18 of WV code). That project became the Basic Skills/Computer Education (BS/CE) Program which began in 1990 under the stewardship of then Governor Gaston Caperton. In addition to just-in-time training by the two software vendors, the BS/CE program was developed to ultimately put the equivalent of four computers in every elementary

school classroom across the state. The first year of the program started in kindergarten classrooms, and each year subsequent, the next grade level up was targeted. Thus, after the first seven years of the program, all K-6 students were to be in schools with the equivalent of at least four computers per classroom and working with teachers who had received extensive professional development on technology integration.

That the BS/CE program still remains funded and in effect over 15 years later is truly remarkable, as are other aspects around the program. The West Virginia Department of Education's Office of Technology has been under the leadership of the same Executive Director, Brenda Williams, since the inception of the BS/CE program. Williams has been an extraordinary advocate for the teachers and students of West Virginia, and is active on the national level in organizations such as the State Education Technology Directors Association (SETDA). In addition to Williams' consistent leadership, the program remains unusually focused on its simple, coherent agenda of promoting student achievement through technology integration. There has been only one hardware vendor throughout the lifespan of the program and less than a handful of software vendors. As a result, teachers and students are not inundated with new systems or new programs.

In the last few years, the West Virginia Department of Education's Office of Technology has used federal funds to support a consistent and coherent program of technology integration support for teachers. The Technology Model Schools (TMS) program offers counties the opportunity to apply for funds for

technology integration specialists (TIS) who work full or part-time in one or more schools. The success of the TMS program has been and continues to be documented through federal and state funded research (Becker, 2007).

The results of the BS/CE program (and now the TMS program as well) with respect to student computer use are clear from the findings of this analysis, and the results with respect to improving student learning have been documented as well. The Milken Exchange on Educational Technology commissioned an independent evaluation of the West Virginia BS/CE program. Mann, Shakeshaft, Becker and Kottkamp (1999) conducted the evaluation, and conducted a cross-sectional analysis of scores on the Stanford Achievement Test Series (9th Edition) from a representative sample of 950 fifth-grade students in 18 schools across the state. Fitting a model that mirrored the implementation goals of the program to the data, the authors concluded that consistent access to the technology, positive attitudes towards technology, and professional development combined to produce positive achievement gains. BS/CE accounted for eleven percent of the total variation in test scores across the state. Additionally, Lewis Solmon, of the Milken Family Foundation, conducted a cost-benefit analysis included in an addendum to the report, which concluded that BS/CE was significantly more cost-effective than other standard policy initiatives such as class size reduction and peer tutoring (Mann et al., 1999).

Unquestionably, West Virginia's approach stands as an exemplar for state-level education technology policy. Mostly, the stability of leadership

combined with consistency and coherence of statewide policies has fostered a culture of computer-assisted teaching and learning that is a national model.

Regionalism (Competition)

Another notable trend in the data is the regional nature of student computing. As many of the figures in particular show rather clearly, daily computer use in schools is very much a southeastern phenomenon. That is to say, for the most part, the states that show up as green on the maps (i.e. computer use in those states is statistically significantly higher than the national average) are in the southeastern part of the United States. Furthermore, computer use in schools in New England states is typically less frequent than then national averages.

The most likely explanation for this phenomenon is the competition or horserace mentality that has developed within the educational technology policy arena. This mentality is often apparent at the local level. Typically, where one local education agency engages in a large-scale technology initiative, the surrounding LEAs develop a need to “keep up,” at least to maintain the appearance of being technologically-advanced and competitive to the surrounding systems. This mindset appears to exist across state education agencies as well. West Virginia, as described above, implemented a large-scale, statewide technology initiative in the mid-1990’s. Florida was also early to the educational technology policy Table. Surrounding states soon learned from their neighbors and embarked on their own technology initiatives.

In sum, there are clear differences in the frequency of computer use in schools across the states. Making that same claim across time is a bit more tentative since the NAEP background questionnaire items changed over time. However, the data about student computer use for math demonstrate a significant growth in the amount of computer use in schools in the years leading up to the early 21st Century. There are reasonable disagreements within the educational policy arena about appropriate amounts of computer use in schools. Those debates are necessary, but as we move deeper into the 21st Century, it is important to make sure that our students are being fully prepared for an increasingly global, technologically-suffused society. That 20% of the nation's fourth graders reported never or hardly ever using a computer in school in 2003 and 64% of fourth graders in 2007 reported never or hardly ever using a computer for math suggests that we may need to push the educational technology agenda farther along and faster than its current trajectory.

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