

A Laptop for Every Student?

Only a few years ago, the idea of assigning individual students their own computers would have seemed like a fantasy. But now the concept is gaining ground – and showing results. It's time New York considered it.

The season's first snow was falling quietly outside Michael J. Petrides School on Staten Island, and Gerry Vassillatos saw that his seventh-graders were starting to look out the windows rather than focus on his lesson about the scientific process.

So he told his students to flip open their laptop computers, log onto the Internet, and find a website

In New York State, the educational system is moving into technology more slowly than most other states.

devoted to "The Snowflake Man," Wilson A. Bentley, a Vermont farmer who started photographing snowflakes in 1885 in an effort to discover whether any two were alike. In less than a minute this classroom of 12-year-olds was abuzz with excitement, as the kids found the site

(www.snowflakebentley.com) and began paging through some of the 5,000 amazing micro-photographs that Bentley took over the course of 45 years.

One student after another would pick up his computer and rush over to show off a particular photograph to a friend, or to the teacher – something that was easy to do, since the laptops had no wires; each one was battery-powered and each one had a wireless connection to the World Wide Web. A student wanted to know more about snow; this was easy to find, because his laptop included a copy of the *World Book* encyclopedia. Another student asked how woolly

INSIDE

- ◆ Students have progressed from learning *about* computers, to learning *from* computers.
- ◆ Research shows that learning from computers works—improving math scores, writing, and more.
- ◆ The next step is learning *with* computers—using technology to help students explore the world of knowledge.
- ◆ That means students need ready access to computers that connect to the Internet. And it means teachers need good training in how to take advantage of it.
- ◆ New York lags well behind in student access to connected computers—especially in high-poverty schools.
- ◆ This state appears to lag behind in teacher preparation for the use of technology, as well.

It seems increasingly clear that the basic principle at work at Petrides—every student getting individual access to a computer for research and work, whenever he or she needs it—is going to become the norm.

bear caterpillars survive the snow, and a friend pointed him to a website with information about that.

Vassillatos moved among the work tables, looking at the snowflakes and driving home his point for the day: that Bentley had been in the grip of an inspiration—his *hypothesis*—that every snowflake was unique. The scientific process requires experimentation, measurement, quantification, and proof—but the lesson for today was that without an initial hypothesis, and the inspiration that lies behind it, science would never even get started.

Ten years ago or less, the scene in Vassillatos' classroom would have been almost unimaginable. There were computers in the schools, yes; but invariably they were big, heavy desktops, locked up in computer labs, or perhaps wheeled on carts from room to room. They were a mere adjunct to the educational process.

At Petrides, a “magnet” school with a robust mixture of middle-class, poor, immigrant and native-born students, all 850 middle- and high-school pupils have been equipped with their own, individual Apple iBook laptops. The computers certainly aren't the *heart* of the educational process; everything still depends upon having a teacher, like Vassillatos, with the training and skill to use this new asset to enhance student learning. But computers seem to have become a central *tool* in the process—just as they are in the real world of work outside the schools.

Students use their iBooks in the Petrides classrooms to look up information, to graph the results of experiments, to drill their math skills, to work on group presentations and projects. They take them home at night to write their homework assignments—easy to do, because the laptops are smaller and lighter than the average textbook. When they need to do research, an Internet connection gets them into what is, in effect, a worldwide library of information.

Computers in the classroom

Computers at Petrides don't make everything perfect or solve all problems, just as they don't in the working world. But it seems increasingly clear that the basic principle at work at this school—every student getting individual access to a computer for research and work, whenever he or she needs it—is going to become the norm in American education over the next decade or so.

It is also clear, however, that in New York, the education system is moving in this direction more slowly than most. Petrides and a few other schools are really exceptions to the rule in this state. Despite school spending that is at the top in the nation, New York lags well behind the national average—and behind most competing states—in making connected computing in any form (let alone individually assigned computers) available to its students. New York lags even *further* behind in the computing power available in high-poverty schools—the very schools whose students are least likely to have computers available at home. (See Table 1, page 3.) And schools in other states, such as Maine, Virginia, Michigan and Texas, are moving faster in implementing one-to-one computing for their students. New York needs to start thinking seriously about how to catch up.

Although the ubiquitous computing at Petrides is unusual, computers have been making their way into the schools since the early 1980s. The process started with the old Apple IIs and the original IBM PCs, almost always assigned to

Table 1

Computer Use in New York Schools, Compared to the Five Other Largest States and the U.S. National Average

*New York lags behind in this area, despite much higher levels of overall school spending.
Our shortfall is particularly dramatic in high-poverty schools.*

	Students per Internet-connected computer (overall)	Students per Internet computer, high-poverty schools	Total Spending on Schools, Per Pupil (2000-01)
California	10.1	11.7	\$ 6,965
Texas	5.9	6.5	6,460
New York	8.1	15.1	\$ 10,922
Florida	7.1	7.9	6,020
Illinois	6.9	10.6	7,585
Pennsylvania	7.2	9.8	8,191
U.S. average	6.8	8.1	\$ 7,284

Sources: Computer ratios per pupil are for 2001, taken from Education Week On-line, www.educationweek.org/sreports/tc02. Per-pupil spending ratios are from the U.S. Census Bureau. Same data are illustrated in graph on back page of this report.

computer labs or to a corner in the library. Gradually more and more classrooms acquired better Windows-based or Macintosh computers, with hard drives, color graphics monitors, multimedia capabilities, and occasionally a modem. The current high end of educational hardware is defined by laptops with wireless Internet connections, like those at Petrides.

The ratio of students to computers in U.S. schools dropped from one computer for every 125 students in 1983-84, to one for every 10.5 in 1994-95. As of school year 2000-01, the most recent year for which comprehensive statistics are available, the ratio had fallen to one computer of some sort for every 4.2 students. (The nationwide ratio for computers connected to the Internet, the best indicator of a computer broadly useful for educational tasks today, was one for every 6.8 students in 2000-01.)¹

The way computers are used in the schools has evolved in step with the improvements in the hardware. Experts in the field divide computer use in education into three progressively higher stages – from using computers to learn *about* computers, to learning *from* computers, to learning *with* computers. Each stage has more potential benefits for educational outcomes. But each also requires more equipment and more teacher training.

Learning *about* computers is still what most people seem to think of first, when they talk about computers in the schools. Computers are used in the working world, and students need to be prepared for their careers, so: therefore the schools are supposed to teach them how to use computers. Students would go to the lab

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to learn about floppy disks, copying files, and using word processing programs. Some would take a class in programming. For years, virtually every student in America has had computer exposure at this level.

There have been benefits from this stage – not the least of which is the how-to help that parents and teachers are now accustomed to receiving from kids. Skills like word processing can help students complete their school assignments, provided they can get access to a computer when needed. And although computers and software are changing rapidly and will no doubt be very different by the time today’s students are actually in the working world, it has been of value for the schools to establish a basic familiarity with computers.

But this approach only scratches the surface of what computers can do for education.

Learning from computers: what the research says

The next stage has been learning *from* computers, using software designed to teach or drill a particular subject. There is now a vast amount of software used in this way, and after word processing this appears to be the most common use for computers in the schools. Nationwide 64 percent of fourth-grade teachers, for example, report that the primary use of computers by their students for math instruction is either drill or teaching games. (The comparable figure for New York State teachers is 58 percent.)² Test preparation software is also widely used; there is, for example, a comprehensive site that offers help in preparing for New York’s Regents exams, hosted by the Oswego City School District but available to anyone (www.regentsprep.org).

At this “learning from” stage, computers have won favor with educators because they make it possible to give individualized attention and instruction to students who need extra time and help with a particular topic – or, who are ready to move ahead of the pace of the rest of the class.

There is a very substantial amount of research suggesting that well-thought-out use of computers in the “learning from” mode (as opposed to “learning about”) can have a significant, positive impact on student performance.

In 1994, for example, IBM launched a \$70 million experimental initiative called the Reinventing Education Program, to test the educational impact of a comprehensive use of computers in the schools, backed up by appropriate teacher training. Grants were given to 15 school districts in six states in the U.S., as well as to schools in Australia, Brazil, Ireland, Italy, Mexico, Singapore, the United Kingdom and Vietnam. The Education Development Center, Inc., reported after a three-year study of the program that it had yielded “significant performance gains for students in grades 7 through 11,” as well as strengthening teacher training and school management.³

A long-running program to incorporate computer-based learning in elementary schools in West Virginia found that computer instruction was “more cost-effective in improving student achievement than (1) class size reduction from 35 to 20 students, (2) increasing instructional time, and (3) cross-age tutoring programs.” Scores on achievement tests rose, and the more computers had been used at a particular school, the greater the observed improvement.⁴

A long-running, multi-site research effort called Project CHILD reported higher test scores and fewer disciplinary problems among elementary school students given access to computer-based learning—and also found that these students continued to do better than their peers at the middle-school level.⁵

Numerous studies have found that student use of word processing improves the quality of writing, increases the quantity of writing, and improves student interaction. According to a compilation of these studies published in February 2003, “average students who use computers when learning to write produce written work that is about .4 standard deviations better than students who develop writing skills on paper,” statistically a significant improvement.⁶

A national study of over 7,000 fourth- and eighth-grade students and their teachers found that the students who used computers to develop math skills showed gains in math scores of up to 15 weeks above grade level—and the students of *teachers* who received professional development on computers also showed gains, of up to 13 weeks above grade level.⁷

So there is now no question that computers in the schools are more than a frill; students can and do learn from them.

Learning *with* computers: the next stage

The line between learning *from* computers, and learning *with* them, is not perfectly distinct. But in general the idea is that at the “with” stage, computers provide a powerful kind of window on the world, through which students can explore and experiment, with a certain amount of independence—and motivated as much by their own interests, as by directions from a teacher. Take, for example, the Petrides students who wanted to get information about snow, or woolly bear caterpillars, after looking at the photographs of snowflakes.

The Internet is a large part of what now makes this possible, but it’s not the whole story. Students conducting science experiments can use their computers to record test data, tabulate it and graph it—in the process, making it possible for them to run more experiments in less time, and understand the results better. Students researching a history topic can use their computers to develop multi-media presentations on the subject—experiencing the especially intense learning that is always essential when you’re trying to figure out how to illustrate and explain something to somebody else. Even the simple use of word processing has elements of learning *with* computers, because it facilitates constant revision and improvement in written work.

Seymour Papert, who co-founded the Artificial Intelligence Laboratory at MIT in the 1960s, has written that technology “makes possible projects that are both very difficult and very engaging.”

Through technology, Papert says, school can become “a place where students learn largely by working on projects that come from their own interests—their own visions of a place they want to be, a thing they want to make or a subject they want to explore.”

By its very nature, this kind of learning with computers tends to give rise to a desire to have “one-to-one” computing—a single computer available to a single

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student at all times. If you're encouraging students to explore at their own pace and their own initiative, you don't want them to have to stop until time on a shared computer is scheduled. As Papert says, "access to a personally owned computer that is available all the time is fundamentally different from the kind of access a student can get from a handful of computers in a classroom."⁸

Michael Davino, the principal of the Petrides School on Staten Island, decided to provide that "fundamentally different" kind of access. He used a special New York State magnet school technology grant to acquire Apple laptops for each of his middle- and high-school students, and to install the classroom receivers that provide wireless Internet access. Petrides high-school students got their computers in September of 2000, and grades 6-8 were added in September of 2001.

Laptops were the only choice for the one-to-one program, Davino says, because desktops would take up too much room in the classroom, would require extra furniture, and couldn't be taken home. A bonus of the program was that he closed existing computer labs, gaining much-needed space and saving some money in the bargain. The laptops are a size sixth-graders can handle with ease.

"It's worked beyond our wildest dreams," says Davino. "This really opens up the world to them. The computers allow up-to-date research in any class, any time. On weekends, a lot of these kids have parents who are working. How are they going to get to the library? *This* is how they get to the library."

A smaller program is under way at Community School District 10 in the Bronx, which has arranged laptop leases for 138 students in five middle-school classes. Irma Zardoya, the superintendent, says students in the program are doing better work, are better organized and are completing assignments more quickly.

The district of Half Hollow Hills on Long Island hopes to implement a one-to-one program for 1,000 students this coming fall. Similar programs are on the way in places as diverse as Edinburgh, Scotland, and the eastern townships of Quebec.

Some other school systems seem to be laying the groundwork for one-to-one computing. The city of Houston and the state of Michigan are moving in that direction with programs that start by equipping all teachers with laptops, first, to get them comfortable with the idea and proficient in the use of computers. Detroit has just launched an experiment with a combination of laptops and handheld wireless devices in two middle schools.

Programs in Virginia and Maine

But by far the largest and best-known programs involving one-to-one computing are those newly under way in Henrico County, Virginia, and in the state of Maine.

In May of 2001, the school system in the Richmond suburb of Henrico (a county-wide district with 43,000 students, approximately the size of New York State's second-largest district, Buffalo) committed to supplying a wireless laptop to every student and every teacher. Some 13,000 Apple iBooks were distributed to students at the beginning of the 2001-02 school year. Some 10,500 are being supplied to middle-school students and teachers over the course of the current school year. Another 12,000 are supposed to be distributed to teachers and

students in the elementary grades by 2005.

In Maine, then Gov. Angus King went on a crusade in 2000 to invest \$50 million from a one-time state budget surplus in a Maine Learning Technology Endowment to jumpstart technology in the schools. The state created a study commission that recommended, in January of 2001, that the endowment be used as a revolving fund to finance the implementation of a one-to-one, wireless laptop program for every teacher and student in the seventh and eighth grades.

After intense debate in the Maine legislature – and in the face of initial opposition from many educators – the program was adopted. A few test sites were developed in the 2001-02 school year. Teachers went for training in the summer of 2002 (although in some cases, only for two days). Almost 17,000 Apple iBooks were delivered to seventh-graders this fall. (They will take their laptops with them into the eighth grade next fall, and the new seventh-grade class will get new computers then. Whether the program will be carried forward into upper grades has not yet been decided.)

The Maine program already appears to be wildly popular; efforts to cut it in the face of two consecutive tight budget years were turned back handily. Key legislators who opposed it initially now say they are converts. It's attracted nationwide attention, and financial help, as well – including contributions of \$1 million each from MBNA and from the Gates Foundation, and a software donation by EDS valued at \$400 million.

In both Maine and Henrico, some of the rhetoric around the one-to-one initiative is a throwback to the idea of learning “about” computers. Leaders in both places cite the programs in their economic development efforts, telling potential employers that their workforces will be ready for the computer age.

But in the classroom, there appears to be an ample focus on learning “with” computers. “I never realized the worlds that this can open,” 17-year-old Henrico student Meredith Bristow said last June as she regretfully turned her computer in for the summer. In Maine, Sandy Wheeler, a teacher in Boothbay, showed a visiting television crew how her students were using their computers in biology class. “The benefits of using the laptop with this microscope project have been tremendous,” she said. “In the past when we were working with microscopes, it was really hard to get them to see the differences. Oftentimes I’d have them go to the microscope and they’d try to draw what they saw, and then they were comparing two drawings. Now they can take the actual images and put them side-by-side on their computer, so that they get to compare an animal cell and a plant cell, and make the distinctions that we’re looking for.”⁹

Clearly, these two programs have not been in place long enough to establish long-term improvements in outcomes. But anecdotal reports and short-term results are encouraging. Henrico Superintendent Mark Edwards says his high-school students last year improved their results on 9 of 11 core curricular tests. The greatest gains came in the subjects in which Henrico used computers the most: history, reading and writing. A pilot study in one Maine district reported that 73 percent of students raised their grades in three or more subjects.¹⁰

There have also, of course, been technical glitches, and some complaints that teachers did not receive adequate training before the laptops were deployed. Still,

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given the way ubiquitous computing has transformed the working world, as well as higher education, it is hard not to believe that sooner rather than later, one-to-one computing will become the norm in secondary education, as well. Where Maine is going, every state will want to go, within a few years.

Where is New York now?

If computers are becoming more and more important to education, where does New York State stand on the journey? Short answer: *Behind*.

That may not be what you'd expect to hear about the Empire State – which takes great pride in its schools and its high standards, and which every year ranks at, or almost at, the top of the nation in terms of per-pupil spending on education.

But by the best available comparisons of educational computing, published each year by *Education Week* magazine and derived from Market Data Retrieval surveys, state governments' reports and the National Assessment of Educational Progress, New York languishes below the national average in terms of putting computer power in the hands of students – and in terms of training for teachers.

Ranking the states in terms of the ratio of students per Internet-connected computer, New York comes in at 41st – with about 20 percent fewer connected computers than it would have if it met the national average. (See Table 2, page 9.) Compared to its key competitors, the five other largest states, New York lags behind all but California. (Table 1, page 3, and graph, back page.) Among our neighboring states, only Connecticut ranks lower.¹¹

Even more serious, New York has an unusually large gap between the computing resources available to students in high-poverty schools, and those available in other schools. High-poverty schools in New York report having only one Internet-connected computer for every 15.1 students – compared to a statewide average of one to 8.1 for all schools. None of the five other largest states have so wide a gap between the poor and the rest. Only two other states – New Hampshire and Connecticut – appear to have wider gaps than New York in this area. This is a concern for two reasons:

- First, there is evidence that the benefits students can gain from educational computers are greater for minority and poor students than for students generally.¹²
- And second, although home ownership of computers is growing rapidly even in poorer households, students from poor families are still almost three times as likely not to have access to a computer at home as are students from other families.¹³

Equally serious, there appears to be a training gap in New York, as well. Twenty-nine states require technology coursework or competency of all licensed teachers; New York is one of 21 states with no such requirement. *Education Week* reports that 33 percent of teachers in New York were rated as “beginners” when it comes to technology – compared to a national average of 24 percent. And again, the technology gap was larger in New York's high-poverty schools; 51 percent of teachers in those schools were ranked as “beginners” in this state, compared to a national average of 29 percent.

Table 2**States Ranked by Student Access to the Internet***Ratio of Students to Internet-Connected Computers in Public Schools*

Rank	Ratio	Rank	Ratio		
1	South Dakota	3.4	27	Colorado	6.7
2	Wyoming	3.8	27	New Hampshire	6.7
3	Nebraska	4.6	27	Utah	6.7
4	North Dakota	4.9	30	New Jersey	6.8
5	Idaho	5.1	30	Oregon	6.8
5	Kansas	5.1	30	Vermont	6.8
7	Alaska	5.2		U.S.	6.8
7	Delaware	5.2	33	Illinois	6.9
9	Iowa	5.3	34	Arizona	7.1
9	Minnesota	5.3	34	Florida	7.1
11	Indiana	5.6	36	Pennsylvania	7.2
11	Oklahoma	5.6	37	Massachusetts	7.3
11	West Virginia	5.6	38	Georgia	7.5
11	Wisconsin	5.6	39	Tennessee	7.6
15	Ohio	5.7	40	Mississippi	7.9
16	Maine	5.8	41	NEW YORK	8.1
16	Missouri	5.8	42	Rhode Island	8.3
16	South Carolina	5.8	43	Hawaii	8.4
19	Montana	5.9	44	Maryland	8.5
19	Texas	5.9	45	Alabama	8.6
21	Kentucky	6.0	45	D.C.	8.6
22	New Mexico	6.2	47	Connecticut	8.7
23	Virginia	6.3	48	Nevada	8.8
24	Arkansas	6.4	48	North Carolina	8.8
25	Michigan	6.5	50	Louisiana	9.3
25	Washington	6.5	51	California	10.1

Source: Education Week

There appears to be a training gap in New York, as well. Some 51 percent of teachers in high-poverty schools in this state were ranked as 'beginners' in technology, compared to a national average of 29 percent in such schools.

Can we afford to do better?

New York has commendable ambitions of addressing these shortfalls. A draft "Technology Plan" circulated by the state Education Department in February 2003 identifies a "vision" in which "Learning technologies will be widely and equitably used in every school building in New York State to support the engagement of students, teachers, administrators, parents and the community in helping all students to achieve high standards. Educational technology applications will deepen student engagement and improve student achievement by enabling them to access and analyze information, solve problems, collaborate with others, and communicate their thoughts and ideas. Effective use of learning technologies will allow students to become self-directed, self-motivated and lifelong learners."¹⁴

In other words, New York aspires to an environment of learning *with* computers.

The investment needed isn't just in equipment, but also in staff development for teachers, so they can effectively incorporate these tools into the work of the classroom.

But how can we possibly afford it? School administrators will say that this is an especially big question right now, with huge budget gaps and fiscal problems confronting both the state government and its school districts.

The money may not be at hand right now, but that doesn't mean New York educators shouldn't start working on the issue. Businesses find that in hard times, it's wise to prune expenditures that are less than productive, while also planning for wise investment of the resources that will become available once times are better. The same principles can be applied to technology planning for the schools.

Moreover, if having lots of money was the whole key to technology, the state-by-state patterns in educational computing would look very different from the way they are now. Why is New York—the nation's top spender on schools, at 49 percent above the national average per pupil—only 41st in Internet-connected computers for its students? How can South Dakota—which spends 16 percent *less* than the national average—be ranked first in computer access?

Teacher training is essential

Computers in the schools aren't cheap. The investment needed isn't just in equipment, but also in staff development for teachers, so they can effectively incorporate these tools into the work of the classroom. A federal rule-of-thumb is that schools should budget to spend at least 25 percent of their technology budget on training, rather than equipment.

The equipment itself becomes less expensive all the time. A student-class laptop can now be had for under \$700. Assuming the computer lasts three years, the cost of the unit—plus staff development for the teachers, networking installation in the school building, and maintenance—will probably add up to somewhere between \$400 to \$600 a year per student.¹⁵

New York can't plunge ahead and buy laptops for every student. But a phased-in approach would allow the state to study what works and what doesn't, test the best approaches to staff development, curriculum, and so on. There *is* money to do that. Schools in New York State are probably spending around \$700 million this year on all technology needs—from computers to video.¹⁶ If, say, one-third of that \$700 million were focused specifically on gradual adoption of one-to-one computing for the secondary grades, this money alone would be enough to add 125,000 to 150,000 students a year to the state's laptop-using cohort.¹⁷ Some additional help is already available from the new federal No Child Left Behind Act, which allocates \$61 million in technology funding to New York State this year, half of it designated for high-poverty schools.

A presidential task force recommended in 1997 that technology spending in the schools be raised to 5 percent of budgets. New York could probably make that shift over a period of, say, three to five years, without noticeable suffering in any other area of educational spending. If only half of such a 5 percent quota were devoted to implementing one-to-one computing—or about \$1 billion a year (2.5 percent of \$40 billion)—it could take less than three years to train teachers and to equip every one of the 1.7 million middle- and high-school students in the state. In truth this is well within the range of possibility, given the enormous amounts of money New York is already spending on schools.

What stands in the way of the idea is not so much money, as inertia—skepticism about the benefits, and a suspicion of change.

Those were factors in Maine, too, of course. But they now seem mostly to be in the past tense.

When she first heard about Maine's program, says Catherine Anderson, a English teacher at King Middle School in Portland, "I did not want it to happen."

But now, "the kids who have been the most reluctant as writers... this moment happens when they're seeing their own words in front of them, and there's *great* pride. These are kids who would not pick up a Langston Hughes poetry book. But on a web site where they get to pick their favorite stanza—it just happens!

"So that struggle piece disappeared. And for me, that was breathtaking."

Endnotes

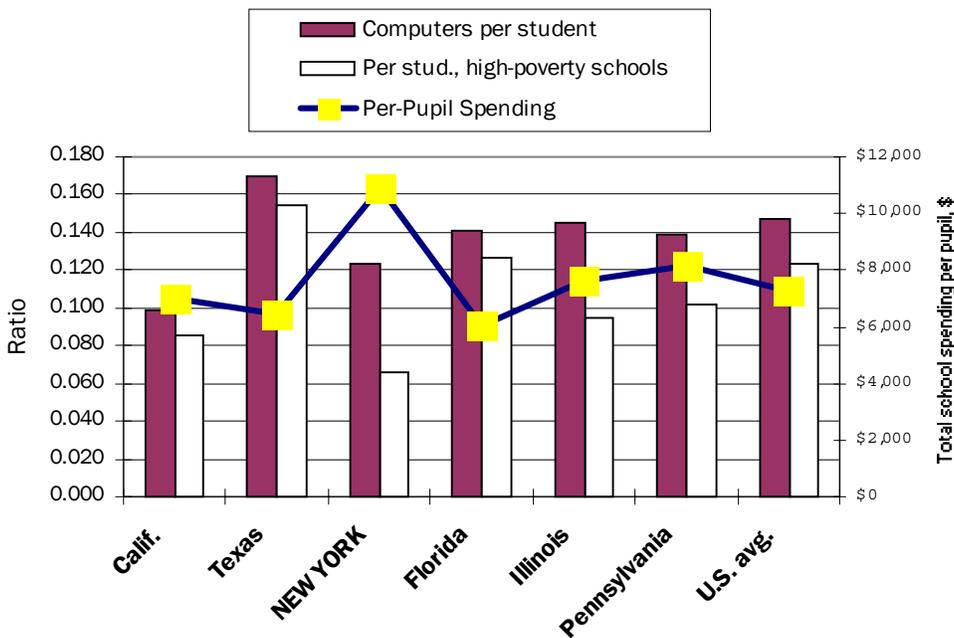
1. Data for 2000-01 from www.educationweek.org/sreports/tc02. Data for earlier years from President's Committee of Advisors on Science and Technology, March 1997, www.ostp.gov/PCAST/k-12ed.html.
2. www.educationweek.org
3. www.edc.org/spotlight/Tech/IBM2.htm
4. John Schacter, "The Impact of Education Technology on Student Achievement," the Milken Exchange, 1999, available at www.milkenexchange.org. See also "The Learning Return on our Educational Technology Investment, WestEd, 2002, at www.westedrtec.org.
5. WestEd, *op. cit.*, p. 4.
6. Goldberg, Russell and Cook, "The Effect of Computers on Student Writing: A Meta-Analysis of Studies from 1992 to 2002," *The Journal of Technology, Learning and Assessment*, Feb. 2003, p. 20. See www.jtla.org.
7. Harold Wenglinsky, Educational Testing Service Policy Information Center, 1998.
8. Caperton, Gaston and Paper, Seymour, "Vision for Education: The Caperton-Papert Platform." See www.papert.org.
9. "Big Changes in Small Packages," aired on Maine Public Television on February 16, 2003.
10. See Edwards' report at www.aasa.org/publications/sa/2003_04/edwards.htm. A mid-year evaluation report on the Maine program is available at www.mainelearns.org. The Maine report found widespread delight with the program among teachers, students and parents, and suggested that, among other things, the program is increasing the number of hours a week that students spend on schoolwork.
11. New York also ranks below the national average in the ratio of instructional computers of any sort, whether or not connected to the Internet. The ratio is one for every 4.4 students in New York, compared to one for every 4.2 students nationwide. For students in high-poverty schools, the ratio in New York is one to every 6.4, significantly inferior to the national ratio of one to every 4.5. (*Education Week* data from Market Data Retrieval surveys.)
12. The President's Committee of Advisors on Science and Technology, *ref.* above, reported on studies showing that computer drill had a far greater impact in improving the math skills of low-income students than on students generally, and that use of word processing had a somewhat greater impact in improving the quality of written work by low-income students.
13. *Education Week* reported in May of 2002 that 34 percent of fourth-graders from poor families in New York did not have access to a computer at home, compared to 10 percent from non-poor families, and that 24 percent of eighth-graders from poor families did not, compared to 9 percent in non-poor families. These figures roughly match the national averages.
14. www.emsc.nysed.gov/deputy/Documents/technology/tech-plan-2-03.html
15. Maine set a target cost of \$300 per student, and officials say they have come in close to that. However, that state's taxpayer spending has been augmented by foundation and corporate donations. And it appears Maine may end up spending more than originally anticipated on staff development, maintenance and support.
16. Industry data put total nationwide spending on school technology at \$7 billion in 2001. New York accounts for 9.2 percent of total school spending; 9.2 percent of \$7 billion is \$643 million.
17. The state Education Department says that in 2000, the last year for which statistics are at hand, schools in New York purchased a total of 121,000 computers for instructional use.

Some additional help is already available from the new federal No Child Left Behind Act, which allocates \$61 million in technology funding to New York State this year.

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New York Lags in Using Computers in the Schools

*Internet-Connected Computers Per Student,
 Compared to Five Other Largest States and to U.S.*



Sources: Education Week; Census Bureau