One-to-One Computing in Public Schools:
Lessons from "Laptops for All" Programs

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Introduction

In the spring of 2007, the *New York Times* ran a story that marked a turning point in the burgeoning education initiative to place a laptop computer in the hands of every student in middle and high school classrooms.[1] The article cites several school districts that were abandoning their technology efforts in the face of security issues, inappropriate usage, bandwidth shortages, equipment problems, and little evidence of student progress. Despite the challenges of technology integration, many policymakers and educators across the country have exhibited a growing interest in what has been termed "one-to-one computing." At least 33 states have implemented one-to-one computing programs, and the number is expected to grow.[2] A 2006 survey of 2,500 US school districts found that 24% have implemented or are moving towards one-to-one computer applications.[3] While the vision of every student reaching competency in technology and the notion of decreasing the digital divide are appealing, it remains questionable whether using laptop computers in schools is linked to increased student achievement.

A definition of one-to-one computing:

The basic tenet of one-to-one computing is that the student and teacher have Internet-connected, wireless computing devices in the classroom and optimally at home as well. Also known as "ubiquitous computing," this strategy assumes that every teacher and student has her own computing device and obviates the need for moving classes to computer labs. William Penuel, Senior Researcher at SRI's Center for Technology in Learning, further ascribes the following characteristics to one-to-one computing efforts:

1. "providing students with use of portable laptop computers loaded with contemporary productivity software (e.g., word processing tools, spreadsheet tools, etc.)

2. enabling students to access the Internet through schools/wireless networks, and

3. a focus on using laptops to help complete academic tasks such as homework assignments, test, and presentations."[4]

The Case for Ubiquitous Computing

While each one-to-one initiative has slightly different goals, generally, these programs are designed to:[5]

1. **increase academic achievement;**

2. **transform the quality of instruction and the type of learning, leading to a higher level of student engagement;**
   One-to-one programs strive to transform the classroom from one in which a

teacher disseminates information and the students receive it into one in which students are active and engaged learners. With laptops, students can more easily work on projects individually and collaboratively in order to acquire, synthesize, question, and apply new information.[6] This student-centered learning encourages higher order thinking skills and deeper learning.[7]

3. **increase equity of access and minimize the digital divide;**
   There is a clear disparity between students who have ready access to computer technology and those who do not. Providing every student with a laptop has the potential of minimizing this inequity.[8]

4. **increase the economic competitiveness of students and the region by employing technology to teach twenty-first-century skills.**
   Using technology in schools is essential for preparing students for future work that requires knowledge of technology as well as information-gathering, communication, and problem-solving skills.[9] Laptops provide students with the multimedia resources they need to develop these crucial skills.[10]

To a lesser degree, some educators have sought one-to-one initiatives to improve school communication with parents and increase productivity of administrators and teachers.

I. Large Scale Laptop Programs in US Schools

While several significant one-to-one laptop programs have been implemented since 2000, there are still relatively few large scale programs with longevity. This report examines the largest state-driven one-to-one computing initiatives in Maine, Michigan, Texas, and Pennsylvania as well as district-wide laptop programs in Henrico County, Virginia and Talbot County, Maryland. With the exception of Pennsylvania, each of these programs is an example of ubiquitous computing, in which at least some students are permitted to take the laptop computers home.

State Computing Initiatives

1. Maine (2002)

In 2002, Maine launched an ambitious statewide initiative to provide all middle school students and teachers in the state with laptop computers. Proposed as a strategy to equip all middle school students and their teachers with a personal learning device by then-Governor Angus King,[11] the Maine Learning Technology Initiative (MLTI) was designed to "transform Maine into the premier state for utilizing technology."[12] MLTI targeted all 7th and 8th grade students and their teachers and provided laptop computers, technical assistance, and professional development for integrating technology in the classroom. Most, but not all, of the students were permitted to bring laptops home.

With funding from The Bill & Melinda Gates Foundation, an "exploration school" was identified in each of the nine superintendent regions throughout Maine. Seventh grade students and their teachers in these schools were given laptop computers, and a program of professional development for teachers acquainted them with basic computer skills.

Professional development was identified early in the MLTI process to be integral to program success. Each school selected a teacher to be the Regional Integration Mentor of the area. The Integration Mentor was charged with helping to design practices and procedures for laptop use within the designated "exploration schools," as well as assisting MLTI staff in the development of a statewide network of professional development related to technology integration in middle schools.

In the fall of 2002, the first full implementation phase of the MLTI began. Over 17,000 7th grade students and their teachers from 243 schools throughout the state received wireless iBooks. Simultaneously, the Maine State Board of Education established an extensive professional development network, including the deployment of Teacher Leaders and Technology Coordinators in each school to direct the MLTI rollout. More recently MLTI created the positions of Content Leaders and Content Mentors; Content Leaders are regional technology experts assigned to one of the nine superintendent regions, and Content Mentors are technology specialists that serve in individual schools.

The second phase of MLTI began the following fall of 2003, as every 7th and 8th grade student and their teachers were equipped with laptop computers. In 2007-2008, 7,000 laptops were distributed to teachers in grades 9-12 but not to high school students. Thus far, 100,000 Maine students have participated in the laptop program. Maine is not expanding its laptop program in 2008-2009, but it would like to include high school students in 2009-2010, if funding is available.[13]

Cost:
The initial phase of MLTI, lasting from 2002 to 2006, cost the state $41 million.[14] In 2006, the Maine Department of Education signed another four-year contract worth $41 million with Apple to equip 32,000 students and 4,000 teachers with wireless iBook notebook computers. Maine's 2007 decision to equip an additional 7,000 high school teachers with laptops increased the cost of the contract to $49 million. The multimillion-dollar deal also included software, software assurance (updates if newer versions of software are released), technological support, warranty support, repair, back-up storage, email for all students, an online learning environment (an online resource similar to Blackboard), professional development, battery protection, a wireless network in every school, project management (a team of Apple workers that lives in the state and manages the project), and asset management (an online system that keeps track of the location of the computers). Based on this contract, Maine's laptop initiative costs over $10 million annually. Because the additional school system salaries for technology support are not factored in, the total cost of ownership would be much higher than the contract cost of $290 per student.[15]

Findings:
The Maine Education Policy Research Institute (MEPRI) was charged with evaluating the impact of MLTI on classroom teaching and learning processes and consequently has conducted several evaluations. Two recent evaluations were published in April 2007 and October 2007 and used longitudinal surveys of teachers, students, and principals; site visits and observations; analysis of documents; and a controlled experimental study sampling mathematics classrooms throughout the state.[16]

The October 2007 report includes the most up-to-date findings regarding laptop programs and improved student achievement on standardized tests.[17]

- With the exception of writing, there was no appreciable change in Maine Education Assessment (MEA) scores since the inception of the laptop program.
- Writing scores on the MEA improved significantly between 2000 and 2005. An average student in 2005 had a higher score than approximately two thirds of all students in 2000. Greater levels of laptop use in the writing process (drafts, edits, final copy) were linked to significant increases in writing scores. Whether writing was done by hand or with a computer did not affect students' writing scores.

As regards laptop use by teachers and students, the April 2007 evaluation reports:

- 79% of students use laptops to research information, with 44% using to write/edit papers, 42% to take notes, and 41% to organize information.
- 74% of teachers use laptops to communicate with colleagues, and 64% use to develop instructional materials or provide classroom instruction.

Impacts of laptops on instruction and learning:

- Approximately 60% of teachers "strongly agreed" or "agreed" that students are more engaged while using laptops.
- Approximately half of teachers "strongly agreed" or "agreed" that the quality of student work increased when using laptops.
- Only 30% of teachers "strongly agreed" or "agreed" that students are better able to understand when using laptops.

According to the report, there is growing evidence to indicate that:

- teachers are more effectively helping children achieve Maine's state learning standards;
- students are more motivated to learn;
- students are acquiring twenty-first-century technology skills such as gathering data from multiple sources (61%) or evaluating information obtained on the Internet (51%); and
- the laptop program is positively impacting how knowledge is acquired because it provides access to up-to-date information, increases the speed of student learning, and individualizes student learning.

MEPRI is currently working on two studies related to the laptop initiative's effect on math achievement. The findings from one study should be released in the next six months, but the other is still in the data-collection phase.[18]

2. Michigan, Freedom to Learn Initiative (2002)

The Freedom to Learn (FTL) program was initiated by the state of Michigan in 2002 with the goal of helping students develop into self-sustaining, self-directed learners. FTL was implemented in two stages: a Demonstration phase and a Single Solution phase. During the 2002-2003 school year, $7.5 million in state and federal funds were awarded to 15 schools through a competitive grant process. Each of the 15 schools was given the latitude to design and implement its own program using wireless laptops or handheld devices and to designate the grade levels to be served. As envisioned, FTL was targeted at 6th grade students, but in most cases, it expanded to 7th and 8th grades and some high schools. A total of 7,256 students participated in the demonstration phase that determined that the project would proceed using laptops and not handhelds.

In fall 2004, the FTL program expanded with a focus on middle school students, using Hewlett Packard as the sole vendor. To participate in the program, Michigan school districts had to qualify for federal funding as "high need" districts. In addition, interested school districts had to meet eligibility criteria approved by the Michigan State Board of Education, including high need (poverty), high priority (not meeting AYP standards), and "technology readiness." Each district designed its own laptop program; in many, but not all, students were permitted to bring laptops home.

As of June 2008, FTL serves 30,000 students and 1,500 teachers in 200 schools across 100 school districts.[19] Thousands of Michigan educators have participated in related professional development activities.

Cost:
FTL is funded by a reallocation of federal Title II, Part D (Enhancing Education Through Technology, No Child Left Behind Act of 2001) as well as state funds from the Michigan State School Aid Act. FTL was originally designed as a lease program, allocating $1,100 per pupil over the four-year program duration ($250 per pupil per year plus $25 per pupil per year school district contribution not including supporting salary costs). In July 2004, the state decided that program would be better served with a purchase rather than a lease of the computers.

As regards sustainability, Michigan must return to its legislature every year to renew funding for the laptop initiative. As of June 2008, a total of $37 million has been allocated to the FTL program, and the Michigan Department of Education has provided $8 million of the federal grant funds to statewide professional development.[20] Additionally, the state appropriated $3.7 million in state funds in 2004/05 for FTL administration and evaluation, professional development, content resources, assessment, and grant awards to eligible school districts.

Findings:
The initial 2004/05 Evaluation Report of Michigan's Freedom to Learn Program (FTL) by the Center for Research in Educational Policy (CREP) did not include analysis of student learning and achievement in core academic subjects.[21] Nor is significant improvement expected, according to an email from the report's co-author, Dr. Steven Ross:

"Despite the highly impressive impacts of the laptop program in engaging students' higher-level learning activities and improving their technology skills substantially, we are not necessarily expecting noticeable achievement gains on the Michigan Educational Assessment Program (MEAP). The latter, like all state tests, is a high stakes multiple-choice assessment that seemingly has little direct connection with the real-world skills that laptop students are acquiring. The higher student engagement and effective teaching associated with the laptops might produce some carryover

effect on MEAP, but it may also be that the latter is not sufficiently sensitive to detect such impacts."

In a telephone conversation in June 2008, Dr. Ross corroborated that he does not expect to report any student achievement findings in the upcoming report due for release in Fall 2008.

However, based on the 2004/05 surveys of Michigan FTL students and faculty:

- Students reported that they were more interested in learning (61%), and made schoolwork easier (60%).
- Teachers reported that student-centered practices increased (88%), as did student motivation (90%), and technological skills (95%).
- Teachers (85%) believed that instruction and learning improved when students engaged in one-to-one computing.

The most recent evaluation by CREP (March 2007) for the 2005/06 school year confirms the above findings and adds those below; it also does not present any evidence linking computer usage to student achievement on tests.[22]

- Goal 1: Enhance student learning and achievement in core academic subjects.
  FTL students have demonstrated higher problem-solving skills and greater ability to use Internet resources and presentation software than non-FTL students.
- Goal 2: Provide greater access to equal educational opportunities.
  Laptops are available to students in 195 schools, and students report using laptops to aid schoolwork and learning.
- Goal 3: Foster effective use of wireless technology through professional development.
  Evidence of training effectiveness was seen in teachers' abilities to integrate technology, but professional development must be increased in frequency and scope.
- Goal 4: Empower parents with tools to become more involved.
  Approximately half of FTL schools reported that parents were supportive but actual parental involvement with FTL was minimal.
- Goal 5: Support innovative structural changes in schools.
  FTL schools were observed to have more classroom activities that engaged students in independent research using laptops.

3. Texas, Technology Immersion Project (2004)

From 2004-2008, the Texas Technology Immersion Project (TIP) provided competitive grants to schools in 23 districts under one of four campus configurations: as a whole district, as a vertical team of feeder schools, as a single secondary school, or as a middle school serving grades 6-8. In the first two years of the Project, 7,873 students and 636 teachers received laptops.[23]

Established in 2003 by the Texas Legislature, TIP is charged with the "primary goal of… increas[ing] the academic progress of students by immersing campuses in technologies that are directly linked to the enterprise of teaching and learning."[24] In order to achieve this goal, TIP advocates for technology immersion. Every participating school receives a technology package with six components, including a wireless mobile computing device for every student and teacher, productivity software, online content in the core curriculum areas, online formative assessment tools, ongoing professional development, and on demand technical support.

From 2004-2006, with $16 million from Title II, TIP funded one small rural district of schools (970 students), one team of feeder schools in a large urban district (3,900 students and 315 teachers), one middle school grades 7-8 in a large urban district (660 students and 40 teachers), and 22 middle schools grades 6-8.

With the exception of the 22 middle schools (grades 6-8) that used an approved technology package from the Texas Education Agency, each school district could choose to use the state's pre-approved technology package or to design its own, provided the plan included the six required components. The grant required that all students in the middle schools be permitted to take laptops home. Out of the 22 middle schools, 70% of the students came from economically disadvantaged backgrounds, 56% of the students were Hispanic, and 9% were African American. One third of the districts were in large cities or suburbs in the vicinity of cities.[25]

Due to financial limitations in 2006, TIP funding continued only for the 22 immersed middle schools.[26] It also started funding the 22 middle schools that had served as a comparison in the first phase evaluation of TIP. In 2007-2008, students in the control middle schools also received laptops.[27] Again due to funding limitations, control schools were required to immerse at least one grade level of students and teachers but not the entire schools.[28] In 2006 only the teachers in the control schools received laptops, in order to assess the extent to which teacher experience and training with laptops affect student outcomes. From 2006-2008 there were 681 teachers and 9,219 students in control campuses, but the number of students and teachers that actually received laptops is unknown.[29]

Cost:
In its first two years through 2006, TIP drew upon more than $16 million of federal funding from Title II, Part D (Enhancing Education through Technology, NCLB 2001).[30] In 2006 TIP received $12 million in Title II continuation funding.[31] For a three-year period, initial package costs ranged from $1,200 to $1,800 per student, or $400 to $600 per student annually, and were supplied by Dell Computer Inc., Apple Computer Inc., and the Region 1 Education Service Center.[32]

Findings:
TIP received a $1.95 million grant in 2004 from the U.S. Department of Education through the Texas Education Agency to conduct a multi-year evaluation of TIP in 22 immersed and 22 control middle schools (grades 6-8). The Texas Center for Educational Research (TCER) has annually evaluated the impact of laptop immersion on student achievement and other school-related outcomes using surveys of principals, students, and teachers; state education data sources; and site visits to each campus.[33]

TCER's most recent of three evaluations focuses on the program's third year (2006-2007) and reports the following findings:[34]

Effects on Students and Teachers:

- "Technology immersion significantly increased students' technology proficiency,…reduced the proficiency gap between economically advantaged and disadvantaged students," and significantly increased the frequency of interactions with peers in small-group activities.[35]
- Immersion students had significantly fewer disciplinary actions (0.65 compared to 0.90 in Cohort 1 [eighth graders], 0.53 compared to 0.86 in Cohort 2 [seventh graders], and 0.47 compared to 0.75 in Cohort 3 [sixth graders]) than control group students.
- Immersion students also had significantly lower school attendance rates (96.3% compared to 97.2%).

Effects on Academic Achievement on the Texas Assessment of Knowledge and Skills (TAKS)

- Immersion had no statistically significant effect on students' TAKS reading scores and the effects on social studies, science, and writing scores are inconclusive.
- Immersion had a statistically significant effect on TAKS mathematics scores, especially for students who were economically advantaged or higher achieving.
- Students who had more access to laptops and used laptops for learning to a great degree, especially outside of schools, (based on the number of days they had access to laptops throughout the school year, frequency of technology use for learning in core-subject classes, and laptop use for homework and learning games) had significantly higher TAKS reading and math scores.
- The positive effects on TAKS scores became stronger over time. The third year is the first one to show significant positive effects of immersion on achievement.

The report finds that only a quarter of the schools in the project had reached "substantial immersion" by the third year and that larger schools with a higher proportion of economically disadvantaged students had lower levels of implementation.

Looking ahead to academic year 2008-2009, Texas has applied for new competitive Title D funding for its Vision 2020 (or the Long-Range Plan for Technology 2006-2020). Vision 2020 aims to create an education system in which digital tools and resources are available to students, parents, and educators 24 hours per day, seven days a week. Vision 2020 will focus on the practices of earlier pilots in Texas that were the most successful, including TIP and the Virtual School Pilot (VSP), which provides online course offerings at some Texas schools.[36]

II. District-Wide Computing Initiatives

1. Henrico County Public School System, Virginia (2001)
In 2001, Henrico County Public Schools (HCPS) launched their iBook Teaching and Learning initiative with Apple/Dell, becoming the largest school district in the country to implement a one-to-one computing program.[37] Today HCPS provides laptops to every student and teacher in grades 6-12, approximately 31,000 teachers and students in 22 secondary and 48 elementary schools, in addition to every staff worker in grades K-12 and the central office.[38]

The iBook initiative in Henrico County emerged from a request by the HCPS school board to vastly improve technology usage in the school system. In developing a six-year technology plan, administrators discovered that less than half of HCPS students had home access to computers. Furthermore, while millions of dollars had been invested in the development of computer labs, HCPS students averaged just one session per week in these labs.[39]

Less than two thirds the size of Baltimore City's school population,[4]0 HCPS reported a 30% free and reduced price lunch rate in 2006/07,[41] significantly less than the 69% of students who are eligible in the Baltimore City Public School System (BCPSS).[42]

While individual schools implemented their one-to-one computing programs differently within HCPS, there were several common practices. Assistant principals were assigned to oversee the creation of an infrastructure to distribute and manage the laptops in each school. They were responsible for creating a laptop tracking system using barcodes, collecting insurance forms and payment from students, organizing a school Help Desk to provide technical support to students, and managing the general care of the laptops.[43]

Beginning with high school teachers, laptops were distributed prior to the 2001/02 school year; high school students received their laptops that fall. School staff discussed the use and care of the laptops and insurance with parents, who were then required to sign a contract stating that they understood the acceptable use policy. Training was provided to students once they received their laptops.[44]

Middle school teachers received laptops in January 2002; students were introduced to the iBooks via mobile labs before they were distributed to each student individually in January 2003. Parents were required to attend a 90-minute training session before their child received a laptop. The program also included the development of a student information system (K12 Planet) so that parents with computer access could be informed about their child's performance.[45]

Cost:
HCPS has invested over $50 million into its laptop initiative from 2001 to 2008 or an average of $7.5 million annually.[46] In 2001, it dedicated 5 percent of its operating budget (approximately $20 million) to fund a four-year lease of 25,000 iBook computers from Apple Computers. The original lease included maintenance support and the gradual replacement of older computers with newer models.[47] In addition, there was an annual allocation of $300,000 to provide professional development, tuition assistance, and training for teachers, but related technology salaries are not included in the system's quoted $300 per pupil cost.[48] Students and their families were asked to pay a $50 insurance deposit, though support was available in cases of financial hardship.[49] Importantly, HCPS agreed to subsidize low-cost home Internet connections of eligible students at a cost of $9.95 per month.[50]

Findings:
The most recent evaluation of the HCPS iBook initiative by Interactive Inc. analyzes data from 2005-06 to 2007-08.[51]

- Based on surveys of laptop use and "pinging data" ("randomly taking selections of laptops to see who is using them"),[52] students who used laptops the most frequently had significantly higher scores on Virginia's Standards of Learning (SOL) tests in World History, Biology, Reading, and Chemistry.
- Students who used laptops the most frequently had significantly lower scores in Algebra I & II and Writing.
- Over time, use of laptops in Henrico County has increased: at any given moment, 40% of students are using their laptops.

An earlier 2005 evaluation of Henrico's program was a joint collaboration between SRI International and Education Development Center, Inc. Researchers collected data through the end of the 2003-04 school year using primary data from the 2002/03 and 2003/04 school years as well as interviews and focus groups with over 100 administrators, staff, students, and parents.[53]

- Over the course of three years, Henrico County demonstrated that a large scale implementation of one-to-one computing is possible.
- There was an increase in student and family access to resources, student and teacher access to up-to-date instructional materials, and home-school communication.
- Teacher professional productivity, teacher collaboration with other teachers, teacher flexibility during instruction, and student-teacher interactions improved.
- Student engagement, motivation, interest, and self-directed learning increased.
- The project increased the need for planning time and increased classroom management issues.

2. Talbot County Public School System, Maryland (2005)

From 2005-2008, using over $1 million in private funding in addition to funding from Title II Parts A and D, Talbot County Public Schools (TCPS) launched a district-wide one-to-one laptop initiative, the first of its kind in Maryland.[54] In addition to increasing student achievement, Talbot County's initiative aims to demonstrate effective use of instructional technology, increase student engagement in learning, improve educational access for high-risk students, and provide a system that supports technology rich instruction.[55] Although Talbot County is much smaller, rural, and can count only 21% of its high school population as FARMS (compared with 51% in Baltimore City),[56] it is nonetheless instructive to look at another Maryland district operating under the same state and NCLB expectations.

In fall 2005, all 400 incoming ninth grade students from the district's two high schools received laptop computers for school and home use. TCPS added a grade to its program each year and will provide Mac Books to all high school teachers and 1,550 students in grades 9-12 in 2008-2009.[57]

Cost:

Most recently, the Talbot County Council budgeted $775,000 for the laptop initiative in its 2009 budget.[58] TCPS has a lease purchase agreement with an independent vendor that costs over $200,000 per grade level annually for laptops and infrastructure technology.[59] The lender allowed an "unfunded release" clause because Maryland school systems do not have an independent taxing authority, and TCPS relies on the County Council budget approval each year.[60] TCPS also spends approximately $150,000 per year on related expenses including a Help Desk technician, a repair technician, extended warranty coverage, breakage insurance, repair, software used in class to teach specific content, and licensed software tools that support general use such as SAT Prep.[61] This equates to a total cost of ownership of approximately $600 per student.

Some of the software is the same that has been and would be used in computer labs, and other software is beginning to replace print resources like textbooks. Additionally, Easton Utilities donated free or reduced-price dial-up Internet access for students who qualify for free or reduced price lunch.[62]

Parents are assessed $50 per year and must attend a laptop training session before a computer is issued to the student. TCPS provides discounts for students with economic hardship or for families with more than one student.[63]

In addition to school system allocations, Talbot County has raised $1,165,000 in donations and pledges since 2005, including a two-year commitment of $320,000 from The Grayce B. Kerr Fund.[64]

Findings:
The Center for Technology in Education (CTE) at the Johns Hopkins University is evaluating the TCPS program.

The most recent Year II (2006-07) evaluation found that[65]

- Students with teachers who have had two years of experience using laptops for instruction (graduating class of 2010) had the greatest academic improvement. A significantly higher proportion of students in the graduating class of 2010 passed the Maryland Algebra HSA (90%) compared to students graduating in 2008 and 2009 (55% in 2008 and 66% in 2009). This is consistent with Year I (2005-2006) evaluation findings that the class of 2009 with laptop access had higher final average grades in Algebra I than the 2008 cohort who did not have access to laptops.
- A significantly greater number of students in the class of 2009, which had laptops, passed the Biology and English HSA tests than the students graduating in 2008 who did not have laptops.
- More than half of students reported that laptops made classes more interesting, and a majority of teachers reported that students appeared more interested in classes when they used laptops.
- Teachers felt that the laptop initiative was very helpful for students with special needs (100% of teachers), students of lower economic backgrounds and students with limited English proficiency (more than 90% of teachers), and students at risk of falling behind because of poor academic performance (72% of teachers).

The evaluation notes that high-quality professional development and a responsive technical support and building management staff were essential to the success of the laptop initiative. Community support also was important because it encouraged private funding for the initiative.

Among other recommendations, the study suggests that a high level of professional development should be sustained and extended. At-risk students should be given specific assistance, and Special Education should be more involved in the initiative. Students should also be challenged to be more knowledgeable about complex programs and should be encouraged to gain awareness of the value of using laptops in elective classes (foreign language, art, music, etc).

III. Later Iteration of the One-on-One Computing Initiative:

Pennsylvania, Classrooms for the Future (2006)
In 2006, Governor Ed Rendell and Pennsylvania launched Classrooms for the Future, an initiative designed to change "the way teachers teach and students learn in Pennsylvania high schools by putting laptops on student desks in core classes and providing teachers with intensive training so they can effectively use the power of the Internet to engage the Technology Generation and make learning come alive."[66] In its first two years, the state spent over $126 million (or approximately $362 per pupil) on Classrooms for the Future and has provided over 110,000 laptops and related equipment to students; more than 356,000 students have benefited from access to these laptops.[67]

Unlike the other laptop initiatives, Pennsylvania's one-to-one laptop program does not give each teacher and student her own laptop for use in classroom and at home. Rather, laptops stay in the high school classrooms of core subject areas – English, math, science, and social studies.[68] Furthermore, Classrooms for the Future also pays for the purchase of related equipment such as Smartboards, projectors, web cameras, other video cameras, and imaging software.[69]

Cost:
In 2006-2007, Pennsylvania appropriated $20 million from the state's education budget for grants to school districts, providing 18,929 laptops and other equipment to 103 schools.[70] Pennsylvania also spent $5.8 million on teacher training that year, meaning that the average cost per school was $250,000. In its second year, Pennsylvania allocated $90 million to purchase an additional 90,264 laptops and equipment and $11 million for teacher training ($1,120 per laptop).[71] Governor Rendell is asking the state for $101 million from the state to continue the program in 2008-2009.[72]

Findings:
Researchers from Penn State University, Bloomsburg University, and the University of Michigan have co-authored a preliminary report on the first few months of Classrooms for the Future.[73]

- Teachers are spending significantly less time leading whole class lectures and are spending more time with individual students.
- Students are spending significantly more time working collaboratively with other students, participating in projects, and mastering twenty-first-century skills.
- Students are significantly more engaged in learning.

The report notes that the top three challenges with implementation are the need for continuing professional development, computer failures, and network downtime.

The next report, which should be released in August 2008, will examine Classrooms for the Future's effect on student achievement.[74]

IV. Conclusions:

The predominant model for one-to-one laptop programs focuses on secondary students and is targeted specifically towards middle school students beginning in 6th or 7th grades. A majority of the programs allow students to take laptops home and are frequently implemented using a grade-by-grade phase-in model.

There is not yet conclusive evidence that personal laptop use leads to gains in student achievement.
With the exception of Michigan, each state and district discussed has seen some improvements on standardized test scores as a result of their laptop initiatives. However, the gains in student achievement are inconsistent and sometimes contradictory. While both Texas and Talbot County report significant improvements in mathematics test scores, Henrico County reports significant decreases in mathematics test scores. While Maine reports significant gains in writing scores, Henrico County reports significant losses. Both Talbot and Henrico Counties report a positive effect on biology scores, and only Maine reports a positive effect on history and chemistry scores. Significantly, only Henrico County has documented negative effects of the laptop initiative.

Like implementation of laptop initiatives, findings on these programs have less than five years of data to draw upon. Accordingly, researchers of the Texas Technology Program note that the impact of this program on student achievement has grown over time with a minimum of three years needed to see significant differences.

Higher use of laptops yields higher academic gains.
While findings have not compared those programs that allow students to take computers home with those that contain the technology to school usage, Texas and Henrico County found that those who have more access to laptops with the ability to take them home (and subsequently use them most frequently) have significantly higher math and reading scores.

Laptops appear to increase the level of student engagement in learning.
Students and teachers in each state or district report that learning has become more student-centered, students are more engaged in learning, and that collaboration among and between students and teachers has increased. While teachers in Maine report that students are more engaged and the quality of work has improved, they do not believe that laptops aid understanding.

In Texas, laptops have led to fewer disciplinary actions, although teachers in all studies report that classroom management becomes more challenging with laptops. There is no evidence that one-to-one computing increases attendance. In fact, Texas found that those students with greater laptop use had lower attendance rates.

Talbot County reports that its laptop initiative has been particularly motivating for students who qualify for special education or FARMS or those with lower academic performance.

One-to-one initiatives have increased the equity of access to technology.
As illustrated in these school, district, or statewide programs, every student is served by technology. Furthermore, because the majority of the programs established criteria to serve poor students, many FARMS students and families became the beneficiaries of laptop computers and subsidized or free Internet access in their homes. Mark Warschauer, professor at University of California, Irvine, however, cautions that already-privileged students will continue to have an advantage working with laptops because of their prior experience with technology, their advanced academic skills, and support they receive at home. He argues that while laptops will help underprivileged students, the expectation that laptops will eliminate achievement gaps is unreasonable.[75]

Students and teachers have gained technology skills and other related workplace skills.
Schools with technology immersion programs report that increased use of technology has helped students develop problem-solving skills, learn to research information independently, use resources related to real life issues, and to utilize technology more proficiently. These twenty-first-century skills are likely to help students in the workplace. At the same time, as teachers become more proficient integrating technology with instruction, there is greater productivity and potentially gains in achievement.

It is difficult to gauge the total "cost of ownership" of one-to-one computing programs.
The total cost of ownership of laptop programs far exceeds the purchase of the computers (Zucker 2005, Robinett et al., Bielefeldt, Warschauer). Funding of the infrastructure to support one-to-one computer technology includes the wireless Internet connectivity in schools and homes, the extra technical support personnel, software, professional development of teachers, and repair and ongoing maintenance of the equipment. There is a wide range in reported cost per student (from $300 to $600 per pupil annually) depending on the size of the initiative and whether the related training and technical service costs are included; many districts include only the equipment lease or purchase costs rather than all related costs. A majority of programs have chosen to lease equipment on a four-year basis and generally are funded through district budget and Title II funding.

To date, laptop programs have little impact on increasing parental engagement.
With the exception of Henrico County, states and districts have engaged parents only to guarantee supervision of the equipment. Henrico County, however, designed its program using technology to increase home-school communication and has found that laptops have been useful in doing so.

Although not significant, there is a degree of laptop loss, theft, and damage that must be accounted for in planning a one-to-one initiative.
While minor repairs are covered by warranties under lease agreements, states and school districts need to replace laptops if they are damaged beyond repair, lost, or stolen. In Maine, less than one percent of laptops (40-45 of 4500 laptops) have been catastrophically broken, lost, or stolen since 2006.[76] While Michigan[77] and Talbot County[78] also report minimal laptop repair, loss, and theft, almost all of the laptop-immersed campuses in Texas reported hardware issues in the first and second years of implementation.[79] Henrico County dealt with so many hardware issues in its first year of implementation that it returned all of its laptops to Apple to replace faulty parts; the high frequency of breakage and the need for repair were significant barriers to successful implementation.[80] Even Maine reports that the rate of laptop damage was higher in the first few years of the laptop initiative.[81]

In order to ensure that students have continuous access to laptops, Talbot County and some districts in Texas have "laptop loaners," which are extra laptops that students can borrow if they are unable to use their own.[82] In Henrico County, Apple opened a local repair depot in order to complete repairs in under a week.[83]

Interestingly, in Texas, more students needed repairs at schools that allowed students to take laptops home (10 to 43 percent of students), compared to schools that kept laptops in the classroom (10 to 15 percent of students).[84]

A successful laptop initiative requires a long-term commitment of at least five years and recommends phased-in implementation.
Both ongoing professional development (Penuel, Zucker 2005, Rboinett et al., "America's Digital Schools 2006," Barrios) and technical support (Penuel, Barrios, Bielefeldt) at the school level are essential to the success of one-to-one programs. Most programs began implementation with one grade level per year and expanded laptop use to additional students over a number of years. The challenges of integrating large-scale technology use in lower-performing schools cannot be underestimated. For instance, after three years of implementation, only one quarter of Texas' immersion schools had reached a rating of "substantial immersion" based on teacher and student use and access to technology.

Successful implementation is dependent upon active educational and community support.
As emphasized by the evaluations of the Texas, Talbot County, and Maine laptop initiatives, the extent to which teachers, administrators, and the surrounding community support an initiative like this has a significant impact on its implementation and effectiveness (Penuel, Bielefeldt).

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