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Laptop Initiatives: Summary of Research Across Sctcl St_res

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Introduction

Schools and districts across the country are expanding their use of educational technology through the adoption of one-to-one (1:1) computing initiatives. One-to-one initiatives provide every student and teacher with a personal digital wireless device that includes up-to-date software and access to the Internet at school (Penuel, 2006). These initiatives also emphasize the use of 1:1 devices for teaching and learning (Muir, Manchester, & Moulton, 2005) to meet goals such as increasing equity of access to technology, updating teachers' knowledge and skills to improve instructional quality, increasing student engagement, improving academic achievement and technology literacy, providing more effective learning opportunities for students with special needs, increasing economic competitiveness, and enhancing home-to-school connections.

This brief summarizes findings from the evaluations of seven major 1:1 initiatives: Florida's Leveraging Laptops, Maine's Learning Technology Initiative (MLTI), North Carolina's 1:1 Learning Technology Initiative (NCLTI), Michigan's Freedom to Learn (FTL), Pennsylvania's Classrooms for the Future (CFF), Texas's Immersion Pilot (TIP), and Henrico County, Virginia's Teaching and Learning Initiative. The brief begins with an overview of each initiative and a description of the methodology used by evaluators. It continues with a description of the findings reported by evaluators in three areas: student outcomes, instructional practices, and planning and implementation. The brief concludes with a summary of major findings and a list of critical issues to consider when planning a 1:1 initiative.

Overview of the Initiatives

Florida *(Leveraging Laptops)*

Florida's Leveraging Laptops program (funded through the US Department of Education's Title II-D program, Enhancing Education through Technology) was created with the purpose of developing "effective models for enhancing student achievement through the integration of the laptop computer as a tool for teaching and learning in the classroom" (Florida Department of Education, 2009, p. 2). During the 2006-2007 school year, the program served 47 K-12 schools (15 elementary, 13 middle, and 11 high) in 11 districts and reached 440 teachers and about 20,000 students (Cavanaugh, Dawson, & White, 2007). The program continued in the 2008-2009 school year under the title Leveraging Laptops through the Florida Digital Educator. This new phase of the project focused on the "effective integration of innovative learning tools and project-based learning activities in K-12 curricula" (Florida Department of Education, 2009, p. 4) and involved 73 K-12 schools and 559 teachers in 16 districts (Cavanaugh, Dawson, and Buraphadeja, 2009). As of February 2009, the 16 districts participating in the program were providing students access to laptops through one or more of these methods: mobile carts, computers in the classrooms, and computer labs. Only four of the 16 districts were implementing true 1:1 programs (Cavanaugh, et al., 2009).

Maine ***(Learning Technology Initiative - MLTI)***

The Maine Learning Technology Initiative (MLTI) is a statewide program through which students in seventh and eighth grade are given a laptop computer. Seventh grade students and their teachers in more than 240 schools first received laptops in Fall 2002 (Fairman, 2004; Silvernail & Lane 2004); eighth grade students and their teachers received laptops the following year. In all, laptops were distributed to over 34,000 students and 3,000 teachers during the initial phase, and since that time, all Maine seventh and eighth graders have received laptops. In 2009, the MLTI was expanded to include Maine high schools with the distribution of about 65,000 laptops to students and faculty in grades 7 through 12. As of January 2010, participants in the MLTI included 226 middle schools (100%), 66 public (55%) and 1 private high school, 29,570 7-8th grade students, 23,717 9-12th grade students, 4,468 7-8th teachers, and 7, 401 9-12th grade teachers (Maine Department of Education, 2010)

Michigan ***(Freedom to Learn - FTL)***

The Freedom to Learn (FTL) program was implemented in 195 Michigan schools during 2005-2006. The primary goal of the FTL program was to improve student learning and achievement in Michigan through the integration of 21st century technology in K-12 classrooms. Participating schools included elementary, middle, and high schools, although initial implementation occurred primarily at the sixth grade level (Lowther, Strahl, Inan, & Bates, 2007). A total of 30,000 laptops were distributed to students and their teachers (L. Wilson, personal communication).

North Carolina ***(NC 1:1 Learning Technology Initiative - NCLTI)***

Beginning in the spring of 2008, a public-private partnership between the North Carolina State Board of Education, North Carolina Department of Public Instruction, Golden LEAF Foundation, and SAS supported the NC 1:1 Learning Technology Initiative (NCLTI). The NCLTI included eight Early College (EC) high schools and ten traditional high schools, with a total across the eighteen schools of approximately 9,500 students and 600 school staff. In these schools, every teacher and student received a laptop computer, and wireless Internet access was provided throughout the school. The overall goal of the initiative was to use the technology to improve teaching practices, increase student achievement, and better prepare students for work, citizenship, and life in the 21st century.

Pennsylvania ***(Classrooms for the Future - CFF)***

The Classrooms for the Future (CFF) initiative was implemented during the 2006-2007 school year. The purpose of the CFF initiative was to transform Pennsylvania's high schools into future-ready environments and to enhance teaching and learning (Peck, Clausen, Vilberg, Meidl, & Murray, 2008). By the end of the 2009-10 school year, the initiative had impacted 12,000 teachers and 500,000 students (Pennsylvania Department of Education, 2010).

Texas *(Texas Immersion Pilot - TIP)*

The Texas Immersion Pilot (TIP) was initiated in 2003 by the Texas Legislature to immerse schools in technology by providing tools, training, and support for teachers to fully integrate technology into their classrooms (Shaply, Sheehan, Maloney, & Caranikas-Walker, 2008). Twenty-three school districts across the state participate in the TIP project. A major goal of TIP is to increase students' academic achievement through technology immersion. Technology immersion consists of providing participating teachers and students with key technology resources, including a laptop computer, various hardware/software packages, ongoing professional development, and on-demand technical support (The Texas Immersion Pilot, 2006). As of 2008, the Texas Immersion Pilot has reached approximately 14,399 students and 755 teachers in 29 schools across 23 different school districts.

Henrico County, Virginia *(Teaching and Learning Initiative)*

The Henrico County Public School System in Virginia is the largest school system in the United States to have deployed a 1:1 laptop program on its own. Their Teaching and Learning Initiative began in 2001 with goals to improve students' 21st century skills, close the "digital divide," and reduce the system's reliance on textbooks (Henrico County Public Schools, 2009). Since 2001, Henrico County Public Schools have deployed approximately 24,000 laptops to all students in grades six through twelve, and about 3,300 laptops to teachers and administrators (Henrico County Public Schools, 2009).

Methodology Used in Evaluations

Evaluators have examined the impact of the initiatives on a variety of areas:

- Teaching practices (Florida, Henrico, North Carolina)
- Teachers' and students' roles in the classroom (Maine, North Carolina)
- Student achievement (Maine, Michigan, Pennsylvania, Texas, Henrico)
- Students with special needs (Maine)
- Fidelity of implementation of the initiative at the school level (Texas)
- Development of students' 21st century skills (Michigan, North Carolina)
- Effectiveness of professional development (Florida, Michigan, Maine, North Carolina)
- Teacher and administrator perceptions (Henrico, North Carolina)
- Parent involvement (Michigan, Henrico).

In most of the evaluations, researchers employed mixed-methods approaches. Data included: administrator, technology leader, teacher, student, and parent surveys; administrator, technology leader, teacher, and student interviews; classroom observations; extant documents (various school documents and student work samples); and results from standardized state assessments and on-demand student performance-based assessments.

Data collection instruments included the School Observation Measure,

Survey of Computer Use, Rubric for Student-Centered Activities, a Style of Learning Inventory, Torrance Tests of Creative Thinking, Arlin Test of Formal Reasoning, questionnaires, and interview protocols (see Appendix for a table summarizing the methods used in each evaluation).

The Findings

I. Student Outcomes

Engagement: Teachers and students generally agree that laptops increase student engagement. In Michigan, students reported that laptops made it easier to do school work, and that they helped increase their interest in learning (Lowther et al., 2007). Evaluators of Maine's LTI reported that students were more engaged and more actively involved in their own learning (Lane, 2003; Silvernail & Lane, 2004). Higher levels of engagement were observed especially among special needs students (Silvenail & Lane, 2004), students with disabilities (Harris & Smith, 2004), and at-risk and low-achieving students (Mitchell Institute, 2004). Maine students also reported "an increase in interest in their school work and an increase in the amount of work they are doing both in and out of school" (Silvernail & Harris, 2003, p. ii); in particular, a study by Berry and Wintle (2009) reported that even though students in Maine found a technology rich project to be more challenging and time consuming than a traditional one, they also tended to agree that such projects were more fun and engaging. Evaluators in Florida observed significant increases in student attention and engagement (Cavanaugh et al., 2007). They also reported that more than half of teachers' action research results documented an increase in conditions that support learning (e.g., enjoyment, motivation, engagement, on-task behavior, and positive school experience). Evaluators of the Texas Immersion Pilot found that teachers in schools in which implementation of various components of a 1:1 immersion model was most thorough believed that immersion increased student engagement (Shapley et al., 2008), and North Carolina teachers also felt that technology enhanced student engagement, though they noted that it could also be a distraction during class (Corn, 2009).

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Motivation: Teachers and students in some states concur that laptops increase student motivation, but results are mixed. Students in Maine reported that they were more motivated to learn (Silvernail & Lane, 2004) and more interested in school (Mitchell Institute, 2004). Motivation increased among all students, but larger increases were reported for students with disabilities (Harris & Smith, 2004) and at-risk and low-achieving students (Mitchell Institute, 2004). In Michigan, teachers reported that having laptops increased student motivation (Lowther et al., 2007). Conversely, many students in lower-implementing schools in Texas were glad that they would not have the laptops in high school (Shapley et al., 2008), and at the end of the third year, teachers in Henrico County felt that the laptops had not made a difference in students' desire to learn or their interest in classes (Mann, 2008).

Achievement: Teachers and students in some implementing states believe that the use of laptops positively impacts student achievement,

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but only some analyses of test scores support this belief. Maine teachers believed that the laptops improved student achievement in general (Mitchell Institute, 2004), and in particular that the quantity and quality of writing by students with disabilities improved because laptops "removed the motor coordination challenge of writing with pen and pencil and allowed [the students] to produce work that was easily edited and looked as good as the work of their non-disabled peers" (Harris & Smith, 2004, p. ii). Similarly, Michigan teachers reported that laptops increased student learning (Lowther et al., 2007), and in Florida, more than half of teachers' action research results documented changes in student achievement (as measured by test scores, higher-level thinking skills, retention, and transfer of learning; Cavanaugh et al., 2007). In Texas, teachers in higher-implementing schools believed that immersion improved the quality of students' products and narrowed the equity gap, while teachers in lower-implementing schools associated it with lower state test scores. Like their teachers, students in higher-implementing schools linked immersion to better grades and greater preparation for the state tests, whereas students in lower-implementing schools felt that the project had little if any effects on learning due to infrequent laptop use (Shapley et al., 2008).

Data from several studies support these perceptions. Muir, Knezek, and Christensen (2004) analyzed three years of standardized achievement data for eighth grade students who took the 2002 and 2003 Maine Educational Assessments (MEA) and participated in one of the nine Exploration Schools that implemented the initiative ahead of the other middle schools. They found that the students at the demonstration schools scored significantly higher in science, math, and social studies than did students at the comparison schools. In addition, Silvernail and Gritter (2007) found a statistically significant improvement in students' scores on the writing section of the MEA between 2000, two years before the implementation of the Maine Learning Technology Initiative, and 2005, when many schools were in their third year of laptop use. They reported that in 2005 the average writing scale score was 3.4 points higher than it was in 2000: "This difference represents an Effect Size of .32, indicating improvement in writing performance of approximately 1/3 of a standard deviation. Thus, an average student in 2005 scored better than approximately two thirds of all students in 2000" (p. i). They also noted that in 2000, only 29.1% of the eighth grade students met the writing proficiency standard on the MEA, but by 2005, the proportion had risen to 41.4%. In a related analysis, the researchers also found a statistically significant difference between the scores of students who did and students who did not use the laptops for writing. Students who used the laptop consistently in all stages of the writing process (e.g., drafting, editing, and reviewing) scored higher than did students who never used them for writing, as evidenced by the proportion of each group of students who met the writing proficiency standard on the MEA (43.7% for laptop users versus 21% for non-laptop users). Finally, the researchers found that using laptops in the writing process had a long-term positive effect on students' writing skills, helping them become better writers in general, and not just helping them write better when they used the laptops.

However, unlike the evaluations of the Michigan, Maine, and Florida initiatives, which reported positive relationships between the presence of 1:1 classrooms and student achievement, the evaluation of Henrico County's Teaching and Learning Initiative presented mixed results. In Mann's (2008) three-year longitudinal study, gains in achievement, as measured by state standardized tests, were associated with increased laptop use across several curriculum areas (including the sciences, history, and reading); however, there was a negative relationship between laptop use and Algebra I and II scores over the three years. This negative relationship was significant for the first two years, but the negative association did dissipate by year three. Mann also found a negative but non-significant relationship between geometry scores and laptop use for the first two years. In year three, there was a significant gain in geometry test scores when laptops were used once or twice a week, compared to when they were not used. A significant positive relationship surfaced between writing scores and computer use during the first year, but the relationship was significantly negative during the second and third years. The author attributed the negative relationship between writing scores and laptop use to the fact that teachers may be reluctant to use laptops since students take a paper-based writing test. At the end of the third year, teachers in Henrico County felt that the laptops had not made a difference in students' grades, quality of work, and written expression, nor had they made a difference in the achievement of failing students or in bridging the performance gap. Similarly, while Henrico administrators felt that the laptops made assessment more feasible and believed the laptops positively impacted students in numerous ways, they also believed that the laptops did not help the achievement of failing students (Mann, 2008).

Attendance: Findings regarding the improvement of student attendance after implementation of the 1:1 initiatives are mixed. Maine teachers and principals reported anecdotal evidence that laptops have had a positive impact on student attendance (Silvernail & Lane, 2004). Harris & Smith (2004) reported that attendance had increased among Maine students with disabilities. In Henrico, teachers and administrators felt that the laptops had not made a difference in students' attendance (Mann 2008). North Carolina high schools experienced a drop in student withdrawals the first year the laptops were introduced; however, this trend did not persist in the second year of implementation (Corn, 2009).

Discipline: Results regarding the impact of the initiatives on discipline are mixed. Maine teachers and principals reported that the laptops had a positive impact on student behavior (Silvernail & Lane, 2004). Lower-implementing teachers in Texas felt that 1:1 immersion had negative effects on student behavior (Shapley et al., 2008). In Henrico, teachers were concerned that the laptops were distracting and reduced attention. They were dissatisfied with student adherence to acceptable-use policies and said they had difficulty getting students to bring their laptops to class (Mann, 2008). North Carolina school staff saw the need for common consequences for laptop misuse across all classrooms, such as inappropriate storage of laptops in bags with multiple books, which led to the most common repair issue of broken screens (Corn, 2009).

Students tend to develop 21st century skills after implementation of 1:1 initiatives.

21st Century Skills: Students tend to develop 21st century skills after implementation of 1:1 initiatives. Students in higher-implementing schools in Texas felt that they would be better prepared for the future as a result of the initiative (Shapley et al., 2008). Similarly, students in Michigan said that they believed that their work with laptops would help them secure better jobs in the future (Lowther et al., 2007). Cavanaugh et al. (2007) reported that Florida students developed workforce skills as a result of the laptop initiative.

Technology skills. Students' technology skills tended to improve after the implementation of 1:1 initiatives (Cavanaugh et al., 2007; Lowther et al., 2007; Mitchell Institute, 2004; Shapley et al., 2008). In Michigan, teachers reported that having laptops improved not only student computer skills but also their own personal technology skills (Lowther et al., 2007). North Carolina teachers echoed this sentiment, reporting that student skills increased in areas such as creating websites, working with databases and spreadsheets, using digital images and video, social networking, blogging, and podcasting (Corn, 2009). Students in the Michigan initiative also reported that laptops improved their Internet research skills, and these students did indeed demonstrate significantly greater Internet and presentation software ability than matched-control students (Lowther et al., 2007). Students in Florida's initiative developed their abilities as producers of digital content (Cavanaugh et al., 2007). In higher-implementation schools in Texas, students felt that immersion improved their technology skills, and teachers believed that immersion narrowed the technology equity gap (Shapley et al., 2008).

Learning and innovation skills. Students in 1:1 initiatives also developed learning and innovation skills. Students in Florida's initiative showed signs of developing innovation and creativity (Cavanaugh et al., 2007). Students in higher-implementing schools in Texas expressed that immersion improved their learning skills and that they felt more organized and responsible as a result of the project (Shapley et al., 2008). Evaluators of the Florida initiative observed significant increases in student use of computers to support critical thinking skills as well as significant decreases in student use of computer to support lower-level thinking (Cavanaugh et al., 2007). One-to-one students in Michigan were more likely to use higher-order thinking strategies, and they demonstrated significantly higher problem-solving ability than did matched-control students (Lowther et al., 2007). A large number of North Carolina students reported that they used the technology every day to analyze information, create new information, assess their learning, and submit assignments electronically (Corn, 2009).

Communication and collaboration skills. Researchers in Florida observed significant increases in cooperative and collaborative learning and significant decreases in independent seatwork (Cavanaugh et al., 2007). In Maine, Harris and Smith (2004) reported that laptops helped Maine students with disabilities interact more with other students and with teachers. Also, the ability of at-risk and low-achieving students to work in groups increased more than did that of traditional and high-achieving students (Mitchell Institute, 2004), and low-performing and special-needs students often taught others about technology (Fairman, 2004). Recognition of students' technology knowledge and skills by

teachers (Fairman, 2004) and the capacity to produce work of similar quality as that produced by non-disabled students (Harris & Smith, 2004) helped to increase the self-esteem and confidence of students, as well as the respect they received from others in the school and the community (Fairman, 2004).

Self-directed learning. Students not only were participating more in group work but also were engaging in self-directed learning. Researchers observed significant increases in independent inquiry and research (Cavanaugh et al. 2007), and at-risk and low-achieving students were more engaged in self-directed learning than were traditional and high achieving students (Mitchell Institute, 2004). Students in higher-implementing schools in the Texas Immersion Pilot indicated that immersion allowed them to become more responsible and better prepared for college (Shapley et al., 2008). Henrico teachers believed that the laptops enhanced the learning experiences of students with different learning styles (Mann, 2008) and Maine teachers believed that laptops increased opportunities for individualized learning (Fairman, 2004). Since the start of the Pennsylvania initiative, students have been more likely to choose and complete projects based on their interests, and their teachers also have been more likely to allow them to choose whether they worked independently or in groups (Peck et al., 2008).

II. Changes to Instructional Practices

Technology use for instruction: Teachers and students use laptops for a variety of tasks germane to learning and instruction. Teachers in the Maine initiative often used their laptops to develop instructional material (e.g., plan instruction, create integrated lessons, present lessons, and create student assignments; Beaudry, 2004; Silvernail & Harris, 2003), quickly access up-to-date information related to instruction (Silvernail & Harris, 2003; Silvernail & Lane, 2004), and communicate or collaborate with colleagues (Beaudry, 2004; Silvernail & Lane, 2004), but they used them less frequently to assess student work and provide feedback to students (Beaudry, 2004). Researchers also found that teachers with more advanced technology skills used the laptops 20% to 30% more often than did their peers (Silvernail & Lane, 2004). Teachers in the Maine initiative also perceived benefits of 1:1 that ranged from improvements to their technology knowledge and skills to classroom management benefits as a result of allowing tech-savvy students to handle peers' technology-related questions and problems during class time (Fairman, 2004).

In Maine, students used the laptops to locate information (Harris & Smith, 2004; Silvernail & Harris, 2003; Silvernail & Lane, 2004), organize information, take class notes (Silvernail & Lane, 2004), compose using a word processor (Harris & Smith, 2004), complete assignments, create projects, and communicate with teachers and other students (Silvernail & Harris, 2003). Students in the Maine initiative also reported that the laptops helped them to be better organized, get their work done more quickly, and do work of better quality (Silvernail & Lane, 2004). North Carolina Early College high schools experienced a significant increase over time in student use of laptops to present content, give online quizzes, present steps in an activity, take virtual field trips, and use

instructional websites or blogs (Corn, 2009). In higher-implementing schools and among higher-implementing teachers in Texas, students used the laptops more frequently and for a more sophisticated range of activities than did lower-implementing schools and teachers. Among lower-implementing schools and teachers, laptops were used most often for skills practice, state test review, games, or free time (Shapley et al., 2008).

Pedagogy: Implementation of 1:1 often leads to several changes in pedagogy and classroom practices. The classroom approach shifted from a teacher-centered to a student-centered focus (Fairman, 2004; Mitchell Institute, 2004) and innovative practices, such as authentic learning (Lowther et al., 2007), experiential, hands-on learning activities (Lowther, Strahl, Zoblotsky, & Huang, 2008), project-based learning (Cavanaugh et al., 2007; Corn, 2009; Lowther et al., 2007; Lowther et al., 2008; Peck et al., 2008), multi-modal teaching, peer teaching (Lowther et al., 2007; Peck et al., 2008), inquiry approach/research, interdisciplinary approaches (Cavanaugh et al., 2007; Fairman, 2004: Lowther et al., 2007; Lowther et al., 2008), collaborative/cooperative learning (Cavanaugh et al., 2007; Fairman, 2004: Lowther et al., 2007; Lowther et al., 2008; Peck et al., 2008), differentiated instruction (Fairman, 2004; Mitchell Institute, 2004; Silvernail & Lane, 2004), academically focused class time; using computers used as a learning tool, using computers to support critical thinking skills (Cavanaugh et al., 2007), and teacher use of higher-level questioning strategies (Lowther et al., 2008), replaced traditional teacher-centered practices. Researchers also observed changes in the physical organization of the classroom, such as having clusters of three to five desks instead of the traditional row design (Lowther et al., 2007; Peck et al., 2008).

Teachers in the initiatives reported a positive impact on classroom instruction, and teacher readiness to integrate technology. Teachers in the Michigan initiative showed great confidence that they knew how to meaningfully integrate laptop use into lessons, align use of the laptops with curriculum standards, and conduct lessons with students using laptops (Lowther et al., 2007). Similarly, teachers in Maine said that the laptops helped them better meet curriculum goals as well as Maine statewide learning standards (Silvernail & Lane, 2004).

In several of the 1:1 initiatives, teachers shifted away from traditional pedagogical approaches and became facilitators and coaches (Cavanaugh et al., 2007; Corn, 2009; Fairman, 2004; Lowther et al., 2008; Peck et al., 2008), and students became more engaged in student-centered activities (Lowther et al., 2008).

Teacher and student roles: Teacher and student roles tend to shift after implementation of 1:1. In several of the 1:1 initiatives, teachers shifted away from traditional pedagogical approaches and became facilitators and coaches (Cavanaugh et al., 2007; Corn, 2009; Fairman, 2004; Lowther et al., 2008; Peck et al., 2008), and students became more engaged in student-centered activities (Lowther et al., 2008). Teachers in Michigan reported that having laptops increased their use of student-centered practices. They spent significantly less time on whole-class lecture and more time working with individual students and walking through the room observing and interacting with students (Lowther et al., 2007). In Maine, teachers and students agreed that using laptops in the classroom led to a more reciprocal relationship between teachers and students: Students became teachers and teachers became learners. Students comfortable with technology helped other students and adults in the school with technology-related tasks in both informal (e.g.,

unplanned activities) and formal ways (e.g., teacher-planned activities and school-sponsored clubs), while teachers learned from their tech-savvy students, who offered them suggestions or provided technical support in the classroom (Fairman, 2004).

III. Planning and Implementation

Leadership: Effective leadership is crucial for the success of a 1:1 initiative. Leadership that promotes a shared vision for technology usage can influence greatly the outcomes of a 1:1 initiative (Peck et al., 2008). Silvernail and Lane (2007) found that another factor that contributes to the effectiveness of 1:1 initiatives is "the presence of one or more key individuals in the schools who [serve] as champions of the laptop program and [provide] strong leadership during implementation of the program. In some cases, this was the school principal, in others it was a formally designated or informally designated teacher leader, and in a few cases it was a technology coordinator" (pp. 33-34). In higher-implementation schools in Texas, principals supported and encouraged 1:1, and district-level administrators also demonstrated strong buy-in. In addition, these district leaders maintained a close, ongoing relationship with the schools. By contrast, in lower-implementing schools initial strong support waned and involvement from key administrators and principals decreased as the project progressed. Consequently, teachers in higher-implementing schools exhibited positive attitudes about the laptop project, expressed an awareness of why immersion was important, appreciated and enjoyed the professional development opportunities, and felt an increase in confidence and in their technology skills. By contrast, teachers in lower-implementing schools resisted the instructional and structural changes required by the initiative and often abandoned technology-related efforts when faced with technical problems (Shapley et al., 2008).

Successful 1:1 implementation also requires leaders to model what they expect from teachers and students (Peck et al., 2008) and provide support and encouragement for the initiative. In Henrico, for example, administrators reported using the laptops for communication and data management tasks (Mann, 2008). Similarly, the North Carolina evaluation recommended that leaders support related professional development, set reasonable expectations for 1:1 integration, model technology use, provide resources and support, and communicate the vision and expectations of the initiative to all stakeholders (Corn, 2009).

Successful 1:1 implementation requires leaders to model what they expect from teachers and students (Peck et al., 2008) and provide support and encouragement for the initiative.

Professional development: High-quality professional development is necessary for the success of 1:1 initiatives. Silvernail and Buffington (2009) studied a two-year, 200-hour 1:1 professional development program and found that it "was effective in changing teaching and technology practices, which in turn led to improved student performance on standardized mathematics tests" (p. i), suggesting that well-planned and sustained professional development is more effective than sporadic training. A key finding from the evaluation studies in Texas was that the structure of professional development impacted the subsequent level of implementation. Higher-implementing schools developed and maintained close relationships with professional development providers. These

schools also gave professional development high priority by building in training days, basing training on teachers' evolving needs, and holding teachers accountable for implementing what they had learned (Shapley et al., 2008).

Professional development that is not sensitive to the needs of implementing teachers and schools was less effective. Lower-implementing schools in Texas experienced frequent changes in trainers, and teachers typically only participated in brief professional development sessions during or after school. Their professional development was characterized by an emphasis on proficiency with the products, rather than on ways to integrate laptops into their teaching environments (Shapley et al., 2008). Teachers in Maine identified lack of time and a lack of professional opportunities as obstacles to the integration of laptops into their curriculum (Silvernail & Lane, 2004). Teachers in Pennsylvania also felt that the necessity of ongoing professional development was an obstacle (Peck et al., 2008). Teachers in North Carolina echoed this sentiment, along with a desire for opportunities to collaborate and share successful lessons for a 1:1 classroom environment (Corn, 2009).

Infrastructure: 1:1 initiatives tend to be more successful in schools with robust technology infrastructures and efficient technical and instructional support. In Texas, higher-implementing schools had infrastructures in place that were sufficient for conversion to 1:1, including stable networks with adequate bandwidth and ongoing, timely technical support (Shapley et al., 2008). These schools also had loaner laptops available, as well as desktop computers in classrooms. Lower-implementing schools had less-than-optimal infrastructure in place: Their networks were undependable and technicians suffered from work overload (Shapley et al., 2008). In North Carolina, Technology Facilitators and technicians have been essential in helping teachers effectively integrate 1:1 technology into their classroom. Technology Facilitator responsibilities typically include providing instructional support and professional development to teachers, while technicians focus primarily on providing technical support to teachers and students (e.g., setting up computers, installing software, troubleshooting, and handling virus protection and removal; Corn, 2009). Maine teachers identified lack of technical support as one of the obstacles to the integration of laptops into their curriculum (Silvernail & Lane, 2004). In North Carolina, problematic infrastructure issues have included lack of Internet access in temporary classrooms and networks that were not ready for the heavy demand that accompanies 1:1 implementation (Corn, 2009).

Summary

Evaluators of the 1:1 initiatives in Florida, Maine, Michigan, North Carolina, Pennsylvania, Texas, and Virginia found generally positive relationships between 1:1 environments and various aspects of the teaching and learning process. They reported that teachers used the laptops to develop instructional materials, access information related to instruction, and communicate with colleagues; students used laptops to complete classroom assignments and conduct research. Since the implementation of the initiatives, in many implementing locales there has been a shift from teacher-centered to student-centered instructional practices in the classroom, with teachers facilitating more and presenting less, and many students becoming more self-directed learners. Students have shown an increase in engagement and motivation after the implementation of several of the 1:1 initiatives. Some but not all of the evaluations also have found an association between laptop use and increased student achievement in several academic areas. Evaluators also report that laptops have facilitated the development of 21st century skills (e.g., digital literacy, creativity and innovation skills, critical thinking and problem solving skills, communication and collaboration, and self-directed learning) among students.

Critical Issues for Planning and Implementation

Successful planning and implementation of a 1:1 initiative demands careful attention to a variety of factors. Effective leadership is fundamental for the successful implementation and sustainability of the initiative, as are thorough planning, initial and ongoing targeted professional development, buy-in from all stakeholders, and a robust infrastructure. Implementers should plan to assess the initiative's impact on student learning and use the results to make adjustments to improve that learning. In particular, those initiating or expanding a 1:1 laptop project should consider the following recommendations:

- Develop a thorough implementation plan and train teachers before distributing digital devices;
- Ascertain that the school or district has the appropriate technological and leadership infrastructures to run the program;
- Secure strong buy-in from all stakeholders, including district and school leadership, teachers, students, parents, and the community;
- Construct a leadership team with an eye toward members who will commit long-term to the initiative and support it;
- Provide continuous professional development that is aligned with teacher needs;
- Ensure continuous availability of efficient technical and instructional support personnel;
- Enact policies for the appropriate use of digital devices and resources; and
- Use data from project evaluations to inform and improve future program decisions.

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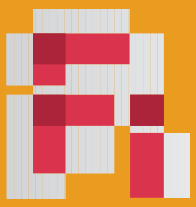
Appendix

Data collection methods used in the evaluation of 1:1 initiatives

State	Survey*				Interview*						Teacher Observation	Document Analysis (*e.g.*, test scores, rubrics, videos)	Action Research
	S	T	A	TC	S	T	A	TF	P	DPC			
Florida		X								X	X	X	X
Maine	X	X		X	X	X	X		X		X	X	
Michigan	X	X						X			X	X	
North Carolina	X	X	X					X			X	X	
Pennsylvania	X	X					X				X	X	
Texas	X	X	X		X	X					X	X	
Virginia (Henrico)	X	X	X		X	X	X				X	X	

*Note: S=Student, T=Teacher, A=Administrator, TC=Technology Coordinator, P=Parent, TF=Technology Facilitator, DPC=District Project Coordinator



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