Statewide Study of 1:1 Computing: The Impact on Teaching and Achievement

Cathy Cavanaugh & Kara Dawson
University of Florida

Albert Ritzhaupt
University of North Carolina, Wilmington

Abstract: This paper presents the results of a one-year 1:1 computing study conducted in 440 K-12 classrooms in eleven school districts in Florida. The purpose of the research was to identify changes in teaching practices and student learning that occurred after an infusion of professional development experiences, classroom technology, and support. Each teacher participated in a summer institute that emphasized student-centered, tool-based integration of technology, followed by professional development in the school and district during the implementation year. Each classroom received laptop computers, networking capabilities, and peripheral devices. Classrooms were supported by technical and curriculum support. Data included a survey of teachers' perceptions of technology, multiple observations in each classroom, and teacher reports of student achievement. The results describe the impact of laptops and professional development on teaching and student achievement within eleven different implementation models.

Research on 1:1 classroom computing has demonstrated that changing the learning environment by making computers available with concomitant changes in the teachers' expertise in teaching in the new environment results in changes in teaching practices (Henriquez and Riconscente 1999, Stevenson 1998, Rockman et. al 1998, Fairman 2004, Fisher & Stolarchuk 1998, Warschauer & Sahl 2002, Fairman 2004). The primary motivation for providing 1:1 classroom technology and teacher professional development is the belief that the new learning environment will support engaged students and increases in academic achievement (Barrios 2004). Approximately a decade of classroom laptop research supports these views, but has provided limited guidance into the specific models of implementation that are most likely to lead to positive outcomes (van 't Hooft, Swan, Cook & Lin 2007). Because each of the eleven district implementation models in this research was unique, we were able to explore the nature of the changes in teaching and learning under a range of conditions with the goal of describing the features of effective laptop implementation models.

Florida's *Leveraging Laptops: Effective Models for Enhancing Student Achievement* grant competition funded eleven school districts to implement ubiquitous computing in K-12 classrooms. The purpose of the *Leveraging Laptops* program was to develop effective models for enhancing student achievement through integration of 1:1 computer tools and student-centered instruction. The *Leveraging Laptops* program also supported a multi-university research team to study and evaluate the effects of these initiatives. This research involved 440 teachers across all subject areas in 47 K-12 schools in eleven Florida districts. The purpose of this paper is to present the results of this research.

Each district's model included classroom and networking technology resources, a professional development program, and support for the classrooms, all of which were selected to address an expressed need in the district. This study focuses on the changes in teaching and learning that were documented in the new learning environments. Learning was broadly defined to encompass al academic knowledge and skill as well as the behaviors and dispositions that support learning.

The specific objectives of the study were to identify the changes in tool-based student-centered teaching that happened in classrooms that experienced an infusion of technology, professional development, and support, as well as to identify the features of the implementation models associated with the changes. The following questions align with the framework and guided the research and evaluation efforts:

(1) What are the **conditions** (i.e. goals, technologies, settings, implementation plans, etc.) of the 1:1 computing initiatives in each school district?
(2) What are the **processes** (i.e. including professional development experiences, teaching practices, technology deployment, support and parental involvement, etc.) of the 1:1 computing initiatives in each school district?
(3) What are the **consequences** (i.e. including student achievement, changes in teacher practices, impact on parents, sustainability, etc.) of the 1:1 computing initiatives in each school district?

Multiple methods of data collection were used to answer the research questions. In this section, each strategy is specified below and aligned with the research questions.

(1) *School Observations*: The *School Observation Measure (SOM)* (Ross, Smith, Lowther & Alberg, 2006) and the *Survey of Computer Use (SCU)* (Lowther & Ross, 2000) were used to ascertain teaching and instructional practices within schools involved in the 1:1 computing initiatives. Specifically, the SOM is a valid and reliable measure used throughout the country to capture the frequency of research-based instructional practices ranging from traditional (i.e. direct instruction, seatwork, etc.) to student-centered (i.e. project-based learning, inquiry, etc.) The SCU is also a valid and reliable measure used throughout the country to capture the technology configuration, technology use, and types of technology implemented within schools. Numerous classroom observers were trained in SOM and SCU techniques and observations of all schools involved in the 1:1 initiatives occurred multiple times throughout the evaluation. These observations inform our knowledge of questions 2 (processes) and 3 (consequences)

(2) *Document Analysis*: An analysis of the grant proposals, district web sites and other artifacts helped to inform question 1 (conditions).

(3) *Interview with Grant Coordinators*: Semi-structured interviews with grant coordinators were conducted to triangulate document analysis and inform question 1 (conditions).

(4) *Teacher Inquiry*: Teachers from 1:1 computing classrooms in each district conducted action research to inform question 3 (consequences). Specifically, these teachers received

mentoring in using Dana and Silva's (2003) model of teacher inquiry to determine how their 1:1 computing efforts influenced student achievement. This strategy allowed us to explore student achievement at the classroom level and through the eyes of the teacher. Teacher inquiry was chosen because it provided deep data from a specific use of technology that fit within the limited time frame of our evaluation, it avoided the inherent problems of using standardized test data to document the effect of technology use (Haertel & Means, 2004) and it fit with the need for documenting classroom-based student achievement (Dawson & Ferdig, 2006).

(5) *Teacher Survey*: A survey was administered to all teachers participating in the 1:1 computing initiatives. The survey was designed to measure four relevant domains: technology integration; support; preparation, confidence and comfort; and attitude toward computer use. In a previous validation study of this instrument, exploratory factor analyses results demonstrated psychometrically sound factors and measures of internal consistency reliability (Cronbach alpha) exceeding 0.7 for each domain (Harmes, Kemker, Kalaydjian & Barron 2000; Hogarty & Kromrey, 2000). This survey was used to triangulate data collected by other means and to inform question 1 (conditions), question 2 (processes) and question 3 (consequences).

Theoretical Framework

The *Leveraging Laptops* study is based on the premise that changes in the learning environment foster changes in learning. When learning environments more closely approximate authentic performance environments, the actions of teachers and students changes in ways that approach the norms of the new environment (Herrington & Oliver 2000). Technology-rich learning environments bridge the gap between knowing and doing, thereby moving knowledge from an inert to an active state as it is applied to immediate problems presented through the technology. When a classroom has anytime access to problem-solving tools that closely simulate the tools used by expert problem-solvers, then the participants in that classroom are likely to assume the roles of problem-solvers, which typically involve teamwork and a flattened hierarchy. These environments therefore support and encourage tool-based student-centered teaching and learning.

Recent research in 1:1 computing initiatives in K-12 classrooms demonstrates that the learning environment has a powerful effect on the roles of the students and teachers in those environments. Reports of changes in teaching practices include shifts toward more student-centered practices (Henriquez and Riconscente, 1999; Stevenson, 1998; Rockman et. al, 1998; Fairman, 2004), an increased emphasis on inquiry-based practices (Fisher & Stolarchuk, 1998), an increase in cooperative learning and project-based instruction (Warschauer & Sahl, 2002; Fairman, 2004), and more differentiated instruction (Fairman, 2004). Other positive effects of laptop use include better teacher/student relationships (Fairman, 2004), improved home-school relationships (Russell, Bebell & Higgins, 2004), bridging the digital divide (Gravelle, 2003) and the perception that laptops provide social and academic benefits for special education students (Harris & Smith, 2004).

Findings related to laptop use in schools and their impact on student achievement are less conclusive. Some studies report increased levels of academic performance as compared to

students without laptops (Stevenson, 1998; Lowther, Ross & Morrison, 2003; Warschauer, 2006) while other studies report marginal effects (Gardner, 1993; Silvernail, 2005; Warschauer & Grimes, 2005). Recent studies focusing on literacy and laptop use report advantages for laptop users on tests of writing and problem solving skills (Lowther, Ross & Morrison, 2003) while others claim that standardized paper and pencil tests of writing skill do not adequately reflect the writing skills developed through extensive experience with the computer (Russell & Plati, 2002).

Research Design and Methods

By adopting an authentic learning environments framework, we were able to study and document the integration of 1:1 computing in schools across their unique contexts and to identify numerous forms of outcomes. The theoretical framework and research purposes outline above provided the basis for the study to address the primary research goal.

The eleven participating districts represented the diversity that is present in public education in Florida. The districts ranged in size from the smallest with just six K-12 schools to the largest with 317 K-12 schools. A wide array of economies was represented in the participating communities, from urban to agricultural. Correspondingly, the numbers of schools and teachers reached in this program varied by district.

The researchers used a cluster evaluation model to examine the features of the eleven participating districts' models (Patton, 2001) along with Hall's (1995) conception of conditions, processes and consequences to frame the study. This framework is very similar in theory to the "Evaluation Framework for 1:1 Computing" developed by SRI International (Zucker 2004). Hall's terminology was chosen because it is easier to comprehend; however, the SRI International evaluation framework informed much of our work. Table 1 outlines the data collection strategies used to describe each district model's conditions, processes and consequences.

Conditions		**Processes**		**Consequences**	
Conditions examined	**Data collection strategies**	**Conditions examined**	**Data collection strategies**	**Conditions examined**	**Data collection strategies**
Technology used	Documents, interviews	Professional development	Documents, interviews, surveys	Student achievement	Teacher inquiry
Setting	Documents, interviews	Teaching practices: student-centered and tool-based	School observations	Changes in teacher practices: student-centered and tool-based	School observations, surveys
Implementation plan	Documents, interviews, survey	Technology deployment	Documents, interviews, surveys	Impact on parents	Documents, interviews
Goals and objectives	Documents, interviews	Support	Documents, interviews, surveys	Sustainability	All
		Parent involvement	Documents, interviews		

Table 1. Data collection strategies within research framework

Data Analysis and Results

A mixed method approach to data analysis was implemented. Data from each strategy was first analyzed independently and then a qualitative synthesis across strategies contributed to the description of the eleven district laptop implementation models. The *observation* data were analyzed by way of repeated measures Analysis of Variance (ANOVA) in which baseline and end-of-year differences were investigated for each of the strategies and categories assessed on the School Observation Measure (SOM) and Survey of Computer Use (SCU). The *survey* analyses consisted of a descriptive analysis of response frequencies and measures of central tendency and variation, and internal consistency reliability analysis. *Document analysis and interview transcripts* were analyzed using qualitative analytic procedures (Rossman & Rallis, 1999). *Teacher inquiry* results were analyzed using modified meta-analysis procedures (Clausen, 2006). From these independent analyses a profile of the conditions, process and consequences of 1:1 computing in each district was developed. Then, a conditional matrix (Strauss & Corbin, 1990) was used to organize the wealth of data and distinguish linkages between and among the conditions, processes and consequences of 1:1 computing in the 11 districts. Statistical analyses such as cross tabulations and Pearson correlations were also used as appropriate between and among findings.

Teacher Survey

The online teacher survey provided a baseline picture at the start of the 1:1 computing program year of each teacher's professional development experiences, uses of classroom technology, and perceptions of classroom technology, as well as demographic information including grade and subject area taught, teaching experience, teaching certification, and technology experience. Scales on the survey were designed to measure four domains relevant to a teacher's background and dispositions for teaching in a technology-integrated learning environment: technology integration; perceived support; preparation, confidence and comfort; and attitude toward computer use. Each item was formatted as either dichotomous response items (e.g. certified in grades 6-12 mathematics), five-level Likert ranging from strongly agree (5) to strongly disagree, or five-point frequency of use scale ranging from not at all (1) to every day (5).

The teachers represented all grade levels K-12, all subjects areas, and a range of teaching experience from first year to over 30 years. The majority of the laptops in their classrooms were new for the 1:1 program, representing an aspect of the new learning environment. The teachers' preparation to make effective use of the new learning environment is in part a function of their technology skill. More than 50 percent of the respondents reported acquiring computer skills to a small extent or not at all as part of their college coursework, distance learning courses, or summer institutes which all participating teachers attended. More than 50 percent of the respondents reported acquiring computer skills moderately to entirely from professional development, independent learning and interaction with other faculty and staff, as shown in Table 2.

Computer Skills Source	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)
As part of your college coursework	28.02	25.82	21.15	19.23	4.12
Professional development	3.3	22.53	32.42	37.09	3.85
Independent learning	3.3	18.68	27.2	43.41	6.04
Interaction with other faculty/staff	2.75	23.9	37.91	31.32	3.3
Distance learning courses	55.22	20.33	13.46	6.59	1.65
Teaching and Learning Summer Institute	28.02	25	27.2	16.21	1.92

1 - Not at all , 2 - To a small extent, 3 - To a moderate extent, 4 - To a great extent, 5 – Entirely

Table 2. Source of teacher computer skills as percentages.

School Observations

All *Leveraging Laptops* teachers were observed teaching at least once in the first half of the project school year and at least once in second half of the year by trained observers using the *School Observation Measure* and the *Survey of Computer Use*. Key SOM strategies of importance to this research are those recommended as research-based best practices for enhancing learning through student use of technology as a tool to solve authentic problems.

These strategies are:

- cooperative/collaborative learning,
- higher level instructional feedback (written or verbal) to enhance student learning;
- project-based learning;
- use of higher-level questioning strategies;
- teacher acting as a coach/facilitator;
- experiential, hands-on learning;
- independent inquiry/research on the part of students;
- student discussion;
- and technology as a learning tool or resource (e.g. Internet research, spreadsheet or database creation, development of multimedia products).

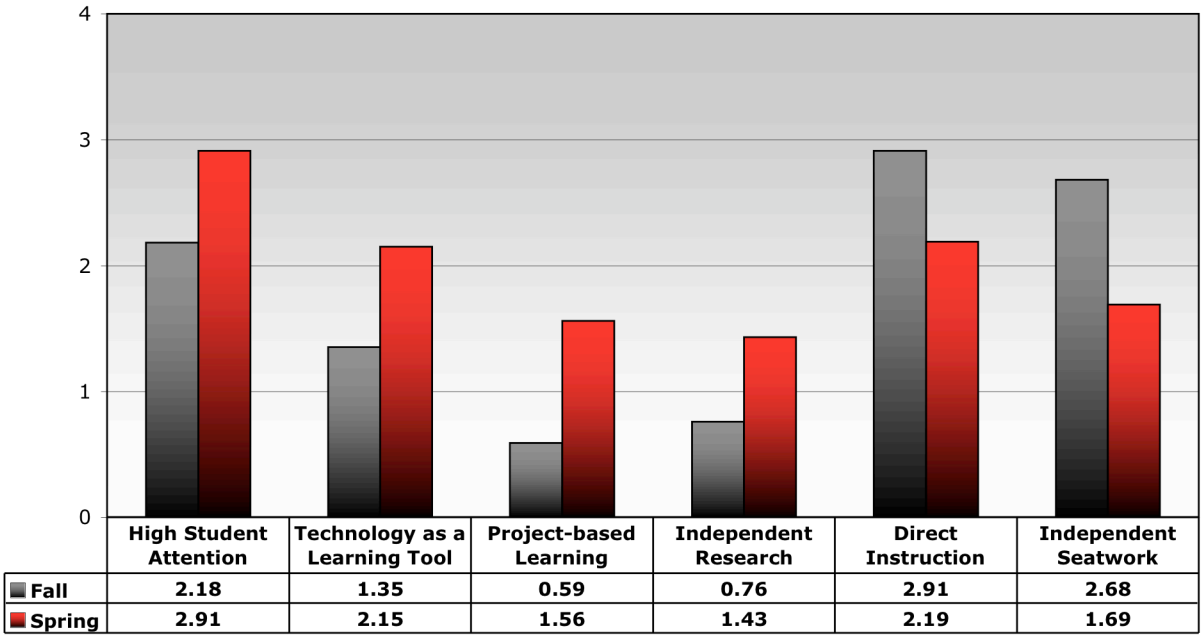
The SCU was designed to capture student access to, ability with, and use of computers rather than teacher use of technology.

Four primary types of data were recorded:

(a) Computer capacity and currency: the age and type of computers available for student use and whether or not Internet access is available.
(b) Configuration: the number of students working at each computer (e.g., alone, in pairs, in small groups).
(c) Student computer ability: the number of students who are computer literate (e.g., easily used software features/menus, saved or printed documents), and the number of students who easily used the keyboard to enter text or numerical information.
(d) Student activities while using computers.

SOM and SCU data were analyzed to identify baseline vs. end-of-year differences for each of the 24 strategies assessed. Both the SOM and SCU use a 5-point scale that includes (0) not observed, (1) rarely, (2) occasionally, (3) frequently, and (4) extensively. Two additional items were assessed via the SOM: the relative frequency with which a high level of academically focused class time and a high level of student interest/attention were observed, where responses include: low, moderate, and high frequency.

A total of 381 hours of direct classroom observations were conducted in the classrooms of 428 teachers teaching approximately 8500 students. Of the 41 schools that participated, 12 were elementary schools, 17 were middle schools, and 12 were high schools. Both the SOM and SCU Multi-Class and Targeted observations revealed significant Fall to Spring differences in the use of teacher-centered practices. For the SOM, significant increases were found in student engagement in "project-based learning," "independent inquiry/research," and student use of "technology as a learning tool or resource." The SCU results yielded significant increases in students' overall use of newer and more up-to date computers (laptops) and positive trends toward increased uses of production tools and internet/research tools to support learning. A key finding that emerged from the results was the significant increase in the frequency with which teachers implemented meaningful computer activities that engaged students in higher-order thinking and problem-solving through effective use of laptop-based technology tools.



	High Student Attention	Technology as a Learning Tool	Project-based Learning	Independent Research	Direct Instruction	Independent Seatwork
Fall	2.18	1.35	0.59	0.76	2.91	2.68
Spring	2.91	2.15	1.56	1.43	2.19	1.69

Figure 1. SOM: Significant Fall vs. Spring Differences

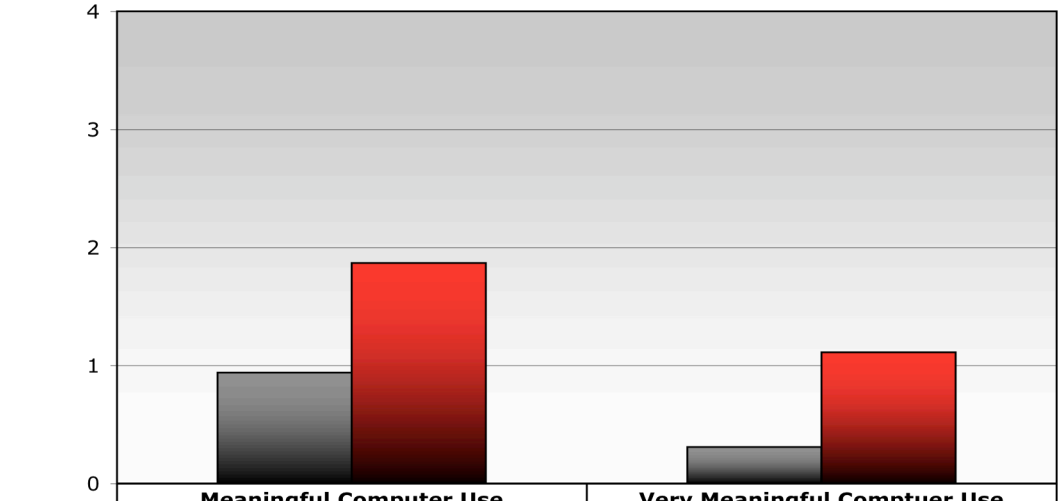


Figure 2. SCU: Mean Scores of Significant Fall vs. Spring Differences

These first-year results show promising trends in that the *Leveraging Laptops* program seems to be serving as a catalyst for positive changes from traditional teaching environments to ones that are student-centered and engage learners in meaningful use of computers to enhance learning. The data also reveal room for growth due to the modest frequency with which most of the changed practices occurred.

Teacher Inquiry

Teacher action research (AR), also known as teacher inquiry, is a strategy for helping educators through a systematic, intentional study of their own professional practice (Cochran-Smith & Lytle, 1993; N. Dana & Silva, 2000; Hubbard & Power, 1993). In general, action research engages teachers in the design, data collection, and interpretation of data around their questions.

> The process of teacher inquiry involves teachers
> (1) defining a question that emerges from their practice,
> (2) developing a research plan for data collection through such mechanisms as journals, student work, interviews with students, and field notes,
> (3) analyzing their collective data in relationship to their wondering to develop a picture of their learning,
> (4) taking action to implement what was learned through their investigation, and
> (5) sharing the results of their work with other professionals (Dana & Yendol-Silva, 2003).

Forty six teachers from ten of the eleven districts completed action research in their classrooms with the guidance of an experienced AR Mentor who was assigned to each district. The educational results reported by the teachers were mostly positive.

Reported AR result	Number of teachers reporting (N=46)
Changes in student achievement including test scores, higher level thinking skills, retention, and transfer of learning	35
Increases in conditions that support learning: enjoyment, motivation, engagement, on-task behavior, and positive school experience	26
Strong 21st Century Skills such as collaboration, computer skills, workforce skills, increased productivity, communication skills, leadership abilities, innovation and creativity	13
Decrease in writing scores and a high level of frustration, attributed to inexperience in the students with the technology that they were learning to use simultaneously with learning the class lesson	3

Table 3. Selected Teacher AR results

In nearly every case, teachers reported noticeable improvements in student performance, in some cases exceeding the teachers' expectations. Small numbers of teachers documented positive changes in their teaching, changes in the classroom culture or dynamic due to unique technology affordances, and improved ability to reach students of varying abilities. In addition, each teacher reported the long-term impacts that the *Laptops for Learning* program has caused in his or her professional life. Nineteen teachers expressed commitments to continue using, investigating, and learning to teach with technology. Fifteen teachers had taken leadership actions including sharing their successes with colleagues either informally or through presentations and other formal venues. Other teachers explained ways that they had become advocates of technology for students.

Discussion

Results suggest that the 1:1 funding had positive impacts across districts particularly in terms of changes in teaching practices. Specifically, baseline and end-of-year observations showed increases in meaningful uses of technology for student-centered, project-based learning, increases in academically focused class time, increases in student attention and motivation, increases in Internet integration and decreases in some forms of direct instruction. Increases in student achievement were also demonstrated via teacher inquiry across districts, grade levels, content areas and student types. The magnitude of these outcomes (or *consequences*) varied by district. Much of this variability can be attributed to the *conditions* within individual schools and districts such as the quality of technology leadership, teachers' attitudes toward technology-infused teaching, the clarity of grant goals and objectives and equipment availability. Likewise, the *processes* employed to support technology-infused teaching and learning such as professional development opportunities for teachers, technical and curricular support and involvement of community stakeholders influenced outcomes in individual districts.

The following tables summarize the Conditions, Processes, and Consequences of the *Laptops for Learning* program. Further detail is included in the following sections of this report.

Conditions	
Technology used	In addition to the laptops, districts selected a range of supporting hardware, software, and web services for teacher and student use.
Setting	The number of participating schools in each district ranged from one to eight, with most districts focusing on between two and five schools for this project. Fifteen of the schools were elementary schools, 13 were middle schools, and 11 were high schools. Three of the districts were large urban districts, four were mid-sized suburban districts, and four were small rural districts. In each district, the number of classrooms involved ranged from 11 to 128. All grades from 1-12 were involved, and most classroom subjects were represented. The districts' prior experience with 1:1 classroom computing varied from no prior laptop program to a school with nearly a 1:1 student-computer ratio. Two districts had at least one school with 1:1 computing, and the remaining five districts had schools in which computer lab carts were used.
Implementation plan	District planners considered several factors in developing their project designs. The most frequently stated factors were low academic performance of students (4 districts), the need to fill a technology gap primarily in areas of poverty in which students lacked access to technology within the district (6 districts), and a commitment to fostering the types of student-centered and project-based teaching that require increased access to technology (4 districts). Other factors that influenced project designs were a desire to build on a history of strong professional development in technology (1 district), and the need to provide technology in a growing district (1 district). In determining the types of technology to provide with the funding, the district planners most often considered the fit between the technology and the project goals (7 districts), but also considered the fit between the technology and broader district goals (6 districts), and the fit between the technology and the desired teaching and learning outcomes (1 district).
Goals and objectives	Most of the projects were designed to achieve multiple goals. The most common goal among the districts was to promote student-centered, project-based, inquiry-oriented, or active learning (7 districts). Other goals included improving academic performance in language arts and science (8 districts total), providing the tools students and teachers need to succeed (3 districts), improving student motivation and behavior (2 districts), and supporting community-centered learning (1 district).
Summary of state conditions: Each district determined its own needs and goals, and then planned accordingly. The result was a wide range of conditions within which the 1:1 projects took place. It is noteworthy that student needs drove each design and that each district took into account multiple factors during the decision-making stages in order to succeed.	

Table 4. Conditions in place for the laptop programs

Processes	
Professional development	Districts used several strategies for supporting teacher learning during the project. Most of the participating teachers took part in the Florida Digital Educator summer institutes offered around the state. Three districts provided additional targeted summer in-service experiences. During the school year, districts provided professional development sessions focused on the project's hardware, software, teaching methods, and academic content. Seven districts

	provided access to continual online professional development opportunities. Additional professional development processes used by small numbers of districts included learning communities (3), 1:1 coaching and modeling (3), use of external trainers (1), custom consulting for teachers (3), and off-site experiences at community sites (1). Two districts offered professional development for the school and districts administrators who were involved in the laptop project.
Teaching and instructional practices: student-centered and tool-based	In the first half of the year when the classrooms had just received the technology, over 90% of teachers were observed using direct instructional methods occasionally or frequently, and fewer than 30% were using cooperative/collaborative teaching. Only 20% were occasionally using project-based teaching, about 40% were teaching as coach/facilitator, and 85% were using independent seatwork. Nearly 80% were using technology for instruction, but only about 40% were using it as a learning tool or resource. The next table, "Consequences," describes the changes seen in the second half of the year.
Technology deployment	All districts provided network/Internet access for classroom computers, either wired or wireless. Most districts placed the hardware and software in classrooms and in shared school spaces on carts. Three districts allowed home check out of computers.
Support	All districts provided either full-time school-based or district-based technical support to the participating teachers. Two districts prepared student technicians to support the technology. Two districts identified teachers or coaches on assignment to provide curricular support to the teachers.
Parent involvement	Eight districts scheduled open houses, parent nights, or workshops for parents at the schools. Schools in three districts used print newsletters to inform parents of the project. All districts employed some or all of the following approaches: project and classroom websites for parent communication, parent volunteers, and school technology clubs open to parents.
Summary of state processes: Each district carefully selected and provided appropriate technology, support, and communication with stakeholders. Innovative methods were used to meet specific local needs in these areas.	

Table 5. Processes used in laptop programs

Consequences	
Student achievement	76% of teachers engaged in Action Research documented changes in student achievement. In three classrooms, negative effects were reported, and in each case these effects were attributed to inexperience in the students with the technology that they were learning to use simultaneously with learning the class lesson. In all other cases, teachers reported noticeable or significant improvements in student performance, in some cases exceeding the teachers' expectations.
Changes in teacher practices: student-centered and tool-based	In the second half of the year, the following changes in teaching were observed: • Direct instructional methods decreased significantly from over 90% of teachers occasionally or frequently observed to 78% • Cooperative/collaborative teaching increased from fewer than 30% occasionally or frequently observed to 52% • Project based teaching increased significantly from 20% occasionally observed to 50% occasionally or frequently observed, and exceeded national norms

	• Teaching as coach/facilitator increased from about 40% occasionally or frequently observed to 70% • Independent seatwork decreased significantly from about 85% occasionally or frequently observed to 54% • Student independent inquiry and research increased significantly, and exceeded national norms • The use of technology as a learning resource or tool increased significantly from 41% occasionally or frequently observed to 72%, and exceeded national norms • The levels of student attention, interest, and engagement significantly increased from fall to spring • Use of all types of production and Internet tool technology increased from fall to spring, and exceeded national norms in all categories • Overall meaningful and very meaningful use of technology increased significantly
Summary of state consequences: Every district saw positive academic outcomes as a result of the project and is committed to finding ways to continue this and similar initiatives.	

Table 6. Results of laptop programs

Implications and Recommendations

Results suggest that 1:1 computing efforts designed to impact student achievement via student-centered teaching practices can be successfully implemented by districts when a state supports a high degree of district autonomy. However, results also suggest that states should require districts to provide evidence of their readiness to undertake such tasks and support those districts that may not have the technical or personnel infrastructure to fully implement such reform. Results also suggest that states should consider ways to provide longer term funding for such efforts. While this funding yielded successful results in less than one year, it is anticipated that even greater outcomes would be observed if the initiatives had a longitudinal focus.

Florida's *Leveraging Laptops* initiative is particularly interesting because of the autonomy given to individual districts, because of each districts' unique plan to implement and evaluate 1:1 computing and because of the combination of quantitative and qualitative measures used to evaluate effectiveness across districts. This study also provides support for statewide 1:1 funding, highlights effective 1:1 practices and calls attention to systemic issues associated with successful 1:1 implementation.

For teachers, administrators, and school district staff, we make the following recommendations.

- Based on the significant changes in teaching practices and student performance that occurred in the spring of the project year, it is reasonable for educators to have high expectations for teaching and learning with the infusion of professional development, support, and technology. Each of those three elements is necessary and must be integrated together in ways that work toward achieving school, district and state goals.

- The first year of a major change in teaching is a year for learning by teachers, administrators, and students, and it is likely that, given sustained professional development and support, the changes observed in classrooms will continue and probably magnify as teachers refine their practices and students acquire and apply technology and information skills to their academic work.
- The types of 21st century skills developed in this project have limited presence on current standardized tests. Teachers, administrators, and school district staff who value the benefits of integrating technology should recognize that increases in student motivation, engagement, and other affective traits that have been seen in association with project-based, community-based, and other important forms of learning may not lead to improvements in all skills as they are assessed on current standardized tests.
- Students who are new to using technology for educational purposes and students who struggle academically may need specific instruction on how to learn with technology. Students who use school computers outside of school need guidelines and information about policies for caring for their computers.

References

Barrios, T. (2004). *Laptops for Learning: Final report and recommendations of the Laptops for Learning Task Force*. Retrieved October 18, 2007 from http://etc.usf.edu/L4L/.

Clausen, K.W. (2006). It there meta in the madness?: Action research and the use of meta-analysis. *The Ontario Action Researcher* [Online serial], 8(3). Available: http://www.nipissingu.ca/oar/archive-V83E.htm.

Dana, N. F., & Silva, D. Y. (2003). *The reflective educator's guide to classroom research: Learning to teach and teaching to learn through practitioner inquiry*. Thousand Oaks, CA: Corwin Press.

Dawson, K., & Ferdig, R. E. (2006). Commentary: Expanding notions of acceptable research evidence in educational technology: A Response to Schrum et al. *Contemporary Issues in Technology and Teacher Education* [Online serial], *6*(1). Available: http://www.citejournal.org/vol6/iss1/general/article2.cf

Fairman, J. (2004). Trading roles: Teachers and students learn with technology. Paper presented at the annual conference of the New England Educational Research Organization, Portsmouth, NH.

Fisher, D., & Stolarchuk, E. (1998). The effect of using laptop computers on achievement, attitude to science and classroom environment in science. *Proceedings from the Western Australian Institute for Educational Research Forum*. Retrieved February 20, 2007 from http://www.waier.org.au/forums/1998/fisher.html

Harmes, C., Kemker, K., Kalaydjian, K., and Barron, A. E. (2000). *Working toward national technology standards: Teacher use of computers in the classroom*. Paper presented at the annual Meeting of the Florida Educational Research Association (FERA), Tallahassee, Florida.

Haertel, G. & Means, B. (2004). Evaluating educational technology: Effective research designs for improving learning. New York, NY: Teachers College Press.

Henriquez, A., & Riconscente, M. (1999). *Rhode Island Teachers and Technology Initiative: Program evaluation final report.* New York: Education Development Center, Center for Children and Technology.

Herrington, J., & Oliver, R. (2000). An instructional design framework for authentic learning environments. *Educational Technology Research and Development, 48*(3), 23-48.
Hogarty, K. and Kromrey, J. (2000). *The nature of technology use in Classrooms: The development and validation of an instrument to measure teachers' perceptions*. Paper presented at the annual Meeting of the Florida Educational Research Association (FERA), Tallahassee, Florida.
Lowther, D.L. & Ross, S. (2000). *Survey of computer use: Basic observation guidelines.* The University of Memphis: Center for Research in Educational Policy.
Patton, M. (1994). Developmental evaluation. *Evaluation Practice 15*(3), 311-319.
Patton, M. (2001). Evaluation, knowledge management, best practices, and high quality lesson learned. *American Journal of Evaluation 22*(3), 329-336.
Rockman, et. al. (1998). "Powerful tools for schooling: Second year study of the laptop program." Retrieved February 20, 2007 from http://www.microsoft.com/Education/aalresearch2.mspx
Ross, S., Smith, L., Lowther, D.L. & Alberg, M.J. (2006). *The school observation model*. The University of Memphis: Center for Research in Educational Policy.
Rossman, G.B., & Rallis, S.F. (1998). *Learning in the field: An introduction to qualitative research*. Thousand Oaks, CA; London; New Delhi: Sage.
Stevenson, K. R. (1998). "Evaluation report-Year 2: Schoolbook laptop project." Beaufort County School District: Beaufort, S.C. Retrieved February 21, 2007 fromhttp://www.beaufort.k12.sc.us/district/ltopeval.html
Strauss, A., & Corbin, J. (1990). *Basics of qualitative research: grounded theory procedures and techniques.* Newbury Park, CA: SAGE Publications.
van 't Hooft, M., Swan, K., Cook, D. & Lin, Y. (2007). What is ubiquitous computing? In van 't Hooft & Swan (Eds.). *Ubiquitous Computing in Education*. Mahwah, NJ: Lawrence Erlbaum Associates.
Warschauer, M. & Sahl, K. (2002). Tracing teachers' use of technology in a laptop computer school: The interplay of teacher beliefs, social dynamics and institutional culture. *American Educational Research Journal, 39*(1), 165-205.
Zucker, A. (2004). Developing a research agenda for ubiquitous computing in schools. *Journal of Educational Computing Research, 30*(4), 371-386.