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The Tech-Savvy Teacher: Instruction in a 1:1 Learning Environment

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A research team conducted an evaluation of a laptop initiative in 18 North Carolina high schools through administrator, teacher, and student focus groups; teacher and student surveys; and classroom observations. The study aimed to provide information about the value of the laptop initiative in enhancing student learning. In addition, it intended to identify challenges to the successful implementation of 1:1 programs, strategies for meeting those challenges, and services and supports needed to enable successful 1:1 programs throughout the state. This paper explores how the initiative affected instructional practice in areas such as technology use, communication, the role of the teacher, and the learning environment. It also discusses unique challenges for teachers in a 1:1 environment, as well as implications for educators and administrators.

Keywords: *1:1 learning; evaluation; instructional practice; laptop initiative; technology*

Introduction

In the spring of 2008, the North Carolina State Board of Education awarded a contract to the Friday Institute for Educational Innovation to conduct a 3-year evaluation of the NC 1:1 Learning Technology Initiative (NC1:1LTI) pilot schools. The evaluation included 8 early college (EC) high schools and 10 traditional high schools, with a total across the 18 schools of approximately 9,500 students and 600 school staff. These schools participated in a 1:1 laptop initiative, during which 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. The evaluation intended to provide information about whether the initiative enhanced student learning, as well as to identify challenges to successful implementation of 1:1 programs, strategies for meeting those challenges, and services and supports needed to enable successful programs throughout the state. After a brief overview of the NC1:1LTI and its evaluation, this paper examines the role of instructional practices in successful implementation of a 1:1 program.

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Project Overview

Participant Schools

The 18 1:1 pilot high schools are located across North Carolina (Figure 1) in areas that reflect the state's diverse geographic, economic, and cultural landscapes.

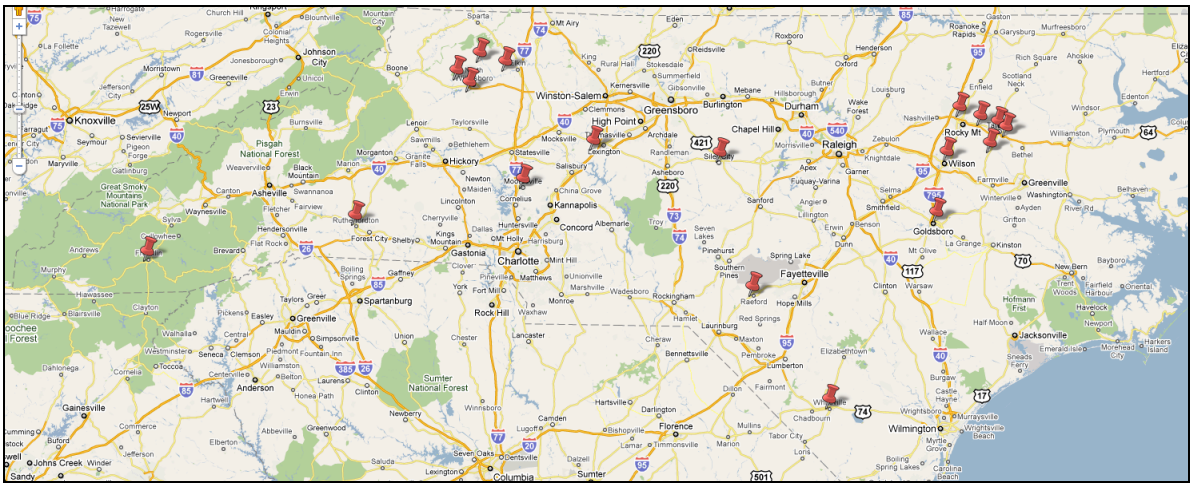

Figure 1: *Map of 1:1 Pilot High Schools in North Carolina*

The participating schools initiated their 1:1 projects over a series of years. Because of this staggered implementation model, the Friday Institute evaluation team grouped schools into cohorts depending upon when the laptops were distributed to the teachers and students and whether the school was a traditional or EC high school (Table 1).

Table 1: *1:1 School Cohorts*

School	# Students	# Teachers	Laptops Distributed
			Cohort A
Trad1	1,344	84	To teachers March 2007; to students September 2007
EC1	112	4	To teachers November 2007; to students March 2008
EC2	132	7	
EC3	138	5	
EC4	243	13	
EC5	153	6	
EC6	193	9	
EC7	207	11	
			Cohort B
Trad3	378	30	To teachers September 2008; to students January 2009
Trad4	975	59	
Trad5	721	47	
Trad6	1,611	83	To teachers February 2008; to students September 2008
			Cohort C
Trad7	539	34	To teachers April 2009; to students November 2009
Trad8	728	48	
Trad9	877	55	
Trad10	636	42	
Trad12	716	55	To teachers September 2005; to students September 2009
EC8	61	3	To teachers September 2009; to students November 2009
Total	9,764	595	

Note: EC = early college; trad = traditional

Of the 1:1 teacher population (n = 595): 93% are fully licensed, 25% have advanced degrees, 15% are National Board Certified, 18% have fewer than 3 years of experience, 26% have 4 to 10 years of experience, and 56% have more than 10 years of experience. Of the 1:1 student population (n = 9764), 0.5% are American Indian, 1% are Asian, 9% are Hispanic, 30% are Black, and 60% are White.

Data Sources and Evaluation Questions

The evaluation team used data from the schools above to address several questions that collectively assess school progress toward implementation of a functional 1:1 environment. Table 2 summarizes the alignment of the NC1:1LTI project goals, evaluation questions, and data sources.

Table 2: *Alignment of NC1:1LTI Project Goals, Evaluation Questions, and Data Sources*

Project Goals	Evaluation Questions	Data Sources
1. Improve school infrastructure and support systems to meet 21st century needs (school level)	How have school infrastructures and support systems evolved to meet staff and student 21st century needs?	Policies/procedures 1:1 online survey Focus groups Site visit checklist Laptop repair checklist 1:1 PD inventory/quality
2. Improve staff attitudes and skills related to technology (teacher level)	How have staff attitudes and skills changed over time?	Classroom observations 1:1 online survey Focus groups
3. Enhance instructional practices by facilitating teachers' ability to infuse instructional technology into routine classroom pedagogy (classroom level)	How have teachers' instructional practices changed over time?	Classroom observations 1:1 online survey Exemplary lesson plans Focus groups
4. Improve student learning (student level)	How have students' 21st century skills changed over time? How have student learning and achievement in core academic subjects changed over time?	Classroom observations 1:1 online survey Focus groups EOCs Attendance Discipline

Note: PD = professional development; EOCs = end-of-course exams

These evaluation efforts have enabled the identification of several important *critical issues* areas for successful implementation of 1:1 learning environments: leadership, instructional practice, student learning outcomes, infrastructure, special populations, and quality of implementation. The remainder of this paper discusses in detail the role of instructional practice in successful 1:1 schools.

Literature Review of 1:1 and Instructional Practice

Much of the research on ubiquitous technology learning environments has focused on how teachers use laptops for planning and instruction in 1:1 classrooms and how the learning environment changes as a result. Teachers use laptops to develop instructional material (Beaudry, 2004; Silvernail & Harris, 2003), quickly access up-to-date information related to instruction (Silvernail & Harris, 2003; Silvernail & Lane, 2004), and communicate and collaborate with colleagues (Beaudry, 2004; Silvernail & Lane, 2004). Teachers in 1:1 schools report benefits such as improved technology knowledge and skills, increased assistance with technology questions and problems, and improved classroom management (Fairman, 2004). Teachers also are more likely to take on the roles of facilitator and coach (Cavanaugh et al., 2007; Fairman, 2004; Lowther, Strahl, Zoblotsky, & Huang, 2008; Peck, Clausen, Vilberg, Meidl, & Murray, 2008), and they often find that the laptops help them better meet curriculum goals and address statewide learning standards (Silvernail & Lane, 2004).

The impact on students is also broad. Students use 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 also become more engaged in student-centered activities (Lowther et al., 2008), such as authentic learning (Lowther, Strahl, Inan, & Bates, 2007), experiential hands-on learning activities (Lowther et al., 2008), and project-based learning (Cavanaugh et al., 2007; Lowther et al., 2007; Lowther et al., 2008; Peck et al., 2008). Researchers in Florida observed significant increases in cooperative and collaborative learning and significant decreases in independent seatwork in 1:1 classrooms. Students were not only more active in group work, but also in self-directed learning (Cavanaugh et al. 2007; Mitchell Institute & Bill & Melinda Gates Foundation, 2004).

Data Analysis

For this critical issue, differences in survey responses from the first and last years of data collection at the 1:1 schools were analyzed using standard *t* tests. These tests are useful in determining whether there are significant differences between two groups (in this case, between the first and last year of survey administration). Focus group data were audiotaped, transcribed, and then imported into ATLAS.ti (qualitative data analysis software manufactured in Germany). Transcripts from focus groups with students, teachers, and school leaders were open-coded first, after which themes and pertinent quotes were extracted.

Findings

Various themes arose from the data regarding instructional practice. Results revealed that 1:1 initiatives sharply impact technology use, communication, the role of the teacher, and students' learning within a new environment; these impacts are discussed below. The results also suggest that 1:1 initiatives can create unique challenges for teachers as well; these challenges are outlined at the end of this report.

Technology Use

Teacher Technology Skills

Survey results across all cohorts indicated growth in teachers' positive perceptions of their technology skills over time. This supports a previous finding that many participating teachers indicated that they needed time to become comfortable operating a laptop and helping their students do the same. In the initial surveys, no more than 30% of teachers self-reported advanced technology skill levels. In the final surveys, however, most schools saw an increase in the number of teachers reporting that they perceived themselves to be more advanced. This finding suggests that teachers at most schools improved their technology skills over the course of the laptop initiative (see Table 3). Cohort C teachers, where the laptop projects were in their initial year, showed a slight drop in self-reported technology skills. This result is similar to findings for Cohort A and B schools during their first year of implementation. Teachers' self-reported technology skills tend to drop during the first year due to technical challenges, along with the process of adapting to a whole new style of teaching; skills tend to rebound during subsequent implementation years (Corn, 2009).

Table 3: *Percent of Teachers Indicating Advanced Technology Skills*

Schools	Time 1	Time 2
1:1 EC, Cohort A	31.7	47.2
1:1 Traditional, Cohort A	31.2	40.0
1:1 Traditional, Cohort B	24.5	31.4
1:1 Traditional, Cohort C	29.1	27.7

Note: Time 1 = Spring 2008 for Cohort A and B and Spring 2009 for Cohort C; Time 2 = Spring 2010 for all schools

Teacher Attitudes and Beliefs About Technology

Teacher responses to questions about their attitudes toward and beliefs about technology suggested that, although laptops may pose implementation challenges for them, they believe that the use of laptops in the classroom can lead students to a more thorough understanding of content, help them complete higher-level assignments, and individualize their learning experiences.

Between the first and last surveys, significantly more teachers from 1:1 traditional schools believed that laptops were disruptive to their teaching (Figures 2 and 3). Furthermore, significantly more 1:1 traditional teachers agreed that it was necessary to create backup lesson plans due to problems with the technology (Figures 2 and 4).

Between the first and last survey, however, significantly more 1:1 EC teachers agreed that their teaching benefitted from laptop use, that they were better able to individualize curriculum to fit student needs as a result of having the laptops, that having laptops increased their expectations for students' work, and that they were able to explore topics in greater depth when they used the laptops (Figure 5). Similarly, in the final survey, significantly more 1:1 traditional teachers in Cohort A agreed that having the laptops increased expectations for students' work and helped them to create instructional materials that better met the NC Standard Course of Study (Figure 2).

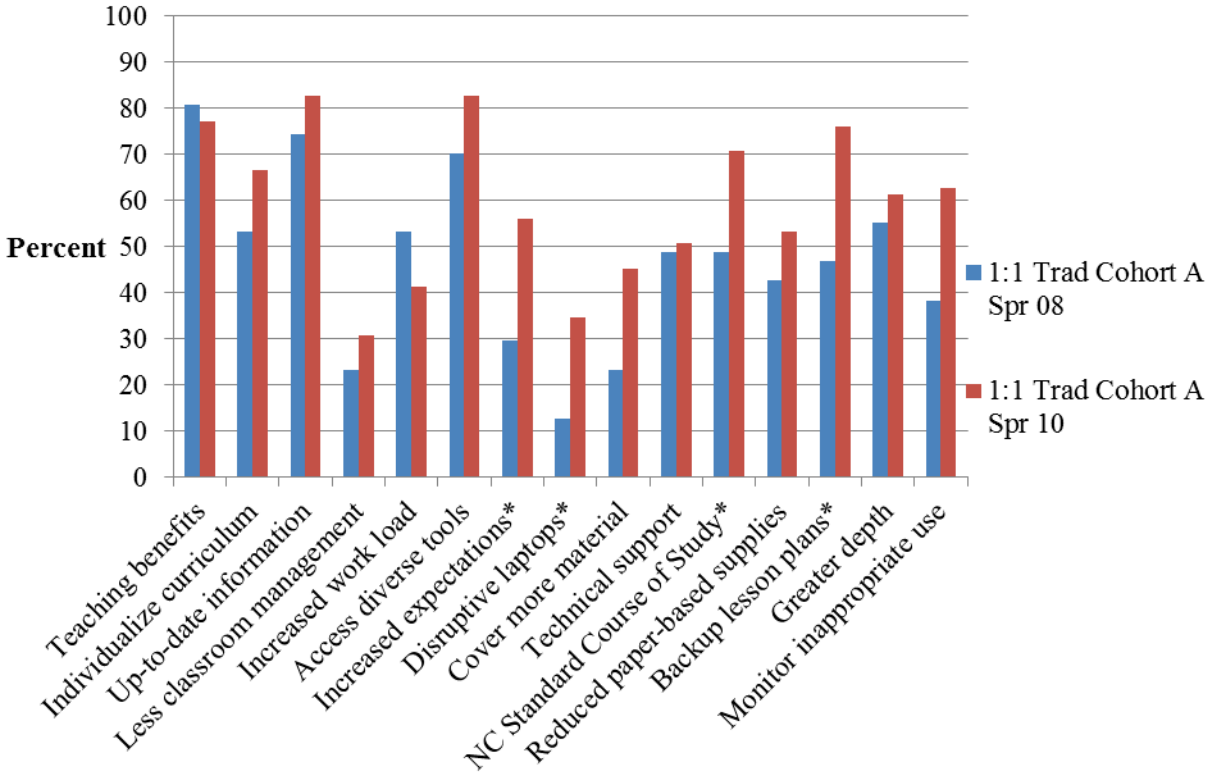

Figure 2: *Proportion of 1:1 Cohort A Traditional Teachers (*n *= 47, Spring 2008;* n *= 75, Spring 2010) Indicating Agreement (Strongly Agree or Agree) With Various Statements Related to Technology Attitudes and Beliefs. *Indicates significant difference at the .05 level.*

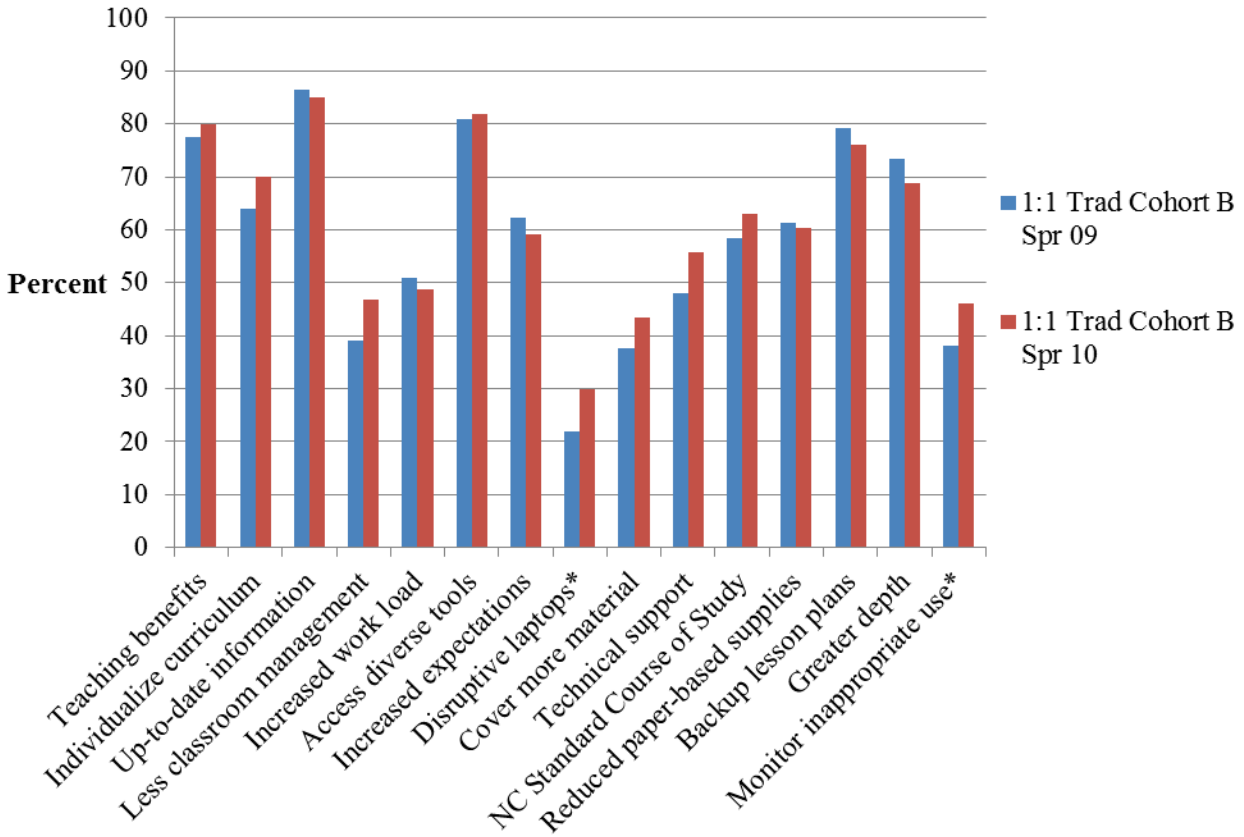

Figure 3: *Proportion of 1:1 Cohort B Traditional Teachers (*n *= 236, Spring 2009;* n *= 154, Spring 2010) Indicating Agreement (Strongly Agree or Agree) With Various Statements Related to Technology Attitudes and Beliefs. *Indicates significant difference at the .05 level.*

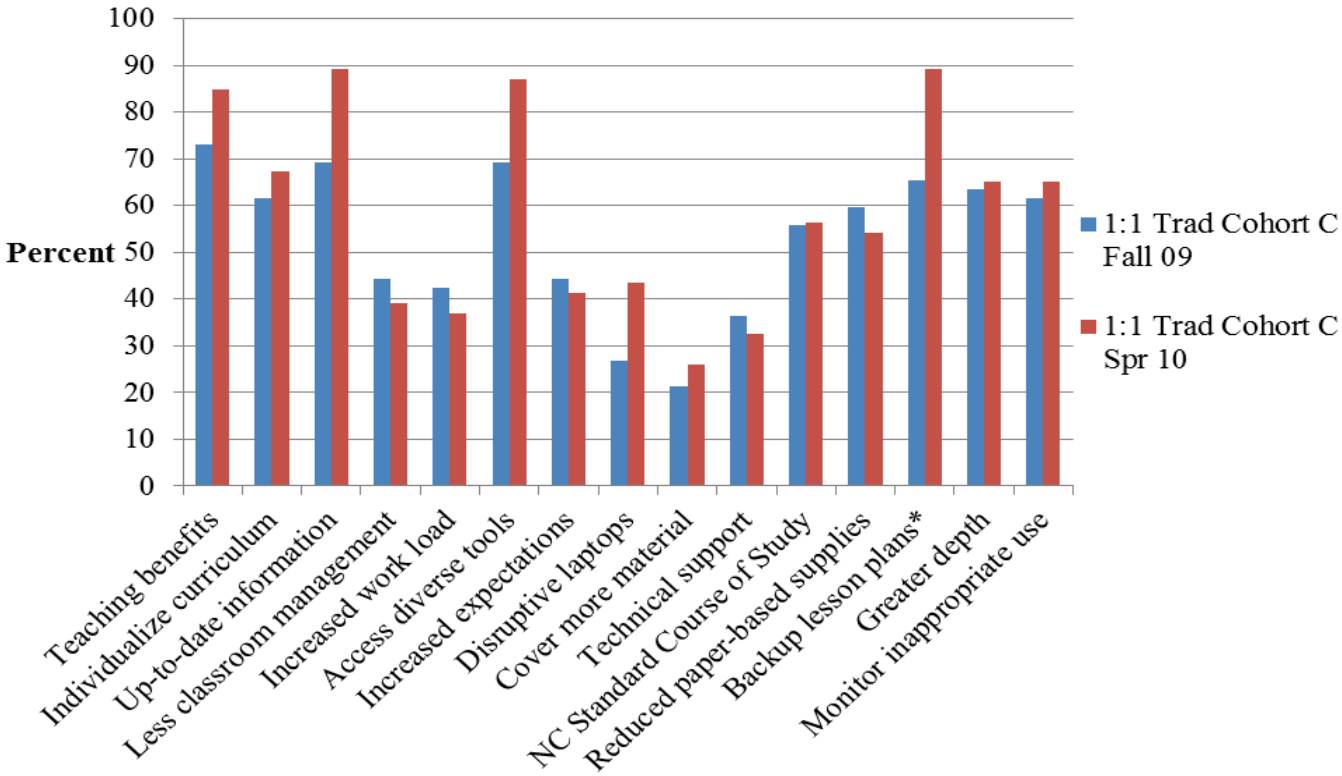

Figure 4: *Proportion of 1:1 Cohort C Traditional Teachers (*n *= 52, Fall 2009;* n *= 46, Spring 2010) Indicating Agreement (Strongly Agree or Agree) With Various Statements Related to Technology Attitudes and Beliefs Regarding Teaching and Laptops. *Indicates significant difference at the .05 level.*

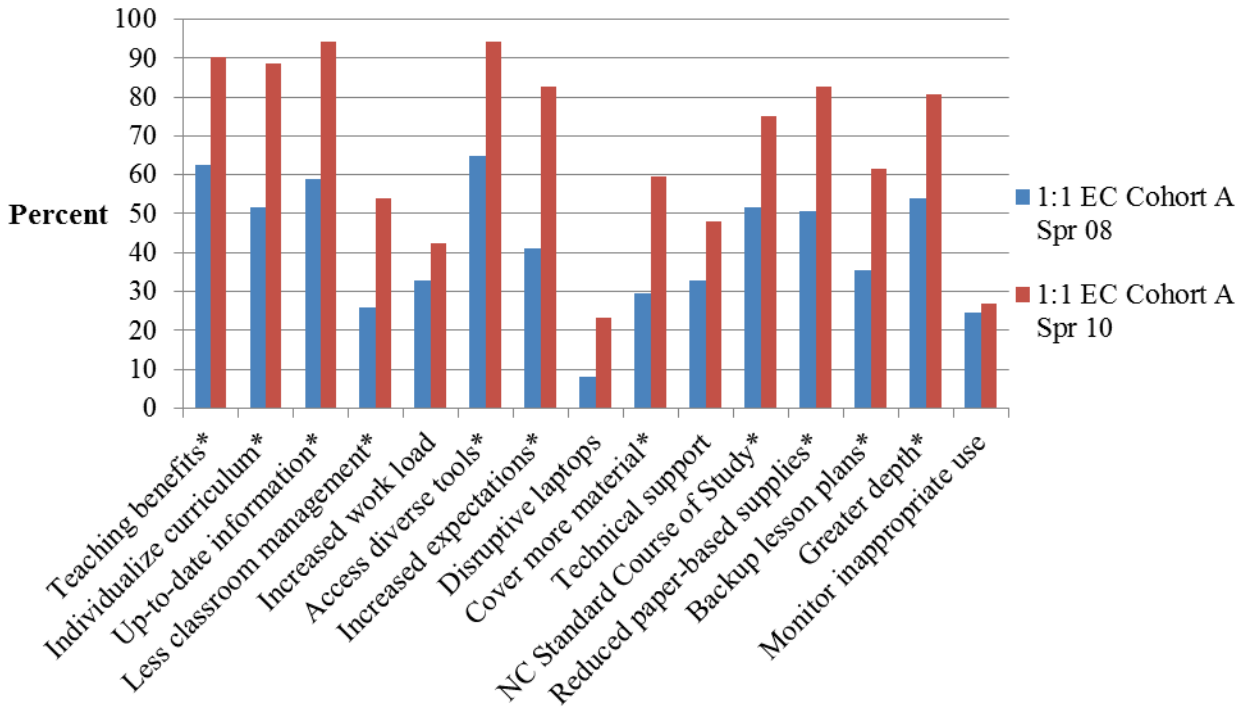

Figure 5: *Proportion of Cohort A EC Teachers (*n *= 85, Spring 2008;* n *= 52, Spring 2010) Indicating Agreement (Strongly Agree or Agree) With Various Statements Related to Technology Attitudes and Beliefs. *Indicates a significant difference at the .05 level.*

Teacher Technology Use

Teachers in traditional high schools in Cohorts A and B demonstrated significant increases in the frequency with which they used technology since starting their 1:1 initiative. Teachers from Cohort A reported using technology for a variety of activities in class, as well as an increase in technology use for accessing or posting curriculum content, online textbook resources, websites/blogs, online assessments, activity instruction, out-of-classroom activities, and online guest speakers. Significantly more teachers used technology for online assessments at Time 2 (Figure 6).

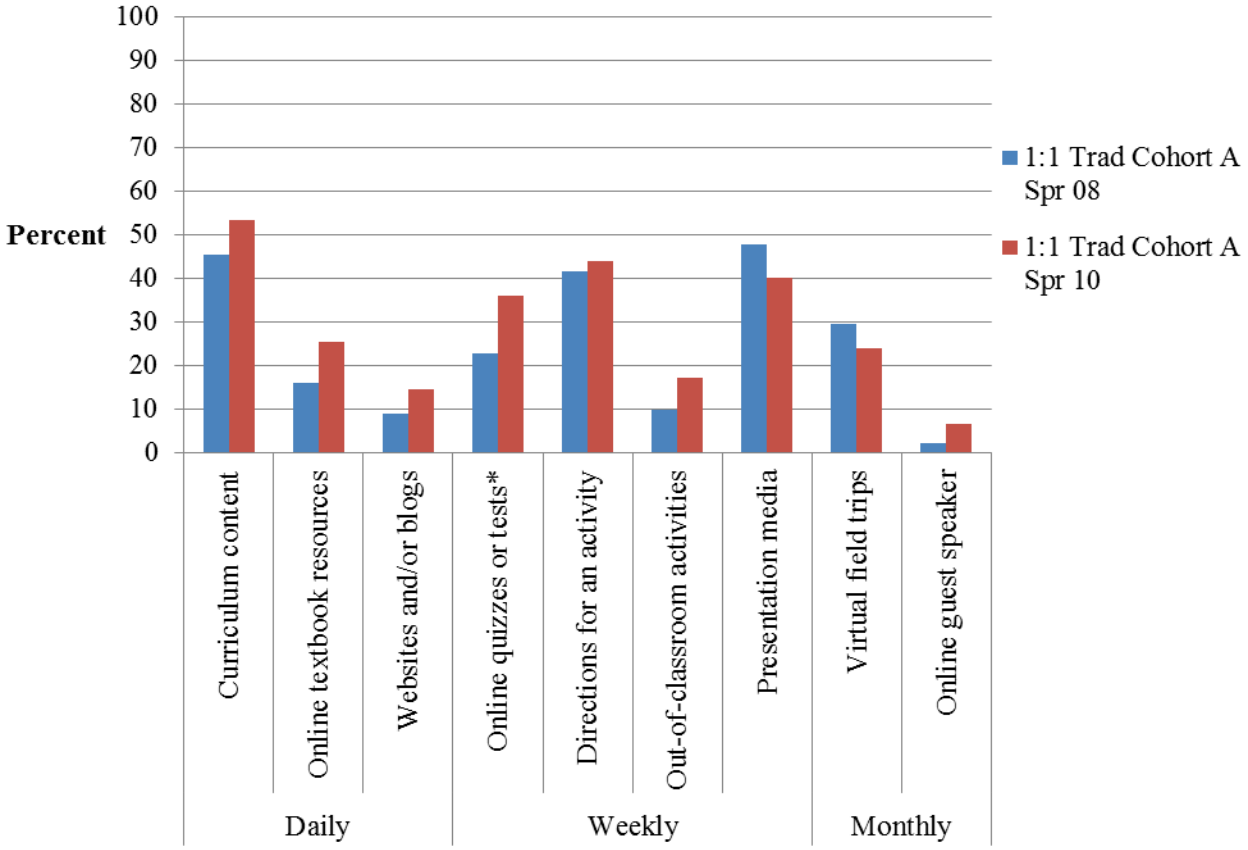

Figure 6: *Proportion of 1:1 Cohort A Traditional Teachers (*n *= 61, Spring 2008;* n *= 52, Spring 2010) Indicating Frequency of Various Instructional Technology Use. *Indicates a significant difference at the .05 level.*

Like teachers in Cohort A, teachers in Cohort B indicated significant increases in their use of online assessments at Time 2 (Figure 7). Teachers from Cohort B reported an increase in technology use for accessing or posting websites/blogs, online assessments, activity instruction, out-of-classroom activities, and online guest speakers.

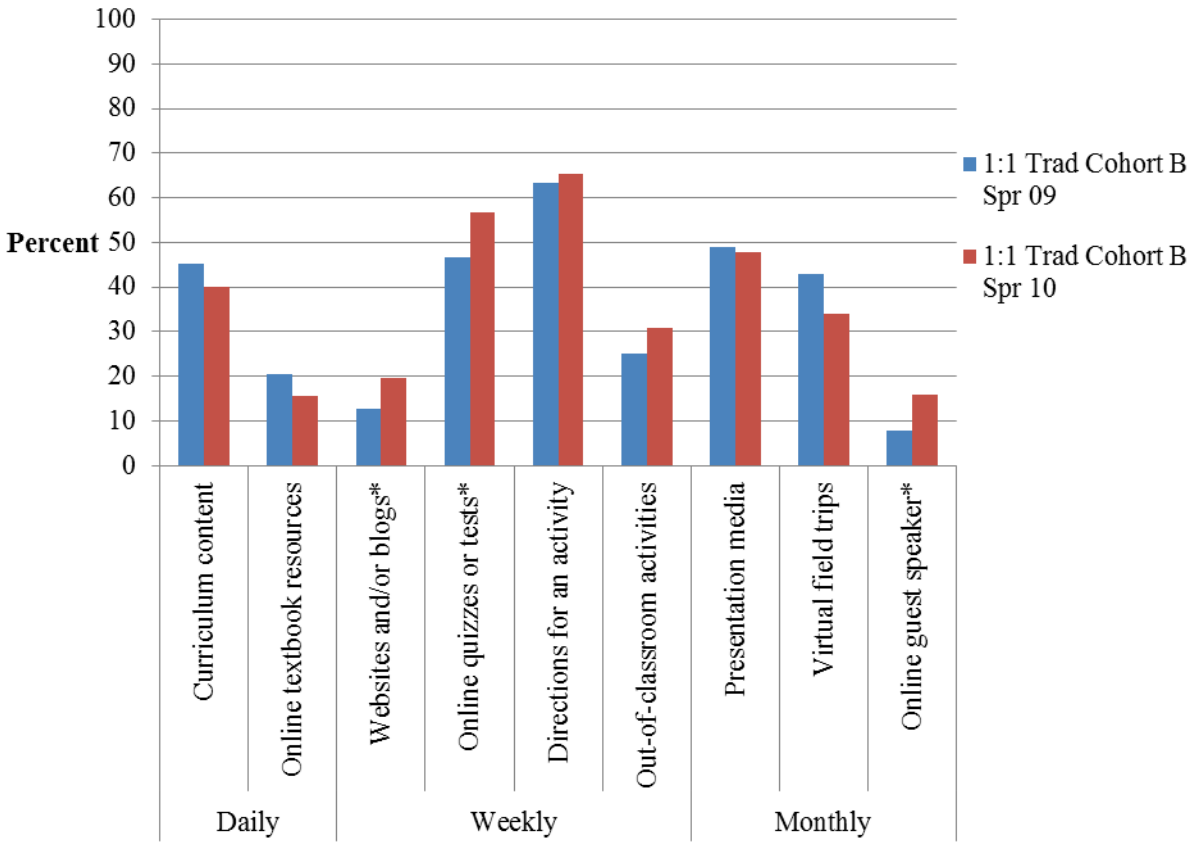

Figure 7: *Proportion of 1:1 Cohort B Traditional Teachers (*n *= 234, Spring 2009;* n *= 153, Spring 2010) Indicating Frequency of Various Instructional Technology Use. *Indicates significant difference at the .05 level.*

Teachers tended to be more resistant to technology use in the classroom during the first year their school implemented the 1:1 initiative. Teachers from Cohort C reported a decreased use of technology for all areas except for accessing online textbook resources (Figure 8). This trend followed a similar pattern seen in other 1:1 schools during their first year of implementation. Some teachers resisted the full adoption of the laptops after the initial excitement wore off because they claimed to be completely overwhelmed with having to adjust their traditional way of "doing business" for planning and instruction (Corn, 2009).

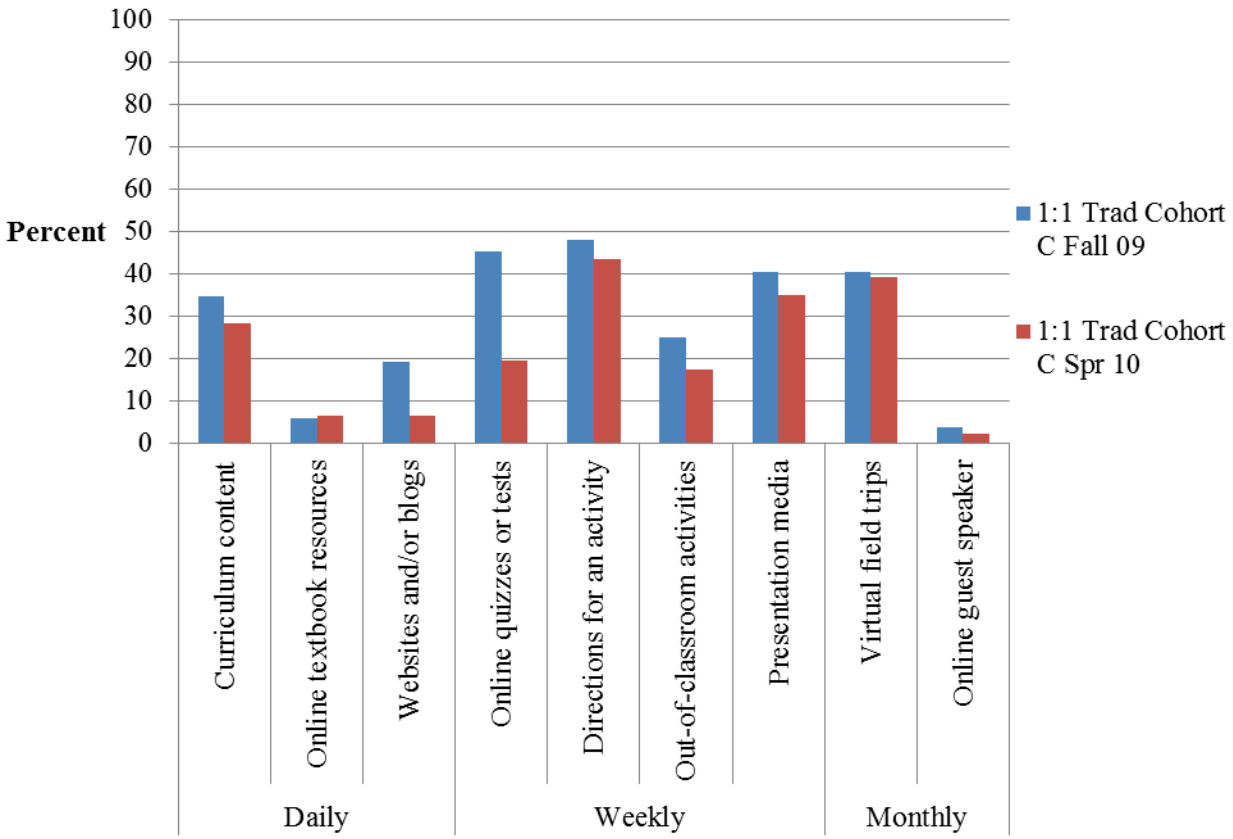

Figure 8: *Proportion of 1:1 Cohort C Traditional Teachers (*n *= 52, Fall 2009;* n *= 46, Spring 2010) Indicating Frequency of Various Instructional Technology Use. *Indicates a significant difference at the .05 level.*

Communication

Teachers

Laptop initiatives tend to enhance frequency and quality of communication between teachers, students, and administrators (Corn, 2009), and evidence from these evaluations supports that conclusion. Significantly more EC high school teachers in Cohort A agreed that use of the laptops facilitated more open communication between their students and themselves by Spring 2010. Teachers from the traditional high school in Cohort A also noted an increase in open communication, although this finding was not statistically significant.

Evidence from focus groups and interviews also demonstrates the impact of 1:1 environments on teacher-student communication. For instance, many shy students appreciated not having to go to the front of the room to talk with their teacher. Several teachers chatted with their students through tools like Google Docs, a popular Web-based office suite. Teachers also used e-mail to communicate with students about grades.

Teachers who led student clubs often had e-mail or Facebook groups for members, so students stayed up-to-date on club happenings. Communications were not limited to students alone, with several

teachers appreciating the ability to e-mail the entire student, faculty, and school populations. They used e-mail and chat features quite often during the day for instant communication with one another.

Students

Communication between teachers and students was often two-way, with students initiating dialog as well. For example, in some schools, students sent instant messages to teachers about their senior projects and used the chat feature in a Web-based learning management system to discuss their homework. In addition, some students considered electronic communication with faculty less difficult than face-to-face communication. Students found peer-to-peer communication beneficial as well. For instance, absenteeism was no longer an excuse to avoid submitting work, as fellow students could simply e-mail their notes and missed assignments to the absent peer. Students also used e-mail, chat features, and discussion boards to talk about homework after the school day ended.

Students at ECs in particular reported enhanced communication as a result of the availability of connected laptops:

> [Student]…it's a family bond that we have, it just makes you a lot more comfortable with your peers, it makes you a lot more comfortable with your instructors, and it gives you that feeling that you can go to any single person you know with a problem or situation or ask for help, whereas in traditional schools…you're actually a little bit timid to seek help.

There is also evidence that creating e-mail messages helped sharpen students' written communication skills.

Community

The benefits were not limited to students and teachers; parents were better able to communicate with teachers, as well. Teachers using eChalk, a school-hosted online learning platform, invited parents to register their e-mail addresses to receive important information from the school. E-mail also provided a direct line of communication between teachers and parents (in addition to phone communication) uninterrupted by the student.

Role of Teacher

Laptop initiatives impacted the role of the teacher in numerous ways, primarily by shifting teachers out of traditional prescriptive roles and into more substantive ones. Teachers reported that they had become facilitators:

> [Teacher] It's that giving up control and just being one of them and we're in this together, I'm going to facilitate this, we're going to get into groups and just figure it out as we go… that's a new way to look at teaching.

In general, teachers reportedly appreciated the shift to self-directed learning that took place during the initiative. Administrators commented on the increased emphasis on metacognition; as one principal said, "Students began thinking about their own thinking."

Students indicated their teachers were more engaged:

> [Student] Teachers seem a little bit more excited to work, because they know that they get to work with technology, like the students…all teachers are kids at heart, so they want to work with technology just as much as we do.

Another shift for some teachers was into technology leadership roles at the school and district levels. For example, an English teacher won a district-wide competition in which teachers demonstrated how they wanted to use technology in the classroom; a math teacher applied for funding to buy a classroom performance system; a Spanish teacher tried out new technologies and attended a web conference; seasoned teachers tutored new teachers through a lesson building and classroom management platform; nine teachers applied to a special program and received technology tools; and teachers at one school obtained digital versions of their science and math textbooks.

Learning Environment

> *It's not just the same old lesson plan anymore. (Teacher, fall 2009)*

Evidence from this evaluation suggests that laptop initiatives tend to change the learning environments and experiences teachers design; almost every aspect of the learning environment changes because teachers include more project-based learning and more opportunities for student collaboration. Teachers in the 1:1 initiatives enhanced lesson plans, redefined pedagogical approaches, and increased use of authentic learning tools and assessments.

Enhanced Lesson Plans

Interview and focus group data suggested that lesson plans started to exhibit more creativity and authenticity as teachers and students gained access to new technologies. Teachers invested significant time up front as they converted older lesson plans and developed new ones in the initial stages of laptop programs, but after this initial conversion phase, time commitments shrank and they were able to make small changes to the plans as needed going forward. Specific activities facilitated by access to technology are listed in Table 4.

Lesson plans such as these could last one day or a period of weeks, depending on the activity. A math teacher may use classroom performance systems on a daily basis, for instance, and then have a house-buying project that lasts for half the term. Time was the resounding issue many teachers cite for not altering their lesson plans as quickly as they would like to after receiving laptops. Although lesson plans have become more creative and appear to be helping students acquire 21st century skills such as technology literacy, information literacy, civic literacy, understanding of the global world, and group collaboration, student learning is ultimately measured by performance on end-of-course exams (EOCs), which assess whether students have met the goals and objectives of the NC Standard Course of Study for only a limited number of courses (North Carolina Department of Public Instruction, 2005). Because there is not an EOC for every course, teachers of non-EOC courses reported that they could integrate technology more freely than teachers in courses with high-stakes tests. Numerous teachers expressed the desire for more time to teach students creative, tech-savvy, and challenging lessons.

Table 4: *Technology-Enabled Classroom Activities*

Subject Area	Innovations
Health	Students gathered information online to compare/contrast the calorie, carbohydrate, and fat contents of three favorite restaurants.
History	Students created a digital narrative of the events that led up to the turbulence of the 1920s. Students created websites about different aspects of life in the 1950s. The teacher placed all the links on the class web page and discussed as a whole group. Students created colonial travel brochures that highlighted the geographical and cultural resources of the 13 colonies.
Language Arts	Students used photo editing software to contribute to a class electronic magazine. Teachers provided vocabulary practice through OneNote; students included a real-world example, picture, diagram, and/or formula to accompany the definition. Students designed a brochure to reflect migrant workers, the Depression, and mental facilities while reading Of Mice and Men. Teachers used Grammar Girl (http://grammar.quickanddirtytips.com/), which allowed students to read text while listening to an audio file that reinforced grammar skills.
Math	Teachers demonstrated how to use a calculator using software on the presentation board, then had students practice problems on their own. Teachers gave students a "Quadratic Formula Learning Styles Quiz" to see if they were auditory, visual, or kinesthetic learners and adjusted teaching accordingly using interactive white boards. Teachers used classroom performance systems (e.g., clickers) for formative assessment. Teachers explored sci-fi math games in which students had to solve problems to get to the next level in the game. Students "bought" a house as a class and used the Internet to locate the house, understand the market, and calculate payments. Students used Microsoft Excel to create an income statement based on research of their desired career paths.
Foreign Language	Students researched a foreign country of their choice online and pretended that they had visited this country at some point in the past. Next, students created a presentation to talk about their trip (including information on culture, food, economy, history, etc.). Students created menus for a restaurant in a foreign language.
Special Needs	Teachers used technology for self-directed learning based on students' individual learning styles and abilities. English language learners created Microsoft PowerPoint presentations for academic classes. One teacher reported, "This boosted my students' visibility in class, and their teachers' awareness of them."

Redefined Pedagogical Approaches

Another emerging conclusion from the ongoing evaluations is that laptop initiatives tend to redefine the pedagogical strategies employed by teachers. A major change that students experienced in 1:1 learning was an increase in small-group or individual learning activities; some schools even transitioned to more extensive use of the North Carolina Virtual Public School, which offers over 100 online courses, including advanced placement, world language, occupational course of study, and credit recovery courses to students across the state.

By converting lessons from text-based only to lessons that included images, videos, and online documents, students received the information through multiple channels. This type of extension also resolved issues of unconstructive and unstructured time for students who completed assignments and tests early by allowing them to move forward and be more productive and efficient with their time. After a test in an English class, for example, students were asked to visit www.sparknotes.com to research a book. Teachers felt that this increased efficiency was beneficial to student learning.

Student Learning

By observing the laptop initiative through the lens of the Framework for 21st Century Learning (Partnership for 21st Century Skills, 2009), one may better understand how technology changes learning. The Framework for 21st Century Learning illustrates a view of learning in the 21st century that is focused on student outcomes (life and career skills, learning and innovation skills, and information, media, and technology skills) undergirded by support systems such as learning environments, professional development, and curriculum design (Partnership for 21st Century Skills, 2009).

The 1:1 initiatives immersed students in multiple modes of writing beyond the typical research paper. Students created digital magazines, class blogs, and newsletters through Microsoft Publisher. English teachers asserted that laptops helped to reinforce grade-level learning goals, provide remediation, and accelerate grammar skills. They also reported that writing improved as a result of the 1:1 initiative, and papers were "better and longer." Students began writing for worldwide audiences rather than only for the teacher or peers. By having their academic writing made public, students were encouraged to write about topics that interest them and ensure that their ideas were communicated clearly.

Information, media, and technology skills comprise an essential part of the Framework for 21st Century Learning. Students enter high school with a range of technology skills; some may not have much experience with technology or typing if they do not have a computer at home. Laptops provided the opportunity for schools to bridge the digital divide. Students realized that they could no longer make excuses for leaving their homework at home when they learned how to manage and organize electronic files. Some schools even provided electronic textbooks (distributed online or through individual CDs), which lightened students' backpacks and helped to improve the quality of study time.

All teachers reported an increase in student typing and technology skills, including file and folder management, e-mail attachments, and the ethics of digital citizenship. One teacher reported, "They're learning how to appropriately behave in a digital world." This skill is especially important for digital learners of the 21st century.

Teachers reported that learning is greatly improved by laptops, and they are wary of those who assert that test scores and learning are equivalent. One administrator explained, "We have kids using [Windows] Movie Maker to put their ideas together that summarize a story, that doesn't translate necessarily into test scores, right? And unfortunately that's how we're measured." Research

seems to support her sentiments; laptop programs in general have shown no gains in test scores beyond those previously attained before laptop implementation (Warschauer, 2006). Teachers reported that technology influenced grades, but oftentimes it is the professional development and redesigned curriculum that had a direct impact on student achievement. Research is underway to determine any further effects that laptop distribution may have on EOC testing in North Carolina.

Authentic Learning

Teachers reported that their students experienced more authentic learning as a result of instant access to software and online resources. Students reported that they learned a great deal from authentic activities such as mini-research projects; storyboarding; creating PowerPoint presentations, study guide websites, and podcasts; editing digital photographs and video; playing games for review; and writing articles in Microsoft Word. Some of their favorite online activities included career planning, WebQuests, virtual tours, watching videos on YouTube, and researching current events topics such as ethnic conflict and global poverty. Relatively new software and tools that teachers recommended for authentic activities included the GNU Image Manipulation Program (more commonly known as GIMP; www.gimp.org), a freely distributed piece of software for such tasks as photo retouching, image composition and image authoring; Google Sites (sites.google.com), a free and easy way to create and share webpages; Google Earth (earth.google.com), which provides views of Earth using satellite imagery, maps, terrain, and 3D buildings; and SAS Curriculum Pathways (www.sascurriculumpathways.com), a web portal that provides innovative, web-based resources in the core disciplines for grades 8–14. Students and teachers noted specific websites for classroom use such as XtraNormal (www.xtranormal.com), a web-based application used to create short 3D animated movies from simple text-based movie-scripts; MyPyramid (www.mypyramid.gov), online resources about the new food pyramid; Quizlet (quizlet.com), digital flashcards and quizzes; and WallWisher (www.wallwisher.com), an online notice board maker.

Assessment

Teachers used information from formative assessments, along with collaborative planning, to adjust their instructional practices. Many teachers let students decide the type of product by which they were to be assessed, as well as the method of submission (print or electronic). Teachers enjoyed collecting assignments electronically, and they looked forward to transitioning to paperless classrooms. They also appreciated the organization made possible by having blogs, discussion boards, and assignment submission all contained within a single online learning platform such as Angel or Moodle.

All 1:1 schools utilized laptops for standardized test preparation and administration. Students at EC schools took the Measurements of Academic Progress assessment online. Schools in each cohort prepared for EOCs on their laptops; some even allowed students to take EOCs online. One traditional teacher asked students to read EOC questions on their laptops and then discuss answers as a group. Another teacher at the same high school asked students to prepare for tests through a whole-class activity at www.usatestprep.com. Elements of the new classroom, such as varied assignments, efficient use of time, and test preparation, are sure to appear more often as virtual schools expand across the country.

Challenges to Effective Use of the Laptops for Teaching and Learning

One item on the survey asked teachers to describe two to three major barriers or challenges they faced when using their laptops for planning and instruction. The most commonly cited technical problems were

- not all students or all grades had laptops,
- SMART Boards were not available in every classroom,
- technology restrictions (including blocked websites and the inability to update their own computers) hindered full incorporation,
- networks were often overloaded or server issues existed,
- there were limitations on the size of files they could transfer to students (e.g., files larger than 2 megabytes),
- laptops had brief battery life, and
- not everyone had access to open wireless systems outside of school.

The most commonly cited instructional barriers were

- inadequate time to learn new ways to incorporate technology,
- variable technology skill levels of students,
- difficulties monitoring student work from teacher computers,
- lack of knowledge about how to incorporate certain technologies into a lesson,
- varying levels of student Internet access at home, and
- keeping students on task.

Additionally, teachers expressed some frustration about professional development efforts at the 1:1 schools, which was sometimes untimely (such as being offered during planning time) or too much information to process all at once. Finally, some teachers from Cohorts A and B voiced concerns about technology becoming a crutch for students:

> [Teacher] They [students] have quick access to procedures for finding the answers, but sometimes they still don't understand what processes they're using…when you get a question like, "Density's mass per unit volume," and you say, "Well, do I divide the mass by the volume or the volume by the mass?" that tells me the relationship is fuzzy, and sometimes technology makes it too easy to skirt that understanding.

Discussion

Overall, the presence of laptops appears to have enhanced multiple aspects of instructional practice. Teachers used the laptops for administrative tasks, such as designing new lesson plans, communicating with parents, developing teacher websites, and administering online and electronic assessment, as well as for instructional tasks, such as communicating with students and presenting learning activities in new environments. Laptops made communication faster and more effective for teachers and students. Teachers became facilitators of learning who helped students improve their quality of work and enjoy school.

Previous research indicates that appropriate professional development is essential for teachers in schools undergoing any type of technology integration (Klieger, Ben-Hur, & Bar-Yossef, 2010), and the insights gleaned from this study verify that finding. Teachers need sufficient professional development time, preparation, and a chance to provide their own input regarding the types of professional development they will experience. District and school leaders must ensure that teacher training is delivered in a reasonable and timely manner. The schools with the highest proportion of teachers who reacted negatively to the laptop initiative were those who had ill-planned professional

development or who taught at schools in which not all students had laptops (For instance, some teachers had questions regarding how to teach classes that consisted of juniors who did not have laptops and seniors who did). Those who may be planning a laptop initiative must realize that ongoing professional development is imperative to a successful technology rollout (Corn, 2009).

Some teachers expressed concerns that technology is taking away necessary skills such as handwriting and basic math knowledge that students should still possess. Math teachers were more likely to use calculators in the classroom than laptops. Students asserted that if the laptops are not tablets which may be written upon, they tend to not be useful in math class. Teachers commented that although the laptops may not be as useful in math classes as in other content areas, SMART Boards have changed the way they teach and enhanced student learning. One teacher, concerned about national declines in science and math skills, said, "Kids are not learning the skills of science and math, they're learning the skills of putting it into a machine and have it do the calculation, and until they learn the actual skill, they're becoming dependent on technology that they don't fully understand, therefore they may have access to that tool but not know how to fully use it."

One administrator reported seeing decreases in academic achievement during the first year of 1:1 learning in specific content areas. Although some research shows a drop in positive attitudes toward new technologies after the novelty wears off, students in the 1:1 initiative maintained a positive regard for the laptops (Corn, 2009). Another concern with 1:1 learning is that the computer can be a distraction for students. They may be overwhelmed by their access to so much information at their fingertips and simply stop paying attention to the teacher. Access to e-mail and other websites was the typical cause of student distraction. This was especially true in the case of special needs students who were already highly distractible or anxious. These students tend to become overstimulated and frustrated over minor glitches (Harris and Smith, 2004). Students also reported that teachers should not overuse the same type of assignment, such as creating a PowerPoint presentation, when they first receive the laptops. The secret to engagement, with or without laptops, seems to be the use of varied, appropriate teaching styles and assessment methods.

Teachers generally expressed positive sentiments about technology attitudes and beliefs, and the proportion of teachers expressing agreement with many survey items increased over time. The 1:1 initiatives enhanced various areas of instructional practice including technology use, communication, the role of the teacher, the learning environment, and professional development. From the blackboard to the SMART Board, the way teachers utilize any learning tool will always have an impact on how students learn. By having universal and round-the-clock access to information, students are beginning to see that some goals that seemed impossible before—such as moving on to higher education, considering a broad slate of potential careers, and developing a lifelong love of learning—are now within their reach. Ultimately, when laptop initiatives are grounded in quality professional development, careful lesson planning, and thoughtful technology use, instructional practice and the nature of learning become more appealing to 21st century educators and students alike. Future research at the Friday Institute will explore further the exciting realm of how technology initiatives help educators effectively reach digital learners.

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