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Cloud Computing: Short Term Impacts of 1:1 Computing in the Sixth Grade

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Abstract

Many parents, educators, and policy makers see great potential for leveraging tools like laptop computers, tablets, and smartphones in the classrooms of the world. Under budget constraints and shared access to equipment for students and teachers, the impacts have been irregular but hint at greater possibilities in 1:1 student computing settings. This study examines practices and short-term outcomes of a 1:1 program in two suburban 6th grade classrooms that used low-cost netbook computers and leveraged cloud-based software resources. The mixed-methods pre/post comparison study documented that, with planning, teachers and students used 1:1 computing resources to engage in constructive learning activities across the core curriculum. Teacher surveys and classroom observations found that students in the 1:1 pilot setting increased the frequency and quality of their social interactions in class. Pre/post surveys and classroom observation data all indicated that the technology-enhanced pilot setting had higher levels of engagement than observed in the conventional classrooms. Pilot students also achieved larger average achievement gains on standardized English Language Arts (ELA) state tests than their fellow 6th graders.

Keywords: 1:1 computing, student achievement, cloud computing, netbooks, middle school, communication, student engagement, social interactions, educational technology

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Introduction

In just the last few decades, computing technologies have transformed the personal and professional lives of large segments of the world's population. Similarly, the integration of computer technologies into traditional school settings has been widespread and far-reaching. Many parents, educators, and policy makers see great potential for leveraging tools like laptop computers, tablets, and smartphones in the classrooms of the world (Bebell & O'Dwyer, 2010). At the same time, critics have decried the lack of evidence from investments on costly educational technology expenditures, particularly on student achievement (Weston & Bain, 2010). As summarized in a New York Times feature story: "schools are spending billions on technology, even as they cut budgets and lay off teachers, with little proof that this approach is improving basic learning" (Richtel, 2011, para 8).

This paper seeks to contribute to the ongoing debate and growing educational literature through an empirical research study that examined the practices and short-term outcomes of a pilot 1:1 student program in two suburban 6th grade classrooms. This mixed-methods pre/post comparison study documented how teachers and students used low-cost netbook computers and leveraged cloud-based software resources to engage in constructive learning activities across the core curriculum resulting in increased social interactions, increased student engagement, and student achievement gains.

Literature Review

Despite the hopes and concerns of different stakeholders, it is clear that increased access to these powerful technologies is dramatically changing many of the world's classrooms and with it changing the reality of teaching and learning in the 21st century. Students' access to computing devices and information in much of the world today would have been nearly impossible to imagine just one generation ago. The ratio of students to computers in schools, a common metric for indicating students' access to computing devices, shows this precipitous change since 1983, when an average of 125 U.S. students shared a single computer (125:1). By 2011, U.S. students' access had increased more than 40-fold, with 3 students per computing device (3:1) and nearly 100% of U.S. classrooms connected to the Internet (Russell, Bebell, & Higgins, 2004; Snyder & Dillow, 2012). As computing technologies have become even more widespread across culture, industry, and education, many theorists and leadership organizations argue that teaching and learning need to be re-rooted in real-world tasks that integrate the use of technology to develop higher order skills and adequately prepare students to learn and work collaboratively with emerging technologies throughout their lives (International Society for Technology in Education, 2007; Partnership for 21st Century Skills, 2009; Puentedura, 2013).

As increased access and more powerful technologies have permeated the classroom, the variety of ways in which teachers and students use computer-based technologies has also expanded. For example, evidence for this can be seen in the findings of research exploring the role and effects of computers on teaching and learning that suggest a wide variety of potential benefits including the following: increased student engagement (Bebell & Kay, 2010; Donovan, Green, & Hartley, 2010; Maine Education Policy Research Institute, 2003; Mouza, 2008); increased use of computers for writing, analysis, and research (Bebell & Kay, 2009; Grimes & Warschauer, 2008; Lowther, Inan, Ross, & Strahl, 2012; Russell, Bebell, & Higgins, 2004); improved standardized test scores in English Language Arts (Bebell & Kay, 2010; Gulek & Demirtas, 2005; Suhr, Hernandez, Grimes, & Warschauer, 2010); and a movement towards student-centered pedagogy (Russell, Bebell, & Higgins, 2004; Mouza, 2008; Lowther et al., 2012). However, for any effect to be realized from educational technology, the technology must be actively and frequently used. Understanding this, research has also focused on exploring what factors and conditions are necessary to allow different technology uses to occur (Bebell, Russell, & O'Dwyer, 2004; Becker, 1999; O'Bannon & Thomas, 2014).

Given the ways in which technology resources have been traditionally distributed within schools (e.g., in labs, libraries, or on shared carts), many have theorized that the scarcity of major student achievement outcomes were a consequence of shared technology access resulting in relatively limited use and impact (Bebell & O'Dwyer, 2010; Papert, 1996). In fact, both proponents and opponents of educational technology agree that the full effects of any digital resource in school cannot be fully realized until the technology is no longer a shared resource (Weston & Bain, 2010). Recognizing the limitations of sharing technology access across students and classrooms, there has been a steady and growing interest in 1:1 technology scenarios, wherein each teacher and student have full and independent access to a computing device. Such programs seek to leverage students' access to technology in their classrooms so that students' historically limited or shared access to technology is no longer an obstacle.

Initiatives to provide computers to students at a 1:1 ratio first began in 1989 when the Methodist Ladies College in Australia required all incoming students (5^{th} through 12^{th} grade) to purchase school-approved Toshiba laptops. Other Australian schools have adopted similar initiatives so that by the late 1990s over 50,000 Australian children were in 1:1 computing programs (Stager, 1998). Within the U.S. as well, several schools experimented with 1:1 programs during the 1990s. Due to the financial challenge of sustaining 1:1 computing programs, these isolated programs were often financed through one-time budget opportunities, fund-raisers (Stevenson, 1999), local foundations and grants (Cromwell, 1999), and increases in tuition at private schools (Thompson, 2001). In addition, district or state funded 1:1 programs have been piloted in South Dakota, Pennsylvania, New Hampshire, Texas, California, Florida, Massachusetts, Maine, and Michigan (Bebell & O'Dwyer, 2010; Zucker & Hug, 2008). Beginning in 2007, Uruguay launched the world's first countrywide 1:1 initiative and has distributed over one million laptops to primary school students.

Despite the massive investments and expectations of 1:1 computing programs, it is challenging to summarize the impacts across different 1:1 student computing programs. By definition, 1:1 computing describes only the access ratio of technology to students and says nothing about the actual teaching and learning practices. Many educational leaders and theorists hold a general presumption that 1:1 access enables more constructivist pedagogies and student centered classrooms, but the only unifying feature of any 1:1 program is the ubiquity of the student device, not a specific application or use. Therefore, different 1:1 programs can be initiated for vastly different purposes and have vastly different expectations for student outcomes.

It is also important to consider that educational technology and its uses are evolving so quickly that much of the literature from even five years ago fails to address the dynamic digital learning tools that are now commonplace such as the Apple iPad (Project Tomorrow, 2014). Studies have also shown that many 1:1 computing programs have been inconsistently implemented leading to only sporadic impacts (Weston & Bain, 2010). Therefore, in order to fully evaluate the effectiveness of any 1:1 program it is necessary to first consider and quantify how teachers and students are actually using the digital tools.

With increased pressure for more quantitative outcomes, a number of studies have focused on the relationship between student achievement and participation in laptop programs. For example, the Journal of Technology, Learning and Assessment published a special issue on empirical research emerging from 1:1 technology settings and included three papers that explored student achievement outcomes. Studies from Massachusetts (Bebell & Kay, 2010), Texas (Shapley, Sheehan, Maloney, & Caranikas-Walker, 2010) and California (Suhr et al., 2010) each examined the impact of 1:1 participation and practices on measures of student achievement and reported statistically significant impacts in English Language Arts performance.

In 2010, the U.S. Department of Education updated the National Education Technology Plan to support a technology infrastructure that "is always on, available to students, educators, and administrators regardless of their location or time of day (p.13)". This infrastructure would include universal access to computing devices as well as adequate network facilities (U.S. Department of Education, Office of Educational Technology, 2010). However, in a sustained sluggish economy, funding educational technology (particularly laptops for students) remains a major challenge and obstacle at the federal, state, district, and school levels. Education leaders are predicting increased technology expenditures in the future, and are increasingly considering different cost-effective options within their budgets to sustain and grow their educational technology programs (Brown & Green, 2013). As one recent example, there has been huge growth in Bring Your Own Device (BYOD) programs where schools encourage students and families to purchase computing devices for students' use in school (Burns-Sardone, 2014). Laptop alternatives like tablets, smartphones, and netbooks are also increasingly popular hardware options for providing students 1:1 access to a digital computing device in budget constrained schools.

Recognizing the limits of the previous research, the current study involved a university research team and a school district collaborating to study the implementation and efficacy of using low-cost netbook computers and a cloud network to create a pilot 1:1 computing environment. Cloud computing represents an emerging model for educational computing whereby software, systems, and other resources are hosted via the Internet. One of the key advantages of cloud computing is that the hardware requirements (and costs) are significantly lower than traditional laptops where the platform, software, and other resources must reside locally, rather than in an Internet-based "cloud". Given the limitless scalability and infrastructure inherent in cloud computing, this model offers an attractive student and teacher computing solution. Although it has only been documented in a few education settings (Erenben, 2009; Zhang, Cheng, & Boutaba, 2010)**,** the New Media Consortium predicts increased adoption of cloud computing models across K-12 settings (Johnson, Adams, & Haywood, 2011).

The current paper summarizes the implementation and emerging results from a year-long pre/post comparative study of a sixth grade pilot 1:1 netbook/cloud computing program. Specifically, this mixed-methods investigation explored how classroom activities were impacted by 1:1 computing resources, including the types of projects students worked on, the way social interactions were articulated, and in what way these activities affected student engagement. In addition, the study explores how student participation in this pilot 1:1 program impacted standardized test scores and considers the relationship between student achievement, technology access, and classroom practices.

Setting and Learning Conditions

This paper presents selected results from the Newton Public Schools 21st Century Pilot Study. Newton Public Schools is a suburban school district serving approximately 11,500 students across fifteen elementary schools, four middle schools, and two high schools in eastern Massachusetts. The express aim of this yearlong pilot program and evaluation study was to explore the implementation and impacts of a 6th grade 1:1 student-computing program. Through a pre/post comparison study design, it was possible to investigate how traditional teaching and learning practices evolved with the adoption of 10-inch Dell netbooks for each student, with wireless network accessibility for cloud computing. Principal outcomes that the district sought to document through the yearlong pilot included changes in:

- teachers' and students' technology use and general classroom practices,
- types and frequency of products that students created,
- social interactions among and between teachers and students,
- student engagement, and
- measures of student achievement.

Both quantitative (student and teacher surveys, student test score analyses, etc.) and qualitative (classroom observations, interviews, etc.) research methods documented student and teacher experiences during the implementation period and how the technology-rich setting impacted each of the targeted outcomes.

By focusing on the student device and its immediate use in the classroom, studies of 1:1 computing programs too often provide a false impression of the time and money invested to implement and sustain a successful 1:1 computing initiative. After developing and internally experimenting with an initial pre-pilot program, Newton Public Schools, with funding from the Newton Schools Foundation, solicited a district-wide request for proposals for core teaching teams (English, social studies, math and science) to apply for the 21st Century Classroom grant. After selecting a 6th grade winning team, the two teachers were requested to develop educational materials and curricula that focused on innovation, critical and creative thinking, and collaborative problem solving. Their classroom environment would be transformed from possessing a few shared computers to one when where a suite of digital resources would be highly accessible and supported. Specifically, each classroom was equipped with:

- 1:1 student netbooks for use throughout the school day,
- an interactive white board with mounted projector,
- a new teacher laptop,
- a student response system (clickers), and
- targeted technical and instructional support.

The participating teacher team was required to measure "student performance using a variety of assessments, such as rubrics and exemplars" and work collaboratively with the school-based Instructional Technology Specialist (ITS), library teachers, and Curriculum Coordinators to align classroom uses of technology with district benchmarks. Additional requirements and responsibilities for the participating teachers included:

1. Attend a two-day introduction/training workshop.
2. Participate in staff development and team meetings once a month after school.
3. Share knowledge with other teachers by posting lessons on the district website and presenting at a faculty meeting.
4. Host visitors in order to demonstrate best practices of teaching with technology tools.
5. Participate in the evaluation of the 21st Century Classroom Initiative by assessing student work, facilitating and completing questionnaires, and writing reflections about the value of the project.

Given that this was a pilot program, an important component of the initiative was a third party research and evaluation study. The overall aim of the evaluation study was to provide formative data to facilitate the implementation process as well as summative results to empirically address the educational outcomes of the new technology investments and classroom environment. A summary of the study timeline and data collection procedures is presented in Table 1.

Table 1 - 21st Century Classroom Project and data collection timeline

Timeline	21C Pilot Activity	Evaluation Activity
Aug 2009	Introduction	Develop survey instruments; Identify 2 traditional “control” classrooms
Sep/Oct 2009	Orientation, Focus and Design	Pre-pilot data collection student and teacher survey in pilot and control classes, student drawings, teacher interviews
January 2010	**Students get wireless laptops**	Classroom observations in pilot and comparison classrooms
Mar/Apr 2010	Design /State Assessment	Classroom observations continued
May/Jun 2010	Publish Lessons	Classroom observations continued, final student and teacher surveys in pilot and control classrooms, student focus group, student drawings, teacher interviews
Summer 2010		Collection of records and student achievement data, analyses of observation data, interview, drawing, and survey data
Sep 2010	Exhibition, Next Steps	*Final evaluation report*

Below, the study methods are presented in more detail, followed by a summary of the study results and a discussion of the relevant findings as they may apply to other schools and future 1:1 implementations.

Methodology for the Evaluation Study

A 13-month pre/post matched comparison evaluation study was designed and implemented to examine how a suite of newly introduced digital resources might potentially impact teaching and learning in a traditional middle school environment. As previously described, the pilot classrooms received 1:1 student netbooks and other resources while the two comparison classrooms (in the same school and serving the same grade level) had only traditional technology access including a teacher’s laptop, access to the school’s computer lab, access to mobile laptop carts shared across the school, and one LCD projector and document camera per class. As one would expect within the same school and grade, students in both the pilot and comparison settings shared similar demographic characteristics. Table 2 provides a general description of student background characteristics and a summary of the number of student participants in each study setting.

Table 2 – Pilot and comparison student demographic information

Setting	Participating students	Gender		Race/Ethnicity		Primary home language is not English
		Male	Female	White	Other	
Pilot	46	48%	52%	67%	33%	17%
Comparison	45	53%	47%	73%	27%	4%
Total	91	51%	49%	70%	30%	11%

To best capture the wide range of potential outcomes, the study relied on an assortment of data collection tools and instruments. Specifically, both quantitative (student and teacher surveys, student test score analyses, and school record analysis) and qualitative (classroom observations, teacher interviews, student drawings, and teacher weblogs) research methods were employed to ascertain how the pilot setting may impact student achievement, student engagement, classroom interactions, and teaching and learning practices over the course of the year-long study period.

Student Survey

All pilot (n=46) and comparison students (n=45) completed a survey in September 2009 to record baseline conditions, resulting in a 100% response rate. After about six months of 1:1 computing, a post-pilot survey was conducted in June 2010, with a 96% response rate. Customized from previously validated instruments, the student survey included measures of students' perceived access to technology in school, their use of technology in school across subject areas, personal comfort level with technology, attitudes and perspectives towards technology and digital content, access to technology at home, and the frequency of a variety home technology uses.

Teacher Survey

Both of the pilot class teachers (n=2) and comparison class teachers (n=2) completed a teacher survey on two occasions during the 2009/2010 school year. Specifically, teachers completed a pre-1:1 survey very early in the school year to provide an approximation of baseline conditions across each setting and again in May 2010 to demonstrate how changes in digital resources and training may have impacted teaching and learning. More specifically the teacher survey was developed to capture the variety and extent of teachers' technology use, teachers' attitude toward technology, teaching, and learning, as well as teachers' beliefs on student motivation and engagement. The survey also included a brief item set that measured more general pedagogical practices and classroom practices. Collectively, these items provide a source of evidence for changes in the approach and delivery of the curriculum (as well as various aspects of teacher/student interactions) from the teachers' own perspective. Looking across the teacher surveys over time from both pilot and control classrooms, the survey can provide additional documentation on the impacts of the pilot initiative on teacher and student practices. In addition, the May 2010 teacher survey captures teachers' perceptions of the impacts of 1:1 computing on their students, including student engagement, student achievement and discipline.

Classroom Observations

A total of 107 classroom observations were recorded across all pre and post conditions in both pilot and comparison classrooms. Class periods were sampled according to the teachers' and observer's convenience with some effort made to get equal time from both pilot and comparison classes as well as the core subject areas (English Language Arts, science, math, and world geography). Typically, each observation lasted for one class period or about 45 minutes.

Fifty classroom observations were conducted in December 2009 and January 2010, before students had received the netbooks. Student netbooks were deployed in January and the observations were not conducted throughout February to allow pilot teachers time to integrate the new equipment into their procedures. The remaining 57 observations were made from March through the end of May 2010. Collectively, observations were recorded across a total of 1,828 and 2,438 minutes of classroom lessons, before and after implementation.

As developed over prior research studies (Russell, Bebell, & Higgins, 2004; Russell, Bebell, Cowan, & Corbelli, 2003), a trained researcher conducted classroom observations using customized data collection software for capturing and categorizing observation notes (See the Appendix). During an observation, students' engagement level, the number of students working with technology, the number of students working independently, in pairs, in small groups, or in large groups and the role of the teacher were quantitatively recorded every ten minutes via an automated observational checklist. In addition, the observer recorded narrative accounts of the activities occurring throughout each class observation, with a specific emphasis on teacher-student interactions, student-student interactions, uses of technology, and student engagement. Observation notes were coded by blinded readers using holistic coding, while emergent analytic content analysis was applied to explore potential differences in recorded practices between the pilot and comparison classrooms over the pre and post observation periods (Stemler, 2001).

Student Test Score Analyses

Given the overall climate of test score-based accountability, the impact of varied classroom practices on student achievement in English Language Arts (ELA) was measured through analysis of Massachusetts Comprehensive Assessment System (MCAS) results. As we have demonstrated through past research, such analysis using the MCAS as the primary outcome measure has numerous limitations, and the analysis of such a relatively small sample of students in the two learning conditions also presents limitations (Bebell & Kay, 2009; O'Dwyer, Russell, Bebell, & Tucker- Seeley, 2005, 2008). However, until PARCC [The Partnership for Assessment of Readiness for College and Careers] is fully implemented, the MCAS remains the *de facto* measure of student achievement for many policy makers and educational leaders in the district and state.

For those with parent consent, a unique student ID was used to merge the student survey data with school record data including state test scores. Three previous years of student level test score results were accessed from students' pre-grade 6 records to provide a covariate of prior student achievement. This rich database allows for a nuanced exploration of the relative gain or loss in test scores experienced by pilot and comparison students and the relationship between achievement, classroom practices, and learning conditions as reported in the surveys.

Data Analysis

A variety of methodological approaches were used to analyze each of these data sources. Due to the low sample size of the study, most analyses can be categorized as descriptive statistics. Inferential statistics were only used when comparing the MCAS test performances for all sixth grade students. For all of the descriptive and inferential techniques used to analyze the data, the Statistical Package for the Social Sciences (SPSS) software was used.

The student surveys were analyzed using descriptive statistics to understand the distribution of responses across the pilot and comparison groups. With a sample size of two, the teacher surveys were too small to analyze using statistical software and so the results of the teacher survey were used to add support to the findings of the student surveys.

The classroom observations were collected using customized Access software which categorized and coded all student to student, student to technology, and student to teacher interactions. With such a robust dataset, SPSS software was used to perform a series of descriptive analyses to understand how the distribution of responses differed in the pilot and comparison groups for the counts and frequencies that were collected in observations. As for the narrative components of the observations, blinded researchers coded each narrative using a content analysis technique as prescribed by Stemler (2001).

Lastly, as mentioned before, the student test score analysis was performed using both descriptive and inferential statistics in SPSS. While the achievement scores were analyzed using descriptive statistics, the difference in growth for each group was analyzed using Somer's D measures of association to understand whether the difference in median growth percentiles is statistically significant.

Results

This section summarizes the results of the analyses performed on four of the collected data sources from the pilot evaluation: student survey, teacher survey, observations, and MCAS data. To better organize the information collected through each data source, the current paper focuses on five major findings:

1. teachers' and students' technology use and general classroom practices,
2. types and frequency of products that students created,
3. social interactions among and between teachers and students,
4. student engagement, and
5. measures of student achievement.

Increased Resources, Increased Technology Use

Perhaps one of the most universal and salient results from most 1:1 computing implementations is the major increase in students' use of technology in school (Bebell & O'Dywer, 2010). Within the first months of the Newton pilot implementation, students' 1:1 computer access was clearly associated with increased levels of computer use in the classroom. As shown in Figure 1, the frequency of classroom observation where students were using computers increased dramatically in the post-1:1 pilot setting.

Specifically, Figure 1 shows the pilot students use of computers in class increase from 23% to 61% across observations, while decreasing slightly in the comparison setting. Similarly, when analyzing the ten-minute interval data from the observation notes, the average number of pilot students using computers in the pre-pilot classes was about two. After the netbooks were introduced, an average of 10.5 students, or about half of the class, were found to be using computers in each ten-minute interval. Across the comparison settings, however, the average number of students using computers remained below two students throughout of the study.

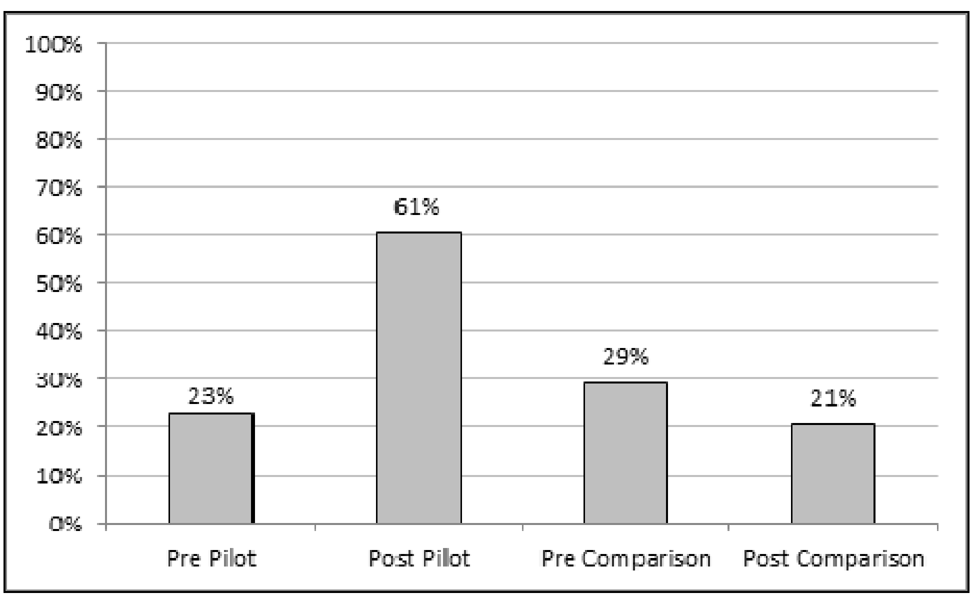


Figure 1 - Percent of class periods where students were observed using technology including computers, calculators, and projectors

Student survey data, collected both before and after the pilot 1:1 implementation, triangulates the observation results showing major increases in students use in class (% of class time) across different subject areas and school locations. Figure 2a shows the average number of days that pilot and comparison students reported using computing devices in different locations across pre- and post-1:1 conditions, while Figure 2b shows this information for each of the core subject areas.

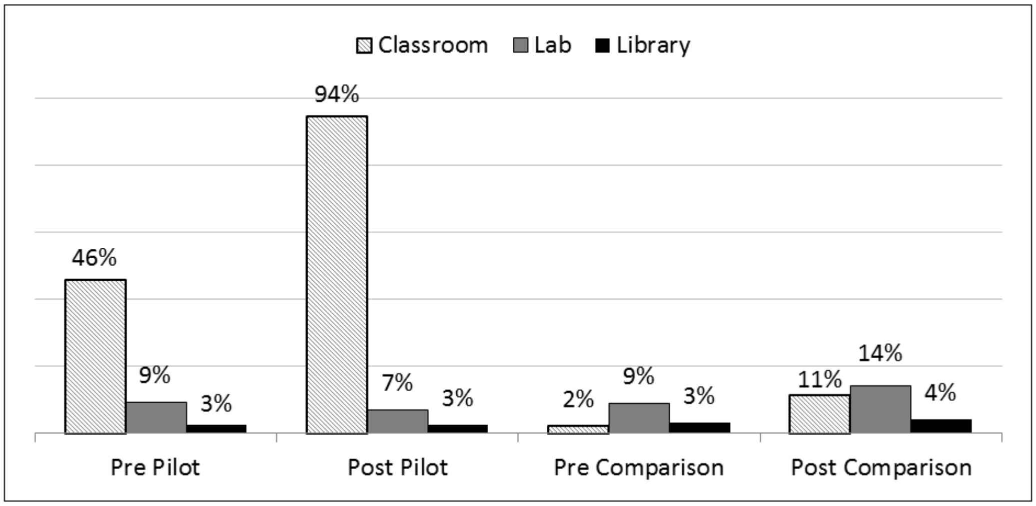


Figure 2a – Average percent of school days where students reported using computers across spaces in school

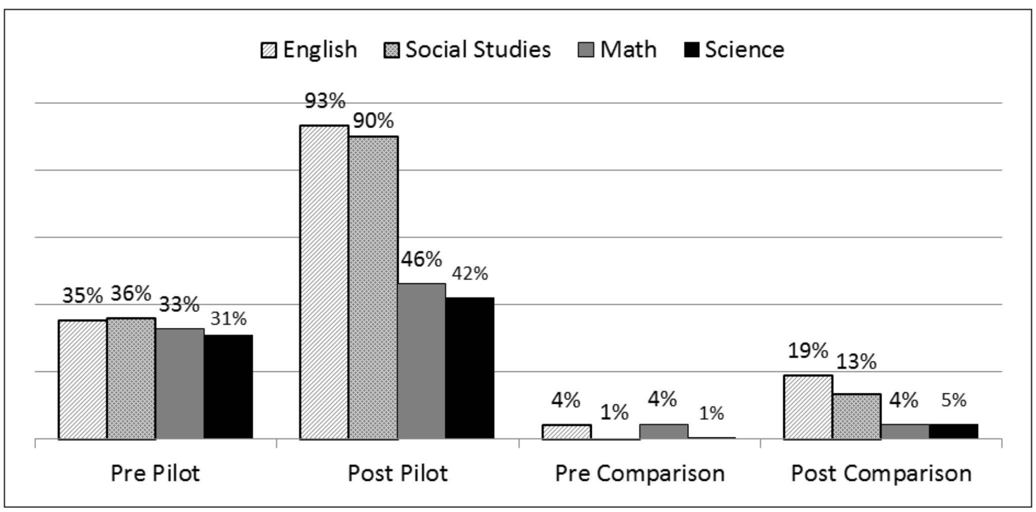


Figure 2b – Average percent of school days where students reported using computers across subject areas

As shown in Figure 2a, pilot students reported that their average frequency of computer use in the classroom more than doubled during the year-long pilot, but was basically unchanged in non-classroom settings (computer lab and library). Similarly, Figure 2b shows that the 1:1 pilot students reported increased technology use across all of their core subject areas by the end of the year, with largest increases reported in English and Social studies, echoing classroom observations and teacher survey results. Examining the hundreds of interval data points observed across English classes, pilot students were observed using computers in class during only 2% of pre-pilot sessions, compared to 76% of the observed intervals recorded in the 1:1 English classes.

Student survey, teacher survey, and classroom observation results all suggest that pilot students in the 1:1 environment used computers in class and across the curriculum with much greater frequency than comparison students and recorded past levels.

Students' Computer Use Goes Beyond Writing

Analyses across the different data sources not only demonstrate that 1:1 *access* significantly increased the frequency of students computer *use* in class, but also provided an opportunity to explore more of the contextual characteristics associated with students' technology use in a 1:1 setting. For example, the pilot students increased use of computers in ELA and social studies was found to be partially due to the ease of word processor use in writing and geographic information systems (GIS) in social studies. Given that pilot teachers were already experienced and comfortable with these types of student activities in their pre-1:1 classes, students' increased access to computers allowed for a nearly immediate increase in these types of uses.

Analyses comparing the pre/post classroom observations show how teaching, learning, and technology use changed during the implementation period. For students, "listening to a presentation" and "producing artifacts in non-written media" were the two activities that changed the most in the pilot classrooms relative to changes in the comparison setting. More specifically, students in the 1:1 setting were observed spending less time in class "listening to a presentation", an activity that increased throughout the school year in the comparison classrooms. Observations also showed that 1:1 students produced a wider variety of artifacts when using netbooks, while writing remained the predominant artifact in the comparison group. Indeed, across all of the recorded classroom observations conducted in the 1:1 pilot setting, 55% recorded students using technology to produce multimedia or non-written artifacts in class.

In addition to the observation findings, the student survey also measured the change in frequency and variety of products students created in the different study settings. Figure 3, shows the percentage of school days that students reported creating different kinds of products and work.

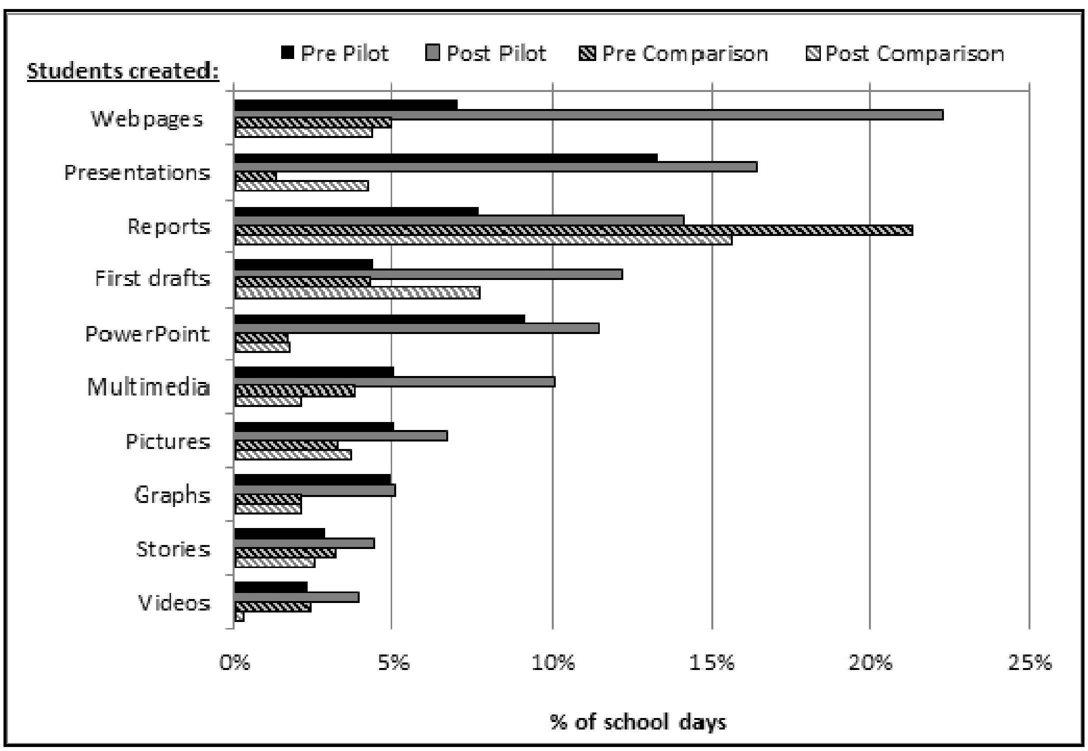


Figure 3 – Percentage of school days that students reported generating various products

As shown in Figure 3, students reported that web pages were the most frequently created product in the 1:1 implementation period. In addition, the frequency with which students created presentation materials and gave presentations increased dramatically. On average, 1:1 pilot students were three times more likely to make presentation slides and four times as likely to give presentations as were comparison group students. One example of the new generation of student products being in the 1:1 setting was a "glog", for "graphic blog". Glogs, hosted by Glogster EDU at www.glogster.com, are essentially websites that can accommodate text, images, audio, and video content. In one observed chemistry class, each student used their netbook to conduct online research about a specific element. Students assembled their resources and information into personal glogs that they later presented and shared with the rest of the class. Throughout this project the teacher worked with students to master the technical skills for navigating the platform, manipulating glog components, and adding audio and video that the students had created themselves. The teacher also used the activity to encourage students to think critically about design issues. In another observed example, 1:1 students worked together across a series of ELA classes to create online multimedia versions of Beowulf. Students worked collaborative using Aviary Myna, a web-based audio editor to create mood music and narrative tracks. Students then scanned their own artwork and used a web-based video editor to add animation and publish their video books. Upon completion, each student group presented their online videos to the class.

Increases in Collaboration and Student Interaction

In addition to the changes in teaching and learning practices in the 1:1 setting, the evaluation study expressly sought to measure the potential impacts of the program on student collaboration and social interactions in the classroom. Table 3 summarizes the observational interval data showing the average number of students working across various configurations across the different settings and conditions. Note that throughout the observations, students were reported as working individually when they had their own material at their desk and worked with it on their own. If students shared their work with others then they were recorded as working in pairs or groups. Students worked as a "whole class" if the structure of the work was a presentation or class discussion where it was clearly expected that all students should be paying attention to the same thing.

Table 3 - Average number of students working across various configurations recorded across the ten-minute interval classroom observations

Students working as:	Pre/Pilot	Post/Pilot	Pre/Comparison	Post/Comparison	Total
Individuals	10.25	8.53	6.62	4.84	7.46
Pairs	1.63	2.83	3.05	2.70	2.57
Groups	3.25	3.51	0.74	1.38	2.22
Whole class	7.56	5.48	10.70	11.16	8.77

It is apparent from the interval observation records shown in Table 3 that students in the pilot classes most often worked individually in the pre-1:1 environment, while comparison students most often worked as a whole class. With the implementation of the 1:1 program, students in the 1:1 setting were less likely to be observed working individually, as they joined in more pairs and groups. Moreover, while comparison students also increased the frequency of working in groups, this remained their least frequent configuration; whereas whole-class configurations also slightly increased and remained dominant throughout the year. These findings suggest that with the implementation of the 1:1 computing resources students increased smaller group work, while decreasing the percentage of time students engaged in both whole-class and individual work. Examining the pre/post teacher surveys, both pilot and comparison teachers similarly reported that student interactions increased when working with technology. After the 1:1 implementation period, pilot teachers reported this belief even more strongly. Triangulating this teacher belief with the observation data in Figure 4 confirms that student interactions occurred in tangent with technology use. Note that student social interactions were primarily verbal exchanges, but also included physical contact, and playing games.

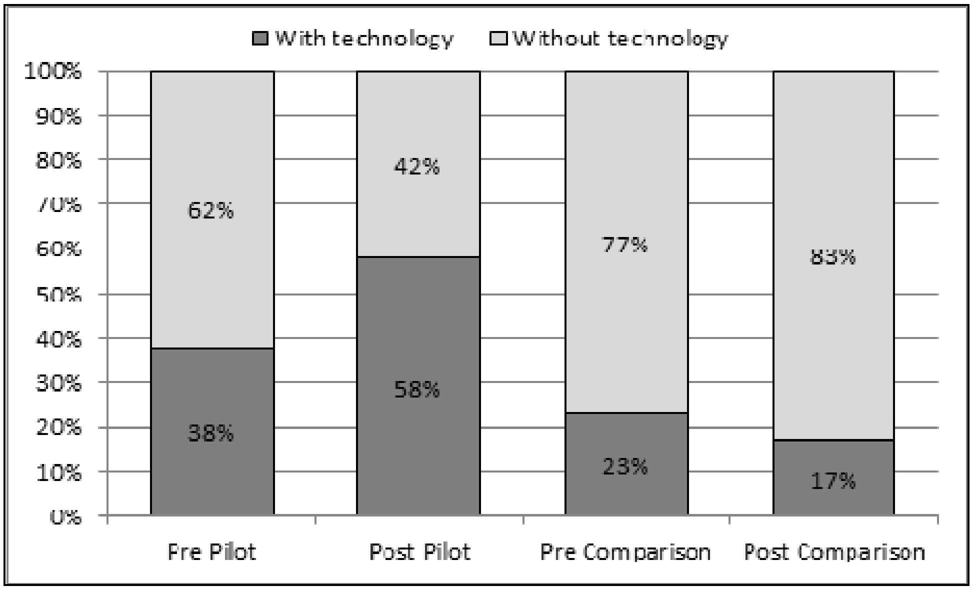


Figure 4 - Proportion of observed student social interactions involving technology

Figure 4 shows how the proportion of students' social interactions involving technology increased for the 1:1 pilot class. One example of how students' social interactions developed in the 1:1 setting can be found in a social studies class observation. In this specific lesson, the teacher asked students to work in groups of four to research and prepare a class presentation on specific aspects of Chinese culture. Students were initially directed to a teacher-created Google Doc that provided further details and requirements of the assignment. One group of boys took their netbooks and sat together on the floor at the back of the room. Students throughout the rest of the class talked to each other, making strategies for their work, helping each other with technology skills, and asking for leads to "good" information. As the planning phase finished up, students in each group were observed working on different facets of the assignment. For example, one student would be searching the internet for information, another may be editing a photo, and a third might be writing text into their Google presentation. During this small group work, the teacher wandered the room answering students' questions, helping with technical issues, and providing encouragement and feedback to students.

In order to better understand the constructive nature of student interactions in class, a secondary analysis of the observation notes was completed by a "blinded" reviewer. We were interested in quantifying the degree that student interactions were either on-task and academically relevant versus off-task and not relevant or constructive to the class. The level of productivity observed across all student interactions in the observation notes were blindly scored using a simple dichotomous rubric: 'less constructive' or 'very constructive'. If an observation described social interactions that were disconnected from the lesson or that were disruptive to the class, the observation was coded as 'less constructive'. Conversely, if the observed interactions lacked off-task discussion or included details consistent with engaged or on-task behavior, the observation was coded as 'very constructive'. Figure 5 summarizes the distribution of the constructiveness of observed student interactions in each of the study settings.

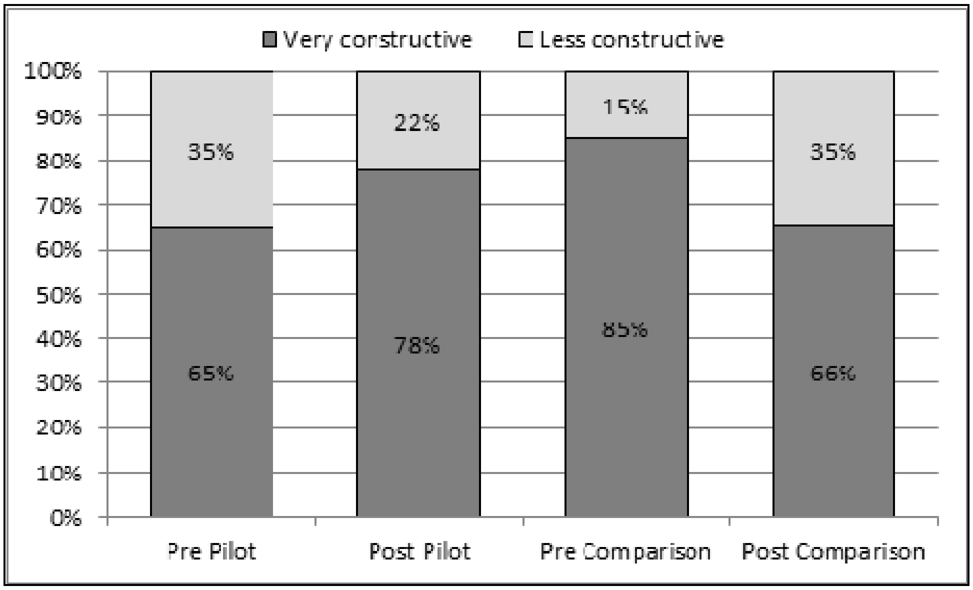


Figure 5 - Proportion of observed student interactions that were academically constructive

Figure 5 shows that in the pilot setting, the proportion of constructive student interactions increased from 65% to 78%. Nearly the opposite trend was observed in the comparison classrooms where the proportion of observations coded as 'very constructive' decreased from 85% to about 66%. This observational data suggests that student interactions not only increased in frequency over the short 1:1 implementation period, but also increased in their relevance to their curriculum and class.

Maintained Higher Levels of Engagement

The current study sought to measure changes in student engagement using a number of different approaches including classroom observations, student surveys, and teacher surveys. For example on both pre and post surveys, teachers were asked to estimate the percentage of time that their students were engaged in their classes. Although many prior studies have operational defined "student engagement" in different ways, we expressly did not define this term for teachers completing the survey, leaving the meaning up to the responding teachers. Figure 6 shows teachers' average estimation of student engagement across pre/post and pilot and comparison settings.

As reported across both administrations of the teacher survey, pilot classroom teachers reported higher levels of student engagement than comparison teachers, on average. From the teachers' own perspective, student engagement decreased over their sixth grade school year in the comparison classrooms, while proportion of class time students were engaged in the 1:1 classes remained over 90%. In other words, teachers reported that student engagement remained high throughout the duration of the school year in the 1:1 settings, whereas student engagement rates dropped in the traditional settings. An analysis of the classroom observation records yield a similar result with pilot students' engagement declining slightly towards the end of the school year, while comparison students' engagement levels declined more drastically. Across all classroom observations, student engagement was coded from the observer's impression of students' level of attention and effort towards learning using a five-point scale ranging from "low engagement" to "high engagement".

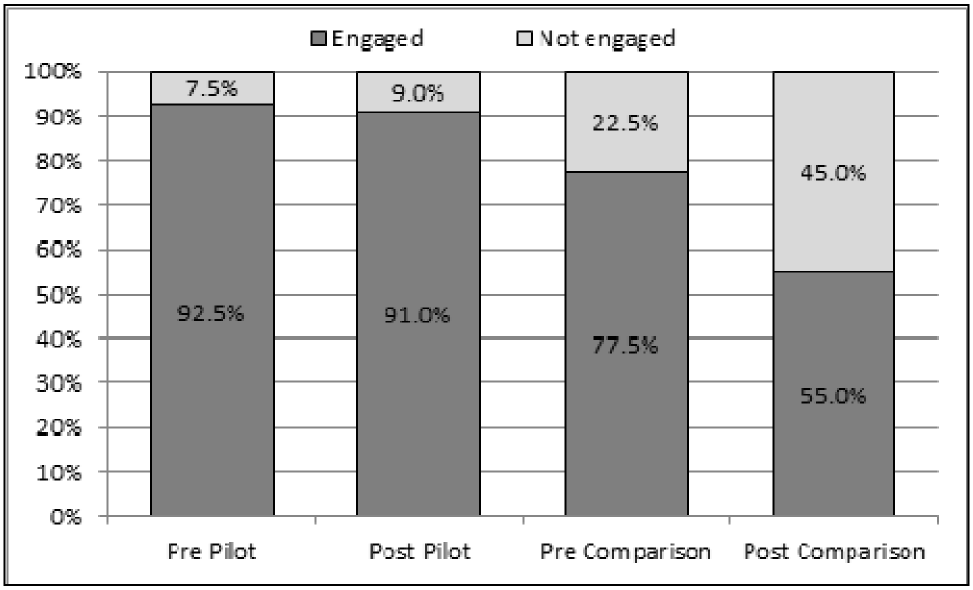


Figure 6 - Teacher-reported levels of student engagement

Stronger Growth in Standardized ELA Test Performance

To demonstrate the potential impact of teaching and learning conditions in 1:1 settings, an analysis of student achievement was conducted. As previously described, students' English Language Arts (ELA) MCAS scores were analyzed as a measure of student achievement across both settings. Figure 7 shows the median ELA MCAS scale scores for the pilot and comparison student cohorts during each of their annual grade level assessments, from 2007 as third graders to 2010 as sixth graders.

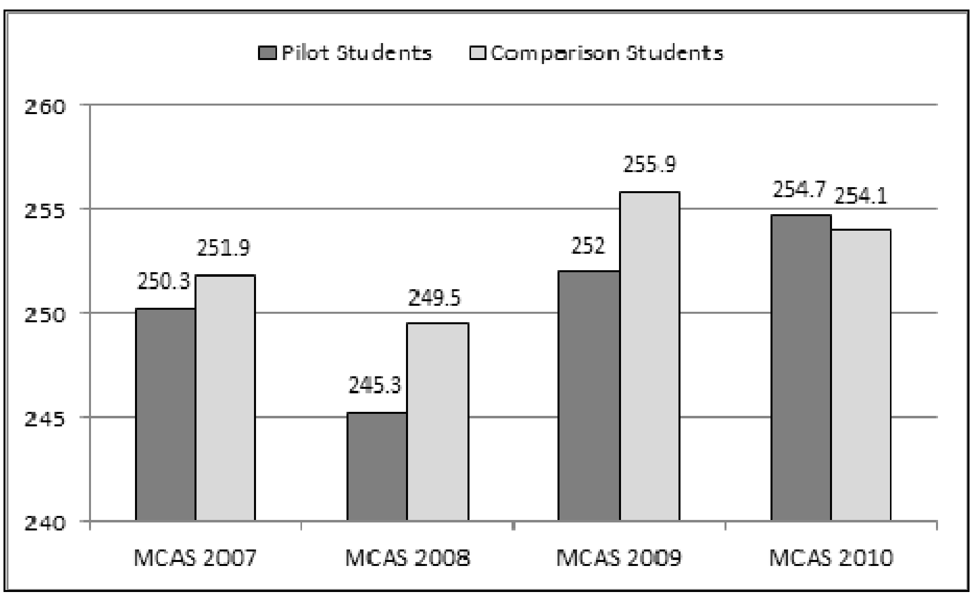


Figure 7 - Students' median English Language Arts MCAS scores from 3rd through 6th grade

In the three years before the pilot program, the cohort of students who became the comparison group consistently earned higher average scores in both math and ELA. However, as shown in

Figure 7, in the 2010 administration of the ELA MCAS, after students were divided into pilot and comparison classrooms for 6th grade, the pilot students' averages rose to their highest recorded scores, even slightly eclipsing the comparison student average ELA performance. Although limited, these results suggest that student performance in the pilot cohort actually did improve relative to the comparison cohort over the course of their 6th grade year.

While the analysis in Figure 7 shows the median ELA score for students in each setting, it does not precisely measure the significance of the growth of students in each setting. From the above analyses, we know that pilot setting scores increased on average and comparison setting scores decreased on average from 2009 to 2010. In order to make inferential statements about the amount of growth in student scores from 2009 to 2010, student growth percentiles (SGPs), as calculated and reported in the state results, will be used. SGPs provide a measure of students' unique performance relative to others in the state that performed similarly in previous years. In other words, for each given assessment, students are provided an index of their relative performance compared to other students in the state who scored similarly on past MCAS subject tests. SGPs are intended to indicate how much students have learned, rather than their particular performance levels. Based on the familiar percentile rank, the average/mean of the SGP is always 50 with a range from 1 to 99. State guidelines for interpreting MCAS SGPs are as follows: "Growth percentiles below 40 suggest that your child's progress is low compared to most students. Growth percentiles between 40 and 60 represent average progress. Growth percentiles above 60 represent better progress than most students" (Massachusetts Department of Elementary & Secondary Education, 2010, p. 3). Figure 8 summarizes pilot and comparison students' average sixth grade SGPs for ELA.

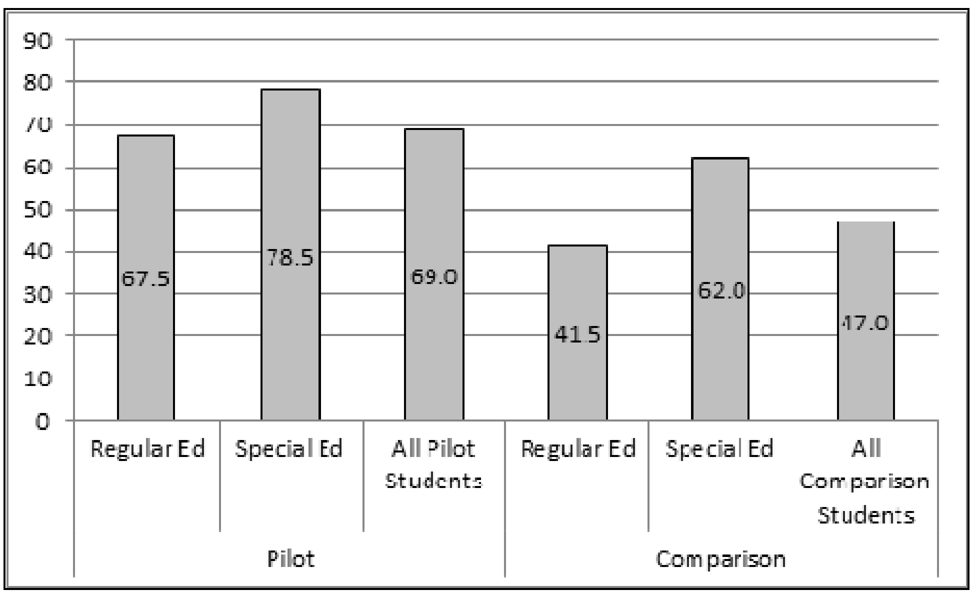


Figure 8 - Students' average 6th grade English language arts SGPs

Overall, the ELA growth percentiles indicate that pilot students were well above the average of 50, indicating that the students achieved much greater 2010 ELA MCAS growth than students from across the state that scored similarly in past ELA examinations. Specifically, pilot students had an average SGP of 69, substantially higher than average growth when compared to similar students statewide. It is also noticeable that special education students performed better than statewide averages.

For comparison students, these ELA gains were much closer to average, with an average SGP of 47. This SGP is interpreted as having made adequate and expected progress throughout the year that is similar to what most comparable students in the state experienced. Similar to the pilot setting, special education students in the comparison setting also experienced higher growth as compared to other students statewide. In both settings, special education students received additional educational supports that were not recorded in the current study; therefore, conclusions should not be drawn about the differences in scores of special education students. However, the difference in SGPs for pilot and comparison students provides evidence about the difference in academic performance for each setting. Somer's D statistic was employed to measure the degree of difference between the pilot and comparison SGPs for the 2010 ELA MCAS, which were found to be statistically significant (Somer's D= -206; n=83, Sig. =.012). Therefore, there is a significant difference between the growth percentiles of each group, with pilot setting students demonstrating higher than average growth in ELA.

Discussion

The current study investigated the short term educational impacts of Newton Public Schools' 21st Century Classroom Pilot Program, which provided a cohort of 6th grade students with a suite of digital learning tools, including interactive whiteboards, classroom performance systems (i.e. "clickers"), and 1:1 student netbooks. A pre/post comparison study employed classroom observations, interviews, student drawings, student and teacher surveys as well as an analysis of student achievement to document the impact of the program. This report aimed to share the experiences and results from this implementation to help inform the greater educational community and policy makers on the roles that digital tools can play in middle school education and their most immediate impacts from one well-documented setting. In summary, the study documented that, with planning, teachers and students used 1:1 computing resources to engage in constructive learning activities across the core curriculum. Teacher surveys and classroom observations found that students in the 1:1 pilot setting increased the frequency and quality of their social interactions in class. Pre/post surveys and classroom observation data all indicated that the technology-enhanced pilot setting had higher levels of engagement than observed in the conventional classrooms. Pilot students also achieved larger average achievement gains on standardized ELA state tests than their fellow 6th graders.

Conclusion

This study provides evidence that both teaching and learning practices shifted markedly with the incorporation of 1:1 student netbooks. Findings showed that students in the pilot setting substantially increased their use of technology, particularly, in their English and social studies classes. Further, students were documented using technology in new and dynamic ways beyond simple word processing and accessing information. After the 1:1 adoption, students increased the different ways they shared their work via technology through presentations as well as through web pages and other web-based documents. With the incorporation of 1:1 student computing, teaching practices shifted as well, with classes moving away from a more teacher-centered orientation, where students primarily listened to teacher presentation, and towards a more student-centered orientation, where students increasingly produced artifacts with non-written media. It was also found that student interactions in class were positively impacted with students spending less time working individually in the 1:1 setting and increasing their frequency of working in small groups of peers.

This study provides another example in the growing literature on the potential short-term impacts that may be possible in technology-rich classrooms, particularly when students have 1:1 access to computers with wireless Internet connectivity. Zhao, Lei, and Frank (2006) have compared schools to ecosystems, suggesting that the integration of new technology in the classroom is akin to introducing a new species into the environment and that the subsequent use of computers depends on how the new elements interact with existing people and practices. In the setting of this study, the newly available learning tools were integrated in a time span of a few short months. Although beyond the formal scope of this study, it seems evident that the advanced planning, training, resources, and support provided by the school and district led to the efficient and successful implementation reported here.

It is clear from our results that access to 1:1 computing served to evolve many of the ways that teachers and students had traditionally used technology in class. For example, in the pre-1:1 settings, students would go to the computer lab to use Google Earth as a GIS platform in Social Studies. In the months following 1:1 access, students' increased access to 1:1 devices meant more individual time was available for them to use Google Earth without leaving their Social Studies classroom. This increase in student access allowed teachers and students to evolve and expand traditional work in more creative and individualized ways. For example, students in the 1:1 setting went beyond their traditional map usage to work in small groups to create and present their own digital "tours" of specific regions.

Lastly, relatively few studies have empirically examined the impacts of 1:1 computing on state achievement test scores. This is an area where more study is needed as many policy makers today, for better or worse, consider student achievement as measured by state-sanctioned standardized tests to be the most important success indicator of any educational investment. Although there are many shortcomings to using MCAS here as our measure of student achievement in ELA, the annual assessment provides a convenient and potentially meaningful measure that is shared across all public schools in Massachusetts. One of the chief reasons for the lack of research exploring student achievement in 1:1 student computing initiatives is the inherent complexity and difficulty involved in effectively measuring emerging technology practices in 1:1 settings and associating them with valid measures of student achievement. The current study seeks to contribute to this expanding literature, showing notable first-year ELA achievement growth from students in the 1:1 pilot setting, reflecting some of the prior ELA research results (Bebell & Kay, 2009; Shapley, 2008; Silvernail, 2008).

Practical Implications

Taken collectively, these findings suggest a pretty compelling story, particularly given the short implementation period. Clearly, introducing 1:1 student computing can have dramatic impacts on a host of teaching and learning practices and outcomes. As much as these results suggest 1:1 computing benefits, it is critical to understand the major role that the 1:1 teachers and the supporting school and district community played through planning and support of the program. The pre-pilot observations across study classrooms illustrate the degree that individual teachers shape how their class is organized and conducted (see Table 3).

There are three aspects of the 1:1 implementation that seem related to these short-term changes in the frequency and quality of student to student interactions in class. First, as previously documented, students with 1:1 Netbook access used Internet and cloud-based resources more frequently. As observed by participating teachers and in the classroom observations, students having shared documents, but unshared terminals for accessing and editing the documents provided for a very efficient level of student/student and teacher/student collaboration. Second, the classroom activities leveraging the 1:1 technology resources were only effective at increasing collaboration because of the teacher's deliberate planning, support and design. The technology resources on their own could have been used in ways that would isolate students from each other. However, in these 1:1 pilot classrooms, teachers leveraged the technology to foster a high level of engagement and interaction. Third, as students exercised more confidence through their access and successful use of digital technology tools in class, both teacher perceptions and classroom observations found instances of students increasing their overall self-esteem. Although impossible to fully prove here, students' increased engagement levels seemed related to their increased interactions in class and the increase in the productivity and quality of those student interactions in the pilot 1:1 settings.

From the perspective of the participating 1:1 teachers, their instructional decisions coupled with the new information sharing capacity provided by the netbooks, altered the nature of students' social interactions in class. Classroom activities grew more social as students moved away from working in isolation or responding as a whole group to teacher-centered instruction, and towards increased collaboration in pairs and small groups. This finding may seem contrary to intuitive predictions that students using 1:1 computers might become so involved with their machines that they fail to interact with each other. Instead, the 1:1 technology resources became a tool and reference point for increasing more social ways of learning. There is some evidence that this improved collegiality and increase in students' mutual support and encouragement may have led to higher standards of rigor in the 1:1 classes. Another aspect of the 1:1 pilot classes that may have improved engagement and students overall experience was the teachers' use of web-based resources to provide increased opportunities for students to make choices about their learning activities (Kohn, 1993). If student engagement is influenced by sustainable mechanisms such as these, rather than novelty, or some other ephemeral process, 1:1 student computing may be a critical characteristic for increasing student learning.

Limitations and Future Direction/Research

Like any research conducted in a real-world educational environment, the current study's findings should be considered in light of its limitations. First, the study involved only four classes in a single suburban, fairly affluent public school. Impacts associated with the technology implementation in this pre/post comparative study are at most referring to the differences between the two pairs of participating teachers. Although the four teachers were rated similarly across study observations for lesson quality, they were essentially unmatched on other potentially influential traits such as teaching experience and inclination to use technology in class. Furthermore, the results presented here are collected from teachers who actively applied to participate in a 1:1 computing pilot program and may not generalize to classroom teachers with differing personal and professional ambitions. In other words, the enthusiasm and preparedness of the teachers in this pilot may prove difficult to replicate when implementing such a program across an entire school population. It is hoped that the study's use of multiple data sources adds to the reliability and validity of the results, but we recognize this alone cannot be sufficient for generalizing results in other settings.

A second general limitation of the study deals with its short duration, particularly the short implementation period of the 1:1 computing resources (six months). In the case of the student laptops, they were placed in the classrooms about midway through the sixth grade year (January 2010) and so had only been used over a limited number of days before classroom observations and follow-up data collection procedures. For example, pilot students had access to their laptops for about 35 instructional days before taking the ELA MCAS. It is reasonable to suspect that such a short period of time is insufficient for many of the technology's impacts to manifest. One of the teachers explained that they would need more time to explore the potential uses of each technological device before determining what the most essential components of their technology resources are. This opinion is consistent with that expressed by teachers in other settings, who after two years or more of 1:1 computing in their classes reported they were still learning how to make best use of the equipment (Bebell & Kay, 2010; Drayton, Falk, Stroud, Hobbs, & Hammerman, 2010).

It is clear that more advanced and nuanced research is needed in this field. Future research efforts must overcome a number of challenges in isolating and measuring the specific teaching and learning practices afforded by 1:1 computing access. Indeed, a research design whereby students usage of specific technology uses are measured and quantified would allow a much richer conversation about the evolution of teaching and learning practices and the resulting impacts of these practices. Methodological examples of such approaches are somewhat rare, but prior studies have applied such methods and approaches to study 1:1 laptop programs in larger settings (Bebell & O'Dwyer, 2010).

How generalizable the positive results from this study would be to different school settings will vary in how much planning and support accompanies the 1:1 student computing program. The study setting described here may be exceptional. Take for example that the district where this study occurred had the far-sightedness to support an external evaluation study of unusual breadth and depth. The timing of technology deployment may have had other confounding impacts. For example, measures of student engagement and changes in instructional styles indicate that enthusiasm diminished more in the comparison setting than in the pilot setting. It may be that the appearance of the computers half-way through the year was a source of novelty, generating increased levels of interest for both teachers and students in the pilot group. If the technology were implemented at the beginning of the year, such results may have been different.

In conclusion, this year-long study informs a growing body of research on the short term impacts of technology on teaching and learning practices. Broadly stated, the netbooks and other technology resources were used extensively across the pilot classes and had positive impacts on student interaction, engagement, and productivity. Further, the incorporation of technology also broadened the scope of products traditionally made in classrooms, such as web pages and other web-based documents. Students were able to use technology to enhance communication and analytic skills through such activities as giving presentations and engaging in Internet research. Finally, student achievement improved during the course of the first year of the implementation. While this finding cannot be wholly attributed to the incorporation of technology, it is important to note that there were no negative effects on achievement associated with the 1:1 teaching and learning. Overall, this study provides encouraging findings for the proponent of 1:1 and other digital technology resources in the classroom. However, these positive results are likely only generalizable to school settings that are adequately prepared and have thoroughly dedicated themselves to improving and evolving teaching and learning practices.

References

Bebell, D., & Kay, R. (2009). *Berkshire Wireless Learning Initiative: Final evaluation report.* Chestnut Hill, MA: Technology and Assessment Study Collaborative.

Bebell, D., & Kay, R. (2010, Jan). One to one computing: A summary of the quantitative results from the Berkshire Wireless Learning Initiative. *The Journal of Technology, Learning and Assessment, 9*(2). Retrieved January 20, 2010, from http://escholarship.bc.edu/jtla/vol9/2/

Bebell, D., & O'Dwyer, L. M. (2010). Educational outcomes and research from 1:1 computing settings. *The Journal of Technology, Learning, and Assessment, 9*(1), 1-15.

Bebell, D., Russell, M., & O'Dwyer, L. (2004). Measuring teachers' technology uses: Why multiple-measures are more revealing. *Journal of Research on Technology in Education, 37*(1), 45-63.

Becker, H. J. (1999). *Internet use by teachers: Conditions of professional use and teacher-directed student use.* The University of California, Irvine & The University of Minnesota, Center for Research on Information Technology and Organizations.

Brown, A., & Green, T. (2013). Issues and trends in instructional technology: Despite lean times, continued interest and opportunity in K-12, buisiness, and higher education. *Educational Media and Technology Yearbook, 37*, 55-71.

Burns-Sardone, N. (2014). Making the case for BYOD instruction in teacher education. *Issues in Informing Science and Information Technology, 11*, 191-201. Retrieved from http://iisit.org/Vol11/IISITv11p191-201Sardone0505.pdf

Cromwell, S. (1999, Nov. 8). *Laptops change curriculum - and students.* Education World. Retrieved Apr. 6, 2011, from http://www.educationworld.com/a_curr/curr178.shtml

Donovan, L., Green, T., & Hartley, K. (2010). An examination of one-to-one computing in the middle school: Does increased access bring about increased student engagement? *Journal of Educational Computing Research, 42*(4), 423-441.

Drayton, B., Falk, J. K., Stroud, R., Hobbs, K., & Hammerman, J. (2010, January). After installation: Ubiquitous computing and high school science in three experienced, high-technology schools. *The Journal of Technology, Learning, and Assessment, 9*(3). Retrieved January 2010 from http://escholarship.bc.edu/jtla/vol9/3/

Erenben, C. (2009, March 4). Cloud computing: The economic imperative. *eSchool News, 12*(3), 13-19.

Grimes, D., & Warschauer, M. (2008). Learning with laptops: A multi-method case study. *Journal of Educational Computing Research, 38*(3), 305-332.

Gulek, J. C., & Demirtas, H. (2005). Learning with technology: The impact of laptop use on student achievement. *The Journal of Technology, Learning, and Assessment, 3*(2), 1-39.

International Society for Technology in Education. (2007). *ISTE Standards - Students.* Retrieved June 12, 2014, from http://www.iste.org/docs/pdfs/20-14_ISTE_Standards-S_PDF.pdf

Johnson, L., Adams, S., & Haywood, K. (2011). *The NMC Horizon Report: 2011 K-12 edition.* Austin, TX: The New Media Consortium.

Kohn, A. (1993). Choices for children: How and when to let students decide. *Phi Delta Kappan, 75*(1), 8-20.

Lowther, D. L., Inan, F. A., Ross, S. M., & Strahl, J. D. (2012). Do one-to-one initiative bridge the way to 21st Century knowledge and skills? *Journal of Educational Computing Research, 46*(1), 1-30.

Maine Education Policy Research Institute. (2003). *The Maine Learning Technology Initiative: Teacher, student, and school perspectives mid-year evaluation report.* Retrieved November 6, 2003, from http://www.usm.maine.edu/cepare/pdf/ts/mlti.pdf

Massachusetts Department of Elementary & Secondary Education. (2010). *MCAS Tests of Spring 2010 Parent/Guardian Report.*

Mouza, C. (2008). Learning with laptops: Implementation and outcomes in an urban, under-privileged school. *Journal of Research on Technology in Education, 40*(4), 447-472.

O'Bannon, B. W., & Thomas, K. (2014). Teacher perceptions of using mobile phones in the classroom: Age matters! *Computers and Education, 74*, 15-25.

O'Dwyer, L. M., Russell, M., Bebell, D., & Tucker-Seeley, K. R. (2005). Examining the relationship between home and school computer use and students' English/language arts test scores. *Journal of Technology, Learning, and Assessment, 3*(3), 1-46.

O'Dwyer, L. M., Russell, M., Bebell, D., & Tucker-Seeley, K. R. (2008). Examining the relationship between students' mathematics test scores and computer use at home and at school. *Journal of Technology, Learning, and Assessment, 6*(5), 1-46.

Papert, S. (1996). *The connected family: Bridging the digital generation gap.* Atlanta, GA: Long Street Press.

Partnership for 21st Century Skills. (2009, Dec.). *Framework for 21st Century learning.* Retrieved Apr. 6, 2011, from http://www.p21.org/index.php?option=com_content&task=view&id=254&Itemid=120

Project Tomorrow. (2014). *The new digital learning playbook: Understanding the spectrum of students' activities and aspirations.* Retrieved June 13, 2014, from http://www.tomorrow.org/speakup/pdfs/SU13StudentsReport.pdf

Puentedura, R. R. (2013). *SAMR: An EdTech Quintet perspective.* Retrieved June 12, 2014, from http://www.hippasus.com/rrpweblog/archives/2013/07/29/SAMRAnETQPerspective.pdf

Richtel, M. (2011, Sept. 3). In classroom of the future, stagnant scores. *The New York Times*. Retrieved May 30, 2014, from http://www.nytimes.com/2011/09/04/technology/technology-in-schools-faces-questions-on-value.html?pagewanted=all&_r=0

Russell, M., Bebell, D., Cowan, J., & Corbelli, M. (2003). An Alphasmart for each student: Does teaching and learning change with full access to word processors? *Computers and Composition, 20*, 51-76.

Russell, M., Bebell, D., & Higgins, J. (2004). Laptop learning: A comparison of teaching and learning in upper elementary equipped with shared carts of laptops and permanent 1:1 laptops. *Journal of Educational Computing Research., 30*(3), 313-330.

Shapley, K. (2008). *Evaluation of the Texas Technology Immersion Pilot (eTxTIP): Year 2 results.* Annual Meeting of the American Educational Research Association. New York, NY.

Shapley, K., Sheehan, D., Maloney, C., & Caranikas-Walker, F. (2010). Evaluating the implementation fidelity of technology immersion and its relationship with student achievement. *The Journal of Technology, Learning, and Assessment, 9*(4), 1-69.

Silvernail, D. (2008). *Maine's Impact Study of Technology in Mathematics (MISTM).* Annual Meeting of the American Educational Research Association. New York, NY.

Snyder, T. D., & Dillow, S. A. (2012). *Digest of education statistics, 2011.* Washington, DC: National Center for Education Statistics.

Stager, G. (1998). Laptops and learning: Can laptop computers put the "C" (for construction) in learning? *Curriculum Administrator, 34*(3).

Stemler, S. (2001). An overview of content analysis. *Practical Assessment, Research & Evaluations, 7*(17).

Stevenson, K. (1999). Learning by laptop. *School Administrator, 56*(4), 18-21.

Suhr, K. A., Hernandez, D. A., Grimes, D., & Warschauer, M. (2010, January). Laptops and fourth grade literacy: Assisting the jump over the fourth-grade slump. *The Journal of Technology, Learning, and Assessment, 9*(5). Retrieved January 2010, from http://ejournals.bc.edu/ojs/index.php/jtla/issue/view/149

Thompson, B. (2001, September 16). Learning to be wired. *Washington Post Magazine.* Retrieved from http://www.washingtonpost.com/wp-adv/archives/front.htm

U.S. Department of Education, Office of Educational Technology. (2010). *Transforming American education: learning powered by technology.* Washington, D.C.

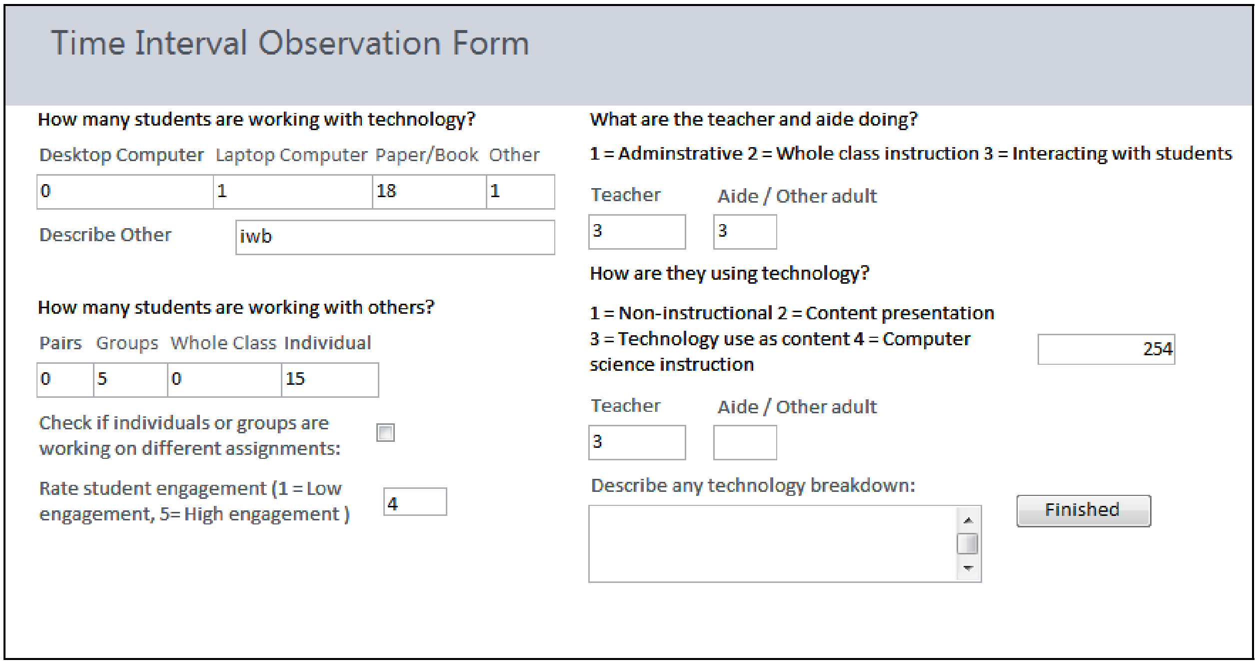
Weston, M., & Bain, A. (2010). The end of techno-critique: The naked truth about 1:1 laptop initiatives and educational change. *Journal of Technology, Learning, and Assessment, 9*(6), 5–25.

Zhang, Q., Cheng, L., & Boutaba, R. (2010). Cloud computing: State-of-the-art and research challenges. *Journal of Internet Services and Applications, 1*(1), 7-18.

Zhao, Y., Lei, J., & Frank, K. A. (2006). The social life of technology: An ecological analysis of technology diffusion in schools. *Pedagogies: An International Journal, 1*(2), 135-149.

Zucker, A. A., & Hug, S. T. (2008). Teaching and learning physics in a 1:1 laptop school. *Journal of Science Education and Technology, 17*(6), 586-594.

Appendix:
Example of the fixed interval observation form


Time Interval Observation Form

How many students are working with technology?

Desktop Computer	Laptop Computer	Paper/Book	Other
0	1	18	1

Describe Other: iwb

How many students are working with others?

Pairs	Groups	Whole Class	Individual
0	5	0	15

Check if individuals or groups are working on different assignments: ☐

Rate student engagement (1 = Low engagement, 5= High engagement): 4

What are the teacher and aide doing?

1 = Adminstrative 2 = Whole class instruction 3 = Interacting with students

Teacher	Aide / Other adult
3	3

How are they using technology?

1 = Non-instructional 2 = Content presentation 3 = Technology use as content 4 = Computer science instruction

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Teacher	Aide / Other adult
3	

Describe any technology breakdown:

Finished

Biographies

Dr. Damian Bebell is an Assistant Research Professor at Boston College's Lynch School of Education and a Senior Research Associate at the Center for the Study of Testing, Evaluation, and Educational Policy. Over the past decade, Damian has led numerous research and evaluation studies investigating the effects of 1-to-1 technology programs and other computer-based technology tools on teaching and learning across wide range of educational settings. In 2010, Damian served as guest editor for a Special Issue of the Journal of Technology, Learning, and Assessment producing the first collection of peer-reviewed research studies emerging from 1:1 computing environments. Damian is the founding Research Director of the Technology Use and Beliefs Study at the International Research Collaborative where he conducts longitudinal research and evaluation studies with international school partners. Damian is an advocate for the use of research, measurement, and evaluation in documenting and evolving teacher and learning practices, and is a frequent speaker and writer on such matters.

Apryl Clarkson works in the Office of Data and Accountability for the Boston Public Schools district. Apryl is a former high school math teacher in the BPS who is currently in the final stages of completing her PhD in Educational Research, Measurement, and Evaluation at Boston College. While in her graduate program, Apryl worked on a variety of projects that included classroom observations, program evaluation, survey development, test development, test statistics, item analysis, and quantitative methods, which include a host of statistical methods including but not limited to logistic regression models, multilevel modeling, IRT, and value-added modeling. Apryl started working for the Boston Public Schools district in the fall of 2012. While in this role, Apryl is responsible for analyzing high school data with the intention of enacting programmatic change. Her areas of work focus on end of secondary assessment and transition including PSAT, SAT, FAFSA application trends, Post-secondary Enrollment, and MCAS/PARCC assessments. In addition to focusing on secondary education, Apryl is completing her dissertation on the transition of teacher education graduates from their preparation program to schools and their varying levels of retention.

James Burraston. After completing his BSc in teaching anthropology at the University of Utah, James worked for five years as the math and biology teacher at the Penikese Island School in Boston Harbor. While there he developed hands-on and differentiated curriculum to meet the needs of high school students with a range of emotional and behavioral difficulties. Afterwards, James completed a MEd in educational research, measurement and evaluation at Boston College and began working with Technology and Assessment Study Collaborative (inTASC) and the Center for the Study of Testing, Evaluation, and Educational Policy (CSTEEP) on the evaluation of educational technology programs, particularly in 1:1 computing settings. Currently, James is working as a private consultant and is studying for an MA in theology and ministry at Boston College.