Balancing the One-To-One Equation: Equity and Access in Three Laptop Programs

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Seeking to improve teaching and learning and to narrow gaps between students of high and low socioeconomic status, many school districts in the United States are implementing one-to-one laptop programs. In this comparative case study, we examine one-to-one laptop programs in Colorado, California, and Alabama, all of which deployed low-cost netbook computers and open source software with the aim of enhancing digital participation and increasing educational equity. In spite of overlapping goals, the projects had very different outcomes. We analyze the roots and implications of these differences.

As more students gain computer and Internet access, disparities in computer use may exacerbate the challenges that disadvantaged learners face. Despite steady growth in the number of computers available in schools (Gray, Thomas, & Lewis, 2010), children from low-income homes continue to face obstacles to full digital participation, such as a lack of home computer and Internet access (Vigdor & Ladd, 2010; Warschauer, 2011). One-to-one laptop programs—in which all students in a class, grade level, or school are provided individual laptop computers (Johnstone, 2003; Lei & Zhao, 2008)—have been proposed as a means to increase technology access, transform teaching

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and learning, and promote digital equity. With meta-analyses of the effects of computers on student performance suggesting a weakly positive relationship between computer use and academic achievement (Kulik, 2003), the problem of how to implement one-to-one programs remains a challenge, especially given the tendency of technology-based programs to exacerbate rather than compensate for inequities in access and use (Attewell & Battle, 1999; Vigdor & Ladd, 2010).

This article compares one-to-one laptop programs implemented among fourth- and fifth-grade students in three U.S. school districts. Although the programs share similarities in student grade level, they vary in ideology, curriculum, teacher development, infrastructure, technical support, technology selection, and most importantly, student outcomes. Evaluating the similarities and differences of these programs—especially in how successful each program is at removing the obstacles to participation faced by at-risk students, such as English language learners (ELLs) and students of low socioeconomic status (SES)—may illuminate strategies for developing more equitable and effective educational technology initiatives.

**BACKGROUND**

Low-SES and ethnic minority students continue to struggle with lesser access to home computers (Fairlie, 2008; National Telecommunications and Information Administration, 2008). However, U.S. public schools are increasingly offering this access. According to the National Center for Education Statistics (2010), the ratio of students to computers with Internet access fell from 7:1 in 2000 to about 3:1 in 2008. Whether this increased computer access benefits students is a point of contention. Although some studies have found that computer use in classrooms has slightly positive effects on student writing outcomes (e.g., Kulik, 2003), other studies found that computer access has mixed effects on student performance (e.g., Bebell & Kay, 2010; Goldberg, Russell, & Cook, 2003; Wenglinsky, 2005; Zheng, Warschauer, & Farkas, 2013). These varied results suggest that access alone is not enough to improve student outcomes.

Access may be the prerequisite first step toward effective technology use. However, it is the way in which students and teachers use technology that impacts learning. Schools have adopted many strategies for using computers in the classroom, and these approaches vary in success. For example, educators implemented technology- and inquiry-based curriculum at a Maine middle school consisting primarily of low-SES and ELL students; a higher percentage of these students achieved proficiency on eighth-grade math (80% versus 69%) and reading (79% versus 59%) scores compared with all public school students in Maine (Warschauer, 2011; State of Maine Department of Education, 2010). In contrast, project-based instruction in a high school science class subverted content instruction with technology skills instruction, as student work on PowerPoint presentations was graded in part on the number of fonts, sounds, and slide transition types they inserted (Warschauer, Knobel, & Stone, 2004).

One-to-one laptop programs have been deployed to both improve student learning—in ways such as improving writing skills (e.g., Gulek & Demirtas, 2005; Lowther, Inan, Ross, & Strahl, 2012; Suhr, Hernandez, Grimes, & Warschauer, 2010), facilitating math and science content knowledge learning (e.g., Clariana, 2009; Dunleavy & Heinecke, 2008; Rosen & Beck-Hill, 2012), and increasing opportunities for students to develop technological skills (e.g., Corn, Tagsold, & Patel, 2011; Lei & Zhao, 2008). Students in one-to-one programs tend to spend more time writing, write more, and receive more feedback from peers and teachers (Jeroski, 2008; Russell, Bebell, & Higgins, 2004). However, studies suggest that ongoing professional development and technical
support is important when implementing one-to-one laptop programs (Drayton, Falk, Stroud, Hobbs, & Hammerman, 2010; Rutledge, Duran, & Carroll-Miranda, 2007). In Massachusetts, for example, one program deployed laptops to middle school students to use throughout the day (Bebell & Kay, 2010). Although teachers and students in this study described how laptops transformed their classrooms into student-centered, collaborative environments, teachers’ use of laptops varied widely. Bebell and Kay (2010, p. 48) suggest that “it is impossible to overstate the power of individual teachers in the success or failure of 1:1 computing” given the amount of teacher training, investment in curriculum development, and creation of new assessment methods required when laptops are introduced. The financial burden of not only deploying laptops, but also implementing new assessments and teacher development is a consideration when implementing these programs in schools. These investments may particularly challenge low-SES schools, which usually face more severe budgetary constraints in providing these ongoing supports. These constraints can lead to inequitable implementation of technology programs (Becker, 2000; Warschauer, Knobel, & Stone, 2004; Wenglinsky, 2005).

Laptop programs also may increase differences within schools between high- and low-achieving students. A study evaluating the Texas Technology Immersion Project, a one-to-one program in middle schools, suggested that test score gains were primarily seen in already high-achieving students (Shapley, Sheehan, Sturges, Caranikas-Walker, Huntsberger, & Maloney, 2007); a subsequent study of this program found that the devices, teachers’ professional development, online curriculum resources, and online student assessments varied across schools and teachers (Shapley, Sheehan, Maloney, & Caranikas-Walker, 2010). These results suggest that laptop programs may increase disparities between high- and low-performing students.

Two of the three districts discussed in this article implemented what might be called an integrative approach, in which provision of hardware and software is balanced with broader forms of infrastructural and social support, including wireless Internet access, technical support, teacher training, and curricular reform (see Warschauer, 2011). The third district we studied was part of the One Laptop per Child (OLPC) program, which emphasizes the transformative potential of children’s ownership and autonomous use of its proprietary laptops and, thus, de-emphasizes funding of teacher training, technology infrastructure, technical support, or curricular reform (see One Laptop per Child, n.d.; Warschauer & Ames, 2010).

Comparing case studies from two school districts (Saugus and Littleton) following the integrative approach and one district (Birmingham) following the OLPC approach, this study examines differences across multiple levels of implementation: models, districts, and case classrooms.

METHODS

Research Sites

The three public school districts in this study—Birmingham, Littleton, and Saugus—share characteristics that make them suitable for comparison: each implemented a one-to-one program in upper elementary classrooms with inexpensive netbooks and open source software. Despite these similarities, the districts vary in their demographics, implementation model, and student outcomes.
**Birmingham**

The laptop program in Birmingham, Alabama, took place during 2008 to 2010 and has thus far been the largest implementation of OLPC in the United States. Birmingham students, of whom over 95% are African American, are predominantly from low-SES households; 80% of the students qualify for free or reduced-fee lunch. OLPC Birmingham was initiated to counter the detrimental effects of poverty. The program was largely conceived and deployed without consulting key stakeholders, such as teachers. Whereas students owned their XOs, teachers’ XOs were owned by the district. (XOs are small, $199 USD, laptops developed by the One Laptop per Child program for deployment in schools in developing countries.) Teachers received an average of two hours of XO training. The 15,000 student laptops were deployed in first through fifth grades. One school, Glen Iris Elementary, was chosen as the focal school for classroom observations and interviews. The school had been the first in the district to deploy laptops and was viewed by the district as being the most successful in its implementation. Data collected in Birmingham included observations and interviews at Glen Iris, interviews with district and city officials, examination of documents related to the program, and results from surveys of fourth and fifth grade students before and after they received their laptop.

**Saugus**

Using an integrative approach, the Saugus Union School District in California is currently implementing a one-to-one laptop program using low-cost Asus Eee PC netbooks. Slightly more than half of Saugus students are white, and nearly 30% of the students are Hispanic. Twenty percent of the students in the district are ELLs and 13% of the total student population receive free or reduced-fee lunch. Funded by a federal grant, this one-to-one deployment is part of a larger learning initiative called SWATTEC: Student Writing Achievement Through Technology Enhanced Collaboration. The goal of this initiative is to improve student writing and English Language Arts outcomes. The selection of the Asus Eee PC, the development of pedagogical goals, and the implementation of the program were the result of planning and communication that included teachers, administrators, parents, and students. The implementation plan involved a multi-stage deployment that also enabled a study of multiple programs: the 2007–2008 school year had no laptop program, the 2008–2009 school year saw a partial implementation in which laptops were available to fourth grade students for about half of the school year, and the 2009–2010 school year had full one-to-one laptop implementation from the beginning to the end of fourth grade. Beginning in January 2009, all fourth grade students were provided with a netbook featuring a Linux-based operating system and open source software. Students also were provided with access to a commercial online writing and essay scoring program called MY Access! (Vantage Learning, 2011). Two online learning communities—one for teachers and one for students—were created to enable collaboration on projects and curriculum. Each year, teachers received 40 hours of SWATTEC program training and 40 additional hours of training from a teacher mentor; one teacher at each school was chosen to serve as a mentor. Surveys, teacher and administrator interviews, and standardized test scores were collected from the entire district. Two diverse schools—one with a large number of low-income ELLs (Skyblue Mesa) and one higher income school with a special education program (North Park) were chosen as schools for this study.
Littleton

Littleton is a predominantly middle-income, white, suburban, English-speaking district. Similar to Saugus, this Colorado school district deployed laptops with the main goal of improving student writing outcomes (see Zheng, Warschauer, & Farkas, 2013). The Inspired Writing laptop initiative was created to provide the means and opportunities for students to write and to share their writing. After an initial pilot study in fifth grade classes, laptops were eventually provided to all students from fifth to tenth grade since the 2009–2010 school year. For the sake of comparison, the current study examines laptop use, participation in social media, and academic outcomes among Littleton fifth graders. As with the Saugus students, each student in Littleton received a Linux-based Asus Eee PC netbook featuring, primarily, open source software. Blogs, wikis, and other social media were used to create opportunities to write for diverse purposes and audiences. Before implementation of this laptop program, a week-long professional development program was provided for teachers to learn to use the laptops and to practice strategies for incorporating netbooks into classroom activities.

In this district, East Elementary and Hopkins Elementary were selected for observations and interviews. Similar to the rest of the district, the majority of Hopkins students are white and from middle-income households. In contrast, East Elementary was chosen for its diversity relative to the district, as 70% of its students are ELLs.

Comparative Case Study

Observations, interviews, and artifacts were collected from the five focal schools. Surveys were conducted district-wide. Test score data also were collected in two districts and are presented elsewhere (Zheng, Warschauer, & Farkas, 2013).

Observations

Classrooms were observed at each focal school. In Birmingham, the researcher was provided with a school tour. Over two days, the researcher walked through the halls and observed XO use both in and out of classrooms. In addition, a fifth-, third-, and second-grade class were each observed from 45 minutes to an hour. The researcher observed students, moved around the classroom, and spoke casually with students and teachers. Field notes collected included observations about how XOs were used and students’ and teachers’ attitudes toward XOs. Students’ and teachers’ comments were also recorded in field notes.

At the Littleton focal schools, seven classrooms were observed over a six-day period. Researchers were allowed to move between classrooms, observe instruction, and move within classrooms. Researchers also were permitted to ask questions and engage in informal discussion with both teachers and students to clarify their observations. Field notes focused on how students made use of digital media and technology to write, the writing instruction methods, and student and teacher attitudes toward, and experiences with, the netbooks. Additional observations of school leadership meetings were conducted via Skype video conferencing. Over 25 observation hours were conducted at Littleton.
Similarly, researchers conducted over 25 hours of observation at Saugus schools. Six days of observation focused on writing instruction, how teachers and students used the netbooks for learning, and teachers’ and students’ attitudes toward the technology. Researchers were allowed to maintain their own travel schedules between and within classrooms and to engage in non-disruptive conversations with students and teachers.

**Interviews**

At each school, formal and informal interviews were conducted with students, teachers, and administrators.

At the Saugus and Littleton focal schools, individual or group interviews were conducted with the school principals, fourth and fifth grade teachers, and a small group of students. Teachers selected students from their classes to represent diverse demographics, experiences with and attitudes toward technology, and academic achievement. Interviews were 15–45 minutes, recorded with permission of the participants, and subsequently transcribed. At Saugus, interviews also were held with the Assistant Superintendent of Instruction & Curriculum, the Director of Information Services and Technology, and with a District Intervention Specialist in writing instruction. A group interview at Littleton was held with representatives of Curriculum, Instruction, and Assessment and Information and Technology Services. In Birmingham, interviews were with one official each from the school district, mayor’s office, and a consulting group supporting the program; nine participants at Glen Iris also were interviewed. These participants included four classroom teachers, the library and media specialist, an English as a Second Language teacher, two students, and the principal, for a total of 12 people interviewed in Birmingham. All but two of the interview participants in Birmingham consented to recording; in lieu of recording, detailed notes were taken.

**Documents**

Publicly available documents related to the OLPC program in Birmingham, such as newspaper articles and published statements from the mayor’s office, were collected. Documents collected from Littleton schools included publicly available district reports and blog posts on the laptop initiative and plans, blog posts from teachers and students, and an Inspired Writing professional development slide presentation provided by the district. From Saugus, publicly available documents, such as district reports on the SWATTEC program, teacher-developed online curriculum and resources, and blog posts by both students and teachers were collected.

**Surveys**

In each district, students were surveyed and asked to report their computer skills, how often and what type of technologies they used, and their opinions of the laptop program. While Saugus and Littleton students were surveyed once at the end of the implementation year, students at Birmingham were surveyed both before and after participation in the program. A total of 914 Saugus students (a response rate of 78.9%) and 675 students in Littleton (a response rate of
67.5%), responded to the survey. In Birmingham, 1,202 students responded to both pre- and post-program surveys (a response rate of 41.2%); students were only eligible for the post-test if they had completed the pre-program survey, which had a 52% response rate.

Teacher surveys also were collected in all three school districts. Forty teachers in Saugus and 33 teachers in Littleton replied to a survey, which included questions similar to those given to students. Whereas the response rate among teachers from Saugus and Littleton districts was 100%, the response rate of Birmingham teachers was very low (less than 5%). At the beginning of the laptop program, teachers were asked to complete an online survey to gauge teacher-reported technology skill level, their training in XO use, attitudes toward technology, and how they used technology in and out of the classroom. Despite efforts to reach out to teachers, few completed the survey. Due to the low response rate, no post-implementation survey was administered to Birmingham teachers, and their survey data were not used.

Test Scores

Although not discussed in this article, state and district test score data were provided by two of the districts: Saugus and Littleton. A lengthier discussion of test score data collection and analysis is available in Zheng, Warschauer, and Farkas (2013).

FINDINGS

In comparing these three case districts and their focal schools, key differences and similarities were observed in the uses of computers by teachers and students and the participation of at-risk students, such as ELLs and students from low-SES households. Marked differences related to sustainability also were observed, especially in comparing the Saugus and Littleton districts with the Birmingham district. That these differences resulted in the ultimate failure of the program in the lowest-SES district suggests that digital divides may exist not only in terms of computer use, but also in regards to administration and management of such programs.

Uses of Computers

While digital inequities are often framed in terms of access, the ways in which students use computers also are important when implementing programs aimed at bridging digital divides. Across the three districts, teachers and students used laptops in many ways. In both Saugus and Littleton, surveys of teachers and students indicated that the netbooks were used about two hours per day, and observations and interviews confirmed widespread classroom use. In these two districts, students reported that the most common use of netbooks was to write and edit papers. Students reported that on average, they used netbooks nearly six times per week for writing or editing papers. Additionally, 70% of students reported that they wrote more with their laptops, and 64% of students agreed that laptop use improved the quality of their writing. These positive attitudes translated partially to improved writing outcomes. In Saugus, overall English Language Arts (ELA) gains during partial and full (.23 SD gain, \( p < 0.001 \); .22 SD gain,
laptop implementation were significantly higher than gains prior to the laptop program. In Littleton, significant gains were found for Hispanics (.23 SD gain compared to Whites, \( p < 0.05 \)) and low-income learners (.18 SD gain versus non-low income, \( p < 0.1 \)), but there was no overall positive effect on writing scores (see Zheng, Warschauer, & Farkas, 2013).

In some classrooms, researchers observed that teachers used laptops to provide extensive opportunities to write, in- and out-of-classroom, for a broad range of audiences other than their teacher via blogs and wikis. In interviews, teachers noted that these opportunities enabled students to understand how to write for a variety of purposes. Because writing—and increasingly, digital writing—is a critical skill for academic success, pursuing careers, and civic engagement (National Commission on Writing, 2003), the use of digital technologies to support writing activities may affect student achievement. At East Elementary in Littleton, for example, laptops were used to transform writing from a solitary activity into a collaborative and interactive activity: students posted blogs, engaged in peer editing, and collaborated on writing projects with students in other schools and countries. Students’ interviews and blog posts suggest that using laptops for writing increased their enthusiasm for writing, as with Littleton fifth grader Lupita, who blogged: “I used to not like writing but now I keep looking at the time and inside I am saying, ‘Is it time for writing yet?’” In examining students’ blog posts and observing classrooms, students in the Littleton focal schools were seen to interact with individuals outside of their classroom via social media. Teachers and students expressed in interviews how having this outside audience was highly motivating. As another Littleton student wrote in her blog: “The pressure of knowing that the whole world is going to see everything that I write and post online, makes me want to do my absolute best.” Likewise, Saugus teachers also made use of writing opportunities afforded by laptops. For example, one teacher and her students interviewed a relative serving in Iraq via Skype and used this interview as a blog writing prompt.

In addition to drafting, students in Littleton and Saugus used netbooks to revise their writing. In the California district, some of this editing was facilitated by the automatic writing evaluation (AWE) MY Access! software, which was deployed to provide students with immediate writing feedback and to ease teacher grading burdens. In survey responses and observations, students had overall neutral or slightly positive attitudes toward the AWE software and its instant feedback on their essays, with over 50% of the surveyed students indicating that they liked the AWE software, that it allowed them to revise more often, and that their confidence had increased after using AWE. Although students were slightly positive about the software, teachers’ initial enthusiasm was observed to decline. Whereas most teachers said that the software eased the burden of essay evaluation, teachers in low-SES classrooms tended to be less enthusiastic, explaining in interviews that the poor typing ability and lesser literacy skills of their students made it more difficult for them to benefit from the online environment and automated feedback. Neither Birmingham nor Littleton districts employed AWE as part of their district-wide laptop programs, though a different AWE program was used at Hopkins Elementary, one of the two focal schools in Littleton.

Other common uses of laptops at Littleton and Saugus included searching for, evaluating, and using information. On average, students across both districts reported using their netbooks more than four times per week to find information online. A student in Littleton, for example, blogged about how frequent access to laptops and the Internet open[ed] a door from the classroom to the world. There is so much more knowledge accessible to students who have access to computers than there is to those in traditional classrooms . . .
information so accessible, the ability and expectation to learn and ask questions is much more present. Computers make the research process far more efficient and allow students to explore every side of a topic.

In Birmingham, laptops were less frequently used for research. Students in Birmingham indicated the applications that they most often used, beyond the automated file record system called Journal, included Chat (synchronous chatting), Record (image, sound, and video capturing), and Memorize (flash card maker). In addition, students reported infrequent laptop use: 20% of students surveyed indicated that they never used laptops at school, while 60% reported using them only a little. This is consistent with what has been found in other OLPC deployments (see Warschauer & Ames, 2010). However, unlike in Saugus and Littleton, students in Birmingham took laptops home where they used them extensively; 52% of students in Birmingham reported using their laptops between one and two hours per day, an additional 35% reported that they use their XOs three or more hours a day. Almost all of this usage occurred at home.

Observations and interviews at the focal school in Birmingham—which had been selected by administrators as a school with the greatest use of XOs—suggested that making and using digital flash cards was one of the principal uses on the infrequent occasions that XOs were used in class. In two of the three classrooms observed, students used XOs exclusively to access the Memorize application for that purpose. In an interview, one teacher explained how she selected XO activities: She did not typically lead the class in activities that would need Internet access because students would have to exit the classroom for wireless access. One teacher also noted

I don’t teach writing with them because I have no way to access students’ written work other than walking around the classroom and looking at it. We even tried to set up student e-mail accounts in my class, but the system blocked everything.

Students’ self-reported use of computers to do research and homework decreased in Birmingham after receipt of the XOs, according to student surveys (see Table 1). This may be explained by the lack of integration of XOs into instruction.

At-Risk Students

In each district, a key one-to-one program goal was to increase opportunities for technology use, new media participation, and academic success—especially for students with fewer such opportunities at home, such as ELLs, minority students, and low-SES students (Fairlie, 2008). In both Saugus and Littleton, ELLs, Hispanics, and students receiving free or reduced-fee lunch used netbooks significantly more frequently than their peers (see Table 2). ELLs used laptops for a variety of learning purposes, including finding information, accessing videos, and writing and editing papers. Compared to non-ELLs, and especially in Littleton, English learners used laptops for these activities more often.

Additional qualitative data also indicate that laptop use with teachers’ integration of technology into collaborative activities was especially helpful for ELLs, who often face additional challenges in school, especially in writing. In interviews, Saugus teachers explained how laptops enabled students to access and communicate with multimodal information, such as images, videos, and
text. Teachers also remarked that laptops afforded ELLs more opportunities to practice their communication skills through writing and online discussion. In East Elementary in Littleton, where more than half of the students are ELLs and Hispanic, laptops also were used to support ELLs; teachers used social media activities to prompt extensive student participation in online writing. For example, students regularly used online forums to discuss class readings and comment on peer work. Both focal schools in Saugus also used laptops to support ELLs through differentiated instruction and through language supports, such as text-to-speech and bilingual dictionaries.

Birmingham is a district overwhelmingly comprised of low-income African American students. Rather than looking at subgroups, we examined the district-wide impact on students’ opportunities for technology use, media participation, and academic achievement. Although the program was largely framed as an effort to bring technology access to underserved children, a majority of students reported having home access to computers (63%) and the Internet (approximately 80%) before receiving XOs. While use of XOs appeared to supplant use of other home computers, students reported a significant increase in total (home and school) use of computers and the Internet from pre- to post-survey (see Table 1). The percent of students describing themselves as very proficient with technology also increased.

One effort to support creative media production with XOs in Birmingham was in the use of Scratch, a multimedia programming language geared toward novices. Scratch is a well-regarded tool for supporting the development of programming and academic skills among young children (Peppler & Kafai, 2007). Though we observed some attempted use of Scratch in classrooms in one of the three focal classrooms, instruction in Scratch was largely accomplished in after-school

| Table 1: Key Findings from Wilcoxon Signed-Rank Tests on Birmingham Student Survey Data |
|-------------------------------------|--------|--------|
| Overall Technology Use             | Pre XOs| Post XOs|
| Computer use***                    | 1.51   | 2.27   |
| Internet use***                    | 1.87   | 2.93   |
| Social and Entertainment Use       |        |        |
| E-mail                             | 1.56   | 1.49   |
| Instant messaging*                 | 1.26   | 1.35   |
| Chat rooms***                      | 1.30   | 1.87   |
| Playing games***                   | 3.28   | 2.87   |
| Create/listen to podcasts**       | 1.16   | 1.01   |
| Editing Wikipedia pages*           | 0.85   | 0.98   |
| Research and Homework Uses        |        |        |
| Do homework***                     | 2.29   | 1.85   |
| Do research***                     | 2.18   | 1.88   |
| Educational Intentions             |        |        |
| Percentage want to go to college* | 94.2   | 91.7   |
| Percentage Self-Reported “Pretty Good” or “Very Good” |
| Computer***                        | 84.3   | 85.2   |
| Internet***                        | 87.5   | 88.5   |

*Note. 0 = never use; 1 = use less than once a week; 2 = at least once a week; 3 = several times a week; 4 = every day
*p ≤ 0.05; **p ≤ 0.01; ***p ≤ 0.001
TABLE 2
Key T-test Results of Students’ Perceived Usage of Netbooks at School in Saugus and Littleton Districts

<table>
<thead>
<tr>
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<th>Saugus District</th>
<th>Littleton District</th>
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<tbody>
<tr>
<td></td>
<td>ELLs (N = 180) Non-ELLS (N = 713) Hispanics (N = 211)</td>
<td>ELLs (N = 43) Non-ELLS (N = 446) Hispanics (N = 59)</td>
</tr>
<tr>
<td>Write or edit paper on your laptop</td>
<td>6.17(.46) 6.05(.23) 5.49(.40) 6.26(.24) 6.03(.72) 6.08(.22)</td>
<td>7.69*(.97) 5.51(.27) 6.62(.84) 5.57(.27) 6.67(.62) 5.45(.28)</td>
</tr>
<tr>
<td>Get news or information online</td>
<td>5.32(.45) 5.03(.22) 5.80* (.37) 4.86(.16) 5.34(.71) 5.06(.21)</td>
<td>6.53**(.98) 2.23(.18) 4.02** (.72) 2.42(.20) 4.83**(.59) 2.03(.18)</td>
</tr>
<tr>
<td>Post my writing in blogs or wikis</td>
<td>1.95(.30) 1.97(.14) 2.20(.29) 1.89(.14) 1.72(.43) 1.98(.13)</td>
<td>5.63**(.97) 1.39(.15) 3.37** (.71) 1.54(.17) 4.01**(.59) 1.18(.14)</td>
</tr>
<tr>
<td>Comment on others’ writing on blogs or wikis</td>
<td>1.88(.30) 1.47(.12) 2.00* (.27) 1.42(.12) 2.29(.56) 1.49(.11)</td>
<td>7.13***(.05) 1.19(.15) 4.14*** (.84) 1.38(.17) 4.66***(.65) .95(.13)</td>
</tr>
<tr>
<td>Access video</td>
<td>3.25*(.39) 2.27(.15) 3.15** (.35) 2.26(.15) 3.20(.60) 2.41(.15)</td>
<td>1.56* (.22) .75(.10) .95(.16) .81(.11) 1.41**(.27) .68(.10)</td>
</tr>
<tr>
<td>Average school use</td>
<td>3.33(.20) 3.02(.10) 3.31(.20) 3.02(.10) 3.46(.37) 3.06(.09)</td>
<td>4.08**(.45) 1.71(.09) 2.84** (.36) 1.79(.09) 3.20**(.30) 1.58(.08)</td>
</tr>
</tbody>
</table>

Note. Perceived usage as reported in surveys and measured in number of times per week; Standard errors in parentheses

*p < 0.05, **p < 0.01, ***p < 0.001
see Zheng, Warschauer, & Farkas, 2013

aSignificantly different from non-ELLS
bSignificantly different from non-Hispanics
cSignificantly different from non-free lunch receivers
clubs and city-wide competitions. Although these out-of-school efforts reached a small minority of students in the district, they represent an exemplary use of XOs to promote creative media production, and some of the individual students we spoke with at Glen Iris were clearly excited about their use of Scratch.

Sustainability

The cost to implement and maintain technology programs is a concern for all districts. For districts serving lower SES populations, financial challenges can further complicate the problem of maintaining one-to-one programs. In addition to the differences in how laptops were used, differences also were observed in the relative sustainability of each program. The deployment and maintenance costs and the degree of stakeholder commitment varied across districts. These factors are examined in the context of the current state of the one-to-one programs in these districts.

Implementation costs were a concern in each of the districts. Low-cost laptops were deployed across schools, with Asus Eee PC netbooks used in Littleton and Saugus and XOs used in Birmingham. Across all districts, the majority of the software was open source. Linux was chosen as the operating system for the netbooks, and the OLPC-developed, open source Sugar is the default operating system for XOs. In following the OLPC tenet of student ownership, Birmingham faced an additional financial burden in that more than one-fourth of the purchased laptops were removed from inventory each year as students moved from the district or graduated to middle school. In Saugus, the proprietary software MY Access! was used for automatic writing evaluation; this software was purchased on a per-student subscription basis. Additional startup costs included professional development for teachers, which varied from one to two hours for Birmingham teachers to 80 hours of teacher training and mentoring at Saugus schools, and the installation of wireless Internet access. Many schools in Birmingham only had wireless access in common areas, such as the library; schools in Littleton and Saugus made wireless Internet available in all classrooms.

Further costs involved maintaining the laptops and wireless networks and providing ongoing teacher training. Whereas computers were owned and maintained by schools in Saugus and Littleton, parents were expected to fix and maintain their children’s laptops in Birmingham (see Cotten, 2010). While this may have been a cost savings, according to our classroom observations, laptops tended to go unrepaired with more than half of fifth- and sixth-graders reporting that their laptops were nonfunctional, a problem seen in other XO deployments (e.g., Lowes & Luhr, 2008; Warschauer & Ames, 2010). Professional development and technical support was provided on an ongoing basis in Saugus and Littleton, while in Birmingham these opportunities were solely provided at the very beginning of the implementation. In interviews, teachers expressed their frustration with the devices: “The XO is not really teacher-friendly. It’s added to what teachers already have to do; it doesn’t function as well as a regular laptop.”

Beyond financial considerations, the amount of buy-in and support from stakeholders also played a role in the sustainability of laptop programs in these three districts. The top-down approach used in Birmingham largely bypassed teachers. Based on interviews, children and teachers often found XOs too small to use. Moreover, little time was provided for training in XO-supported instruction. That few teachers responded to the initial survey may additionally
suggest that their support for the program was lacking. With only a six-week, one-school pilot program, the OLPC program and devices were implemented without evaluating whether they would suit the populations served. The training and planning phases of the Littleton and Saugus programs stand in contrast to the OLPC model. Pilot programs spanning many months were used in Littleton and Saugus. In Littleton, teachers participated in extensive collaboration within and between schools; fifth grade teachers at East Elementary co-taught on a regular basis. Interviews and documents collected from the district-wide forums at Saugus suggest that teachers were able to use this forum to collaborate on projects and to share teaching resources.

The current status of the one-to-one programs cannot be ignored when examining sustainability. Funding was cut from the Birmingham program as of 2010. For a time, some XOs remained in schools. In spring 2011, Birmingham City Schools announced that XOs would be phased out of schools, due to lack of funding and issues of hardware reliability.

Jim Klein, Director of Information Services & Technology at Saugus, revealed that the laptop program has expanded, with a few hundred additional netbooks added to the district’s inventory (personal communication, November 16, 2012). In addition to the fourth grade program, 35% of fifth and sixth grade classrooms have been made one-to-one. Due to budget limitations, these purchases have been facilitated by parent fundraising. Saugus also is pushing for a “bring your own technology” (BYOT) model, wherein parents purchase laptops for their children. The BYOT model, while potentially alleviating the financial burden of one-to-one programs, would not necessarily be possible in a district such as Birmingham where low-SES families may not be able to afford laptops for their children. In Saugus, creating a foundation to provide funds for families who cannot afford the laptops is being considered.

Littleton has been successful in expanding its one-to-one program, which now reaches all fifth to tenth grade students in their reading or language arts classrooms. According to its Chief Information Officer, Dan Maas, the district continues to use Asus Eee PC netbooks, and with their lightweight Linux distribution, four technicians service the 13,000 computers in the district (personal communication, November 6, 2012). Additionally, Littleton has implemented a stipend-funded coaching program wherein volunteer teachers train and support other teachers at their schools.

**DISCUSSION**

These one-to-one programs were implemented as a way to remove barriers to technology access and use for students. Differences in program deployment may have factored into whether obstacles to student access to, and engagement with, technology were overcome. Programs that examined the needs of their student and teacher populations, developed technology infrastructure, and sought support from stakeholders were more successful; the program that relied on technology alone to produce outcomes ultimately failed.

Across programs, teacher support was often tied to the ways in which laptops were used in the classroom. A small number of teachers in Birmingham—such as the teacher using Scratch to teach students programming—worked beyond the limitations of unreliable Internet access and limited XO training to integrate opportunities for students to use XOs in the classroom. Teachers in Littleton and Saugus were provided with week-long trainings and ongoing professional development and technology coaching and were more involved in the initial development of the program.
Infrastructure also played a role in supporting or hindering the laptop programs. The selection of a laptop model appeared to have an impact on maintenance and teacher buy-in. Whereas Saugus and Littleton information technology departments investigated laptops that would be cost effective while suiting the needs of teachers and students, the OLPC program dictated the use of XOs. Although the netbooks used in Saugus and Littleton are small, the XOs are even smaller and slower. The frequent technical difficulties and lack of technical support for the XOs also meant that many laptops were out of commission. Moreover, the school-wide wireless Internet access that enabled students in Littleton to use Google Apps and that allowed Saugus students to collaborate on a district web forum did not exist in Birmingham. Network infrastructure at the focal school in Birmingham was inadequate and prevented teachers from taking advantage of online resources.

Differences in curriculum also may have contributed to the disparate program outcomes. Saugus and Littleton created laptop programs to support a larger writing-focused curricular reform. For example, Littleton schools used laptops and Internet connectivity to enable students to collaborate on and share their writing. Conversely, the XO deployment was envisioned as a way for students to teach themselves and was removed from specific pedagogical aims.

Problems in executing one-to-one programs may affect basic computer access and participation. Surveys of Birmingham students suggested that overall time spent using computers and the Internet for research and homework decreased after receiving XOs. Other research (Lei & Zhao, 2008; Windschitl & Sahl, 2002; Zhao & Frank, 2003) also suggests that the deployment of technology in classrooms is not enough to improve outcomes. Positive effects related to technology may depend on many factors, including selection of technology and technical supports (e.g., Warschauer, 2011), digital literacy considerations (e.g., Lei & Zhao, 2008), and teacher training and social dynamics (e.g., Windschitl & Sahl, 2002).

These findings must be viewed in the context of several key limitations. First, the type of data collected across districts were not uniform, making comparisons difficult. For example, teacher surveys and standardized test score data were not available from Birmingham but were available from the other two districts. Representative students—and in the case of Birmingham, teachers and classrooms—were selected for interviews and observation by either teachers or administrators.

CONCLUSION

With one-to-one programs growing more prevalent in U.S. school districts (Greaves & Hayes, 2008), so too have opportunities arisen for exploring the ways in which such programs proceed. Although research suggests that increased access to technology has positive effects on student learning and achievement (e.g., Kulik, 2003), evidence such as that in the current study also suggests that considered and supported technology programs—from the selection of devices, to teacher training, to social and technological infrastructure development—and not technology alone, might influence these positive outcomes. Our findings suggest that additional social and administrative factors must be considered, but that these may be difficult to address in low-SES communities, where financial issues are often a more pressing concern.

While the findings presented here suggest that the OLPC program did not have the benefit of intensive, stakeholder-supported planning, comparisons among the Birmingham, Littleton, and
Saugus programs are potentially problematic. OLPC was conceived as an international effort aimed at bringing technology to schools in developing countries. The Birmingham district also faced severe problems related to poverty, including a high rate of student turnover, limited funding for school infrastructure, and some of the lowest achieving schools in the state (Pelfrey, 2012). In addition, challenges related to data collection, such as lack of teacher interest in surveys and limited access to classrooms, prevented the breadth and depth of qualitative comparison that might have been possible had these data been available. These findings echo a growing body of research suggesting that technology programs without appropriate pedagogical support may be detrimental to students (Vigdor & Ladd, 2010; Wenglinksky, 2005).

If disadvantaged students face particular barriers to participation in school technology programs (Wenglinksky, 2005), then the development of more equitable programs will require better understanding of how social, technological, and pedagogical decisions affect one-to-one deployments. In comparing these three districts, the programs with more targeted goals, more extensive technical infrastructure, and more developed curriculum saw more positive outcomes and transformative uses of laptops in the classroom. When developing programs to bridge digital divides and bring educational equity for at-risk populations, consideration of these pedagogical goals, social and financial support structures, and community and teacher buy-in may be especially important.

REFERENCES


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