

Laptops and Literacy: A Multi-Site Case Study

Mark Warschauer
University of California, Irvine

This multi-site case study examined literacy practices in 10 U.S. schools with *one-to-one* computing programs where all students had access to laptop computers throughout the school day. Important changes noted in the processes, sources, and products of literacy were along the lines often touted by educational reformers but seldom realized in schools. For example, reading instruction featured more scaffolding and epistemic engagement, whereas student writing became more iterative; more public, visible, and collaborative; more purposeful and authentic; and more diverse in genre. Students also gained important technology-related literacies such as those that involve analysing information or producing multimedia. However, laptop programs were not found to improve test scores or erase academic achievement gaps between students with low and high socioeconomic status. Both the benefits and limitations of laptop programs are discussed in this article.

Due to the development and diffusion of information and communication technologies, we have witnessed the greatest change in our means of communication and production of knowledge since the invention of the printing press (for overviews, see Coiro, Knobel, Lankshear, & Leu, 2008; Reinking, 1998; Warschauer, 1999). The technological, economic, and social transformations of the digital era pose three important literacy and learning challenges that can be summarised as *past/future*, *home/school*, and *rich/poor*. *Past/future* refers to the gap between previously required literacy and learning skills that focus on the mastery of written texts and the broader set of digital literacy, thinking, communication, and productivity skills required for 21st-century life (see North Central Regional Educational Laboratory & the Metiri Group, 2003). *Home/school* refers

to the gap between the media-rich and autonomous literacy experiences that many children enjoy at home and the often more restrictive literacy practices they engage in at school (see Gee, 2003, 2004). Rich/poor refers to the ever present inequity between the literacy and learning achievements of students of high and low socioeconomic status (SES)—a gap made more dangerous by the disappearance of well-paying unskilled jobs and the fact that technological fluency is required for many elite professions (see Castells, 1996; Warschauer, 2003).

Not surprisingly, educators have turned to increased infusions of technology into the classroom to try to address these challenges. However, research suggests that the potential of new educational technologies is far from being realized because logistical, administrative, and pedagogical obstacles make it difficult for teachers to effectively deploy shared computers (see studies by Cuban, 2001; Warschauer, Knobel, & Stone, 2004). In addition, unequal patterns of technological access and use in society get reproduced in schools, as teachers make use of limited computer resources to benefit the most able or privileged students (see Schofield & Davidson, 2004).

To better integrate technology into instruction, many school districts throughout the country are working to create *one-to-one* classroom environments in which each student has access to an Internet-connected laptop computer at school and in most cases, at home. Relatively few studies have focused on one-to-one laptop programs and even fewer are considered methodologically rigorous (see review and critique in Penuel, 2005). At the same time, no prior studies have carried out extensive and systematic observations of laptop programs in more than a few schools and none have used the theoretical lens of literacy as a research focus.

This article presents findings from a 2-year laptop and literacy study conducted in Southern California from 2003 to 2005. The study was designed to examine the relationship of laptop use to student literacy practices. A complete report on the findings can be found in Warschauer (2006). This article is a summary of the study's major findings.

METHOD

The study is based on an examination of laptop use in a purposely stratified sample of 10 schools in California and Maine (see Table 1). The research was based on a sociocultural framework of literacy (e.g., Gee, 1996), which considers the way social and cultural environments and contexts shape and constrain the way meaning-making with diverse types of texts occurs in and out of school.

Research at the 10 schools was directed by the Mark Warschauer and carried out by a team of faculty, graduate students, and undergraduates (see acknowledgments). Data collection involved a combination of observations,

TABLE 1
School Sites

<i>School</i>	<i>Grades of Laptop Program</i>	<i>Location</i>	<i>Principal Ethnic Groups</i>	<i>SES</i>	<i>Programme</i>	<i>Funding</i>	<i>Platform</i>
Henry Elementary	3–6	Suburban, California	White, Asian	High	Gifted	Parental lease	Macintosh
Flower School	3–7	Suburban, California	Asian, White	Medium	General	Parental lease	Macintosh
River Elementary	4	Urban, California	Latino	Low	Language arts/English as a Second Language (ESL)	Private grant	Windows
Nancy Jr. High	7	Urban, California	Latino, White	Low	General	Federal	Macintosh
Howard Middle	7–8	Suburban, Maine	White	High	General	State	Macintosh
Castle Middle	7–8	Urban, Maine,	White, Black	Low	General	State	Macintosh
Freedom Middle	8	Urban, California	Black, Latino	Low	Alternative/At-risk	Private grant	Macintosh
Carlton High	9–12	Urban, California	Asian, White	Medium	Academic core	Parental purchase	Windows & Macintosh
Melville High	9–12	Suburban, California	White, Latino	High	Academic core	Parental purchase	Windows
Plum High	9–12	Rural, Maine	White	Low	General	State and private	Macintosh

Note. Reprinted from Warschauer (2006) with permission from Teachers College Press.

All names are pseudonyms. River Elementary and Castle Middle were referred to as Adelante Elementary and Urbania Middle in a previous article (Warschauer, Grant, Del Real, & Rousseau, 2004).

interviews, surveys, and document reviews. About 5 to 7 students from each school were chosen to participate in individual case studies in order to represent the student diversity at the schools. A total of 650 hours of classroom observations were conducted at the 10 schools, with detailed field notes taken during all observations. Interviews were conducted with a total of 61 teachers, 32 school staff members (administrators, librarians, counselors, and technology coordinators), 67 students, and 31 parents.

Teachers and students in 3 of the 10 schools also completed a voluntary anonymous online survey. We received a response rate of 100% from the teachers (35 out of 35) and 86% from the students (877 out of 1012). We also collected school documents, teaching materials, student assignments, and student test scores.

Data were analysed through standard qualitative methods—first to identify key patterns within each research site, then to make comparisons and find commonalities or differences across research sites. Focusing on systematic analysis of qualitative data is consistent with the theoretical model of situating literacy practices in their social and cultural context. To assist this analysis, all the interviews and field notes were coded using the HyperResearch software program. A bottom-up coding scheme was used that considered whatever items of interest emerged from the data related to the overall theme of literacy and learning with laptops.

No qualitative data were gathered from non-laptop classrooms or schools. However, we were able to make comparisons by interviewing and surveying students, teachers, administrators, and parents about the perceived differences between the laptop and non-laptop classroom and triangulating these opinions.

Finally, although details of test score outcomes and quantitative analysis are not presented in this article, these results have been reported elsewhere (Warschauer & Grimes, 2005), and we refer to them in the discussion section of this article.

Findings are reported in three predetermined categories: reading, writing, and Information and Communication Technology (ICT) literacy. Within these three categories, we examine the main patterns that emerged from the data of the study.

READING

Our study found three important changes in the teaching and learning of reading in the laptop classroom: *scaffolding* (provision of support so students can read more challenging material), *epistemic engagement* (active involvement in knowledge building), and *page to screen* (increased amount of reading online).

A major difficulty that students have with reading, especially from the fourth grade on, is due to the texts' unfamiliar subject matter or linguistic complexity.

Scaffolding allows students to tackle increasingly difficult texts as they gradually improve their reading comprehension. Our study found that the introduction of one-to-one laptop programs greatly expanded the teachers' opportunities for scaffolding texts. The most common way this occurred was by pointing students to textual and multimedia material from the Internet to get background or supplementary knowledge on topics related to their reading. For example, a middle school teacher in California explained to us how she used the Internet to open up her students' understanding of the text:

We read a short poem by Emily Dickinson [*I'm nobody! Who are you*] and they just weren't getting what she was saying in the poem and so we were able to do a quick little search online and they were able to see pictures of her and her dad. And they read about how she lost her father and how she sort of lived this strange isolated life and then I think they grasped the poem.

Other forms of computer-aided scaffolding that were frequently used included online dictionaries (allowing students to easily look up unfamiliar words), graphic organisers (allowing students to map out the plot, timeline, characterization, or other elements), and text-to-speech programs (allowing students to hear unfamiliar words). Although it was less common, we also witnessed teachers using special programs (e.g., SoftChalk, 2005) to mark up online texts, providing pop-up annotations with supportive information or leading questions linked to individual words or phrases.

A second important change in the reading process is what we labelled as *epistemic engagement*. Much of language arts instruction is devoted to what Wells and Chang-Wells (1992) refer to as *performative* literacy activities. In such activities, texts are used for students to demonstrate what they do or do not know—for example, by reading aloud or providing answers to discrete item questions. In contrast, epistemic or knowledge-building literacy activities have students working together to interpret and create meaning from texts. Laptops provided a wealth of opportunity for these kinds of epistemic literacy activities, and most of the teachers we observed took advantage of this. Students analysed short stories through online discussion forums, wrote book reviews and published them on Amazon.com (see Figure 1 for a book review written by a fifth-grade English language learner in California), and interpreted poetry through digital music that they composed to accompany it.

An illustrative example of using laptops for both scaffolding and epistemic engagement was seen in a seventh-grade language arts class of predominately Latino immigrant students at Nancy Junior High in California. Students in the class were reading *Beowulf*, an epic poem considered the earliest existing piece of writing from Old English and which was quite challenging for these students, even in its modernized narrative version. Before reading *Beowulf*, the students went online to gather background information about the author, the story, and the

★★★★★ **Huge Hit!!**, May 6, 2004

A Kid's Review

Sadako and the Thousand Paper Cranes is a great story it's about a brave young girl. The story takes place in Hiroshima, Japan when the atom bomb was dropped. This story is so sad, that when I read it my eyes were filled with tears. If you go to Hiroshima there might be a lot of reminders of her. So I recommend you to get this book. The ending of this story is so, so sad that it will put tears in your eyes.

 [Comment](#) | Was this review helpful to you? Yes No [\(Report this\)](#)

FIGURE 1 Student book review on Amazon.com

conditions of medieval life. They answered questions such as, “What language was *Beowulf* written in?”, “What’s an epic?”, and “What did young people do during medieval times?” While reading the story, they consulted a Web site (Driver, 2000) that included a multimedia narrative account of parts of the story, thus allowing them to draw on imagery to support their language.

After reading the story, the students produced a “*Beowulf* literary newspaper,” which they planned, wrote, and edited in small groups. The newspaper included sections on front-page news, sports, travel, advice, obituaries, comics, and food. Each section was used to summarise and comment on aspects of the *Beowulf* story. For example, the sports section of one newspaper we analysed repackaged the main battle between *Beowulf* and his enemy, Grendel, as a boxing match. The travel section featured a fall festival that humorously captured the lifestyle of medieval Scandinavia, and the crossword puzzle provided a playful way for students to select and define challenging vocabulary from the story.

Work on the newspaper actually required two readings. On the one hand, students had to read and reread *Beowulf* to make sure they sufficiently understood its plot and details. Then they had to consult online newspapers to better understand their genre, content, and formatting. They then had to merge the two by interpreting the plot, setting, and characters from *Beowulf* in a newspaper format. Old English stories are not typically of great interest to junior high students in California. However, by helping students access background information online and giving them the opportunity to design their own creative newspaper on the *Beowulf* theme, the teacher provided a highly engaging way for these immigrant students to enter in the world of medieval English literature.

Teachers we interviewed believed that these opportunities for engagement helped motivate many low-performing readers. As a Reading Specialist teacher in Maine explained,

If I asked [my low-performing students] to pick up a book, I won't hear the end of it of how terrible it is. For instance today, we're learning about nonfiction and the different tools that nonfiction uses to help you learn, such as diagrams, captions,

pictures. They're making a slideshow of each tool that you can use. So today they were doing diagrams and labeling things and these two boys decided to diagram a snake and they spent twenty minutes reading about a snake online and in a book. If I'd asked them to read about snakes, there's no way they would have.

The third and final change in reading instructional patterns was what we call *page to screen*. Simply put, a higher proportion of the students' reading activity in the laptop classroom occurred in computerized environments compared with the traditional classroom. For the most part, online reading skills were not taught explicitly but embedded into numerous assignments instead, many of which required skimming and scanning online content for specific information or summarising main ideas. This took place both in language arts classes and across the curriculum, as students in almost every subject area were expected to read material online. Of course most youth regularly access the Internet outside school as well and they need little encouragement to do so. However, in these classes, students were being socialized to view the Internet not only as a source of games and a venue to chat with friends but also as a source of reading material. They were also gaining practice in reading online for a variety of specific purposes.

WRITING

Laptops were used extensively during each stage of the writing process. Pre-writing activities were assisted by the use of Internet search engines (e.g., for background information) and graphic organisers (for planning). Drafts were almost always done on computer and this caused less fatigue compared with writing by hand. It also offered additional benefits to students whose handwriting could have been affected by coordination, motor skill, or cognitive function difficulties. As a special education teacher explained,

For many of our students with cognitive disabilities, getting the ideas from your brain onto paper is pretty much a torture. But whatever reason, and the reasons are as different as the individual students are, word processing as opposed to writing has been an incredible tool in terms of creatively being able to express themselves and then also working on just the mechanics of written language. . . . It levels the playing field sort of with their peers.

The rewriting stage—where students receive feedback, reread their papers, and edit their work—benefited the most from the use of laptops. Papers written on the computer were read much more easily and quickly compared with handwritten papers, thus allowing teachers to read and respond to student writing more efficiently. In 3 of the 10 schools, students also had access to an automated essay

evaluation software that gave numerical scores and basic feedback. Though this software was far from perfect (see discussion in Warschauer & Ware, 2006), it did provide an additional form of feedback for earlier drafts, allowing teachers to focus on later drafts.

Most important, once students received feedback, they could revise their papers more readily than if they had been written by hand. A middle school teacher in Maine explained how the feedback and editing stage was improved through use of laptops:

The most exhausting part of my job was 1 to 1 writing conferences, especially when you have the red pen out, you can't read their writing, you've got to squeeze in comments in the lines—two or three of those a day were all I could handle. And it was harder for them afterward to go back and remember. So when you have the laptop, it's live, it's right there, you are editing, you are conferencing together. When I need to give them feedback on revisions they needed to make, it was easier for them to just take what I offered and go back right there and do it.

The increased visibility and ease in revising computer-based writing also aided student collaboration, as peers frequently gathered around computer screens to work together. Natalie, a high school student in California, provided an interesting illustration of this point:

My friend who sits with me at my table, Felicia, we'll go back and forth. If I'm not sure how to start my essay out, I'll start reading hers, and I'm like, "OK, now I see what the teacher wants," and then I'll just take it from there. I don't copy what she writes, but it gives me an idea how I should write my paper.

Natalie further explained that such collaboration would not happen in a typical classroom. "Not a lot of people have very legible writing. . . . The intention [to share] might be there, but when you get the piece of paper, you just can't read it."

Other types of sharing and collaboration that took place (through video projectors or online discussion forums) are also not possible in a typical classroom. We witnessed a fascinating example of collaborative online writing in an English class at Plum High, Maine, where students who had read selected short stories worked in small groups, each with his or her own laptop, to collaboratively author an alternate version of the story from a particular character's perspective. They used the shareware program SubEthaEdit (CodingMonkeys, 2005) that allows multiple Macintosh users to edit the same document in real time, with each user's contribution appearing in a different colour. Although this experience may or may not help them on a standardized writing test, such forms of multivocal writing are becoming increasingly common in the real world, and learning how to accomplish such collaboration well is a valuable skill.

Finally, laptops also proved to be valuable in the dissemination stage, as students wrote for near or distant audiences. For example, middle school students in Maine authored, formatted, and printed out children's books in Spanish that were then distributed by a humanitarian organization to children in Guatemala.

Overall, we can summarise seven advantages of writing with laptops. First, computer-based writing became more naturally integrated into instruction. Second, the writing process became more iterative, with students able to receive and respond to feedback better. Third, writing became more public, visible, and collaborative. Students were able to view and improve on each others' work—whether on a classmate's laptop screen or a printout. Most of the laptop classes we observed were “print-rich” and had numerous exemplars of student work posted around the room, often with multiple versions of the same paper. Fourth, writing became more purposeful and authentic, with students able to write things with real objectives (e.g., online book reviews, authentic correspondence, materials for publication). Fifth, students took advantage of the formatting features of computers to write in multiple and diverse genres—producing, among other things, newspapers, informational brochures, pamphlets, business letters, and magazine advertisements. Sixth, by using computer-based language (e.g., spell-check, thesaurus, etc.) and formatting tools and by revising their work for authentic audiences, students produced higher quality writing in which they took more pride. Finally, by having a powerful writing tool available at school and at home, many students also became more autonomous in their writing and even engaged in creative writing during their free time. An elementary school teacher in California summarised how the multiple benefits of laptops helped his students learn to write:

They are writing more, it's better quality, it's produced faster. I think the laptops facilitate the writing because there is less fatigue involved than with cursive or print. Again they have the Internet right there to pull up graphics, they have Apple works drawings to illustrate their stories, so I think the laptop is a great facilitator of writing. I'll give my students prompts to write a short story, and usually before the stories were 2–3 pages, but this year, their short stories are 8–10 pages long.

ICT LITERACY

Beyond the traditional literacy areas of reading and writing, new literacies associated with the use of ICT are now widely recognised. These include both information literacy or the ability to access, manage, evaluate, and make use of information (see American Library Association, 2000) and multimedia literacy or the ability to interpret and produce knowledge in multiple media and modes (see New London Group, 1996). For the purpose of this discussion, we will consider both under the category of *ICT literacy*.

Not surprisingly, there were major changes in the way these new ICT literacies were taught and learned in the laptop classroom. Prior research in typical K–12 schools indicates that much work with computers focuses on the most mechanical aspects of these new literacies (e.g., how to cut and paste information from the Internet or operate the PowerPoint program) rather than more in-depth skills and proficiencies (see Warschauer, Knobel, & Stone, 2004). In contrast, the ongoing access to new technology in one-to-one programs enabled teachers and students to move beyond the basics. Regular access to the Internet allowed more “just-in-time” learning (as students located information at the point of need), more individualised learning (as students’ pursued their own research interests rather than being restricted to material from textbooks or libraries), greater ease in conducting research (due to the vast amount of information on the Internet), more empirical investigation (as students used laptops or laptop-connected scientific probes to gather or analyse data in the classroom), and more opportunities for in-depth learning (classes could pursue subjects of investigation from multiple angles using computer- and Internet-based resources).

As noted earlier, teachers and students reported that looking for information online was one of the two most common instructional uses of laptops. Observations and interviews suggest that this had a large impact on teaching and learning. A social studies teacher in California articulated what many teachers told us:

I had a door totally open up to me in terms of culture, geography, current events, news, all of the things that I have been trying to get my students to learn from a textbook: language, what this sounds like, what that looks like, these five different cultures that live in one square mile, this civil war, that political situation. . . . I can make the Zulu tribe in South Africa come alive for them, versus talk about these people that they’ve never seen, they don’t know, they can’t grasp. And where I was using a newspaper of the previous day’s news to deal with current events, we can literally track an event hour by hour online and change the discussion minute by minute. It totally involves them one hundred percent in the news.

Such changes allowed students to hone their skills at finding, critiquing, and deploying a wide range of information in the pursuit of knowledge. For example, to better understand the U.S. Constitution, one social studies class in Maine visited the Web site of the Bill of Rights Institute, where they found information on recent court cases involving key constitutional issues. Students perused the site and selected cases of interest to them—often those that involved issues of relevance to youth. They then read both case and background information, developed an opinion about the case, and wrote an essay that they emailed to the teacher. They then shared and debated their opinions in class.

This is a very different approach to learning the constitution compared with what typically occurs in schools where students focus their effort on memorising

key facts and information. In contrast, the aforementioned activity forces students to grapple with the meaning of the constitution and its applicability in today's world by drawing on an array of online information in putting together their argument.

In addition, students in laptop classrooms also learned to produce material in a wide variety of modes and media such as musical compositions, videos, animations, and Web sites. In contrast, multimedia production in typical schools is dominated by PowerPoint presentations (see Warschauer, Knobel, & Stone, 2004). In most of the schools we visited, students moved beyond the basics and in many cases developed sophisticated artistic and compositional skills as they explored the features of multimodal genres such as movie trailers, poster advertisements, and digital stories. Such multimodal work also helped students think deeply about texts as they interpreted meaning across domains (see Iedema, 2003; Kress, 2003). An elementary school teacher, for example, explained the value of having her students compose music to interpret poetry:

They had to get the emotion, the tone, the climax of the poem. They had to be very thoughtful and think rhetorically. It wasn't a matter of "this was the answer to the question," but "what was the emotion going on in the poem?" They thought more deeply about the poem.

Castle Middle School in Maine presented a particularly interesting approach to integrating media into the curriculum. The school is the most economically, culturally, and linguistically diverse in the state, encompassing neighborhoods with some of the poorest housing projects of the Eastern seaboard, a sizeable immigrant and refugee community, and some middle and upper middle class suburbs. To better meet the needs of all its students, the school had adopted an Expeditionary Learning curriculum, with the majority of academic work organized in 8–12 week interdisciplinary research projects. Each of the projects results in a series of collaborative multimodal productions such as a CD-rom on endangered species, a Web site analysing issues of war and peace, art collages displayed at a local museum and digitally reproduced for the Internet, as well as student-produced videos that reflect the research and learning process and are creatively archived.

Though the overall organisation of the curriculum was unique at Castle Middle School, the types of multimodal products created and the skills developed in the process were not. Students in all the laptop schools had a greater opportunity to work with a variety of media to a much greater extent compared with typical schools.

In summary, literacy processes, sources, and products in laptop classrooms differed substantially from the typical classroom. These differences are summarised in Table 2.

TABLE 2
Changes in Literacy Processes

<i>Typical Classroom</i>	<i>Laptop Classroom</i>
Literacy Processes	
Mostly teacher controlled	More autonomous student control
Mostly private and individual	More often public and collaborative
Mostly for teacher and a grade	More often for an authentic purpose and audience
Limited revision	More iterative process with greater revision
Little feedback provided	More feedback provided
Some scaffolding	More scaffolding
Literacy Sources	
Use of few published sources (mostly from school libraries or textbooks)	Greater use of published sources, with library and textbook material supplemented by wide range of online material
Limited access to and use of data	Greater access to and use of data from online materials or collected by students in class (using computer-connected probes, etc.)
Limited ability to record and reflect on students' own experiences and prior work	Digitalized audio and video allow better opportunity to record and reflect on students' own experiences and prior work
Literacy Products	
Text products are mostly essays	Essays supplemented by other genres such as brochures, newspapers, and business letters
Multimedia products largely restricted to slide presentations (e.g., PowerPoint)	Greater diversity of multimedia products, including musical composition, videos, animation, and Web sites

CONTRADICTIONS OF THE LAPTOP CLASSROOM

In spite of the many benefits of laptop instruction for learning and literacy development, we also noted two important contradictions of laptop use. First, although laptop programs were broadly viewed as beneficial for student learning, they did not result in higher test scores (for details of our analysis in one California school district, see Warschauer & Grimes, 2005). We believe this discrepancy is partly explained by the newness of laptop programs and the fact that the teachers and students we observed in our study are still in the early stages of learning how best to make use of laptops in the classroom. More important, we noted a mismatch between what is learned in laptop instruction and what is currently covered in standardised tests (see discussion in Silvernail, 2005). For example, laptop-based writing that entails multiple revisions and uses

computer-based scaffolds will not necessarily result in improved scores on a sit-down, one-time handwritten essay. Also, the kinds of multimedia literacy and information literacy promoted in the laptop classroom are barely addressed by standardized tests.

Second, though laptop programs are widely believed to ease educational divides by extending technological access to students who may not have it at home, they did not lessen achievement gaps. On the contrary, low SES students and the schools that served them were often less prepared to take advantage of the full capability of laptops due to students' limited literacy skills and lack of prior experience on working with computers. In contrast, the implementation of laptop programs in high SES schools tended to go smoother as teachers, facing fewer serious discipline problems and with smaller numbers of at-risk learners (e.g., English language learners, students lacking basic reading skills), had an easier time in planning content-rich lessons that used online material and involved autonomous learning. Although some of the low SES schools in our study made outstanding use of laptop computers, this was not because of the laptops' inherent features but rather due to the school's strong overall instructional program. These findings support the notion of Neuman and Celano (2006) that the playing field may have to be *unleveled*—where superior rather than equal educational resources are provided to low-income students in order to overcome many of the disadvantages they face.

Finally, it is important to note that there were many other complexities of the laptop programs that cannot be addressed in a summary of this length. Laptop implementation in particular schools was affected by factors such as curricular goals, leadership ability, district administration, professional development provided to teachers, the accessibility and quality of technical support, and the existence of related hardware such as digital whiteboards (see discussion of the full study in Warschauer, 2006).

CONCLUSION

This multi-site case study of literacy practices and outcomes in 10 K–12 schools found that the processes, sources, and products of students' literacy activities changed noticeably in the one-to-one laptop classroom. Literacy processes became more public, collaborative, authentic, and iterative, with greater amounts of scaffolding and feedback provided. Literacy sources expanded to include a wealth of online materials, more student-collected data, and digital or audio archives of students' own work. Literacy products extended beyond the essays and PowerPoint presentations that dominate typical schools to include a greater variety of textual and multimedia genres. All of these changes are in line with those often touted by technology enthusiasts but have previously not been

regularly achieved through shared uses of educational computers (see Cuban, 2001; Warschauer, Knobel, & Stone, 2004).

The practices that we observed in the laptop classes go a long way toward addressing the first two learning and literacy challenges discussed at the beginning of this article: past/future and home/school. Although there were differences among students, classes, and schools, students' literacy practices in laptop schools closely match the requirements of 21st-century life compared with students in typical classrooms. In addition, opportunities to engage in the kinds of media-rich, autonomous interaction and production at school that so many students carry out at home had greatly increased.

However, we did not find that laptop programs as a whole were successful in addressing the third challenge, that of rich and poor. Rather, the schools in low SES communities in our study had more difficulty developing and sustaining successful laptop programs compared with the high SES schools. This result is consistent with prior research that documented the challenges of implementing educational technology in low SES schools (see Warschauer, 2003; Warschauer, Knobel, & Stone, 2004). Although our study does not suggest that laptop programs are of no value to low SES schools and students, such programs are unlikely to seriously lessen achievement gaps by themselves.

Additionally, we saw no evidence that participation in laptop programs affects students' reading, writing, or English language arts test scores. Studies involving longitudinal data and more sensitive assessment measures will be required to better investigate the long-term impact of laptop programs. Long-term studies could also better indicate whether the initial comparative advantage that high SES schools have in integrating laptops diminishes as low SES students catch up in computer experience and skills over time and whether student enthusiasm for laptop use fades over time as the equipment loses its novelty effect.

Finally, this study did not attempt to carry out a cost-benefit analysis that accounts for the significant expense of laptop programs (e.g., purchase of hardware and software, maintenance and upkeep, professional development) in comparison with other possible uses of such funds. Currently, the expense of laptop programs is a major disincentive to their implementation. However, with laptop purchase and maintenance prices falling steadily (see Computer Economics, 2005), the cost of laptop programs will gradually become less of an obstacle. Trends to date suggest that falling costs, improvements in hardware and software capacity and quality, and a continued growth in the societal importance of digital media will contribute to making laptop programs an increasingly attractive alternative for U.S. schools. The findings of this study suggest that a continued expansion of one-to-one laptop programs—while not a panacea for all learning challenges—will nevertheless contribute positively to promoting improved teaching and learning of literacy in U.S. schools.

ACKNOWLEDGMENTS

This article draws on my lengthier discussion of these issues in *Laptops and Literacy* (Warschauer, 2006). An earlier version of this article was presented at the American Educational Research Association (AERA) annual meeting in San Francisco, April 2006.

Funding for the study has been provided by the Ada Byron Research Center for Diversity in Computing & Information Technology and the Cultural Diversity Program of the Academic Senate Council on Research, Computing and Library Resources, both at the University of California, Irvine.

Research for this article was carried out with the assistance of Paige Ware of Southern Methodist University and Michele Rousseau, Kelly Bruce, Doug Grimes, LaWanna Shelton, Melanie Wade, Jorge Velastegui, Kurt Suhr, Vanitha Chandrasekhar, Bryan Ventura, and Julia Nyberg, all of the University of California, Irvine.

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