ONE-TO-ONE COMPUTING: 
WHAT DOES IT BRING TO SCHOOLS?*

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ABSTRACT

This study investigates students' use of one-to-one laptops for various activities and the impact of one-to-one computing on student learning and school culture. Based on data collected from surveys and interviews of teachers, students, and parents in a Midwestern middle school over one academic year, this study answers the following major questions: 1) How did students use their laptops? 2) What impact did the one-to-one laptop program have on student learning and school culture? 3) What were the perceptions of and concerns over one-to-one computing? A sound understanding of these issues is increasingly important as more and more schools are joining in this one-to-one computing initiative and more money is being invested. Results revealed that students used their laptops for various tasks related to learning, communication, expression, and exploration. Students gained significantly in their technology proficiency. The one-to-one laptops have provided great opportunities and resources for teaching and learning, but also raised issues such as student discipline problems, concerns on digital literacy, and fear of over-dependency on information technology.

*A small part of this section appeared in Lei, Conway, and Zhao (2008).
One-to-one computing is one of the fastest growing yet most controversial phenomena in American classrooms. On the one hand, the last decade witnessed a dramatic increase in the number and the scope of one-to-one computing projects. For example, in 2002, the state of Maine signed a $37 million agreement with Apple on the Learning Technology Initiative which supported the installation of wireless Internet connections in all 239 public middle schools and provided iBook laptops to 34,000 students and 3,000 teachers. Four years later, this statewide laptop program was renewed for another four years with an additional fund of $41 million (Quimby, 2007). Michigan’s Freedom To Learn program spent more than $30 million issuing a combination of laptop computers and Personal Digital Assistants (PDAs) to nearly 30,000 students in 15 school districts (U.S. Department of Education Office of Educational Technology, 2006). Since 2004, Texas’ Technology Immersion Project (TIP) has granted funds to 25 school districts around the state to provide not only one-to-one computing devices, but also “ALL of the tools they need to conduct learning in the 21st Century” (The Technology Immersion Project, n.d.). In 2006, the governor of South Dakota proposed 13 million dollars to provide laptops to high school students in the state (Dunsmoor, 2006). By 2007, this project had expanded to 9,600 high school students in 41 districts across the state (South Dakota Department of Education, 2007). Starting from 2006-2007, Pennsylvania’s Classrooms for the Future would invest $200 million to provide laptops to every high school student in classrooms (Classroom For the Future, 2006).

Currently at least 33 states have schools experimenting one-to-one computing projects and more schools are seriously considering one-to-one programs (Lei, Conway, & Zhao, 2007). According to the 2005-2006 National Technology Assessment conducted by Quality Education Data (2006), 47% of the school districts surveyed expect to mount a major technology initiative or upgrade effort focused on desktops, laptops, and handhelds during the next 24 months. In addition, the groundbreaking One Laptop Per Child (OLPC) initiative is planning on providing US$100 laptops for children in developing countries. The initial roll-out of OLPC focuses on six developing countries (Young, 2005), and five of them—Argentina, Brazil, Libya, Nigeria, and Thailand—had made tentative commitments by the end of 2006 (Markoff, 2006).

On the other hand, there are growing concerns over the effectiveness of such high cost programs, and as a result, there is increasing resistance in some parents, students, educators, and school administrators in implementing one-to-one computing programs because “for some, laptops don’t compute” (Bahrampour, 2006). Some schools are “saying no to school laptops” (Vascellaro, 2006), including some South Dakota schools that were not interested in their governor’s one-to-one proposal (eSchool News, 2006a). In stark contrast to Maine’s $41 million-renewal of its state-wide one-to-one laptop program (Quimby, 2007), a number of schools decided to discontinue their one-to-one laptop programs after a few years’ implementation, such as the Romoland schools in California (Bustamante, 2007),
Matoaca High School in Virginia, and Liverpool High School in New York (Hu, 2007). One-to-one computing was listed as one of the top 10 most significant educational technology stories of 2006 by eSchool News, with a title that reflected the controversy on this topic: “One-to-one computing: Promising solution—or overhyped mistake?” (eSchool News, 2006b).

The mixed reactions and the controversy on one-to-one computing program, to a great extent, arise from the lack of empirical evidence on the effectiveness of one-to-one computing on student learning. Aside from project evaluations, independent research on one-to-one computing is still scarce (Penuel, 2006). There is little research-based evidence to answer some critical questions related to one-to-one computing: What is happening, academically and non-academically, when each child has a networked computer? How are students using technology in this ubiquitous computing environment? Is one-to-one computing making any difference in teaching, learning, and the school culture? As more and more schools are making decisions about one-to-one computing initiatives, it is essential that policymakers, educators, and practitioners alike understand the role of one-to-one computing on student learning and the impact of one-to-one computing on school environment.

This study explores these issues. Since extensive time is necessary for technology to affect student outcomes, this study only examines the first stages of laptop use in schools. Specifically, this study focuses on the following questions: First, how do students use one-to-one laptops? Second, what impact does a one-to-one computer project have on students and the school? Third, how do students, teachers, and parents evaluate such projects and what concerns, if any, do they have regarding one-to-one computing? Answers to these questions are significant for understanding how ubiquitous computing can affect student learning and the school culture, and thus can provide insights for future practice and research.

**LITERATURE REVIEW**

Although one-to-one computing initiatives started nearly 20 years ago (Johnstone, 2003), research in this field has not been able to keep up with its rapid development and expansion (Penuel, 2006; Warschauer, 2006). This was especially the case in the first decade. In a review of one-to-one computing studies conducted by Penuel and colleagues in the SRI International in 2001, the authors found that the research was scarce, and the available studies suffered methodological problems and most studies were of weak quality (Penuel, Kim, Michalchik, Lewis, Means, Murphy, et al., 2001). With the implementation of several state-wide and district-wide large-scale one-to-one computing projects in the first few years in the 21st century and the rapid expansion in the following years, there has been a considerable increase in the number of one-to-one computing evaluation and research studies (Lei, Conway, & Zhao, 2007; Penuel,
In a similar review five years later, Penuel (2006) identified 46 implementation studies and outcome studies on one-to-one laptop programs. The emphasis of these studies mainly focused on two areas: the implementation of one-to-one initiatives and the impact of these projects. A significant amount of one-to-one literature is descriptive studies, or what Penuel (2006) called “Implementation studies.” For instances, a series of state profile reports written by Lemke and Martin (2003, 2004a, 2004b, 2004c) provide an overview of the one-to-one initiatives in the states of Maine, Indiana, Michigan, and Virginia. These implementation studies, in general, introduce the mission and scope of one-to-one initiatives and describe the implementation process, preliminary descriptive impact on student learning, and local responses to the one-to-one initiatives (e.g., Bartels, 2000, 2002; Bebell, 2005; Kerr, Pane, & Barney, 2003).

As a high-stake and high profile endeavor, one-to-one computing attracts much attention to the impact of such investments. It is therefore not surprising to see that a considerable amount of studies on one-to-one computing focus on the return of the investment. In relation to one-to-one computing, there have been many different evaluation contexts including: large-scale district-level evaluations (Zucker & McGhee, 2005); small-scale district level evaluations (Johnstone, 2003; Stevenson, 1999); state level evaluations (e.g., Harris & Smith, 2004; Silvernail & Lane, 2004; Urbain-Lurain & Zhao, 2004); evaluations of small-scale national pilot projects (Conway, 2005); and evaluation of large-scale nationwide initiatives (Rockman et al., 1997, 1998, 1999, 2000). A few studies have incorporated pre-/post-test measures of student achievement in one or more core curricular areas (e.g., Gulek & Demirtas, 2005; Harris & Smith, 2004; Johnstone, 2003; Rockman et al., 2000).

These studies generally report positive impact of one-to-one computing on student outcomes in general, or on one or two specific areas. For example, using a quasi-experimental design, Gulek and Demirtas (2005) explored the impact of one-to-one laptop use on students’ overall grade point averages (GPA), state test results, and district test results. They found that students who participated in the laptop program gained significantly in writings, English-language arts, mathematics, and overall GPAs. Russell and colleagues (2004) compared teaching and learning in classrooms with mobile carts and permanent one-to-one laptops. They reported that in one-to-one classrooms, technology was used more frequently, student motivation and engagement was higher, and students were more likely to use computers as a primary writing tool.

Several studies focus on the impact of one-to-one computing on specific subject areas or specific skills. For instance, McMillian and Honey (1993) reported marked improvement in students’ writing ability when using laptops for writing on one-to-one basis. Similarly, the evaluation of the Wireless Writing Program in Peace River North school district of Canada found that students who participated in the one-to-one iBook program gained substantially in writing skills and attitudes toward writing (Jeroski, 2003, 2004, 2005). Researchers at Rockman
et al. reported students in one-to-one laptop programs scored higher in four writing areas: content, organization, language, and mechanics (2000). Based on multi-site case studies and interviews, Warschauer (2006) found that students who participated in the one-to-one laptop programs gained markedly in the sources, process, and products of their literacy activities.

Another area of studies is the impact of one-to-one computing on students with special needs. For example, Harris and Smith (2004) studied the use of laptops by seventh grade students with disabilities in the Maine Learning Technology Initiative project. They found that the laptops helped students with disabilities to improve their engagement in learning, increase their motivation and ability to work independently, and improve their class participation and interaction with others. Similarly, Conway (2005) reported positive impact of one-to-one laptop program on students with dyslexia and other reading or writing difficulties.

Findings from these research and evaluation studies provide a broad understanding of the implementation and impact of laptops in classrooms. However, there is little research that focuses on how laptops are being used for teaching and learning in environments with one-to-one computing (Bebell, 2005). When it comes to the question of what really happens when every child has a laptop and how the laptops are being used in classrooms, current studies provide only general information on “what” is used, “how much” is used, and the changes in “what” and “how much,” but not much information on “how” the laptops are being used in teaching and learning practices. For example, studies generally report how much class time is used on laptops (Rockman et al., 2004), the use of laptop in selected content areas (Davis et al, 2005; Russell, Bebell, & Higgins, 2004; Silvernail & Harris, 2003), the use of specific technology software or function (Bebell, 2005; Davis, Garas, Hopstock, Kellum, & Stephenson, 2005; Ross & Strahl, 2005; Silvernail & Lane, 2004), and the change in percentage of use of specific technologies such as the Internet (Rockman et al., 2000; Russell et al., 2004; Silvernail & Harris, 2003).

In summary, current research on one-to-one initiatives mainly focuses on the implementation process and whether it works, without sufficient data to picture how students use their own laptops. Further research is needed to provide a deep understanding of learning practices in classrooms with one-to-one laptops (Bebell, 2005; Roschelle, 2003). As Dunleavy, Dexter, and Heinecke (2007) point out “…the general consensus from reviews of the research to date is that additional detailed information is needed from classrooms in order to describe the teacher and student practices and outcomes, and to identify the contributions the access level makes to technology-supported teaching and learning…” (p. 440).

We know from research that the impact of any technology depends on how it is being used, in what context, and for what purposes (Burbules & Callister, 2000; Lei & Zhao, 2007; McFarlane, 1997). To examine the impact of one-to-one initiatives on teaching and learning, we need first to understand how one-to-one
laptops are being used and how the use plays a role in teaching and learning in a complex social context. Research on these issues cannot only provide a sound understanding of the learning practices in one-to-one computing classrooms, but also offer an in-depth analysis of the possible challenges and issues that may rise in learning environments with ubiquitous computing (Dunleavy, Dexter, & Heinecke, 2007). Answers to these questions can be of tremendous value to policymakers, educators, and the public.

THEORETICAL FRAMEWORK

Based on the natural impulses of a child proposed by John Dewey (Dewey, 1943): inquiry, communication, construction, and expression, Bruce and Levin (Bruce & Levin, 1997; Levin & Bruce, 2001) proposed a taxonomy of technology for learning:

1. Media for inquiry;
2. Media for communication;
3. Media for construction; and
4. Media for expression.

This taxonomy provides a useful framework to analyze student technology use for learning, especially for learning different subjects in schools. However, to directly apply this taxonomy as the analyzing framework for this study may not be the most appropriate because of two trends in the development and diffusion of technology. The first trend is the disappearance of technology. After two decades’ generous investments in educational technology, both the quantity and quality of technology access in public schools has increased dramatically (Fox, 2005). Only a few decades ago, computers were very expensive to operate and maintain. Now they are becoming increasingly portable and ubiquitous, and becoming so enmeshed in many people’s daily experiences that they “disappear” (Bruce & Hogan, 1998, p. 269). This is especially the case in one-to-one computing classrooms where students work on and learn from their own computers. It is therefore impossible to study technologies in isolate of the context.

The second trend is the blurring boundaries of learning and play for the new generation. “Growing up digital” (Tapscott, 1998), the new generation’s digital experiences have changed not only the ways they communicate, socialize, and entertain, but also fundamentally changed how they approach learning. They are technology-savvy and reliant upon technology as an “essential and preferred component of every aspect of their lives” (NetDay, 2004, p. 6). They are multi-taskers, often working on two or more tasks using two or more technology devices simultaneously (Rideout, Foehr, & Roberts, 2005; Shifrin, 2006, p. 450). To them, there is no clear distinction between play and learning. They have been learning from playing and have been playing while learning.
Therefore, if we define students’ technology use only based on how technologies are used for learning, we would have missed the important components of students’ daily life in which they use technologies seamlessly for multiple purposes, and we would have missed the important connections between their technology use and the context.

To take students’ multiple-purpose use of technologies into account, in this study we modified Bruce and Levin’s taxonomy into the following categories:

- laptop use for specific learning tasks with explicit learning goals;
- laptop use for communication, such as email, instant messaging and online chatting;
- laptop use for expression, such as writing and publishing; and
- laptop use for exploration, such as working on multi-media products and playing computer games.

The main difference between this model and Bruce and Levin’s taxonomy is that the last three types of uses (communication, expression, and exploration) reflect a significant component of student technology use, but they do not necessarily have an explicit learning purpose. However, this does not mean that learning is excluded from these technology uses. On the contrary, as demonstrated in the examples given in the following sections, students learn from communication, expression, and exploration. We believe that this framework can better reveal the “learn and play” use of technologies among today’s students.

**METHOD**

**Participants**

Participants included 231 students, 28 teachers, and 44 parents in a northwestern middle school in the United States. The school was located in a middle- and upper-class neighborhood with about 1% of students receiving free or reduced-cost lunch. Most students (97.6%) had access to computers at home, and 95.6% of students had home Internet access. This was a comparatively small school, with a total enrollment of 237 for two grades (7th and 8th), and the student-teacher ratio was 9:1. The school had rich technology resources: every classroom was equipped with a computer projector, overhead projector, TV, and VCR, and the whole building had wireless Internet access. This school implemented a one-to-one laptop project at the beginning of the 2003-2004 academic year, giving every teacher and every student an Apple iBook that they could take home everyday. Before the launch of the laptop project, this school had one computer lab and two laptop mobile carts. The school and school district provided teachers with convenient and sufficient professional development opportunities such as subsiding teachers to take courses from a local university, organizing in-school workshops on various technology hardware
and software, and supporting technology issue discussions at weekly teacher team meetings.

**Data Collection**

Survey and interview data were collected over the 2003-2004 academic year.

**Surveys**

Surveys were administered to students, teachers, and parents. Surveys are available from the authors.

**Student Survey**—Student surveys included a Time 1 survey and a Time 2 survey. The Time 1 surveys were administered at the beginning of the academic year before the laptops were distributed; and the Time 2 surveys were administered at the end of the academic year. Both surveys included four sections. The first section asked for Demographic Information including SES, grade, and gender. The second section, Current Technology Usage, included multiple-choice and fill-in-the-blank questions regarding time students spent working on their laptops and the specific tasks they performed on their laptops. The third section focused on student developmental outcome variables such as their attitudes and beliefs toward technology, perception of technology use, attitude toward schooling, self-esteem, and behavior. This section used Likert scale questions using a scale of 1-5 with 1 indicating “strongly disagree” and 5 indicating “strongly agree.” The fourth section measured students’ information technology proficiency. Based on existing literature focusing on student technology standards (e.g., American Association of School Librarians & Association for Educational Communications Technology, 1998; Committee on Information Technology Literacy & National Research Council, 1999), the technology proficiency scale was developed to evaluate students’ information technology proficiency. Participants were provided a series of technology situations and then asked to solve a practical problem and select the appropriate multiple choice answer. The reliability of this technology proficiency scale was 0.77.

The student surveys were administered to all 237 students in this school. Among them, 207 students returned the Time 1 survey, 208 students returned the Time 2 survey, and 177 students filled out both surveys. Data from students with more than one-third of all responses missing were deleted ($N = 34$), and data from special education students were deleted ($N = 10$). Therefore, a total of 133 students’ data were retained for final data analysis. Of the 133 students, 64 (48%) were male, 69 (52%) were female, 64 (48%) were 7th graders, and 69 (52%) were 8th graders.

**Teacher & Parent Survey**—The teacher survey and parent survey, administered at the end of the school year, focused on their perceptions of the laptop project and included questions regarding their attitudes toward student laptop use, their
evaluations of the impact of this project, and their beliefs in using technology at home and school. Statements on attitudes and beliefs about technology use were listed. Teachers and parents were asked to indicate the extent to which they agreed with each statement on a Likert-scale from 1-5 with 1 indicating “strongly disagree” and 5 indicating “strongly agree.” Open-ended questions were also included to better understand teachers’ and parents’ attitudes, thoughts, and reflections about one-to-one computing.

Interview

To obtain in-depth stories on how technology was used, for what purpose(s), and in what contexts, nine teachers and nine students were interviewed. The fundamental selection criterion of interviewees was to have them represent the school population as much as possible. The selection of teachers for interview was based on the grade and subject they taught. Since this was a comparatively small school, generally speaking, there was one teacher for one subject in each grade. The nine teachers included two math teachers, two science teachers, two social studies teachers, one language arts teacher, one technology specialist, and one technology teacher. Five of these teachers were male and four were female. The students were selected based on their level of interest in using technology: two students greatly liked technology; one student did not like technology; and the others were somewhere in between. They were also asked for their perspectives on the impact of technology uses on learning. All participants were interviewed individually, and each interview lasted for 25 to 30 minutes. For data coding purposes, all interviews were audio-recorded with consent and/or assent.

RESULTS AND DISCUSSION

This section describes how one-to-one laptops were used, discusses the impact of one-to-one computers on students and the school, and then reviews the evaluations of the one-to-one computing project by students, teachers, and parents, including both their positive reviews of one-to-one computing and concerns related to this project.

How Students Used Their One-to-One Laptops

One criticism of sizable expenditures for computers in schools is that computers are often “oversold but underused” (Cuban, 2001). In other words, computers are purchased and put in classrooms but are not sufficiently utilized by teachers and students. In a one-to-one computing environment, does this criticism apply? When every student has a computer, will it still be “oversold and underused?”

To find out answers to this question, students were asked to report how much time they spent on their laptops everyday (including both school use and home use). Descriptive analysis results reveal that, as shown in Table 1, 7.7% of the
students spent less than one hour a day on their laptops, 24.6% of the students spent about one to two hours a day, 30.8% of the students spent about two to three hours a day, and 36.9% of them spent more than three hours a day on their laptops. These results suggest that, regarding the regularity or quantity of use, these laptops were being used at a certain frequency. However, as suggested by a number of researchers (e.g., Lei & Zhao, 2007; MacFarlane, 1997), what is more important than the quantity of technology use is the quality of technology use, or how technology is used and for what purposes. To answer this question, we asked students to report the specific activities they used their laptops for. As shown in Table 2, most students (81.4%) used their laptops to do homework, followed by searching information for school work (71.4%), emailing (65.8%), surfing online for entertainment (58%), chatting online (51.1%), and working with specific software (50.2%). About half of the students used computers to play games (48.1%) and 11.3% of students created Websites.

Interviews and surveys revealed that students used their laptops in a variety of ways. The following section describes in detail how students used their own laptops for various purposes.

**Laptop Use for Specific Learning Tasks**

This study revealed that laptops in school were most commonly used for learning purposes. Below we summarize the most common uses for learning as reported by students: taking notes, searching information on the Internet, learning subject content with specific software, and learning through online discussions. 

*Taking notes*—Taking notes was reported as the most common laptop use in school. Instead of carrying a pile of paper notebooks for the different subjects, students now carry their laptop “notebook” from one classroom to the next and use programs such as Microsoft Word, Word Perfect, Notepad, and even PowerPoint.
to take notes. In addition, students reported that they took their laptops to fields to record data and take observational notes in science classes.

Students liked their new “notebooks” and were able to take advantage of the many capabilities including organization, grammar checking, and spell checking. More than 80% of the students reported being more organized, because they learned how to organize their notes for different subjects so that they could easily find them when needed. The folders were “like a binder” but were more organized and easier to maintain. A student told us,

I used to keep a lot of things in my binder. I am not very well organized. I am messy. That’s my problem. In the middle of the year, I started taking notes on the computer and organizing folders. I don’t lose my notes anymore. I am better prepared for my tasks and tests.

Another student viewed himself as a well-organized person, but believed “it helps those unorganized kids a lot”. The computers’ intrinsic capabilities enabled students to keep neater notes with fewer grammatical and spelling errors because of the ease of editing and the spell check features that most programs provide.

Students reported other advantages of taking notes with the computer. Students, especially those who did not like writing or who believed that their handwriting was poor, preferred typing notes versus handwriting notes. One student reported he liked taking notes on his laptop because it was “better for taking quick neat notes, because I have sloppy handwriting and handwriting slowly.” In addition, students could share notes, compare their notes, and share electronic copies with classmates who were absent when the notes were taken.
Searching information on the Internet—With information possibilities that are often more diverse, complete, and updated than that provided by textbooks, the Internet provides a vast information resource for students. Searching information on the Internet was, not surprisingly, most frequently used for learning purposes. Students searched online for different subjects and various tasks including finding additional information, learning or locating specific subject content, and working on course projects. For example, during the presidential election year, students tracked the state primary election, obtained information about the candidates, discovered news on who was running for which offices, and followed the results of the elections at different levels. A student commented, “They (laptops) contribute to my education by allowing me to surf the Internet and learn about the world and current events, not only the information we learn in dated books.” To them, the best thing about having a connected laptop was “you can go to so many places around the world without getting out of your desk and get all the information you want.” Having access to updated information whenever they needed it made them feel powerful because of “having all the information in the world at their fingertips.”

Learning subject content with specific programs—Students reported using their laptops to study topics being discussed in class. They visited teacher-suggested Websites and used on-line programs which allowed them to expand their knowledge, complete exercises, review content, work on projects, and engage in discussions and debates with their classmates. In science classes, students often visited specific Websites such as the NASA Website to collect materials, observe, analyze data, and then summarize what they had learned. When learning about moon cycles, students studied moon faces using an online calendar to figure out the cycles. When learning about continental drift, they visited a Website that explained theories and provided models, diagrams, or simulations on continental drift, providing them with concrete and interactive methods for understanding this concept. When learning Newton’s law, students used an online acceleration track where they could change the mass or the friction of virtual objects and run a program to figure out how inertia, gravity, and similar physical forces work. In these virtual experimental labs students could easily manipulate and control natural forces and processes. For instance, they could explore with an online virtual earthquake simulation to figure out why and how earthquakes happen.

Some programs can serve as the “virtual playground” (Bartels, 2000, p. 3) where students can construct, explore, and learn at their own pace. These types of Websites—along with online programs such as Geometer’s Sketchpad, Carnegie Algebra, and Aleks—were being used for math classes. The Carnegie algebra program provided the procedure and solution for a problem and required students to figure out the logic involved in finding that solution. The Geometer’s Sketchpad was an interactive software program that allows students to construct an object and
then explore its mathematical properties by dragging different parts of the
object by using the mouse.

**Online discussion**—It was reported that all 7th grade students regularly visited
their social science class Website on the online course management system
ASPIRE that their school was licensed to use, where they could ask questions,
voice their opinions, exchange ideas, and sometimes critique and to be critiqued.
Teachers posted question prompts for the discussion, but often, questions also
came from students. Similarly, in a math class, students received a certain
number of points by visiting their ASPIRE math class Website and posting
messages on the discussion boards. The students often posted the construction,
figures, and steps of their mathematical proofs, commented on other students’
proofs explaining how they could be more efficient, and responded to their
classmates’ comments. As the teacher commented, “they critique each other . . .
They often say ‘I looked at so-and-so’s proof and I think I can improve it’ or ‘Do
we have to say this? I think it’s redundant.’” In-depth interactions like this
provided students an opportunity to think critically about the topics and the
content. Peer review and critique also helped them to realize that their opinions
may not always be the best ones and that someone else might be able to improve on
them. The teacher believed that the online discussion was an important learning
experience for students because,

> It allows for a nice rapport. A lot of those kids are used to knowing everything
so they have a tough time developing the idea that not everything they think
is exactly right. So the online critique allowed them to get comfortable
throwing their idea out there and then accepting “the criticism.”

These experiences challenged students to think critically about their peers’
work and their own; and as the teacher pointed out, it hopefully would increase
student’s abilities to “accept criticism and be responsible for their thoughts.”

**Laptop Use for Communication**

With Internet access and at least one email account, students soon learned
how to use their laptops as communication tools between their teachers and
classmates. They visited their teachers’ Websites to locate information about
the course or to leave messages for the teacher. They emailed their teachers
questions about assignments or homework which they did not want to wait
until the next class to ask, or sent requests to schedule a meeting with the teacher.
The laptops provided students more opportunities to ask questions, especially
for those students who were too shy to ask questions in class or were uncom-
fortable talking to the teacher in person. All students mentioned that it was
easier and more convenient to ask questions or set appointments with teachers
through email. One student commented,
I talk to them (teachers) a lot more. If you have a question, even if you are at home, you can email them and ask them. You don’t have to wait until class to ask. By then you may have already forgot. I can get a response pretty quick.

Another student also said that it was easier to email teachers to ask questions because

We don’t have to go and find that specific person. If I am in a different class, I don’t have to walk to find that teacher. I can just email the teacher, “Can I come after lunch and redo this test or something like that.” They can email me back really quickly.

Students used their laptops to communicate with and connect to their friends via email, Instant Messengers, chat rooms, discussion boards, and blogs. In addition to written messages, their emails often included file attachments containing school work, a URL of a cool Website, a nice song that they wanted to share with their friends, pictures they took over a trip, and sometimes even short voice messages transferred via email. Instant messages included many “emoticons” to express their feelings and emotions more accurately and dramatically than words alone, and they used Flash animations to dramatize the conversation.

**Laptop Use for Expression**

Students also used their laptops as a tool to express their ideas and opinions through various activities such as creating Websites (for their personal interests or as part of course requirements), writing, and publishing. Creating a Website often involved hard work, extensive communication, planning, management, sophisticated technical skills, and persistence. The ability to work collaboratively was also required when the Website was a group project. The “State Project” was one such example of a student-designed Website created in a 7th-grade social studies class. To complete the “State Project,” students formed groups of four or five to work on one of the questions posed by the teacher. These questions focused on critical issues that the state was facing, such as pollution, unemployment, and education budget cuts. Students conducted research on the topic of their choice, collected data, suggested solutions for the problems, and created project Websites for each team. On each Website, they introduced the topic, explained how they worked on this project, presented statistical data and their analyses of the current situation, explained their results, and suggested solutions to solve the problem. Upon concluding the project, the Websites were organized according to the topics and listed in the teachers’ course homepage which was accessible to the public.

Laptops also served as a tool for writing, providing students the opportunity to use word processing programs for personal expression. Students used such programs to work on their homework papers, compose essays, and write stories and diaries. For many students, writing on computers was easier than using pencil
and paper because they found they could easily rewrite and edit their work, incorporate images into text, insert hyperlinks to make their work interactive, and improve the design of their final products.

With these technology resources, students were encouraged to express their ideas and present their works in creative ways. One teacher said:

I say present, but I don’t say how. So some kids may do PPT, some kids may do Webpage, some may do imovie . . . so I provide them with the options to be able to do it the way they think best match what they are trying to do.

Laptops Use for Exploration

The laptops, together with the Internet, have spawned a horde of new products on the students’ personal desktops and hard drives. Games, music, videos, streaming media, and other products have flourished as students discover, share, and explore an expanding universe of such media. This provides students a virtual playing field where they follow their interests, acquire, enjoy and share, and explore their potentials. Students in this study explored on their laptops during breaks, after school, in the evenings and over weekends. The most popular exploration activities were playing games and working with multimedia products.

Playing games has always been a popular computer activity among students, despite its being generally viewed as a “bad” use of computers. Adults worry about children becoming addicted to games and influenced by the violence in some games. A ban on games is common in the classrooms and computer labs of K-12 schools, as this was the case in the school in which this study took place. However, the students, ever resourceful, found ways around the barriers. They played games during recess, at home, or sometimes even in class. At the time this study was conducted, about 48.1% of students reported that they played computer games on a regular basis.

Research on the impact of playing video games on children shows very controversial results: some studies reported short-term harmful effects on children, while others reported considerable therapeutic and educational value in playing games (Gee, 2003; Prensky, 2006; Tapscott 1998). Do children learn violence from computer games? Tapscott (1998, p. 165) states that playing violent games has always been part of children’s play throughout history, from tussling, wrestling, playing with tin soldiers and fake guns, to playing cops and robbers. In our study, a teenage boy was asked whether or not he learned violence from the games he played. He said, “No, I actually learned how to avoid violence from playing games.” When asked to explain, he answered, “because I learned the consequences of violence.”

Exploring with multi-media programs and products was another popular activity students engaged in using their laptops. For example, in technology class, students learned how to make a mouse-trap cart, and then they made an iMoive to advertise it. In a Language Arts class, students made movie trailers for
books they read. They read the book, wrote the script, recruited crew members, and made short movies about the book. They also liked to manipulate pictures on their computers by cutting, copying, rotating, changing colors, and adding special effects. For 8th-grader Mary, Adobe Photoshop was an amazing program because she found that she “could do a lot of things on pictures with it.” Teens also love music. Using laptops and the Internet, they were able to research their favorite music and musicians, play back songs, burn CDs, and copy their music from their laptops to iPods or MP3 players. Students also composed their own music on their laptops using music composing programs. They used a program called the Garage Band to create, arrange, and record their own songs. This particular activity often required collaboration among classmates, and generally the team divided the work based on members’ talents. One student wrote the lyrics, for example, while another composed the music, and a third, if necessary, performed as the singer. On other occasions, team members collaborated as a group on every part of the creation process.

Impact of One-to-One Computing: Changes in the School

During this first year of this one-to-one laptop project, what changes have been observed in this school? Did the diverse laptop uses make any difference in this school? To find out the initial impact of one-to-one computing on students and learning, the changes in three major aspects were examined: student technology proficiency, student academic achievement measured by their GPA; and parental involvement.

Student Technology Proficiency

Student technology proficiency was measured using the technology proficiency scale. Students’ scores at the end of the academic year were compared to their scores at the beginning of the academic year. As shown in Table 3, there were significant gains in students’ technological proficiency (Time 1 mean = 7.42, Time 2 mean = 7.94, \( t = 2.26, p < .05 \)).

This finding was not surprising, given that having one-to-one laptops greatly increased students’ opportunities to work on technology and solve technology-related problems, thereby learning new technology skills and acquiring knowledge about the use of technology. At the beginning of the academic year, most students had low technology competency, and many students had never used email. Although taking notes on laptops was the most common use immediately after students received their laptops, many students did not know the basic concepts and skills of working on word processing programs. For some students, it was not easy to remember how to or even why they should save their working documents in certain folders or know where to retrieve the files when needed. Many students did not know how to back-up files, so when their laptops
malfunctioned or appeared to malfunction, there was a predictable and dramatic panic reaction.

As they worked more on their laptops, students gradually learned basic skills and became increasingly technology proficient. They learned from exploring on their laptops, but also from their teachers and friends. A student said during his interview:

Sometimes we learn from our teachers, sometimes from friends. We tell each other what we’ve learned and found out. That’s how we learn.

When talking about how she learned the Photoshop program, Alison, an 8th grader, said:

It’s really kind of like “monkey see, monkey do.” My good friend was working on her picture on Photoshop, and I said “wow, can you show me how you do that?”

Her friend did, and she soon became a Photoshop expert. In similar ways, students not only learned basic technology skills such as word processing or PowerPoint, but also learned more advanced skills such as Website design, programming, and iMovie production.

**Student Academic Outcome (GPA)**

To examine the changes in student academic achievement, we compared students’ cumulative GPA at the end of the previous academic year (Time 1) against their GPA at the end of the academic year during which the one-to-one laptop program was implemented (Time 2). Table 4 below shows the results of Paired Sample Test on student GPAs.

Table 4 shows that student GPA increased over the academic year (GPA Time 1 = 3.27; GPA Time 2 = 3.32), and this increase was marginally significant ($t = 1.97, p = 0.051$). However, we must be cautious in drawing any conclusions on the impact of the laptop use on the change in student academic achievement, because student performance, especially academic outcomes measured by GPA, is

<table>
<thead>
<tr>
<th>Technology proficiency</th>
<th>Paired differences</th>
<th>Std. deviation</th>
<th>Std. error mean</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time 2–Time 1</td>
<td>.514</td>
<td>3.07</td>
<td>.231</td>
<td>2.23</td>
<td>176</td>
<td>.027</td>
</tr>
</tbody>
</table>
influenced by many factors. Technology usage is just one of these factors. The impact of technology use on student outcomes is not determined merely by the particular technology uses, but it is mediated by environmental factors, the users, the technology, pedagogical practices, and the constantly changing interactions and mutual influences. Therefore, it may be unrealistic to expect dramatic changes in student performance through one or two specific technology uses. In addition, student GPA was measured by traditional methods of assessment, which might not be an accurate assessment of student learning with and about technology. As a teacher pointed out, student learning with technology was difficult to measure because much of this kind of learning was hidden. Students had the opportunity and resources to extend and explore much more than what they did in traditional classrooms, so “I don’t think we have a way to evaluate it yet.”

**Parental Involvement**

Parent involvement significantly increased over the academic year. At the beginning of the academic year, in general, parents spent little time with their children working on their homework or on computers. About half of the parents (46.3%) spent no time working with their children on their homework and 78% of them never worked with their children on computers. At the end of the school year, parents spent significantly more time working with their children on their homework and on their computers. The percentage of parents who never spent any time working with their children on their homework or computers decreased to 31.6% and 54.2% respectively.

Paired sample *t*-tests were conducted to compare parental involvement at the beginning of the academic year and at the end of the year. Table 5 shows that parental involvement increased significantly on both items.

One direct benefit of these changes was timely and convenient communication between teachers, students, and parents, thus leading to more equal learning opportunities. During an interview, a teacher said:

Parents cannot say that they are not aware of what’s going on in the school or what’s going on with their child. Students can’t say they don’t know
what’s going on in their classes even if they are on a field trip. Everybody is on an equal ground in terms of information available. The laptops have set everybody on the same page in terms of the goals and objectives of the school.

**Perception on One-to-One Computing**

When asked about their opinions about this laptop project at the end of the first year, teachers, students, and parents expressed their attitudes, beliefs, and concerns. The overall evaluation on the laptop project was positive. For example, 87.5% of students reported that the laptops were important to them. Also 89% of the students believed that the laptops had significantly helped them with their homework and 83.6% of them reported that the laptops had significantly helped them increase their computer knowledge and skills.

Most parents were happy with their children’s participation in this laptop project. For example, 77.3% of the parents were glad that their children had been involved in the project. Further, 72.7% of the parents believed that the laptop was important to their children’s education. Interestingly, but not surprisingly, 81.8% of the parents thought that the laptops had greatly helped their children with their computer knowledge and skills. Three-quarters (75%) of the parents hoped that their children would also have laptops in high school. Parents’ satisfaction with the laptop project was correlated to their ability to handle laptop-related problems ($r = .47$, $p < .01$). The more capable they felt they were at handling problems such as children spending too much time on computers or communicating too much with friends, the more positively they commented on the laptop project, and vice versa.

Comparatively speaking, teachers were the most optimistic group regarding this one-to-one computing project. All teachers (100%) believed that the laptops were very important to both their students and themselves and had greatly helped them in communicating with parents. Most (96.4%) of the teachers thought that the laptops had helped them with communicating with their students.

<table>
<thead>
<tr>
<th>Parental involvement</th>
<th>Mean</th>
<th>SD</th>
<th>SE</th>
<th>Mean</th>
<th>Lower</th>
<th>Upper</th>
<th>t</th>
<th>df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1 Homework</td>
<td>.23</td>
<td>1.01</td>
<td>.09</td>
<td>.06</td>
<td>.41</td>
<td>2.65</td>
<td>129</td>
<td>.009</td>
<td></td>
</tr>
<tr>
<td>Pair 2 Computers</td>
<td>.42</td>
<td>1.13</td>
<td>.09</td>
<td>.24</td>
<td>.58</td>
<td>4.83</td>
<td>129</td>
<td>.000</td>
<td></td>
</tr>
</tbody>
</table>
Concerns Related to Technology Use

However, as an innovation in its experimental stage, the laptop project has inevitably caused some concerns. More than one-third (38.7%) of parents thought that their children spent too much time on the laptops. The more parents thought their children had spent too much time on the laptops, the less positive they were about the laptop project. In addition, 39.3% of the teachers believed that it had become harder for their students to concentrate in class after receiving the laptops, because the students were distracted by the Internet, email, games, music, and so on.

Students, however, were more optimistic about their ability to deal with laptop-related problems. For instance, most of the students (83.9%) did not agree that laptops posed distractions to them in class. Data from interviews also showed that students were able to recognize the potential distractions that laptops could pose, and they were learning to deal with these problems. The issue of students not concentrating in class varied greatly from class to class and from teacher to teacher. Some teachers had effective strategies for monitoring students and were able to keep students engaged in their tasks, while a few teachers were deeply concerned with this problem.

Another concern involved knowing how to teach students to become more efficient at locating information and more evaluative of online resources. Teachers expressed concerns about enabling students to critically select information found on the Internet. Some teachers worried that students might just copy and paste content from the Internet and take everything online as factual without careful scrutiny. Some teachers started to develop ways to address this issue. For instance, through the Media Literacy Grant program, one literacy teacher was teaching students to be more conscious consumers of media and learn how to view information critically with careful examination.

Additional concerns were related to attitudes and beliefs. Some people were more comfortable with traditional ways of teaching and learning and did not feel secure with computers. For example, some parents preferred their children to learn from books to computers and suggested more money to be spent on books, not on computers. Similarly, some teachers worried that students may not be able to retain the ability to read and write with paper and pencil. They hoped students would still value traditional ways of learning through books, paper, and pencil in addition to the laptops. Feelings were mixed because, on the one hand, they acknowledged that students were going to be living in a digital era where paper and pencil might not be as important as in the past; but they still wished students would have good penmanship and appreciate the value of books.

Limitations

This study has some practical limitations. First, this school has rich technology resources that are not available in many schools; thus, it was not a typical school that can represent most of the schools in the United States. This weakness may
limit the generalizability of the findings. However, as more and more schools are considering one-to-one computing initiatives (Lei, Conway, & Zhao, 2007), this study provides a glimpse of where most schools will be in the near future. Second, some quantitative analyses were based on student self-reported data (such as time spent on laptops and types of activities). The validity of the self-reported data could not be checked. Third, data in this study were collected through one academic year, which might be too short a period of time for significant changes to happen. Longitudinal empirical research is needed to identify the long-term impact of such programs. Nevertheless, this study was able to reveal that students gained a wide array of media literacy skills when they participated in such a program.

CONCLUSIONS

This study examined the specific use of laptops by students and the changes that have occurred during the first year of having a one-to-one laptop project. Findings from this study provided preliminary answers to three questions:

1. How do students use technology when they have their own laptops?
2. What changes in student outcomes and the school system occur?
3. What are the perceptions and concerns over one-to-one computing?

In this study, we found that student laptop uses were very imaginative, creative, and diverse. Students used the digital tools to solve many daily problems, including doing homework, searching for information on school work, communicating with friends, developing personal interests, exploration, and having fun. For them, playing is a natural component of their lives and development. They often learn from playing and play in learning. The one-to-one laptops and other related technologies supported learning activities that are not possible or very difficult to organize in an environment without one-to-one computing.

Results from this study suggest that having one-to-one computers can significantly help increase student technology proficiency because of the increased opportunities of learning technology knowledge and skills while using the laptops to work on various tasks for learning, communication, expression, and exploration. Second, interviews with teachers and students suggested that one-to-one computers and related technologies have enriched students’ learning experiences, expanded their horizons, and opened more opportunities and possibilities. Although student GPA increased over the academic year in this study, no attempt was made to draw any conclusions on the relationship between student GPA and laptop use. There is a need to explore and develop evaluation methods and instruments which evaluate student learning with technology. Student technology use and learning is experience-related and at times hidden or subtle; consequently, it may not be assessed through traditional outcome evaluation. Some alternative assessment methods such as performance assessment, essays, and portfolios
might be more effective in assessing student learning with and about technology. Third, teachers and students believed that the laptops were very important and that the one-to-one laptop project greatly helped teaching and learning in spite of some challenges. The one-to-one laptops have provided great opportunities and resources for teaching and learning, but also raised issues such as student discipline problems, concerns on digital literacy, and fear of dependency on information technology. The concerns raised by teachers and parents reflected the perceived uncertainty and complexity of the impact of one-to-one computing, especially at the early stage of the implementation. School administrators need to address these issues and concerns, and provide opportunities to bring teachers, parents, and students together to discuss these issues, exchange their experiences and ideas, and resolve these issues through open communication.

REFERENCES


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