A Study of the 1:1 Laptop Program

at the Denver School of Science & Technology

by

Andrew A. Zucker, Ed.D.
Sarah T. Hug, Ph.D.

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Denver School of Science and Technology
2000 Valentia Street
Denver, CO 80238
http://scienceandtech.org
(303) 320-5570

Executive Summary

In the spring of 2007 the Denver School of Science and Technology commissioned a study of its 1:1 laptop program. Results of that study, which was conducted by Drs. Andrew Zucker and Sarah Hug during the summer and fall of 2007, are presented in this report.

The Denver School of Science and Technology

The Denver School of Science and Technology (DSST) is a public charter high school located in northeast Denver. The school first served ninth grade students in 2004-2005. Each year the school added another set of students until in fall 2007 the school admitted its fourth class of ninth graders and began to serve all four grades, 9-12, for the first time.

The school is racially and economically diverse. About 40% of the students are from low-income families, 35% of the students are White, 29% are African-American students, 25% are Hispanic, 7% Multi-racial, 2% Asian, and 1% are classified as other. Students come from about 50 middle schools in the Denver area, predominantly public schools but also including parochial and private schools. Applicants are accepted on the basis of a lottery. The school's charter says that at least 40% of students will qualify for free or reduced-price lunch (i.e., are from low-income families).

The school's mission is to provide a diverse student body with an outstanding liberal arts high school education that includes a science and technology focus. The school intends to prepare 100% of the students to earn a college degree and aims to create a community of learners and a school culture that fosters both academic and personal success for its students.

The school's test scores have been among the highest in Denver and the entire state. The first set of students graduate in June 2008. All are expected to be admitted to a four-year college. By the end of November, almost 90% already had been admitted to a four-year college.

DSST's 1:1 Laptop Program

DSST opened its doors with a ubiquitous computing environment. Hewlett Packard (HP) provided a grant of computers and related equipment worth about $1 million that allowed DSST to become the first public high school in Colorado in which every student is provided with a wireless, networked personal computer. Students in grades 9 and 10 (the Prep Academy) each receive a laptop, while students in grades 11 and 12 (the Senior Academy) each receive a tablet computer. Nearly every teacher has a tablet computer. The school has a total of about 500 laptop and tablet computers.

DSST's vision for using educational technology notes that

> "Technology should empower and enable, and never replace or reduce the central human role of the teacher in a liberal arts education. The role of a liberal arts education is to enable and facilitate the creation of leaders who value community, individuals and the creation of a truly human society. Technology must serve this end."

By design, much of the demand for computer applications has been generated by teachers making decisions about the software, websites, or other technology applications that serve their own and their students' needs. Although some uses of computers are mandated, for the most part it is department chairs, teachers, and students who decide how, when, and where to use the laptops.

The 1:1 laptop program incorporates many elements besides computers. These include software installed on each laptop; training for ninth graders and professional development for teachers; an active email system; Infinite Campus, web-based software used by Denver Public Schools to record and report students' grades and attendance; technical support provided on-site; and, a wide variety of related technologies, including computer "probes" for science labs (which can download data to the laptops about motion, temperature, pH, or other phenomena), and more than a dozen computer servers supporting wireless Internet networks, email, voicemail, VOIP, and other applications.

The Benchmark Assessment Program

The school's Benchmark Assessment Program was selected as a special focal point for this study because the school's leaders decided that systematic collection and use of data about student achievement would be part of the foundation on which DSST would be built.

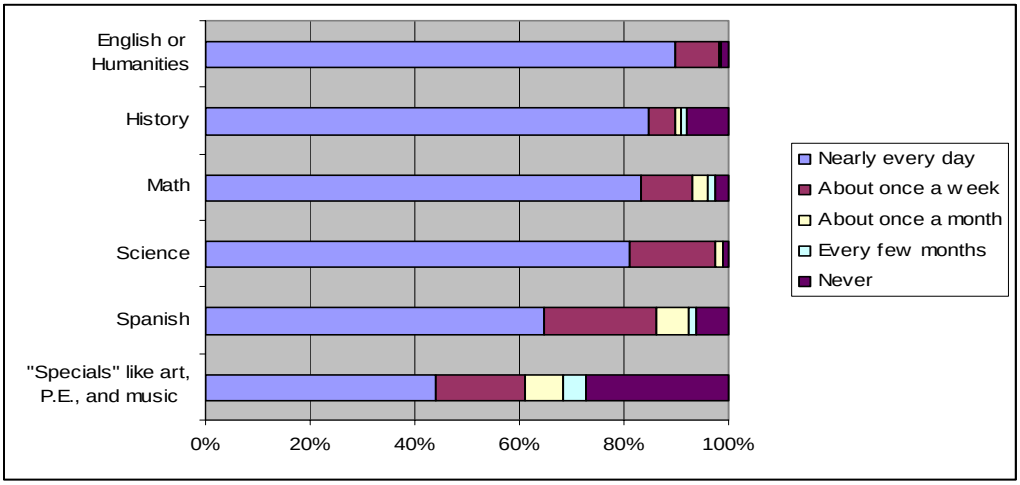
The school developed a single set of college readiness standards in each subject, based on those developed by the ACT program. Instruction at DSST is guided by these standards and the school has developed methods of measuring individual progress toward mastering the standards. For example, the school uses ExamView software once every trimester to administer Interim Assessments, which include multiple-choice questions aligned by DSST to the ACT standards. Immediately following these Assessments, data analysis sessions are convened at which teachers identify student weaknesses and design lessons to address them. So-called reteach weeks are then scheduled to provide instruction and support on targeted standards.

Overview of the Use of 1:1 Laptops by Students and Teachers

DSST teachers and students use laptops daily while at school, for many purposes. This is in marked contrast to students' use of technology in the schools they attended before DSST, when the majority report that they either never used technology in regular classrooms (35%) or used computers in classrooms only once a month or less (38%).

The use of computers varies by subject, with the greatest use reported in English and humanities, history, mathematics, and science. Exhibit S-1 shows students' reports of computer use.

Exhibit S-1: Students' Reports of Frequency Using Computers in Class



The way the computers are used is often subject-specific. Asking students to complete practice drills is more common in mathematics than in other subjects: one-third of the math teachers report asking students to do drills daily, compared to 4% of other teachers. Similarly, half of the history teachers report asking students to conduct research on the Internet daily, compared to 4% of other teachers. And 100% of the English teachers report asking students to use the computers for writing at least a few times per week, compared to about half the others.

Almost all teachers use their computer projector at least a few times a week and nearly 60% use one daily. Almost all teachers use the central file server accessible to all teachers and students and/or email, both to provide and to collect students' assignments and related materials, with more than half the teachers reporting that students access server files daily.

Besides departmental variations, some uses depend on teachers' preferences and the availability of instructional materials. Many of the math, science, and technology teachers, for example, report frequent use of electronic textbooks instead of paper textbooks, while other teachers do not. About a third of the teachers make extensive use of Moodle (an Internet-based software application that allows teachers to organize and interact with digital resources by class).

Teachers in the Senior Academy (eleventh and twelfth grades) report more intensive use of laptops. Whereas 38% of Prep Academy (ninth and tenth grades) teachers report that students are asked to use laptops daily in class or for homework, that figure is 58% for Senior Academy teachers.

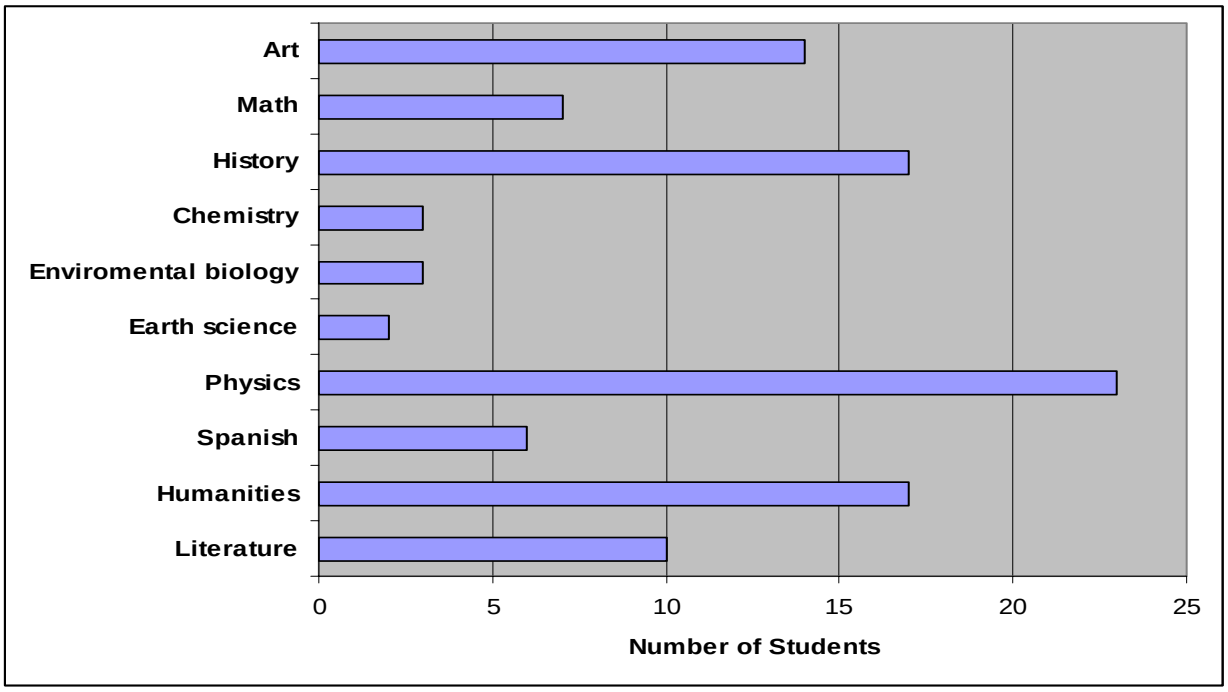
Common applications of laptops also include teachers making whole-class presentations (by projecting their laptop screen for the class to see), word processing (including students' notes, essays, and reports), and student presentations. Graphing calculators and probes are used extensively in mathematics and science classrooms.

Students were asked to identify the technology project or assignment at DSST of which they were most proud. An analysis of more than 100 responses identifying a particular school subject shows that laptops are used in productive ways in *all* disciplines (see Exhibit S-2 below). Similarly, an analysis of responses to the question "what has been the most helpful use of technology by teachers" displays a great range. The two most common types of response by students were: teachers making it easy to access assignments electronically and teachers' classroom presentations.

The great majority of students say that the laptops have a very (65%) or somewhat (29%) positive impact on how much they learn in school. The students also report that the laptops positively influence how well they work with other students, how interested they are in school, their grades, and other things. DSST teachers are also enthusiastic. Nearly all teachers agreed that the laptop program is very (67%) or somewhat (30%) important for students; only 3% disagreed. A large majority of teachers report an increase (57%) or a slight increase (30%) in the depth of students' understanding of the curriculum as a result of the use of laptops and related technology.

Data show that there was a "digital divide" for students before they began attending DSST. Among those who identify themselves as Hispanic, fully 50% report that they rarely or never used computers before they attended DSST. The corresponding figure for African American students is 40%. Only 25% of the Caucasian students report that they rarely or never used computers before coming to DSST, however. These figures may not be surprising but they support the importance of a laptop program in a public, ethnically diverse school serving large numbers of underrepresented students as a way to overcome the digital divide.

Exhibit S-2: Uses of Technology by Students of which they are Most Proud (Subjects)



Students and teachers report that the school provides the supports needed to use laptops effectively. Among the ninth grade students, for example, 46% indicate that the introduction to using computers given to all incoming students was "very helpful" and another 45% found it "somewhat helpful." The great majority of teachers (87%) report that lack of reliability of the network or of computers is *not* a barrier, or only a small barrier, to using technology in classrooms.

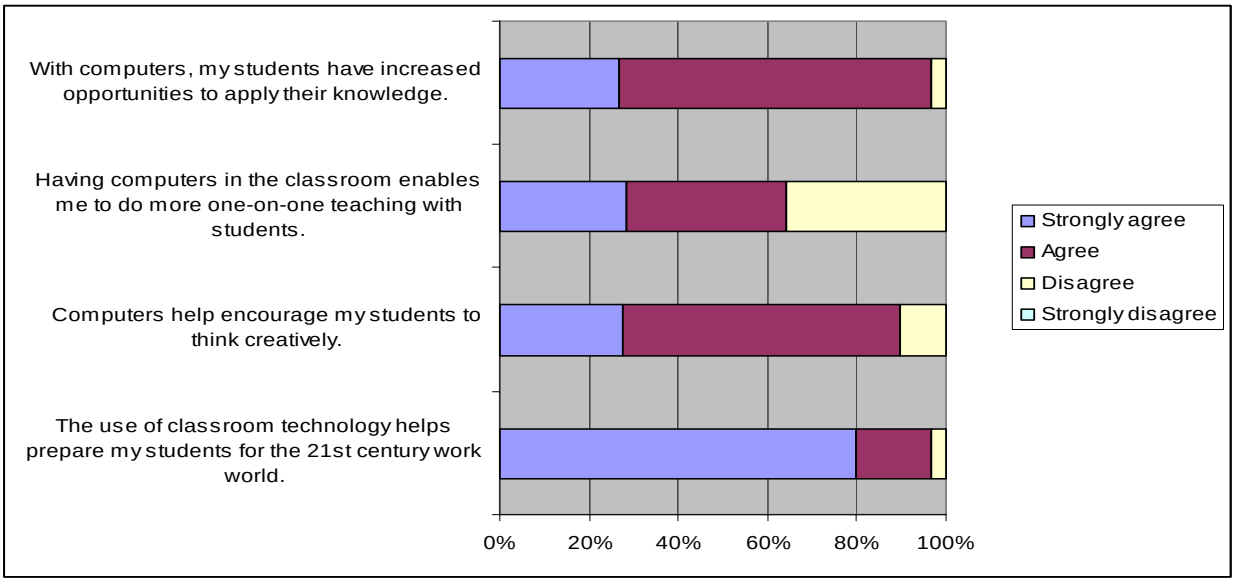
Nonetheless, the use of laptops presents challenges, including managing off-task activities by students. While 75% of Prep Academy teachers report that they ask a student to stop their off-task activities with laptops at least once every class period, by the time students are in the Senior Academy only 36% of the teachers report the same frequency. Laptops also need repair from time to time and students may forget to bring their computer to school. As a result, some students (perhaps 5%) do not have a working laptop any given day. However, the great majority of teachers (79%) report that this is a minor problem or hardly a problem at all. A minority (21%) report that this is a more serious problem. The school reports that this is less of an issue after the first trimester (when this study was done).

Another challenge of using laptops for class assignments is that a significant minority of students (26%) do not have Internet access at home. Nearly two-thirds of the teachers believe that students without home access to the Internet are at a serious disadvantage.

The 1:1 laptop program has changed teachers' instructional practices. Among DSST teachers, more than 90% agree or strongly agree that "I have changed the way I organize classroom activities." Nearly two-thirds report that they rely less on textbooks because of the laptops and over 85% agree or strongly agree that they are better able to meet the needs of students with varying needs (such as struggling students and gifted students). Sixty percent agree or strongly agree that with the laptops they are able to spend more time teaching students individually, one-on-one.

Teachers report a number of other positive impacts of the laptops, including "computers help encourage my students to think creatively" and "with computers, my students have increased opportunities to apply their knowledge." (See Exhibit S-3.)

Exhibit S-3: Teachers' Reports of the Impacts of 1:1 Laptop Computers



Neither teachers nor students would want to give up the laptops. Two-thirds of DSST teachers report that technology is now "essential" or "extremely essential" to their teaching practice. Similarly, the almost unanimous opinion of the teachers (89%) is that the laptop program is important for DSST students. Teachers also report that because of the laptops they are more reflective about basic teaching goals and priorities (80% agree or strongly agree) and they more often ask students to work independently (77%).

Focus on the Physics Courses

This study focused special attention on physics courses. DSST students take physics in their freshman year. About two-thirds of the seniors also take either honors or Advanced Placement (AP) physics (the latter requiring enrollment in calculus). Twelfth graders also take an Advanced Engineering course, which provides physics students with opportunities to apply their knowledge.

More than 120 students enrolled in physics answered survey questions about the use of laptops, probes, and other technology in their physics classes. They report extensive and varied use of technology. Students use their laptops at least once a week to collect data (86%) and analyze data (92%). According to the majority of physics students, teachers use ExamView for student assessment at least once per week (82%), which is supported by physics teacher interview data.

Even the ninth grade students, who were surveyed after only a few months at DSST, report that they use the laptops in physics class virtually every day. For example, physics students use probes and associated software to collect, analyze, and present real time data collected during laboratory work. In addition, each week physics students manipulate computer simulations (such as the behavior of waves) that encourage discovery of physics concepts through experimentation and visualization (see http://phet.colorado.edu/new/index.php).

Thirteen ninth graders report that technology projects they performed in physics were the laptop-related projects of which they were most proud. Eleven of the 13 mentioned physics lab reports in particular, for which they utilized a template to create a report and import relevant graphs and visuals. Similarly, eight physics students describe their physics laboratory experiments as the technology projects that gave them the most pride.

The majority of physics students report using their laptops to communicate about science on a weekly basis (73%) and over half (55%) report using simulations at least weekly. Seventy four percent of students report using a word processor at least weekly, while a slightly smaller percentage said they use Internet search engines for science at least once a week (69%).

The trajectory physics students take from novice physics students to more advanced science reflects deliberate planning. For example, one physics teacher said that "students have to learn how to do (lab work) 'old school,' then they start to use the technology more and more." Each technology tool incorporated into ninth grade physics was reintroduced in twelfth grade, though teachers report that twelfth graders used the physics software, hardware, and probeware more efficiently and more independently.

In twelfth grade, students have more responsibility for using the technology to answer specific, authentic, scientific questions. They put probes and their lab skills to use while also gaining engineering design skills, as demonstrated in an AP physics student's survey. "[The technology project I am most proud of is] my catapult design for AP physics which I made with Solidworks [software] so that it was correctly dimensioned and with moving parts, to use as a blueprint for the actual build which is currently in progress." (See the sample Solidworks view of the Trebuchet project at right, in which students design and build a working catapult.)

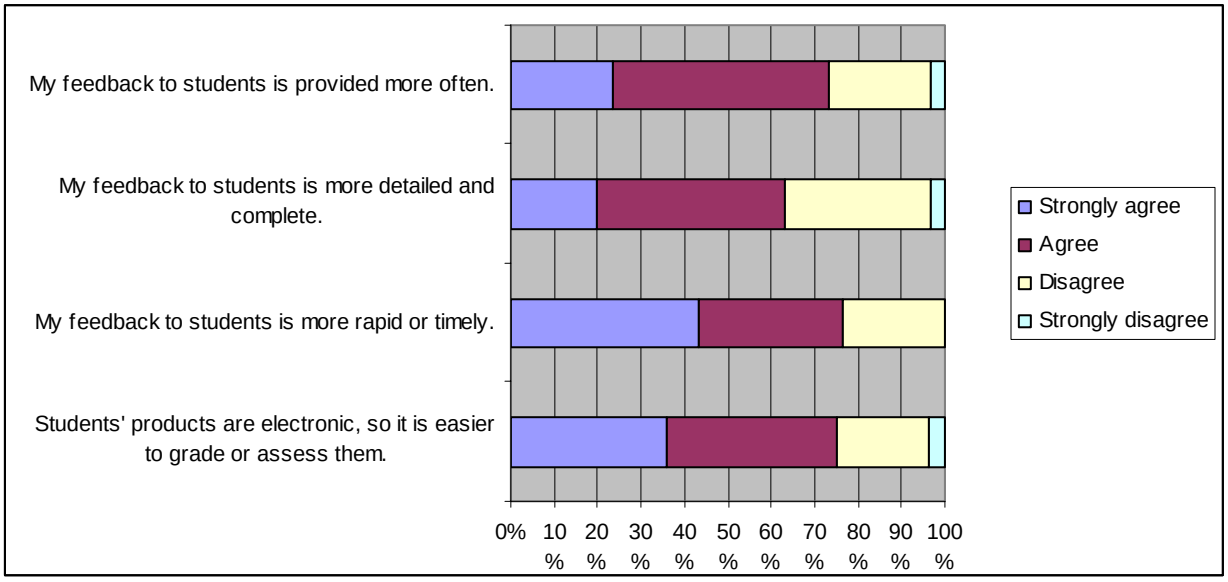
Physics simulations developed by the University of Colorado at Boulder provide graphical information showing the connection between acceleration and velocity. Simulations allow students to rapidly manipulate variables and observe resulting changes obeying the laws of physics. Ninth grade physics students manipulated one of these simulations to make a moving man change position, speed up, and slow down. The theory was that students' experience with the simulations would allow them to later interpret more abstract graphs, disconnected from the dynamic online simulations. Many students see the value in this approach, as illustrated by a twelfth grader's comment:

> "I believe that the most helpful use of technology has been the use of technology to give us interactive lessons or lectures about specific topics. It makes it so much easier to understand a concept if you can see it happen in an animation." Survey response, twelfth grade student.

Focus on the Benchmark Assessment Program

Both teachers and students report significant advantages resulting from the fact that most students' work products are electronic. Large majorities of teachers note the positive impacts on ease of grading, rapidity of feedback, and other aspects of assessment. (See Exhibit S-4.)

Exhibit S-4: Teachers' Opinions about Using Computers for Student Assessment



Asked what has been the one most helpful use of technology by DSST teachers, fifteen students responded testing, the use of ExamView, or something similar. One student wrote, for example, "tests being graded almost immediately," while another reported, "the test taking has been much better." Large numbers of students report that the reteach weeks are either very (44%) or somewhat (35%) helpful to them. Teachers agree, with 41% reporting that the reteach weeks are very important for DSST students and another 48% reporting that they are somewhat important.

Computers are used for assessing students at other times, too, not only in preparation for reteach weeks. Among students, 70% report using ExamView about once a week and another 21% report using ExamView nearly every day. This leaves only 9% of students who report using ExamView less than weekly.

According to an English teacher, the types of reports about the performance of students and classes that are easily available through ExamView are valuable to her and her students. She said,

> "I'm not a numbers person, so I would never run that kind of report [without the software]. It helps tremendously to be able to give students feedback tied to college readiness standards."

Reflections and Conclusions

The picture of the 1:1 laptop program that emerges from the data is a positive one. Laptops are used daily by students as learning tools. As a group, DSST teachers have adopted a large and growing number of instructional, assessment, and administrative practices that take advantage of the unique characteristics of computers and digital media.

The school provides a range of critical support services to its teachers and students, from administrative support and vision statements about how to use technology, to technical support, training, and professional development. This ongoing support promotes teachers' and students' thoughtful use of laptops, the Internet, and other digital technologies in support of DSST's mission.

As a result of the effort that has and continues to go into implementing the 1:1 laptop program, there is widespread support for the laptops by DSST teachers and students. Majorities of teachers report that the computers are very important as a tool for teaching, assessment, communication, and for administrative work. In fact, teachers report that computers are essential.

The multiple data sources—classroom observations, interviews, focus groups, and surveys of teachers and students—paint a consistent picture. The fact that multiple sources of evidence support one another increases confidence. Evidence strongly suggests that the laptop program is contributing in important ways to the DSST community's efforts to reach ambitious goals.

One of the most important study findings is that the school has worked hard to put in place the supports necessary to develop and sustain a successful 1:1 program. The school has a compelling vision of how laptops can contribute to students' and teachers' work. Teachers are encouraged to be innovators and partners in the 1:1 program. The technical support staff shares the school's vision (while in some schools they are more concerned about network security or other issues than about teaching and learning). The school invests in professional development, software licenses, servers, probeware, computer projectors, and other ancillary equipment needed to maximize the utility of the laptops. The laptops themselves, in other words, are part of a complex, interconnected web of devices, networks, activities, and goals whose purpose is to support the school community's efforts to carry out its ambitious mission. Laptops do not stand alone.

This study reinforces the belief that schools setting ambitious goals and aiming for excellence seem more likely to use laptops well than ones without ambitious goals and a supportive school culture. Schools that aim to emulate DSST's success, and the successes of other laptop schools, may learn that a 1:1 laptop program *can* be a powerful tool for helping to reach ambitious goals. But the laptops are not magic boxes. It is the support system, the school goals, the digital resources that teachers and students use, and other factors that enable the laptops to be used as powerful tools. Laptops serve DSST's core mission. Interestingly, the school's mission statement does not itself mention laptops. The devices are primarily means, not ends—even though bridging the digital divide by providing access to computers and information resources is itself an important goal.

DSST's laptop program contributes in important ways to the school community's efforts to reach its goals. The school's 1:1 laptop program, which has been operating for less than four years, is off to an excellent start.

Study Methods

As noted, data for this study come from interviews, focus groups, classroom observations, document reviews, and surveys of teachers and students. The response rate for the teacher surveys was over 90% (of 32 teachers) and for the student surveys it was 77% (of 428 students). These response rates provide confidence that the survey data fairly represent the full range of experiences and views of teachers and students.

Contents

Introduction

In the spring of 2007 the Denver School of Science and Technology (DSST) requested funding from the Colorado Children's Campaign for a study of the school's one-to-one (1:1) laptop program. Because 1:1 programs exist in only a small fraction of all schools, DSST's funding proposal states, "there is still much to be learned about them." As a demonstration school, DSST believed that it would be useful to their program as well as to other charter and regular public schools to carefully document the school's activities, including this study of its 1:1 program.

Research Questions

This 1:1 laptop study focuses primarily on six research questions:

1. What are the parameters of the 1:1 program?
2. In what ways has DSST incorporated computers and other digital tools (e.g., computer projectors, or "probeware" for teaching science) into its academic program?
3. When, where, in which subjects, and for what purposes do teachers and students use their laptops and other digital tools?
4. What are teachers', students', and administrators' opinions about the 1:1 program?
5. With respect to 1:1 computing, what are the experiences and opinions of teachers and students in two specific domains (case studies): physics, and the Benchmark Assessment Program?
6. What lessons can be learned about the DSST 1:1 laptop program?

The study was designed to answer the above research questions, which were the highest priority for the school. This was *not* designed to be an experimental study in which causal claims about student achievement can be made.[1] Students and families choose to attend DSST and the variables that lead to that choice (e.g., knowledge of the school by the applicant, a successful application, reliable transportation, willingness of the student to work hard, etc.) are not easily controlled, nor are such factors as the superb qualifications of the school's faculty and staff. The data collected, analyzed and assembled in this report are valid, however, and represent a useful and detailed picture of this particular learning community. The school's experiences using technology may be useful to other schools, even those with different characteristics than DSST.

Study Methods

During the period from August to November of 2007, data to answer the research questions were collected using quantitative and qualitative methods. Researchers administered teacher and student surveys; conducted student, teacher, and administrator interviews and focus groups; visited classes; and analyzed documents provided by the Denver School of Science and Technology. The research design was determined collaboratively. Key DSST stakeholders, including the President of the school's Board of Directors, Mr. Norwood Robb, and the school's Director of Technology, Mr. Mark Inglis, and others at DSST helped the researchers identify key focal points for the study.

[1] For example, the U.S. Department of Education has funded several rigorous experimental studies of the use of particular technology applications in schools costing millions of dollars per study, and requiring years to complete.

The study was informed by and draws upon prior studies of 1:1 computing (see, for example, research cited at http://ubiqcomputing.org and at http://www.k12one2one.org/.) Some of the survey items, for example, are identical to those used in earlier research, allowing comparisons to be drawn between the results of this study and others.

The study consists of three main parts:

- an overview of the use of laptops and related technology across all grades and subjects;
- a more detailed examination of how teachers and students use computers and related technology in the school's physics courses (at both the ninth and twelfth grade levels); and,
- an investigation of the school's Benchmark Assessment Program, which relies heavily on the laptop computers.

The latter components of the study provide a detailed view of the school's use of technology in two areas that were selected because intensive use of the laptops seemed to be both characteristic of and significant to the way the school works in each of these areas. Data allow us to discover to what extent and how students and teachers actually use technology in these two areas.

Apart from DSST's own experience, there were other reasons to select physics and student assessment as potentially rich areas to study. The digital resources available for teaching physics are exceptionally rich, including a commercially produced digital textbook that incorporates simulations and other interactive learning experiences (which is used at DSST), and a free website designed by a Nobel Prize winner that incorporates other rich simulations designed for teaching and learning physics. Similarly, the use of computers for student assessment is becoming a focal point for many schools, school districts, state agencies, and test companies. States such as Oregon and Virginia have given millions of tests to students using computers. The process can save time and money and allow data about students' performance to be analyzed quickly and comprehensively.

The study director was Dr. Andrew Zucker. Earlier, Dr. Zucker was Principal Investigator on a four-year federally funded project to share information and foster collaboration among about a dozen universities and other institutions studying 1:1 laptop programs in the United States.

Survey Response Rates

Teacher and student surveys were administered in November 2007. Copies of the teacher and student surveys are included in an appendix, including aggregate responses to each item. Both surveys were conducted online using the SurveyMonkey system (www.surveymonkey.com), with respondents accessing the survey through a Web browser during times allocated by the school's leaders. Teachers needed about 30 minutes to complete their survey. The response rate from the 32 teachers at DSST was above 90%. The student survey required only about 15 minutes. The response rate from the 428 DSST students was 73% for students who completed the entire survey (311) and rises to 77% (328) if the 17 students who partially completed the survey are included. Both the teacher and student response rates are high enough to provide confidence that the data fairly represent the full range of teachers' and students' experiences and opinions.[2]

[2] There are a variety of reasons why some students did not complete the survey, none of which appear likely to bias the results. Reasons included absences from school, confusion on the part of a few teachers about the survey procedures, a number of students whose laptops were not working the day of the survey, and other technical difficulties.

Structure of the Report

The next section of this report provides an introduction to the Denver School of Science and Technology. It describes the school's origin, vision, and guiding principles. Information is also provided about the school's 1:1 laptop program and its unusual Benchmark Assessment Program.

The sections that report the study's findings begin with the overview providing information about technology use by teachers and students throughout the school. Findings are then presented about using the laptop computers in physics and as part of the Benchmark Assessment Program.

The last section of the report offers reflections to DSST. Finally, the appendices include copies of the student and teacher surveys, and aggregate responses to them.

The Denver School of Science and Technology

DSST is a public charter high school located on a 10-acre site in the redeveloped Stapleton neighborhood in northeast Denver, where Stapleton airport used to be. The school first served students on August 31, 2004, beginning with 131 ninth-graders at a temporary location. Each year the school added another set of students until in fall 2007 the school admitted its fourth class of ninth graders and began to serve all four grades, 9-12, for the first time. DSST moved into its newly constructed, award-winning facility in January of 2005.

The school is racially and economically diverse. About 40% of the students are from low-income families, 35% of the students are White, 29% are African-American students, 25% are Hispanic, 7% Multi-racial, 2% Asian, and 1% are classified as other. Students come from about 50 middle schools in the Denver area, predominantly public schools but also including parochial and private schools. Applicants are accepted on the basis of a lottery. The school's charter says that at least 40% of students will qualify for free or reduced-price lunch (i.e., are from low-income families).

The school began as a cooperative initiative in 2001 with the support of Governor Bill Owens and the Colorado Small Schools Initiative. Early funding was provided by the Bill and Melinda Gates Foundation. The Denver Public School Board approved the charter of the Denver School of Science and Technology in September of 2002. With additional funding from the Gates Foundation, in 2007 planning began to expand DSST to include a middle school (grades 6-8). Sixth graders will first be enrolled for the 2008-2009 school year.

The mission of the Denver School of Science and Technology is to provide a diverse student body with an outstanding liberal arts high school education that includes a science and technology focus. The school aims to create a learning community centered on core values and a shared commitment to academic excellence, and thereby to increase the number of underrepresented students (women, minorities, and economically disadvantaged youth) who attain college science and liberal arts degrees. According to the school's mission statement, DSST graduates will be responsible, engaged citizens who are prepared to be leaders of the future. The school wants to prepare 100% of the students to earn a college degree.

DSST aims to create a community of learners and a school culture that fosters both academic and personal success for its students by emphasizing a set of six core values: Respect, Responsibility, Integrity, Doing Your Best, Courage, and Curiosity. These values merge academic learning and character development into a common endeavor that serves as the foundation of DSST's mission, vision, and guiding principles.

DSST has had unusual success in its fund-raising efforts and lists major corporations, individuals, and foundations among its donors. Given the focus of this study, one of the notable contributions is that Hewlett Packard donated about $1 million worth of computers and related equipment, which has allowed DSST to loan every student a computer to use as a learning tool.

The school recruits nationally for administrators and faculty. There were more than 100 applicants for the Head of School position. By many measures, the faculty and administration are highly qualified and hard working. Most members of the faculty are available before and after school to work with students who are not performing well; there are English and math seminars that take the place of electives for students needing extra support; and there is a mandatory tutoring

program for students who are struggling. There is also both formal and informal peer student tutoring using National Honor Society students as well as others as tutors. Students and parents sign an agreement that the students will attend the after-school sessions, as necessary. DSST also requires summer school for struggling students.

The school's test scores have been among the highest in Denver and the entire state. In 2007, DSST was one of only three high schools in Colorado to earn an "Excellent" performance rating and a "Significant Improvement" growth rating on state report cards. It was the only high school in the Denver metro area and the Front Range given both of these ratings. And over a two-year period, DSST was the only high school in Colorado to earn these two ratings in consecutive years.

As noted, DSST aims to increase college attendance among underrepresented students and its efforts and achievements reflect that focus. The first set of students graduate in June 2008 and all are expected to be admitted to a four-year college. By the end of November, almost 90% already had been admitted to a four-year college.

The school divides its students into the Prep Academy (grades 9-10) and the Senior Academy (grades 11-12). Prep Academy students focus on skill development while Senior Academy students focus on more applied and project-based work. Faculty and administration members, including the Head of School, also act as advisors who meet with a dozen students in an advisory group for fifty minutes twice each week.

For Prep Academy students, most of the class periods are 75 minutes long, with shorter blocks of time every Wednesday. For Senior Academy students, periods also vary in length, with 95- and 100-minute blocks Tuesdays and Wednesdays for extended classes, including science labs.

DSST was featured by *Newsweek* magazine in 2006 as one of the "great American high schools." A link to the article, as well as more information about the Denver School of Science and Technology, is available on the school's website, http://scienceandtech.org.

The School's 1:1 Laptop Program

DSST opened its doors with a ubiquitous computing environment. Hewlett Packard (HP) provided a grant that allowed DSST to become the first public high school in Colorado in which every student is provided with a (loaned) wireless, networked personal computer. Students in grades 9 and 10 each receive a laptop, while students in grades 11 and 12 each receive a tablet computer. Nearly every teacher has a tablet computer (a very few prefer the laptop). The school has a total of about 500 laptop and tablet computers.

The school's leaders believe that technology is vitally important to DSST's program. The Head of School said that the laptops and related technology are more important to the school than the building, which is remarkable considering that the building won a national architectural award for excellence.[3] At the same time, the administration and the Board believe that computers, the Internet, and other technology is there to serve the core purposes of the school, not as an add-on or a distraction. A vision statement on the school's website states:

[3] The 2006 award was made by the American Architectural Foundation's Great Schools by Design initiative. Further information, including a video about DSST, is at http://www.archfoundation.org/aaf/gsbd/.

> "Technology must not be a simple replacement or enhancement of non-technological methods of learning. Technology is too expensive to be a substitute for the pencil and the chalkboard. Instead it must invite and enable higher order thinking, more creative thinking, learning and expression. It must engender more intense investment and engagement by the student. It must enable collaboration, extrapolation, projection, analysis, demonstration, and closer, tangible interaction with the subject under study that is extremely unlikely or even impossible without it. It must transport the student to places, experiences, modes of thinking, cultures, and people otherwise impossible to reach for the normal high school student."
>
> "Technology should empower and enable, and never replace or reduce the central human role of the teacher in a liberal arts education. The role of a liberal arts education is to enable and facilitate the creation of leaders who value community, individuals and the creation of a truly human society. Technology must serve this end."

Consistent with this philosophy of making the role of teachers central, much of the demand for computer applications has been generated from the bottom up, with teachers investigating, trying out, and making decisions about the software, websites, or other technology applications that serve their own and their students' needs. Although some uses of computers are mandated (such as using ExamView to administer Interim Assessments each quarter, and IM for intra-school staff communication), for the most part it is department chairs, teachers, and the students themselves who decide how, when, and where to use the laptops.

Software. Students' computers include more than a dozen applications, including the Microsoft Office suite, Geometer's Sketchpad (for mathematics), LoggerPro (for collecting data in science labs), ExamView (for taking tests), Inspiration (used to organize ideas), Google Earth, as well as some free, Open Source applications. As in many laptop schools, the students are not allowed to install additional software. They can, however, use the thousands of applets (small programs, often written in Java) and other applications that are available on the World Wide Web.

Professional Development. The school provides orientations and training events for both new students and new teachers. There is a five-day orientation for new teachers in the summer as well as a two-week summer preparation session for *all* teachers. The school supports attendance by teachers and administrators at professional conferences, meetings, and classes during the year. On-the-job training and experience are also important sources of DSST teachers' knowledge about teaching with computers. Teachers lead technology training sessions highlighting best practices and these are offered two or three times a year; teachers can attend several hour-long sessions each time.

Email. Everyone at DSST is provided with an email account, username@scienceandtech.org. The school's email server processes tens of thousands of emails a week, most of it in-house.

Other, Supporting Technologies. Computer projectors are mounted in every classroom and rather than write on a whiteboard teachers usually project the display of their tablet computer, on which they can write with a stylus. The tablets allow teachers to write on a clean slate, display electronic documents (including drawings, photos, and movies), and mark up or annotate pre-existing documents for the whole class to see. More than a dozen servers are used to support wireless Internet networks, e-mail, file sharing, VOIP, and other applications. Students all have graphing calculators. (The school rents calculators to students who cannot afford to buy them and keeps extras on hand, as well.) Science labs are equipped with a variety of probes (e.g., to measure temperature, motion, pH) and associated software (LoggerPro).

Infinite Campus. Like other Denver Public Schools, DSST uses an online application called Infinite Campus (www.infinitecampus.com) to record and report students' grades and attendance. Because it is web-based, the information is accessible from anywhere (such as a teacher's home). Data can be shared across the school district, including with students and parents, as appropriate.

Technical Support and Repairs. Two full-time staff members manage the technology (the computers, servers, network, email, software, etc). During the 2006-2007 school year, DSST averaged about 60 events a month involving students' equipment that required more than a quick, 10-minute fix. About 30 computers a month were sent out for repairs under warranty. A computer-based ticketing system is being implemented to keep track of problems with the computers. It is estimated that at any given moment about 25-30 computers do not work properly and need service.

DSST's Benchmark Assessment Program

When DSST was created, Bill Kurtz, the Head of School, Mariah Dickson, the Director of Curriculum and Instruction, and other staff collected background research about high-performing schools. They found that the systematic use of data to inform instruction is one of about a half-dozen practices used more by high-performing schools than by other schools.[4] As a result, they decided that the systematic collection and use of data about student achievement should be one part of the foundation on which the school would be built.

Colorado has state standards, of course, and many useful sets of national standards exist. Nonetheless, the planning group wondered, what are the standards the school should use to be sure its young people are college-ready? According to Mariah Dickson, the group looked at standards from many organizations and decided that the best bet was to use standards developed by the ACT program (formerly called the American College Testing Program).

The idea was to develop a single set of standards in each subject, namely a one-track college preparatory program for all DSST students. The school was to be built on a clearly articulated set of standards, a plan to teach using those standards, and a method of measuring individual progress toward mastering the standards.

The measurement system developed by DSST is called the Benchmark Assessment Program and uses two types of assessments and associated activities:

1. **Standardized Interim Assessments**

- **Three per year:** Given school wide once every trimester
- **Varied format:** Tests contain both multiple-choice and constructed-response questions, closely aligned to the ACT standards and format
- **PLAN, EXPLORE, and ACT Tests:** Given on a pre/post basis in the ninth, 10th and 11th grades to provide a nationally-normed reference by which to measure student growth, and to ensure Interim Assessment alignment

[4] See, for example: EdSource, Inc. (June 2006). *Similar students different results: Why do some schools do better?* Mountain View, CA: Author. Accessed June 18, 2007, from http://www.edsource.org/pdf/simstusumm06.pdf.

- **Data Analysis Sessions:** Scheduled for teachers after every Interim Assessment Test, these are sessions during which teachers identify student weaknesses and design lessons to address them
- **Re-Teach Week:** Scheduled for students after each Interim Assessment Test to provide additional instruction and support for students who have not yet achieved mastery on targeted standards

2. Standardized Performance-Based Assessments

- **Standardized Performance-Based Assessments**: Completed in class on set dates in the fall and the early spring, in areas such as writing, science lab skills, and historical document analysis
- **Standard Rubrics**: Used by teachers to benchmark performance standards, assess standardized performance tasks, and analyze student mastery levels
- **Re-Teaching Strategies:** Used after each Performance-Based Assessment to provide additional instruction and support for students who have not yet mastered performance tasks

In some respects the school's Benchmark Assessment Program is breaking new ground. The staff found no existing data warehouse system that met DSST's needs, for example. Existing systems, some of which are expensive, do not allow local standards to be entered and are not built for the school's small scale. As a result, teachers take data from the Interim and other assessments and enter it into Excel spreadsheets for analysis. To support the Benchmark Assessment Program, the school also uses a software application called the ExamView® Assessment Suite that delivers tests via computer after they have been formatted appropriately and entered into the school's computer system.

The fact that DSST is a 1:1 laptop school makes it natural for teachers and students to use computers for assessments. Teachers' and students' opinions about the Benchmark Assessment Program are described as part of the study findings in the section on the Benchmark Assessment Program that begins on page 23.

The administration considers buy-in by faculty to be essential to an effective assessment system. "The lack of buy-in kills it in nine out of ten schools," said one administrator. Teachers' opinions about the assessment system are therefore of critical importance.

Overview of the Use of 1:1 Laptops by Students and Teachers

Teachers and students report many positive impacts as a result of the school's laptop program. The great majority of students say that the laptops have a very (65%) or somewhat (29%) positive impact on how much they learn in school. The students also report that the laptops positively influence how well they work with other students, how interested they are in school, their grades, and other factors. DSST teachers are also enthusiastic. Nearly all teachers agreed that the laptop program is very (67%) or somewhat (30%) important for students; only 3% disagreed. A large majority of teachers report an increase (57%) or a slight increase (30%) in the depth of students' understanding of the curriculum as a result of the use of laptops and related technology.

As expected, teachers and students report weaknesses as well as strengths of the 1:1 laptop program. Laptops can be distracting to some students, for example. Slightly more than a third of students report that the impact of the laptop program on maintaining their focus in class is negative. In the same vein, more than half of teachers (58%) report that they ask a student to stop using a computer for off-task activities at least once every class period.

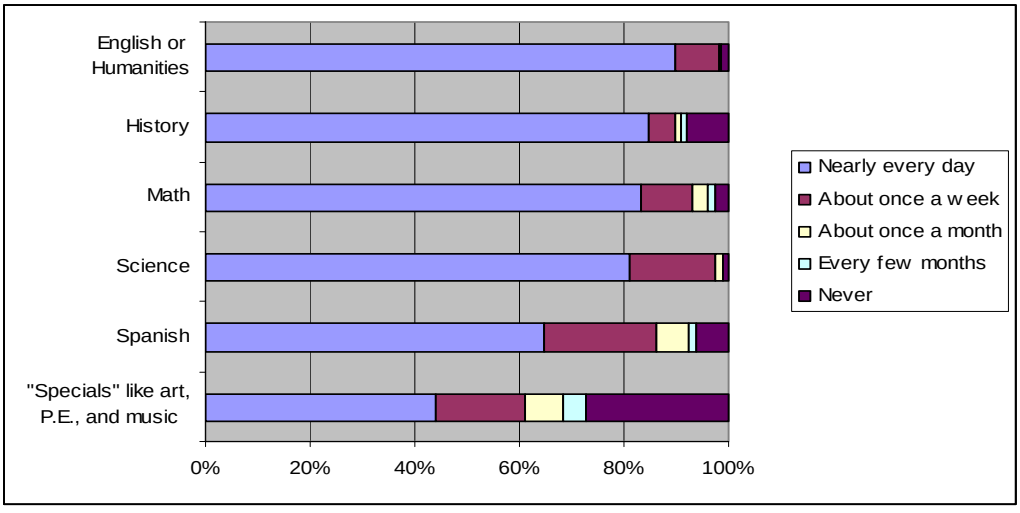
Considering strengths and weaknesses, the overall picture of the laptop program that emerges is positive, with the advantages of providing laptops to students clearly outweighing the disadvantages. The data show that thoughtful judgments about how to use educational technology effectively are being made by the administration, teachers, and students.

How and How Often Technology is Used

DSST teachers and students use laptops daily while at school, for many purposes. This is in marked contrast to students' use of technology in the schools they attended before DSST, when the great majority report that they either never used technology in regular classrooms (35%) or used computers in classrooms only once a month or less (38%).

The use of computers varies by subject, with the greatest use reported in English and humanities, history, mathematics, and science. Exhibit 1 shows students' reports of computer use.

Exhibit 1: Students' Reports of Frequency of Using Computers in Class



Clearly a common use of the computers is for word processing, including taking notes in class. The frequent use of word processing helps explain the high usage of laptops in English, humanities, and history. The way the computers are used is often subject-specific. Asking students to complete practice drills, for example, is more common in mathematics than in other subjects: one-third of the math teachers report asking students to do drills daily, compared to 4% among the other teachers. Similarly, half of the history teachers report asking students to conduct research on the Internet daily, compared to 4% of the others. And 100% of the English teachers report asking students to use computers for writing at least a few times per week, compared to about half of other teachers.

Some patterns of computer use cut across subjects. Almost all teachers use their computer projector at least a few times a week and nearly 60% use one daily. Almost all teachers use the S: drive (a central file server accessible to all teachers and students) and/or email, both to provide and to collect students' assignments and related materials, with more than half the teachers reporting that students access server files daily. At the other end of the spectrum, few teachers report that students often work on a Digital Portfolio (it may be that most such work happens in a concentrated period of time later in the year) and few report using computer software installed on their computers as a way to monitor students' computers.

Other variations in use reflect teachers' preferences and the availability of instructional materials. Three of the nine science teachers, for instance, report that they ask students to use an electronic textbook daily, whereas two other science teachers report that they rarely or never do. Among the ten teachers who report the most frequent use of electronic textbooks, nine teach science, mathematics, and technology and only one teaches in another discipline.

Within a department, computer use may vary by grade level. Among the ninth graders, 77% report that they use their laptops in Spanish class every day, compared to 59% in the other grades. Like their colleagues in other departments, Spanish teachers use the laptops for a wide variety of purposes. For example, teachers record Spanish language radio advertisements and save the audio files on a server so that students can listen to them through Moodle (an Internet-based software application that allows teachers to organize and interact with digital resources by class). Students can also record their own audio files and submit them to their teacher. The laptops also provide access to Spanish language newspapers, online dictionaries, quizzes and flash cards, and many other resources. One Spanish teacher said she finds using the computer useful to her and her students, and also "so much fun."

Not surprisingly, mathematics teachers make greater use of graphing calculators than other teachers. Every math teacher uses the graphing calculators at least a few times per week (and there is also graphing calculator software on teachers' and students' computers). Science teachers also use these devices frequently, with two-thirds using them at least once a week. Science teachers also make frequent use of probes in science labs (examples are provided below in the section on physics).

While the teachers and students already use the laptops extensively, many teachers continue to explore additional ways to use the laptops for instruction. By one estimate, about a third of the teachers now use Moodle to manage digital course materials (access to which requires students to login to the course website). One English teacher said,

> "I have a class website and use the online forum and class resources [there]. The online forum is really cool. Every week a certain number of Moodle posts are due from students. Feedback

from surveys I have given says kids like online discussion. Shy kids benefit. [On the other hand, although] I can post articles on Moodle, it takes four steps, versus one step to put them on the S: drive. I usually use the S: drive."

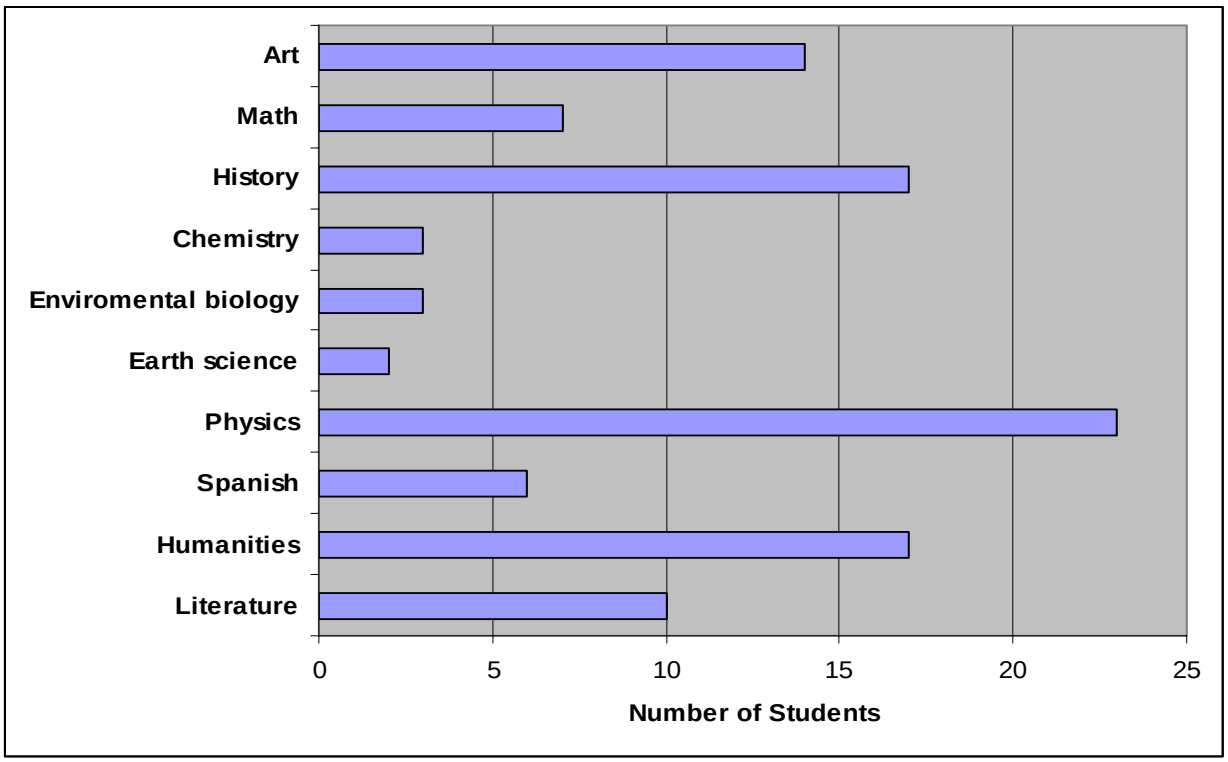
Moodle's online discussions can be password protected, so only students in the class can access them.

A common use of the computers in English, according to one teacher, is for the teacher to project a paragraph so the class can all see it and then edit the paragraph together. Everyone can watch. The results can be shared using Microsoft's OneNote, saved to a file server, or emailed to students, if appropriate. And of course all students write essays and reports using their laptops. According to research, students who learn to write using computers generally become better writers than those who learn without computers.[5]

A mathematics teacher uses software (Camtasia) to make a recording that shows his computer screen as he creates and manipulates graphs students are studying. The teacher narrates as he uses mathematics software. These movies dynamically show the computer screen on which the graphs are displayed, plus the narration, and they are made accessible to students via file servers, providing a new way for students to learn or review the mathematics they are studying, at their own speed.

Students were asked to identify the technology project or assignment at DSST of which they have been most proud. An analysis of more than 100 responses identifying a particular school subject makes it clear that laptops are used in productive ways in *all* disciplines (see Exhibit 2).

Exhibit 2: Uses of Technology by Students of which they are Most Proud (Subjects)



[5] Goldberg, A., Russell, M., & Cook, A. (2002). *Meta-analysis: Writing with computers 1992-2002.* Chestnut Hill, MA: Technology and Assessment Study Collaborative, Boston College.

An analysis of responses to the question "what has been the most helpful use of technology by teachers" also displays a great range. The two most common types of response by students were: teachers making it easy to access assignments electronically and teachers' classroom presentations. It would take dozens of pages, if not a book, to describe the many ways laptops are used. In addition to learning academic subjects, DSST students also become adept computer users, as we will see next.

The Digital Divide

The term "digital divide" refers to the disparity between students who have easy access to computers and use them often, compared to others who lack such access. One reason that policymakers in many locations support laptop programs is to "level the playing field" so that all students have access to computers and the information resources accessible by using them.

There was clearly a digital divide for students before they began attending DSST. Among those who identify themselves as Hispanic, fully 50% report that they rarely or never used computers before they attended DSST. The corresponding figure for African American students is 40%. Only 25% of the Caucasian students report that they rarely or never used computers before coming to DSST, however. These figures may not be surprising but they support the importance of a laptop program in a public, ethnically diverse school serving large numbers of underrepresented students as a way to overcome the digital divide.

Lack of Internet access at home remains a factor for about one-quarter of DSST students. The situation disproportionately affects minority students, with 37% of Hispanics and 32% of African Americans reporting no Internet, or very limited Internet, at home, compared to only 14% of Caucasian/White students. Among students whose home Internet access is limited, the great majority (84%) believe it would be "very important" for them to have a good home Internet connection. Given that 85% of students report using email or the Internet to get help with home-work, it is understandable that those without home Internet access think it is important to get it.

There are also differences in access to computers by gender. For example, 41% of female students report that they rarely or never used computers before attending DSST, compared to 31% of male students. Lack of good home Internet access is reported by nearly a third of the female students (32%) compared to 20% of males. Nonetheless, both male and female students value the laptops highly; for example, 96% of females and 93% of males report a "somewhat" or "very" positive impact of laptop computers on how much they learn in school.

Changes in Students' Use of Computers while at DSST

Students learn a great deal while they are at DSST, including technology skills. Asked to rate their skills both before coming to DSST and at present, students report that their skills have improved, as shown in Exhibit 3. The percentage of students who say they are "very good" using spreadsheets and PowerPoint nearly doubles as they acquire experience at DSST. Similarly, among ninth graders only 35% rate their skill using spreadsheets as "very good," while among seniors the figure grows to 67%.

Exhibit 3: Percent of Students Describing Themselves as "Very Good" Doing Selected Technology Tasks

	Before Attending DSST	At present
Internet search	63%	77%
Word processing	59%	75%
Spreadsheets	27%	52%
PowerPoint presentations	36%	71%
Programming a computer	11%	16%

The teachers also report growth in students' technology skills. Most teachers teach exclusively, or almost exclusively, in the Prep Academy (ninth and tenth grades) or the Senior Academy (eleventh and twelfth grades). Only 13% of the Prep Academy teachers report that their students have advanced skills in using PowerPoint, compared to 42% of the Senior Academy teachers. Similarly, the majority of Prep Academy science teachers report that their students do not have basic skills for using simulation software and applications, but among Senior Academy science teachers *none* report their students lack those skills.

Also, as students become more familiar with using laptops as learning tools, they value the computers more highly. After just a few months at DSST, 56% of ninth graders report that the laptops have a "very positive" impact on how much they learn in school. That figure grows to 69% in the higher grades, after students have gained more experience using the laptops.

Teachers report more intensive use of laptops in the Senior Academy. Whereas 38% of Prep Academy teachers report that students are asked to use laptops in class or for homework daily, the figure is 58% for Senior Academy teachers.[6] The increasing use of laptops in the Senior Academy presumably relates to the finding immediately above, that although DSST students report that the laptops help them in many ways, more students in the upper grades value them highly.

Technology Infrastructure and Support

Both students and teachers believe that DSST provides supports needed to use laptops effectively. Among the ninth grade students, for example, 46% report that the introduction to using computers given to all incoming students was "very helpful" and another 45% found it "somewhat helpful."

The great majority of teachers (87%) report that lack of reliability of the network or of computers is *not* a barrier, or at most a small barrier, to using technology in the classroom. An even higher number (90%) say that lack of support from the administration is *not* a barrier (83%) or a small barrier (7%) to integrating laptops into instruction. However, many teachers (41%) would like more time, including time released from teaching, to develop their activities or lessons that incorporate technology.

Challenges of Managing Computers in the Classroom

As students learn more and better ways to use laptops as powerful learning tools, they also learn to reduce the number of off-task uses of computers in the classroom. While 75% of Prep

[6] This analysis excludes two teachers who teach large numbers of students in both the Prep and Senior Academies.

Academy teachers report that they ask a student to stop their off-task activities with laptops at least once every class period, by the time students are in the Senior Academy only 36% of the teachers report the same frequency. Similarly, in ninth grade, 41% of students report that the laptops have a somewhat or very negative impact on the behavior of other students, but that figure declines to 33% in grades 10 to 12.

All but one of the DSST teachers reports that students are permitted to use laptops during class only when permitted, rather than at any time. Various applications are discouraged, too, even when other computer use is allowed. For example, instant messaging during class is forbidden by 90% of the teachers and nearly all teachers either forbid (52%) or discourage (45%) the use of email during class (although some teachers ask students to email assignments at designated times).

Of course, teachers cannot observe students' laptops at all times and some inappropriate use is inevitable—in the same way that students sometimes do inappropriate things in classrooms without laptops. A majority of teachers (62%) report that the difficulty of monitoring students' activities on the Internet is a major disadvantage of using the laptops.

Laptops also need repair from time to time or students may forget to bring their computer to school. As a result, on any given day some students (perhaps 5%) do not have a working laptop in class. For teachers who integrate the use of laptops into their instruction this creates a challenge. However, the great majority of teachers (79%) report that this is a minor problem or hardly a problem at all. A minority (21%) report that this is a serious problem. The school reports that this is less of an issue after the first trimester (when this study was done).

Another challenge of using laptops for class assignments is that a significant minority of students (26%) do not have Internet access at home. Nearly two-thirds of the teachers believe that students without home access to the Internet are at a serious disadvantage.

Finally, more than half of the teachers report that students confuse finding information about a topic on the Internet with understanding that topic. Interestingly, more teachers in the Senior Academy (75%) report this as a major concern than teachers in the Prep Academy (38%). The fact that the teachers are well aware of the issue suggests that they are confronting it as they teach but that it is a difficult problem to overcome. (Note that this problem is not confined to laptop schools. In 2001, a national survey found that this problem was reported by almost 40% of *all* teachers.[7])

Teachers' Professional Development

A large majority of teachers (67%) report that during the past 12 months they participated in formal (classroom) or informal (video- or computer-based) professional development focused on the use of computers for instruction. Most of them participated for 8 hours or less, and only 10% of the participants were involved for more than 16 hours. (It is unclear whether teachers included the DSST professional development sessions described earlier which, in any case, last fewer than 8 hours per teacher per year.) Almost all the teachers (95%) who engaged in professional development found it useful or somewhat useful.

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[7] Adelman, N., Donnelly, M. B., Dove, T., Tiffany-Morales, J., Wayne, A., & Zucker, A. (2002). *The Integrated Studies of Educational Technology: Professional Development and Teachers' Uses of Technology*. Washington, DC: U.S. Department of Education.

Asked what the most important thing was that they learned, the teachers' responses on the survey varied. Ten teachers mentioned a particular piece of software, including: One-Note (a Microsoft application that allows the user to organize many types of electronic documents into a digital "notebook"); ExamView (used to administer and grade student tests); Geometer's Sketchpad (a powerful, visual program for mathematics); and Infinite Campus, the software used to record and maintain students' grades. Others identified more general topics, notably how to better use technology in the classroom.

Teachers also learn about using computers from their school colleagues. The great majority of DSST teachers (79%) report that lack of support for using educational technology, including advice and training, is *not* a barrier, or is only a small barrier, to using the laptops.

The teachers report that they are competent or highly competent computer users in many respects: integrating computers into lessons (87%); using software tools such as PowerPoint, spreadsheets, and Internet browsers (83%); and developing students' critical thinking skills using educational technology (76%). Still, 30% of teachers do not feel as competent as they would like to be at using data tools for student assessment and evaluation (e.g., ExamView), and an equal fraction feel the same way about their competence using instructional software.

Other Impacts: Perceived Benefits and Challenges

A 1:1 laptop program is intended to change and improve instructional practices and at DSST the program clearly does so. Among DSST teachers, more than 90% agree or strongly agree that "I have changed the way I organize classroom activities." Nearly two-thirds report that they rely less on textbooks because of the laptops and over 85% agree or strongly agree that they are better able to meet the needs of students with varying needs (such as struggling students and gifted students). Sixty percent agree or strongly agree that with the laptops they are able to spend more time teaching students individually, one-on-one.

Neither teachers nor students would want to give up the laptops. Two-thirds of DSST teachers report that technology is now "essential" or "extremely essential" to their teaching practice. Similarly, the all-but-unanimous opinion of the teachers (89%) is that the laptop program is important for DSST students.

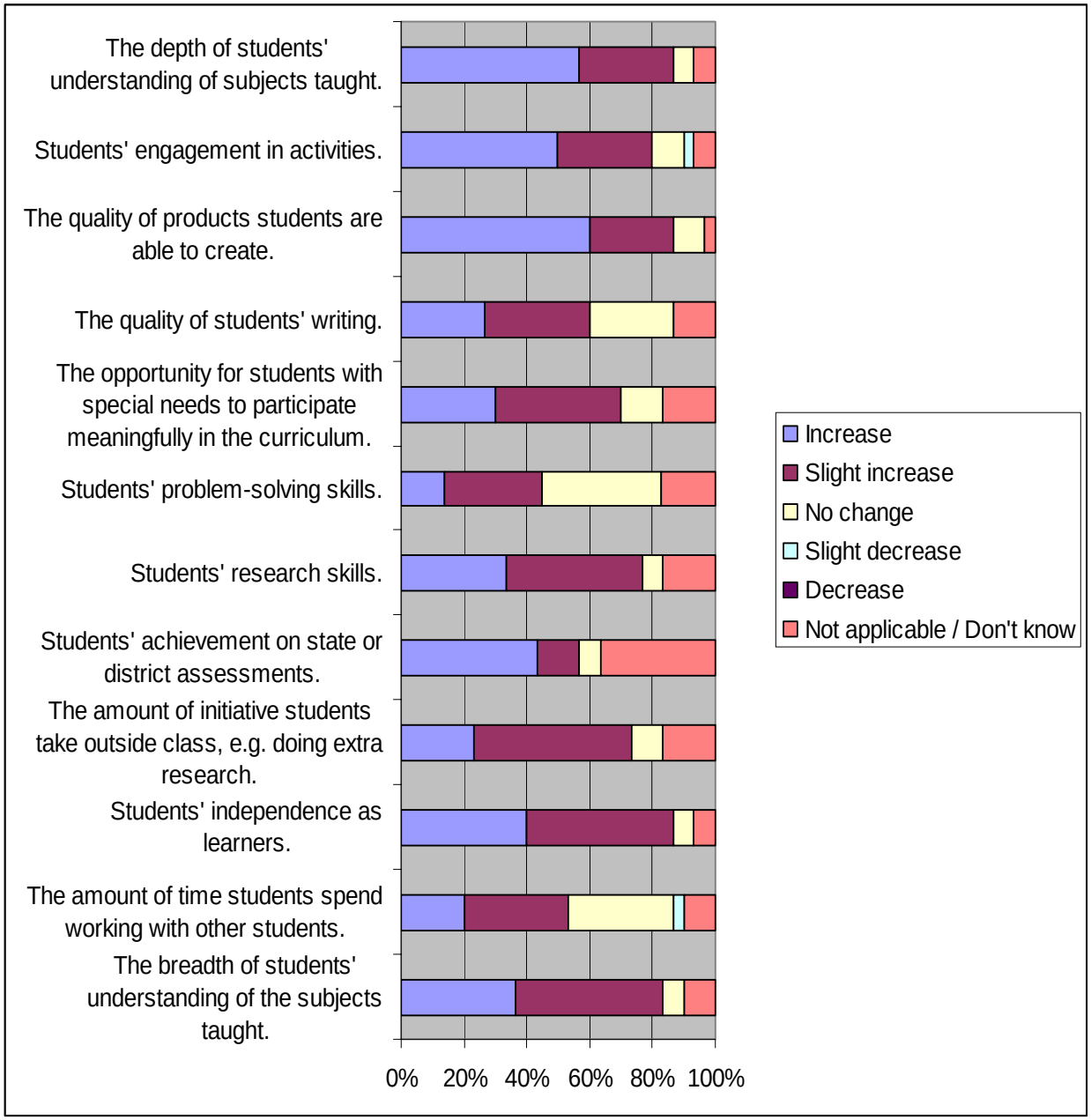
The survey asked teachers to indicate changes they notice in students that may be related to increased use of educational technology at DSST. Among a dozen possible changes, in every case the majority who expressed an opinion reported positive and very positive impacts, as shown in Exhibit 4 below. On only one of these items did many teachers not express an opinion: regarding the impacts of technology on students' achievement on state or district assessments, 11 teachers report that the question is not applicable to what they teach or that they do not have an opinion, as shown in the exhibit below.

Some of the notable findings include that 80% of the teachers believe the laptops increase students' engagement in school activities, that nearly 90% report the laptops increase the quality of students' work products, and that nearly 90% report that the laptops increase students' independence as learners. Each is an important ingredient in promoting students' success.

One finding calling for further explanation is that "only" 60% of the teachers report an increase or a slight increase in the quality of students' writing. Teachers in a number of disciplines

have limited experience with students' expository writing. Among the English teachers, however, 100% report an increase in the quality of students' writing, as do all but one of the history and humanities teachers.

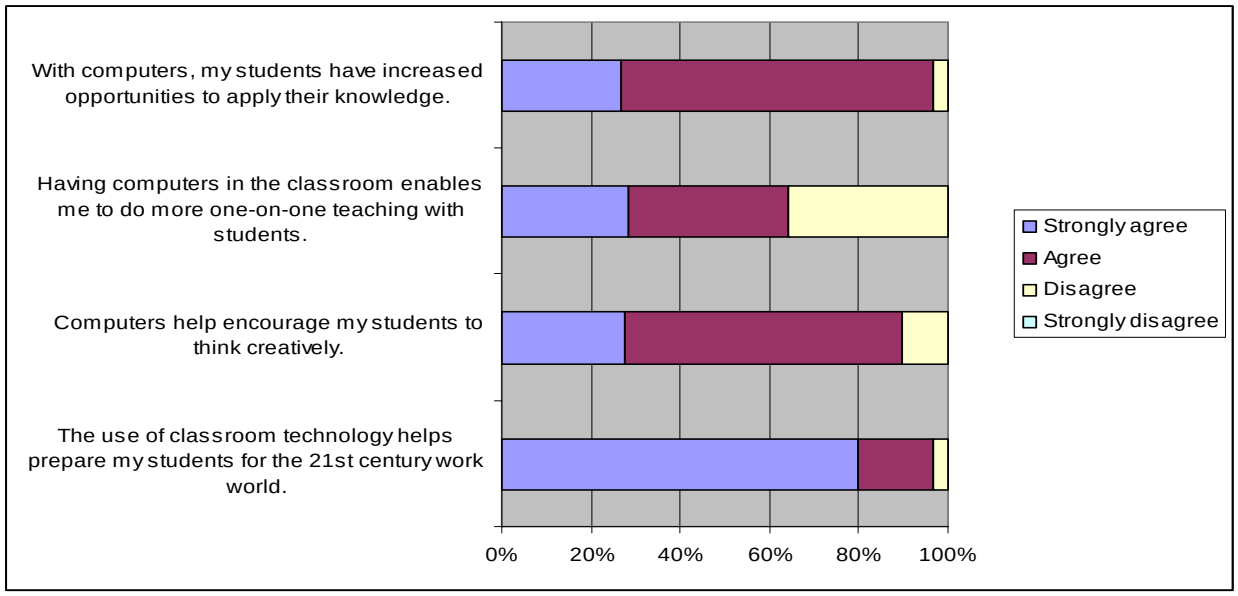
Exhibit 4: Teachers' Reports of Changes that May Be Related to Educational Technology



The survey also asked teachers the extent to which they agree or disagree with some statements about educational technology. Teachers report a number of highly positive impacts of the laptops, including "computers help encourage my students to think creatively" and "with computers, my students have increased opportunities to apply their knowledge." (See Exhibit 5.)

Teachers also report that because of the laptops they are more reflective about basic teaching goals and priorities (80% agree or strongly agree), that they more often ask students to work independently (77%), and that they rely less on textbooks (63%).

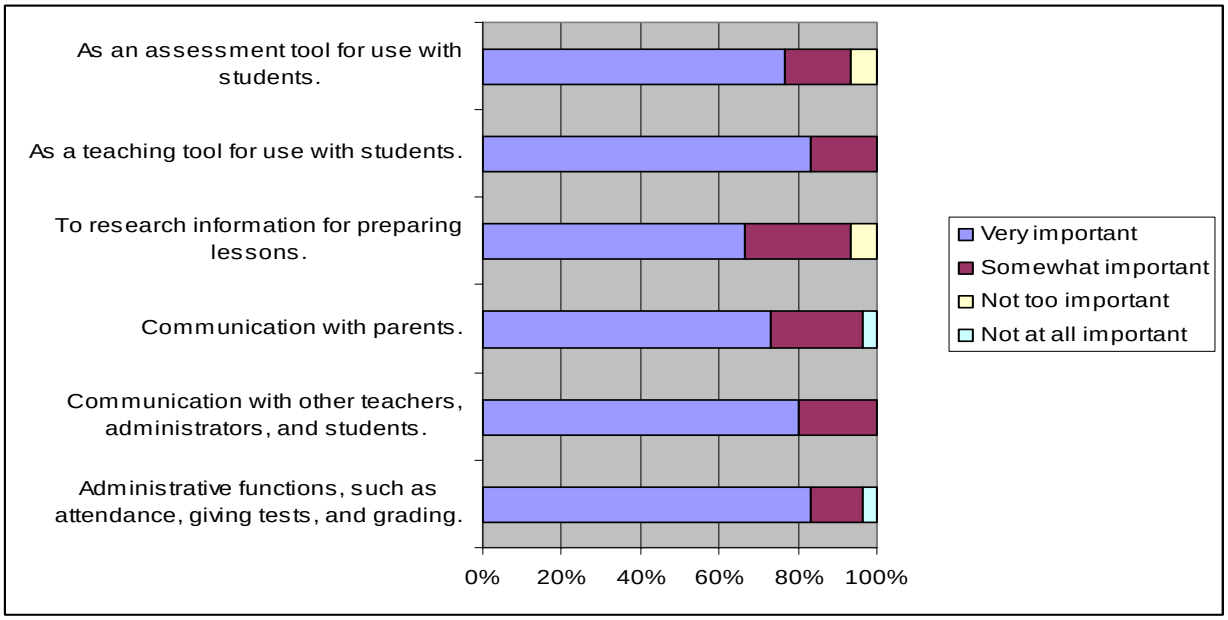
Exhibit 5: Teachers' Reports of the Impacts of 1:1 Laptop Computers



Many of the challenges of using 1:1 laptops have been identified in preceding sections. These challenges include some students becoming distracted by off-task use of the computers, the need for teachers to spend classroom time managing laptop use by students, and the time that it takes for teachers to learn to use educational technology well, including their time to prepare lessons and activities that make good use of the laptops. About a quarter of the students report a negative impact of the laptops on their interest in doing homework; at the same time, 75% report a positive impact. Three teachers (10%) report that with computers too many students often need help at the same time; however, 79% disagreed with that statement.

Finally, teachers were asked to rate the importance of computer technology "for you personally" in each of several areas, as shown in Exhibit 6 below. It is clear that teachers value the laptops highly as tools they use for a wide variety of purposes. Large majorities report that computers are important for each of the six purposes listed: as an assessment tool; a teaching tool to use with students; a research tool to prepare lessons; to communicate with parents; to communicate with other teachers, administrators, and students; and, as a tool for administrative purposes, such as attendance and grading. For example, all 30 teachers who responded indicated that computers are very (83%) or somewhat (17%) important to them as a teaching tool to use with students.

Exhibit 6: Teachers' Ratings of Computers' Importance to Them Personally



Further information about use of the laptops in physics and as part of the Benchmark Assessment Program is reported in the sections that follow.

Focus on the Physics Courses

At DSST, students are required to take physics in their freshman year. The course involves much hands-on lab work, with students completing experiments weekly. About two-thirds of the seniors also take either honors or Advanced Placement (AP) physics (the latter requiring enrollment in calculus). Twelfth graders also take an Advanced Engineering course, which provides the physics students with opportunities to apply their knowledge by building devices using physics principles.

Technology is used extensively in physics courses. Physics students use probes and associated software (collectively known as probeware) to collect, analyze, and present real time data collected during laboratory work. Probes are small devices to measure motion, temperature, pH, or other phenomena. Data from the probes is downloaded directly to student laptops where it is instantly available to be analyzed. In addition, each week physics students manipulate computer simulations (such as the behavior of waves) that encourage discovery of physics concepts through experimentation and visualization (see http://phet.colorado.edu/new/index.php).

An Overview of Students' Use of Technology in Physics Courses

More than 120 students enrolled in physics answered survey questions about the use of laptops, probes, and other technology in their physics classes. They report extensive and varied use of technology. Even the ninth grade students, who were reporting after only a few months at DSST, report that they use the laptops in class virtually every day.

Thirteen ninth graders report that technology projects they performed in physics were the laptop-related projects of which they were most proud. Eleven of the 13 mentioned physics lab reports in particular, for which they utilized a template to create a report and import relevant graphs and visuals. Similarly, eight physics students described their physics laboratory experiments as the technology projects that gave them the most pride.

Students use their laptops at least once a week to collect data (86%) and analyze data (92%). According to the majority of physics students, teachers use ExamView for student assessment at least once per week (82%), which is supported by interviews with the physics teachers.

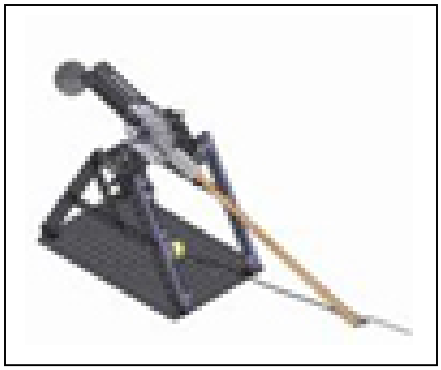
The majority of physics students report using their laptops to communicate about science on a weekly basis (73%) and over half (55%) report using simulations at least weekly. Seventy four percent of students report using a word processor at least weekly, while a slightly smaller percentage of students said they used Internet search engines for science at least once a week (69%).

The trajectory physics students take from novice physics students to more advanced science practitioners is clear and reflects deliberate planning. For example, one physics teacher said that "students have to learn how to do (lab work) 'old school,' then they start to use the technology more and more." Each technology tool incorporated into ninth grade physics was reintroduced in twelfth grade, though teachers report that twelfth graders used the physics software, hardware, and probeware more efficiently and more independently. According to the twelfth grade physics teacher, "In ninth grade they use a lot of simulations and spend a lot of time, sometimes a whole class period, manipulating them. In twelfth grade students use them as a resource, but we don't spend a lot of time on it. They are used more to remind them of the concepts."

Twelfth grade physics builds on skills and knowledge developed in the ninth grade class, particularly in the use of technology. The former ninth grade physics teacher, very aware of the ninth grade syllabus, designed and teaches the twelfth grade physics courses. The skills developed with direct teacher support and scaffolding in ninth grade physics (including collecting multiple types of data; interpreting the data; expressing physics concepts using various media; and presenting scientific arguments in lab reports) are accomplished with much more independence at the twelfth grade level. Students who first explore teacher-facilitated science labs in ninth grade are led to formulate their own scientific hypotheses in twelfth grade, and are given the technological tools to investigate the questions and represent findings in a professional-looking manner. High-tech software, probeware, and textbooks bring the concepts of physics to life for students. Teachers' pedagogical knowledge and skill are enhanced with technology, which allows teachers to serve as guides in the classroom while student-led inquiry projects promote authentic science learning.

Student survey responses illustrate this idea. One ninth grader described his enjoyment of physics work that utilized technology: "The technology assignment that I have been most proud of is my Physics labs, because our physics teacher has a template to help us with writing the assignment. And to type it up and drop (it in the) drop box the next day makes me feel more successful in classes." The technology-rich, simplified format of the ninth grade lab report template helps guide students toward success while producing a professional-looking document.

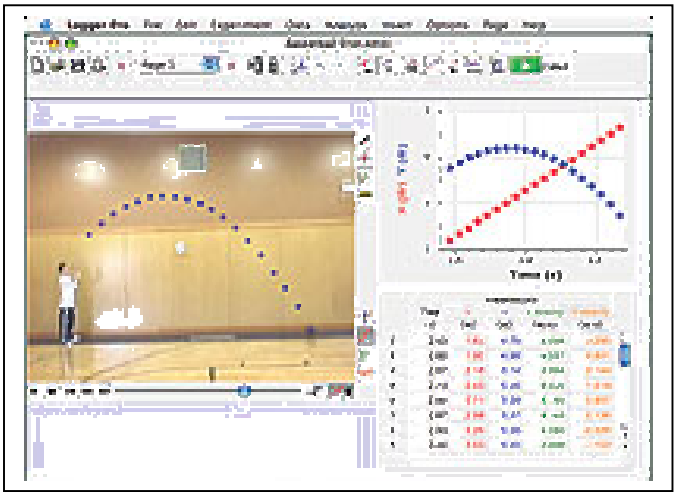
In twelfth grade, students have more responsibility for using the technology to answer specific, authentic, scientific questions. They are putting their LoggerPro lab skills to use, but are also gaining engineering design skills, as demonstrated in an AP physics student's survey. "[The technology project I am most proud of is] my catapult design for AP physics which I made with Solidworks [software] so that it was correctly dimensioned and with moving parts, to use as a blueprint for the actual build which is currently in progress." (See illustration at right for a sample Solidworks view of the Trebuchet project, in which students design and build a working catapult.)



A Glimpse into ninth Grade Physics: Learning to "Do Science" with Technology

One day in early November, ninth grade physics students prepared to show their data collection and interpretation skills as part of individual performance assessments. The physics class reviewed for a test while individual students ventured one-by-one to the "pod," a shared open space between classrooms. Each was asked to set up a simple physics experiment, in which they connected a motion detector to a cart rolling down an inclined plane. Students completed two trials, one in which the cart carried additional weight and one in which the cart was empty. Students used LoggerPro software to measure the acceleration of the carts in both conditions, selected the relevant data from a scatterplot, and answered a question posed by their teacher. (See Exhibit 7 for a sample LoggerPro display on the laptop.)

Exhibit 7: A LoggerPro Scatterplot



During performance assessments, teachers observed students at work assembling the technological materials, manipulating the data, and describing their answers to the scientific research question posed. The teachers recorded student assessment results on their laptops. As students returned to their classrooms, ninth graders passed twelfth grade physics students in the hallway who were in the process of testing similar physics phenomena such as acceleration of objects in freefall.

The performance assessments were designed to ensure that each student had mastered the technical skills necessary to participate in a data-driven, technology-rich physics class. By learning physics using probeware, even ninth graders have access to first-rate laboratory equipment that allows them to pose scientific questions and then gather and analyze data to efficiently test their hypotheses.

When Technology Breaks Down: Teaching as Improvisation

Occasionally, technology fails to work properly, impacting lessons in the classroom. During one visit to a ninth grade physics class, a video would not play on the teacher's computer. First, the class continued with another planned activity (going over the homework), while one student attempted to troubleshoot the technological glitch. When it became apparent that the video was not going to play, the teacher improvised a new lesson.

The purpose of watching the video was for students to visualize the behavior of objects in freefall. "We're going to watch a video of acceleration because I think if you see it visually, it will help you make sense of the concepts," the physics teacher explained. The film showed objects dropped from various heights with gravity as the primary force working on the object. Instead of using the video, the instructor devised a simple laboratory experiment for students to conduct during the remainder of the class. The focus on freefall was the same, though instead of modeling the force on screen, students performed "low-tech" activities with rulers. Each student had a chance to drop a ruler for his or her partner to catch. Each student performed three trials and discovered the average reaction time for him or herself, as well as for a partner, using the distance the object fell and the known acceleration of objects in freefall.

This vignette illustrates the need for teachers in technology-rich schools to be masters of pedagogy. If the instructor had depended solely upon the computer to provide educational opportunities, the lesson on acceleration during freefall would have disintegrated with the technology disruption. Instead, the teacher found another way to address the same physics concept. The class missed a video, but did not miss valuable instruction time.

Understanding Connections between Concepts: Using Simulations

> "I believe that the most helpful use of technology has been the use of technology to give us interactive lessons or lectures about specific topics. It makes it so much easier to understand a concept if you can see it happen in an animation." - Survey response, twelfth grade student.

Physics simulations developed by the University of Colorado at Boulder provide graphical information showing the connection between acceleration and velocity. Simulations allow students to rapidly manipulate variables and observe resulting changes obeying the laws of physics. Ninth grade physics students manipulated one of these simulations to make a moving man change position, speed up, and slow down. (See Exhibit 8, a screenshot of the simulation.[8])

Exhibit 8: The Moving Man Physics Simulation

Students manipulated the motion of the Moving Man, and saw the ways in which their adjustments affected velocity, acceleration, and position of the man in space. Later, during a subsequent physics class, the same students were asked to match graphs of acceleration to graphs of velocity. Similar graphs were first observed by students during their simulation work with the Moving Man but the matching activity was low-tech: the teacher drew graphs on the board, and students used pencil and paper to record their responses. The theory of pedagogy was that students' experience with the simulations would allow them to interpret more abstract graphs, disconnected from the dynamic online simulations.

A Glimpse into Twelfth Grade Physics: Practicing Authentic Scientific Investigation

During an observation of a "pre-lab" day in AP Physics, students divided into seven lab groups, gathered materials, and spread out in the lab room and in the wide hallway just outside the laboratory door. The equipment available included weights, 2-by-4s, string, wheels, paper cups,

[8] Available at http://phet.colorado.edu/new/simulations/sims.php?sim=The_Moving_Man.

carbon paper, tennis balls, rods, metal stands, and screwdrivers. Their technological tools included motion sensors, force meters, cameras, and of course, the students' tablet PCs.

In the pre-lab phase, students were testing possible lab set-ups, variables for experiments, and data collection techniques. All of the students were using LoggerPro in some way to collect and analyze data. LoggerPro is engineering software used in all of the physics labs. Some of the students recorded videos that they then loaded onto their laptops in order to use the LoggerPro software to analyze the videos to measure speed, acceleration, and other phenomena.

Students were adept at using the technological laboratory equipment. They expertly attached video cameras to their tablet PCs, and imported video into LoggerPro to test their experiments. They pulled up graphs and charts of their physics data. Each group was taking notes and typing lab report text during the pre-lab. They referred to their electronic text books as they reviewed their tests. One student used a Texas Instruments graphing calculator software program (which depicts a graphing calculator on the screen of the laptop) to calculate his grade on a homework assignment.

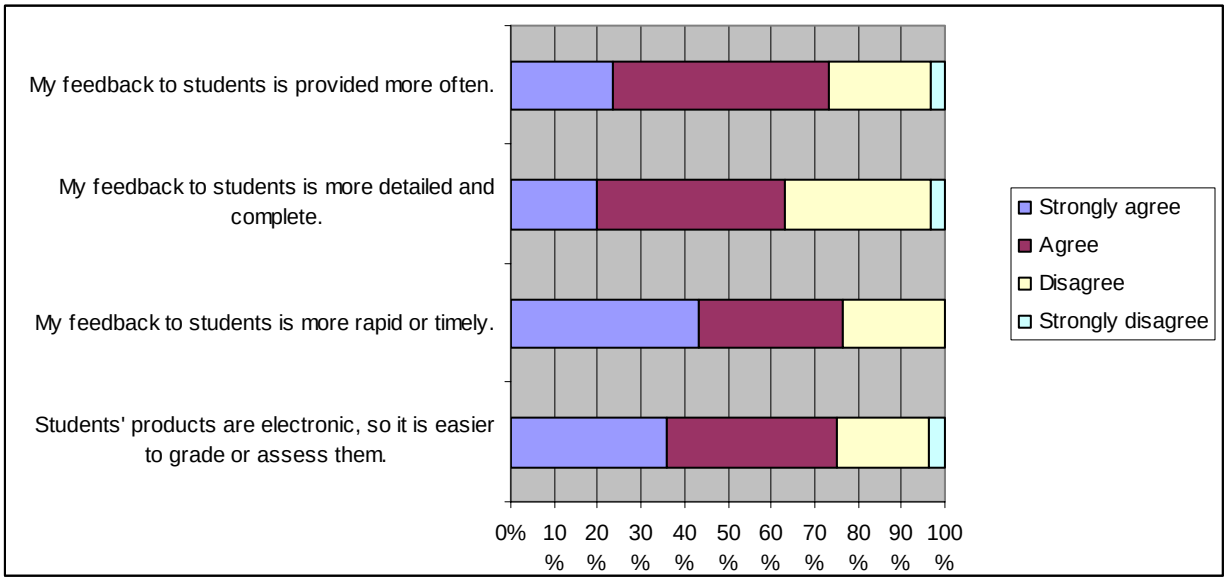
Two students shared their work with the researcher. A cheerful, polite young lady in the class described LoggerPro and used her laptop to guide the observer through the data collection. She said she also used the software during her summer experience at MIT at an amusement park. A young man in another lab group asked if the observer had any questions. He then used his tablet PC to draw a picture of what they hoped to test in their lab the next week. Asked how often he used the tablet feature of his laptop, he replied, "Every day. I take notes in class [with the tablet]."

The twelfth grade physics teacher noted that the textbook is entirely on the students' computers. "It comes from Kinetic Books [www.kineticbooks.com]," she said. "It has a lot of simulations in it. This is a great example of using a text that is on a computer. There are boxes to click with cartoon [animated] movies; students can listen as well as watch."

Focus on the Benchmark Assessment Program

Both teachers and students report significant advantages resulting from the fact that most students' work products are electronic. Large majorities of teachers note the positive impacts on ease of grading, rapidity of feedback, and other aspects of assessment. (See Exhibit 9.)

Exhibit 9: Teachers' Opinions about Using Computers for Student Assessment



ExamView and Reteach Weeks

Asked what has been the one most helpful use of technology by DSST teachers, fifteen students responded testing, the use of ExamView, or something similar. One student wrote, for example, "tests being graded almost immediately," while another reported, "the test taking has been much better."

As described in the Introduction, DSST teachers administer an Interim Assessment each quarter, and then, based on the standards on which students do not demonstrate mastery, they conduct a "reteach week." Large numbers of students report that these reteach weeks are either very (44%) or somewhat (35%) helpful to them. Teachers agree, with 41% reporting that the reteach weeks are very important for DSST students and another 48% reporting that they are somewhat important. There is a small association between students' ethnicity and their opinion about reteach weeks. More Hispanic students (53%) and African American students (45%) report reteach weeks as "very helpful" than Caucasian students (33%). However, these differences are smaller if one also includes students who report the reteach weeks are "somewhat helpful."

Computers are used for assessing students at other times, too, not only in preparation for reteach weeks. Among students, 70% report using ExamView about once a week and another 21% report using ExamView nearly every day. This leaves only 9% of students who report using ExamView less than weekly.

Teachers often separate tests into questions that can be machine-graded, for which they use ExamView, and others that are more open-ended and require extensive teacher attention. Because the software is able to provide students with instant feedback about the machine-graded items, according to one English teacher, "I could focus [my effort] on the essay." Teachers try to focus on helping students improve their scores. "It's all about doing better," a Prep Academy teacher said about the pre-test, post-test approach the school has adopted.

According to one English teacher, the types of reports about the performance of students and classes that are easily available through ExamView are valuable to her and her students. She said,

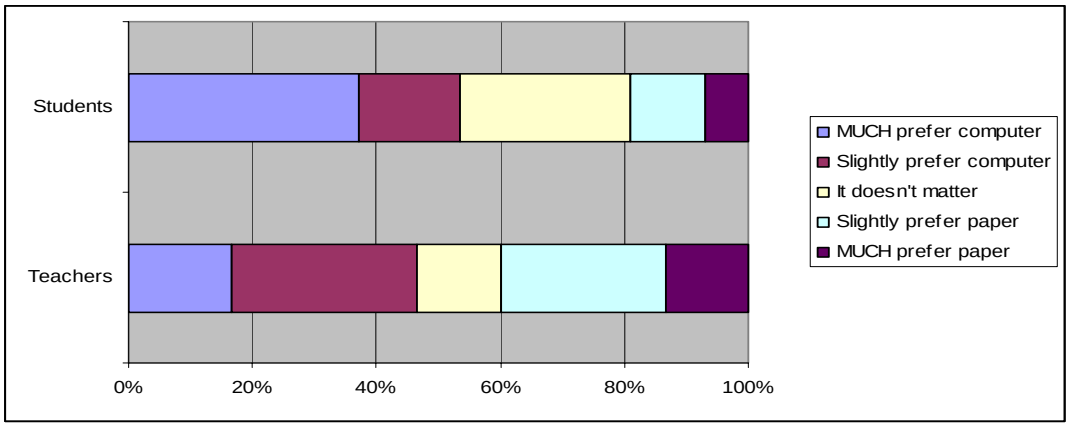
> "I'm not a numbers person, so I would never run that kind of report [without the software]. It helps tremendously to be able to give students feedback tied to college readiness standards."

Helping teachers who are not "numbers people" is an advantage of using ExamView. However, even mathematically experienced teachers find ExamView useful. One physics teacher said,

> "I use Exam View software all the time. It's invaluable. We use it just about every class. You get immediate results, i.e. usable data. The other thing is you get a rich array of analysis tools. I can do a right click and choose analysis and it will tell me all the questions that some threshold percentage of students got wrong. I might set it to 70%. If a lot got it wrong, we can go over it. I usually do that the very same period. It's an opportunity for me and for the students and a good time to correct misconceptions right away. Or I can set it up for instant feedback directly to students as soon as they complete the test."

ExamView was not specifically designed to be used in a wireless laptop environment and perhaps for that reason there are sometimes computer glitches resulting in lost information. Nonetheless, both teachers and students appreciate the benefits of computer-based tests. Students prefer taking tests on a computer more than teachers prefer giving them on a computer (perhaps in part because essays and other types of test item don't lend themselves easily to a computer-based, machine-graded format). While fewer than 20% of students report that they prefer paper tests, about 40% of the teachers do. Still, more teachers (47%) prefer computer-based tests than paper. (See Exhibit 10.)

Exhibit 10: Testing Preferences of Students and Teachers



As noted earlier, 70% of teachers report that they feel competent to use data tools for student assessment and evaluation, but 30% believe they are only "slightly competent" with these tools. Among the latter group, almost all teach in non-mathematically oriented disciplines.

Explore, Plan, and ACT Tests

As part of the Benchmark Assessment Program, all DSST students take the Explore, Plan, and ACT tests. These are given as pre-tests in the fall and post-tests in the spring. Overall, 56% of students report that they know their score on at least one of these tests. Students in the Senior Academy are more likely (74%) to know a score than students in the Prep Academy (41%). Among seniors, each of whom is applying to college, nearly all (95%) know their score. The importance of the tests clearly increases in students' minds as they move through DSST.

Reflections and Recommendations

The range of qualitative and quantitative information collected for this study provides a rich picture of the uses and impacts of 1:1 laptops at the Denver School of Science and Technology. The portrait that emerges is consistently positive. The laptops are used daily by students as learning tools. As a group, DSST teachers have adopted a large and still growing number of instructional, assessment, and administrative practices that take advantage of the unique characteristics of computers and digital media.

The school provides a range of critical support services to its teachers and students, from administrative support and vision statements about how to use technology, to technical support, training, and professional development. This ongoing support from administration and staff promotes teachers' and students' thoughtful use of laptops, the Internet, and other digital technologies in support of DSST's core mission.

As a result of the effort that has and continues to go into implementing the 1:1 laptop program, there is widespread support for the laptops by DSST teachers and students. Large majorities of teachers say that the computers are very important as a teaching tool, an assessment tool, a communication tool, and an administrative tool. Teachers report that computers are essential for doing their work.

Teachers and students believe that the 1:1 laptop program promotes students' learning. Teachers report a range of specific benefits to students, such as increasing students' engagement in school activities, helping students understand the curriculum in greater depth, helping students become more independent as learners, and helping students create higher-quality work products. Students' judgments about the value of the laptops are consistent with the teachers' judgments. Large percentages of students believe that the laptops help them learn more, make school more interesting, and help improve their grades.

Data show that the program helps bridge the digital divide by providing underrepresented students access to computers, computer skills, and sources of information that they did not have equal access to before attending DSST. A faculty member said,

> "The 1:1 laptop program is a critically important element of our college preparatory program. It 'levels the playing field' between students across the economic spectrum. It gives all students access to the same data and develops technological skills essential to higher education and the world of work."

Students and teachers use the laptops for much more than to improve students' computer and information technology skills. Bridging the digital divide is nonetheless an important goal for a school whose charter requires it to serve large numbers of underrepresented students.

A study of one school at a single point in time does not allow policymakers to draw scientifically rigorous causal conclusions (i.e., *this* action leads to *that* result). The fact that teachers, students, and administrators value DSST's 1:1 laptop program highly does not *prove* that the program raises test scores or helps students learn more. Nonetheless, the multiple data sources—classroom observations, interviews, focus groups, and surveys of teachers and students—paint a consistent picture. Such "triangulation" is important because the fact that multiple sources of evidence support one another increases confidence in the findings. The evidence strongly suggests that the laptop

program is contributing in important ways to the DSST community's efforts to reach ambitious goals.

Also, confidence in the findings from this study is supported by results from a variety of other studies. For example, a meta-analysis (re-examination) of 26 studies of writing with computers found that "instructional uses of computers for writing are having a positive impact on student writing, both in terms of quantity and quality."[9] A study of hundreds of schools pointing to the value of thoughtfully using data to inform instruction was cited earlier (page 7). Although a comprehensive review of research on 1:1 laptop programs is far beyond the scope of this study, earlier review articles have noted,

> "We consistently find substantive impacts on teaching and learning, on teachers and students …" "[including] more project-based learning, increased student motivation and experimentation, and higher rates of peer mentoring."[10]

Strengths of DSST's 1:1 Laptop Program

Data presented in this report show that DSST's laptop program is succeeding in many ways. But laptop programs are not successful simply because teachers and students are provided with sophisticated computers. Patterns of teaching, learning, testing, and communication need to change in order for a 1:1 laptop program to work well. The DSST community has clearly worked hard to make this program successful. Technical support; professional development for teachers and training for students; teachers' selections of digital resources and lesson plans; consistent administrative support; investments in hardware, licenses, and support staff; as well as other factors all contribute to this 1:1 program's success.

The Anytime Anywhere Learning Foundation (www.aalf.org) is a non-profit membership association that serves as an advocate for "anytime, anywhere" learning programs based on personal computers. The president of AALF, Bruce Dixon, has written several times about concerns that laptops are not enough, and has asked the question "What if every child had a laptop and nothing changed?" That has happened in some schools. DSST is *not* one of them, as the study data show. Patterns of teaching, learning, and testing at DSST are, in fact, different in significant ways than in non-laptop schools. The two areas about which this study gathered the most fine-grained data, the physics courses and the Benchmark Assessment Program, demonstrate many of the ways in which 1:1 laptops enable educationally significant changes compared to typical, non-laptop high schools.

DSST's decision to develop a Benchmark Assessment Program is one of the many ways in which the school differs from other schools. Writers about educational technology have often focused on changing instruction using computers but fewer have focused educators' attention on the value of computer-based tests (not, of course, to the exclusion of other tests). It is interesting that DSST's assessment program has depended both on administrators, who began it, and on teachers, one of whom first introduced the use of ExamView to the school and many of whom have participated in summer sessions to develop benchmark assessment items. The success of the program depends not only on those two groups but also on the students, who report that they

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[9] Goldberg, Russell, & Cook, op cit.

[10] See: Rockman, S. (2003). Learning from laptops. *Threshold*, **1**:1, 24-28; and, Rockman, S. (2004.) What does the latest research on mobile computing tell us about teachers, students, and testing? http://www.techlearning.com/showArticle.jhtml?articleID=49901145

appreciate the value of the laptops for testing and value the reteach weeks that are guided by data from Interim Assessments administered using ExamView. The use of fine-grained test data as a way to improve instruction and increase student achievement is relatively new. DSST's approach to assessment sets it apart from many schools.

Indeed, the Denver School of Science and Technology is unusual and unusually successful by many measures. Its Colorado Student Assessment Program test scores are among the highest in Denver and the state. In 2007, for example, 67% of DSST tenth graders scored advanced or proficient in mathematics, which was the highest score of any public high school in Denver and more than twice the state average. Similarly, the ACT scores of the eleventh graders tied with Cherry Creek High School as fifth highest in the state, although DSST had more than three times the enrollment of students qualifying for the free and reduced-price lunch program.

DSST is an open enrollment school and as a result, according to teachers, some of the school's students begin high school with third and fourth grade skills. The intensive support provided to students obviously is an important contributor to the school's high test scores and, as noted, DSST is already close to meeting its goal that every senior be admitted to a four-year college. The school has had access to resources that many schools do not have, including the grant from Hewlett Packard that initially funded the 1:1 laptop program. At least as important as the financial resources—and many would argue more important—is the talent pool that the school draws on, including its Board, administration, faculty, and staff.

Some people may believe that these unusual characteristics of DSST mean that there is little that other schools can learn about implementing a 1:1 laptop program from this school's experience. However, there are good reasons to strongly disagree. For example, one of the most important findings is that the school has worked hard to put in place the supports necessary to develop and sustain a successful 1:1 program. The school has a compelling vision of how laptops can contribute to students' and teachers' work. Teachers are encouraged to be innovators and partners in the 1:1 program. The technical support staff shares the school's vision (while in some schools they are more concerned about network security or other issues than about teaching and learning). The school invests in professional development, software licenses, servers, probeware, computer projectors, and other ancillary equipment needed to maximize the utility of the laptops. The laptops themselves, in other words, are part of a complex, interconnected web of devices, networks, activities, and goals whose major purpose is to support the school community's efforts to carry out its ambitious mission. The laptops do not stand alone.

There is, in fact, a kind of paradox about DSST's 1:1 laptop program. If its laptop program disappeared the school would in all likelihood remain an outstanding school, although arguably less excellent. Teaching, learning, assessment, communication, and administration would all be diminished. Data suggest that teachers and students would feel the loss of the laptops acutely.

And yet there is an important lesson in this paradox. A school that sets ambitious goals and aims for excellence is more likely to be able to use laptops well than one without ambitious goals and a school culture that supports reaching them. Computers can be used to reinforce basic skills, including for drill-and-practice in arithmetic and many other fields. Drill can be useful. But that is not where the greatest contributions of computers and the Internet are to be found, nor is that how DSST primarily uses 1:1 laptops. One researcher has written about laptop programs that "…low-SES [low socio-economic-status] students and the schools that serve them were often less prepared

than higher SES students and schools to take advantage of the full capability of laptops,"[11] and documents his claim with useful examples. Yet he and others writing about laptop programs also point to schools serving low-SES students that *are* able to use the laptops well. A focus on schools serving low-SES students is important both because that is part of DSST's charter and because such schools often have difficulty moving beyond a focus on basic skills, as documented in many studies.

Schools that aim to emulate DSST's success, and the successes of other laptop schools, may learn that a 1:1 laptop program *can* be a powerful tool for helping to reach ambitious goals. But the laptop is not some kind of magic wand. It is the support system, the school goals, the digital resources that teachers and students use, and other factors that enable the laptops to be powerful tools. Laptops serve DSST's core mission. The mission statement, reproduced on page 4, does not itself mention laptops. The devices are primarily means, not ends—even though bridging the digital divide by providing access to computers and information resources is itself an important goal for DSST and other schools serving underrepresented students.

The data that show increasing use of and appreciation for the laptops in the upper grades is related to this discussion. One interpretation of these data is reflected in the comment of the teacher (quoted earlier) who said that "students have to learn how to do (lab work) 'old school,' then they start to use the technology more and more." The goals of the curriculum come first, and use of laptops is to support reaching those goals. Sometimes efforts to reach the goals lead to extensive use of laptops, while at other times computers are less important or simply not an appropriate tool.

Challenges

At the same time that DSST's 1:1 laptop program provides many benefits, a number of challenges, problems, and barriers to success have also been identified—as they have been in earlier studies of laptop programs. However, *any* school program faces challenges, whether it is instituting a new schedule, or using a new textbook. In that respect, laptop programs are no different than others.

More than many school programs, however, laptop programs cost substantial amounts of money. This study was not commissioned to investigate the costs of DSST's 1:1 program. Costs are the focus of a separate study being conducted by members of DSST's Board of Directors.

The study data also point to a number of other challenges:

- Managing the computers in the classroom requires time and energy. Sometimes, what is needed is as simple as asking students to put the laptop screens down. Teachers also need to be flexible if laptops, software, or the network are not working. More significantly, teachers need to learn or develop new ways to teach that take advantage of the 1:1 laptops. Such learning takes time.
- Because software programs are complex, and because there are useful new software features and applications available every year, there is always more for teachers to learn about using computers well in the classroom.
- There is a constant challenge to keep laptops in good working condition. Maintenance needs are ongoing; indeed, these problems get more challenging as the machines age.

[11] Warschauer, M. (2006). *Laptops and literacy: Learning in the wireless classroom.* New York: Teachers College Press, p. 148.

- Students may confuse access to information with understanding information they find. As noted earlier, this is a problem that occurs in non-laptop schools, too. However, the challenge may be greater in laptop schools, where Internet searches by a substantial number of students are a daily event.

These and other findings of the laptop study may help DSST's leaders to develop steps to further improve what is already a successful 1:1 program.

Conclusion

The Denver School of Science and Technology has established ambitious goals and in many ways is on its way to meeting them. Evidence collected for this study shows that the laptop program provides important contributions to the school community's efforts to reach its goals. The DSST 1:1 laptop program—which has been operating for less than four years, like the school itself—is off to an excellent start and provides a good model for other schools. Increasingly, technology is being viewed by policymakers as a powerful tool schools can use to transform teaching, learning, assessment, communication, and administration.[12] The Denver School of Science and Technology is demonstrating many different ways that laptops and related technology are used to make schools more engaging, relevant, modern, and effective institutions.

[12] Zucker, A. A. (2008). *Transforming Schools with Technology: How Smart Use of Digital Tools Helps Achieve Six Key Education Goals*. Cambridge, MA: Harvard Education Press.

Appendices

A. Student survey

B. Teacher survey

DSST Student Survey

1. The year BEFORE you came to DSST and received your own laptop, how often did YOU use technology in school?

	Never	Every few months	About once a month	About once a week	Nearly every day	Response Count
In the classroom	**34.5% (112)**	18.5% (60)	19.1% (62)	17.2% (56)	10.8% (35)	325
In the computer lab	6.3% (20)	13.7% (43)	21.3% (67)	**37.5% (118)**	21.3% (67)	315
In technology/computer class	18.6% (58)	8.0% (25)	9.3% (29)	18.9% (59)	**45.2% (141)**	312
In the library	19.3% (60)	20.9% (65)	20.3% (63)	**28.6% (89)**	10.9% (34)	311
					answered question	**328**
					skipped question	**0**

2. The year before you came to DSST, how often did YOUR TEACHER use technology in school?

	Never	Every few months	About once a month	About once a week	Nearly every day	Response Count
In English/language arts/literacy	21.2% (69)	11.0% (36)	12.6% (41)	17.8% (58)	**37.4% (122)**	326
In science	14.2% (45)	9.8% (31)	15.1% (48)	21.8% (69)	**39.1% (124)**	317
In social studies / history	22.8% (71)	9.3% (29)	14.8% (46)	16.7% (52)	**36.3% (113)**	311
In math	**30.5% (95)**	12.9% (40)	8.7% (27)	17.4% (54)	**30.5% (95)**	311
In "specials" like P.E., art, and music	**50.0% (155)**	11.9% (37)	9.4% (29)	11.6% (36)	17.1% (53)	310
					answered question	**328**
					skipped question	**0**

3. The year before you came to DSST, how often did you use a computer FOR SCHOOL ASSIGNMENTS?

	Never	Every few months	About once a month	About once a week	Nearly every day	Response Count
In English/language arts/literacy	14.6% (48)	18.9% (62)	19.8% (65)	**30.5% (100)**	16.2% (53)	328
In science	**26.0% (82)**	19.4% (61)	20.6% (65)	22.5% (71)	11.4% (36)	315
In social studies / history	19.8% (62)	19.8% (62)	22.7% (71)	**23.6% (74)**	14.1% (44)	313
In math	**53.4% (167)**	16.3% (51)	10.5% (33)	11.5% (36)	8.3% (26)	313
In "specials" like P.E., art, and music	**69.2% (213)**	10.1% (31)	6.8% (21)	9.1% (28)	4.9% (15)	308
					answered question	**328**
					skipped question	**0**

4. Before you came to DSST, which of the following statements was true about you?

	Response Percent	Response Count
I never used computers	0.6%	2
I rarely used computers	34.5%	112
I used computers often	**39.1%**	127
I used computers all the time	25.8%	84
	answered question	**325**
	skipped question	**3**

5. Which of the following statements were true of you before you came to DSST? (select ALL that apply)

	Response Percent	Response Count
I was not interested in computers	30.4%	31
I did not have access to computers at home	34.3%	35
I did not have access to computers at school	30.4%	31
I was too busy with other things to spend time using computers	**61.8%**	63
	answered question	**102**
	skipped question	**226**

6. Now that you have your own laptop at DSST, do you enjoy using computer technology?

	Response Percent	Response Count
Yes	**91.4%**	106
No	8.6%	10
	Why or why not?	108
	answered question	**116**
	skipped question	**212**

7. Where did you use computer technology before you came to DSST? (select all that apply)

	Response Percent	Response Count
At the library	58.7%	121
At an afterschool program	9.2%	19
At home	**93.7%**	193
At school	66.0%	136
At a friend/family member's house	51.9%	107
	answered question	**206**
	skipped question	**122**

8. Before you came to DSST, how skilled were you with the following technology tasks?

	I never tried this	Not too good	Pretty good	Very good	Response Count
Internet search	1.0% (2)	3.3% (7)	34.0% (71)	**62.7% (131)**	209
Email	2.9% (6)	7.7% (16)	28.7% (60)	**60.8% (127)**	209
Word processing	3.4% (7)	7.7% (16)	31.4% (65)	**58.9% (122)**	207
Spreadsheets	13.9% (29)	28.4% (59)	**33.7% (70)**	27.4% (57)	208
Powerpoint presentations	6.3% (13)	17.8% (37)	**40.9% (85)**	36.1% (75)	208
Editing photos	19.3% (40)	**29.5% (61)**	28.0% (58)	25.1% (52)	207
Editing/creating music	**35.9% (75)**	24.9% (52)	21.5% (45)	19.6% (41)	209
Editing/creating video	**34.6% (72)**	26.9% (56)	22.6% (47)	16.8% (35)	208

Designing web pages	**39.9% (83)**	25.5% (53)	24.5% (51)	13.9% (29)	208
Programming a computer	**51.2% (107)**	21.1% (44)	19.6% (41)	11.0% (23)	209
				answered question	**209**
				skipped question	**119**

9. Now that you have your own laptop at school, how often do you use computers FOR SCHOOL ASSIGNMENTS in the following subjects (e.g., homework problems, written papers, lab reports)?

	Never	Every few months	About once a month	About once a week	Nearly every day	Response Count
English or Humanities	1.6% (5)	0.3% (1)	0.6% (2)	7.9% (25)	**89.6% (285)**	318
Science	1.3% (4)	0.0% (0)	2.2% (7)	21.0% (66)	**75.6% (238)**	315
History	7.7% (24)	1.0% (3)	0.6% (2)	9.0% (28)	**81.6% (253)**	310
Spanish	4.8% (15)	2.6% (8)	7.1% (22)	24.4% (76)	**61.1% (190)**	311
Math	3.8% (12)	1.0% (3)	3.2% (10)	13.1% (41)	**79.0% (248)**	314
"Specials" like art, P.E., and music	30.1% (93)	4.2% (13)	7.8% (24)	19.1% (59)	**38.8% (120)**	309
					answered question	**317**
					skipped question	**11**

10. Now that you have your own laptop at school, how often do you use computers IN CLASS in the following subjects?						
	Never	**Every few months**	**About once a month**	**About once a week**	**Nearly every day**	**Response Count**
English or Humanities	1.6% (5)	0.3% (1)	0.0% (0)	8.2% (26)	**89.9% (284)**	316
Science	1.0% (3)	0.3% (1)	1.3% (4)	16.2% (51)	**81.3% (256)**	315
History	8.1% (25)	1.0% (3)	1.0% (3)	5.2% (16)	**84.7% (260)**	307
Spanish	6.1% (19)	1.6% (5)	6.1% (19)	21.5% (67)	**64.6% (201)**	311
Math	2.5% (8)	1.6% (5)	2.9% (9)	9.6% (30)	**83.4% (262)**	314
"Specials" like art, P.E., and music	27.3% (84)	4.5% (14)	7.1% (22)	17.2% (53)	**43.8% (135)**	308
					answered question	**315**
					skipped question	**13**

11. How skilled are you TODAY with the following technology tasks?

	I never tried this	Not too good	Pretty good	Very good	Response Count
Internet search	0.6% (2)	0.9% (3)	21.5% (68)	**77.0% (244)**	317
Email	0.3% (1)	2.2% (7)	17.0% (54)	**80.4% (255)**	317
Word processing	1.6% (5)	3.8% (12)	19.9% (63)	**74.8% (237)**	317
Spreadsheets	4.1% (13)	10.1% (32)	34.2% (108)	**51.6% (163)**	316
Powerpoint presentations	0.9% (3)	4.7% (15)	23.1% (73)	**71.2% (225)**	316
Editing photos	9.5% (30)	12.0% (38)	33.2% (105)	**45.3% (143)**	316
Editing/creating music	21.5% (68)	22.5% (71)	26.9% (85)	**29.1% (92)**	316
Editing/creating video	23.3% (74)	22.7% (72)	**27.4% (87)**	26.5% (84)	317
Designing web pages	**27.8% (88)**	26.9% (85)	23.4% (74)	21.8% (69)	316
Programming a computer	**35.5% (111)**	29.4% (92)	19.5% (61)	15.7% (49)	313
				answered question	**316**
				skipped question	**12**

12. Thinking about your classes overall, what effect have laptops had in each of these areas? (A positive effect means technology has improved your interest, etc.)					
	Very positive	**Somewhat positive**	**Somewhat negative**	**Very negative**	**Response Count**
a) How much you learn from school	**65.4% (208)**	28.6% (91)	4.7% (15)	1.3% (4)	318
b) How well you work with other students	**49.1% (156)**	40.6% (129)	7.9% (25)	2.5% (8)	318
c) How well you stay focused in class	18.9% (60)	**45.1% (143)**	28.4% (90)	7.6% (24)	317
d) How interested you are in homework	35.1% (111)	**40.2% (127)**	12.0% (38)	12.7% (40)	316
e) How interesting your classes are	**51.4% (162)**	36.8% (116)	8.3% (26)	3.5% (11)	315
f) How interested you are in learning this year	**51.6% (163)**	38.3% (121)	6.6% (21)	3.5% (11)	316
g) Your grades	40.6% (129)	**42.1% (134)**	11.0% (35)	6.3% (20)	318
h) How well behaved other students are	21.4% (67)	**43.1% (135)**	24.9% (78)	10.5% (33)	313
				answered question	**317**
				skipped question	**11**

13. What has been the most helpful use of technology by teachers at DSST?		
		Response Count
		309
	answered question	**309**
	skipped question	**19**

14. Which technology project or assignment have you been most proud of? Tell us about it.		
		Response Count
		301
	answered question	**301**
	skipped question	**27**

15. What science course are you taking this year?

	Response Percent	Response Count
Biology	24.8%	79
Chemistry	27.0%	86
Physics I (9th grade)	**30.2%**	96
Advanced or AP Physics (12th grade)	11.3%	36
Environmental Bio or Bioscience	6.0%	19
Computer science	0.9%	3
	answered question	**318**
	skipped question	**10**

16. How helpful was the school's introduction to using your laptop computer?

	Response Percent	Response Count
Not helpful	9.6%	9
Somewhat helpful	44.7%	42
Very helpful	**45.7%**	43
	answered question	**94**
	skipped question	**234**

17. For your PHYSICS class, how often do you use your laptop for these topics?

	Never	Every few months	About once a month	About once a week	Nearly every day	Response Count
Do arithmetic or number operations [For example: 3624 / 12 + (423*3 -2)]	**43.4% (56)**	6.2% (8)	10.1% (13)	24.8% (32)	15.5% (20)	129
Collect data (e.g., temperature or motion)	1.6% (2)	3.1% (4)	9.3% (12)	**58.9% (76)**	27.1% (35)	129
Analyze data (For example: Look at graphs and figure out the meaning)	3.1% (4)	1.6% (2)	3.1% (4)	**50.8% (65)**	41.4% (53)	128
Visualize a scientific phenomenon (For example: Watch a movie)	17.8% (23)	10.9% (14)	**32.6% (42)**	23.3% (30)	15.5% (20)	129
Do a computer simulated experiment (e.g., explore waves)	12.4% (16)	11.6% (15)	22.5% (29)	**31.8% (41)**	21.7% (28)	129
Communicate or work with others (For example: Explain your reasoning in writing or work with a classmate on a project)	7.0% (9)	10.9% (14)	12.5% (16)	**36.7% (47)**	32.8% (42)	128
Search for information (For example: Web search)	8.5% (11)	9.3% (12)	13.2% (17)	34.1% (44)	**34.9% (45)**	129
Use a word processor	10.2% (13)	4.7% (6)	11.7% (15)	35.2% (45)	**38.3% (49)**	128
Use Exam View to answer questions	2.3% (3)	2.3% (3)	13.2% (17)	**58.1% (75)**	24.0% (31)	129
					answered question	**129**
					skipped question	**199**

18. This question is about using your laptop outside of school. Select ALL the statements that are true for you.

	Response Percent	Response Count
I have someone who can help me when my computer is not working at home.	52.8%	150
I share my computer with others when I am at home.	26.8%	76
I use email or the Internet to get help with homework.	**84.5%**	240
	answered question	**284**
	skipped question	**44**

19. How is your access to the Internet at home?

	Response Percent	Response Count
I have no Internet at home, or very limited Internet.	25.7%	81
I have good or excellent Internet at home.	**74.3%**	234
	answered question	**315**
	skipped question	**13**

20. How important would it be to you if you had a good Internet connection at home?

	Response Percent	Response Count
Not very important	2.5%	2
Somewhat important	13.6%	11
Very important	**84.0%**	68
	answered question	**81**
	skipped question	**247**

21. How often do you use Exam View to take a test or answer questions on your computer?

	Response Percent	Response Count
Never	0.6%	2
Every few months	1.3%	4
About once a month	7.1%	22
About once a week	**70.1%**	218
Nearly every day	20.9%	65
	answered question	**311**
	skipped question	**17**

22. There are "reteach weeks" at DSST several times each year. How helpful have these been to you?			
		Response Percent	Response Count
Very helpful		**43.9%**	137
Somewhat helpful		34.6%	108
A little bit helpful		14.7%	46
Not helpful		6.7%	21
	answered question		**312**
	skipped question		**16**

23. DSST students take the Explore, Plan, and ACT tests. Do you know your score on any of these tests?			
		Response Percent	Response Count
Yes		**55.8%**	174
No		44.2%	138
	answered question		**312**
	skipped question		**16**

24. Do you prefer taking tests on paper or on a computer?

	Response Percent	Response Count
MUCH prefer paper	7.1%	22
Slightly prefer paper	11.9%	37
It doesn't matter	27.6%	86
Slightly prefer computer	16.3%	51
MUCH prefer computer	**37.2%**	116
	answered question	**312**
	skipped question	**16**

25. What is your gender?

	Response Percent	Response Count
Female	46.8%	146
Male	**53.2%**	166
	answered question	**312**
	skipped question	**16**

26. How would you describe your race/ethnicity? Select all that apply.

	Response Percent	Response Count
African American/Black	36.1%	112
Hispanic/Latino/a/ Chicano/a	29.4%	91
Caucasian/White	**45.2%**	140
Asian/Pacific Islander	6.1%	19
Native American	8.4%	26
	answered question	**310**
	skipped question	**18**

DSST Teacher Survey

1. On average, how often do you integrate technology into your instruction?

	Daily	A few times per week	About once a week	A couple of times per month	About once a month	Rarely/never	Response Count
Students are asked to use laptops in class or for homework.	**50.0% (15)**	**50.0% (15)**	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	30
A computer projector is used in class.	**58.6% (17)**	37.9% (11)	3.4% (1)	0.0% (0)	0.0% (0)	0.0% (0)	29
Students use graphing calculators, probes, or other computer-related tools.	20.0% (6)	16.7% (5)	13.3% (4)	3.3% (1)	3.3% (1)	**43.3% (13)**	30
Students us a computer "drop box", email or a course web page for assignments.	**43.3% (13)**	26.7% (8)	23.3% (7)	3.3% (1)	0.0% (0)	3.3% (1)	30
Students use ExamView or other software to answer test or survey questions.	6.7% (2)	23.3% (7)	**36.7% (11)**	20.0% (6)	0.0% (0)	13.3% (4)	30
Students access server files.	**53.3% (16)**	40.0% (12)	6.7% (2)	0.0% (0)	0.0% (0)	0.0% (0)	30
I monitor students' use of laptops using SynchronEyes or other software.	0.0% (0)	6.7% (2)	0.0% (0)	3.3% (1)	0.0% (0)	**90.0% (27)**	30
						answered question	**30**
						skipped question	**0**

2. How frequently do your students use educational technology to do the following activities?

	Daily	A few times per week	About once a week	A couple of times per month	About once a month	Rarely/never	Response Count
Complete practice drills	10.0% (3)	23.3% (7)	23.3% (7)	**26.7% (8)**	0.0% (0)	16.7% (5)	30
Solve problems/Analyze data	13.8% (4)	**24.1% (7)**	**24.1% (7)**	17.2% (5)	0.0% (0)	20.7% (6)	29
Present information graphically	13.3% (4)	3.3% (1)	13.3% (4)	**43.3% (13)**	0.0% (0)	26.7% (8)	30
Produce multiimedia reports/projects	0.0% (0)	3.3% (1)	20.0% (6)	**36.7% (11)**	20.0% (6)	20.0% (6)	30
Do research on the internet	6.7% (2)	23.3% (7)	**36.7% (11)**	13.3% (4)	6.7% (2)	13.3% (4)	30
Use an electronic textbook	**33.3% (10)**	20.0% (6)	6.7% (2)	3.3% (1)	3.3% (1)	**33.3% (10)**	30
Develop or add to wikis	0.0% (0)	0.0% (0)	3.3% (1)	6.7% (2)	3.3% (1)	**86.7% (26)**	30
Correspond with experts, authors, students from other schools, etc. via the internet and email	0.0% (0)	0.0% (0)	0.0% (0)	7.1% (2)	3.6% (1)	**89.3% (25)**	28
Express themselves in writing	23.3% (7)	**33.3% (10)**	26.7% (8)	3.3% (1)	3.3% (1)	10.0% (3)	30
Create or use podcasts	0.0% (0)	0.0% (0)	3.4% (1)	6.9% (2)	3.4% (1)	**86.2% (25)**	29
Create/modify web pages	0.0% (0)	3.3% (1)	3.3% (1)	0.0% (0)	6.7% (2)	**86.7% (26)**	30
Work on their Digital Portfolio	3.3% (1)	3.3% (1)	0.0% (0)	6.7% (2)	13.3% (4)	**73.3% (22)**	30
						answered question	**30**
						skipped question	**0**

3. Please indicate your level of agreement with the following statements. As a result of using educational technology in teaching,						
	Strongly disagree	**Disagree**	**Agree**	**Strongly agree**	**Not applicable**	**Response Count**
I am more reflective about basic teaching goals and priorities.	0.0% (0)	16.7% (5)	**53.3% (16)**	26.7% (8)	3.3% (1)	30
I have students work independently more, to explore a topic on their own or to revise their own work.	0.0% (0)	20.0% (6)	**43.3% (13)**	33.3% (10)	3.3% (1)	30
I feel like I give up too much instructional responsibility to the computer software, like I'm not really teaching.	**46.7% (14)**	40.0% (12)	10.0% (3)	3.3% (1)	0.0% (0)	30
Often too many students need my help at the same time.	10.3% (3)	**69.0% (20)**	10.3% (3)	10.3% (3)	0.0% (0)	29
I have changed the way I organize classroom activities.	0.0% (0)	3.3% (1)	43.3% (13)	**50.0% (15)**	3.3% (1)	30
I rely less on textbooks.	6.7% (2)	20.0% (6)	**33.3% (10)**	30.0% (9)	10.0% (3)	30
I am better able to meet the needs of students with varying needs (e.g. struggling students and "gifted" students).	0.0% (0)	10.0% (3)	**46.7% (14)**	40.0% (12)	3.3% (1)	30
					answered question	**30**
					skipped question	**0**

4. Please rate the importance of computer technology for you personally in each of the following areas:

	Not at all important	Not too important	Somewhat important	Very important	Response Count
Administrative functions, such as attendance, giving tests, and grading.	3.3% (1)	0.0% (0)	13.3% (4)	**83.3% (25)**	30
Communication with other teachers, administrators, and students.	0.0% (0)	0.0% (0)	20.0% (6)	**80.0% (24)**	30
Communication with parents.	3.3% (1)	0.0% (0)	23.3% (7)	**73.3% (22)**	30
To research information for preparing lessons.	0.0% (0)	6.7% (2)	26.7% (8)	**66.7% (20)**	30
As a teaching tool for use with students.	0.0% (0)	0.0% (0)	16.7% (5)	**83.3% (25)**	30
As an assessment tool for use with students.	0.0% (0)	6.7% (2)	16.7% (5)	**76.7% (23)**	30
				answered question	**30**
				skipped question	**0**

5. To what extent is educational technology essential to your teaching practice?

	Response Percent	Response Count
Not at all essential	0.0%	0
Somewhat essential	33.3%	10
Essential	30.0%	9
Extremely essential	**36.7%**	11
	answered question	**30**
	skipped question	**0**

6. Overall, how important do you believe DSST's laptop program is for students?

	Response Percent	Response Count
Not at all important	0.0%	0
Not very important	3.3%	1
Somewhat important	30.0%	9
Very important	**66.7%**	20
	answered question	**30**
	skipped question	**0**

7. Please indicate the extent to which you agree or disagree with the following statements.						
	Strongly disagree	**Disagree**	**Agree**	**Strongly agree**	**Not applicable/don't know**	**Response Count**
My school's administration supports the use of technology in the classroom.	0.0% (0)	3.3% (1)	10.0% (3)	**86.7% (26)**	0.0% (0)	30
The use of classroom technology helps prepare my students for the 21st century work world.	0.0% (0)	3.3% (1)	16.7% (5)	**80.0% (24)**	0.0% (0)	30
Computers help encourage my students to think creatively.	0.0% (0)	10.0% (3)	**60.0% (18)**	26.7% (8)	3.3% (1)	30
Having computers in the classroom enables me to do more one-on-one teaching with students.	0.0% (0)	**33.3% (10)**	**33.3% (10)**	26.7% (8)	6.7% (2)	30
With computers, my students have increased opportunities to apply their knowledge.	0.0% (0)	3.3% (1)	**70.0% (21)**	26.7% (8)	0.0% (0)	30
					answered question	**30**
					skipped question	**0**

8. To what extent do you agree or disagree with the following statements regarding student assessment? Computer technology has been valuable for assessing students' work because:						
	Strongly disagree	**Disagree**	**Agree**	**Strongly agree**	**No experience or not applicable**	**Response Count**
Students' products are electronic, so it is easier to grade or assess them.	3.4% (1)	20.7% (6)	**37.9% (11)**	34.5% (10)	3.4% (1)	29
My feedback to students is more rapid or timely.	0.0% (0)	23.3% (7)	33.3% (10)	**43.3% (13)**	0.0% (0)	30
My feedback to students is more detailed and complete.	3.3% (1)	33.3% (10)	**43.3% (13)**	20.0% (6)	0.0% (0)	30
My feedback to students is provided more often.	3.3% (1)	23.3% (7)	**50.0% (15)**	23.3% (7)	0.0% (0)	30
					answered question	**30**
					skipped question	**0**

9. Do you prefer testing students using a computer or on paper?

	Response Percent	Response Count
I MUCH prefer paper tests.	13.3%	4
I slightly prefer paper tests.	26.7%	8
It doesn't matter to me.	13.3%	4
I slightly prefer computer tests.	**30.0%**	9
I MUCH prefer computer tests.	16.7%	5
	answered question	**30**
	skipped question	**0**

10. What do you think about student "re-teach weeks" at DSST?

	Response Percent	Response Count
They are very important/helpful for students at DSST	40.7%	11
They are somewhat important/helpful for students at DSST	**48.1%**	13
They are slightly important/helful for students at DSST.	11.1%	3
They are not important/not helpful for students at DSST.	0.0%	0
	Other (please specify)	4
	answered question	**27**

	skipped question	**3**

11. Please indicate your level of competency in the following areas:

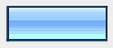
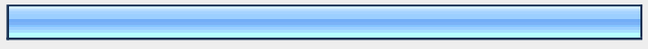
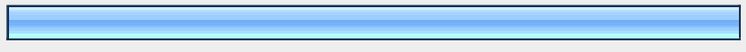
	Not at all competent	Slightly competent	Competent	Highly competent	Don't know	Response Count
Integrating computers into lessons.	0.0% (0)	13.3% (4)	**43.3% (13)**	**43.3% (13)**	0.0% (0)	30
Using instructional software.	0.0% (0)	30.0% (9)	33.3% (10)	**36.7% (11)**	0.0% (0)	30
Using technology to develop students' critical thinking skills.	0.0% (0)	24.1% (7)	**65.5% (19)**	10.3% (3)	0.0% (0)	29
Technology tools such as presentation software, spreadsheets, and the internet.	3.3% (1)	13.3% (4)	26.7% (8)	**56.7% (17)**	0.0% (0)	30
Data tools for student assessment and evaluation.	0.0% (0)	30.0% (9)	**40.0% (12)**	30.0% (9)	0.0% (0)	30
				answered question		**30**
				skipped question		**0**

12. Please indicate to what extent, if any, the following issues create barriers to your use of educational technology.

	Large barrier	Moderate barrier	Small barrier	Not a barrier	Not Applicable	Response Count
Difficulty managing so many students using computers at one time.	3.3% (1)	30.0% (9)	**53.3% (16)**	13.3% (4)	0.0% (0)	30
Concern about student access to inappropriate materials on the Web.	3.3% (1)	**43.3% (13)**	40.0% (12)	13.3% (4)	0.0% (0)	30
The school has not acquired or licensed appropriate software resources.	6.7% (2)	16.7% (5)	16.7% (5)	**50.0% (15)**	10.0% (3)	30
There is a lack of educationally relevant software and websites allgined with our curriculum standards.	3.3% (1)	13.3% (4)	23.3% (7)	**53.3% (16)**	6.7% (2)	30
I don't have time to develop the activities/lessons that use technology.	10.3% (3)	31.0% (9)	**41.4% (12)**	17.2% (5)	0.0% (0)	29
There is a lack of support from the administration.	0.0% (0)	6.7% (2)	6.7% (2)	**83.3% (25)**	3.3% (1)	30
There is a lack of support/advice/training for educational technology use.	10.7% (3)	10.7% (3)	**39.3% (11)**	**39.3% (11)**	0.0% (0)	28
I do not have enough release time to learn, practice, or plan how to use technology well.	20.0% (6)	23.3% (7)	**43.3% (13)**	13.3% (4)	0.0% (0)	30
Computers or the network not sufficiently reliable	6.7% (2)	6.7% (2)	36.7% (11)	**50.0% (15)**	0.0% (0)	30
					answered question	**30**

	skipped question	**0**

13. Since you began teaching, has computer technology changed the way you teach?

		Response Percent	Response Count
Not at all		6.7%	2
Very little		0.0%	0
Yes, somewhat		43.3%	13
Yes, a great deal		**50.0%**	15
	answered question		**30**
	skipped question		**0**

14. Please indicate the degree to which you agree or disagree to the following statements. As a result of using educational technology in teaching,						
	Strongly disagree	**Disagree**	**Agree**	**Strongly agree**	**Not Applicable**	**Response Count**
I need longer blocks of instructional time.	6.7% (2)	**66.7% (20)**	16.7% (5)	6.7% (2)	3.3% (1)	30
Students work more collaboratively with one another.	0.0% (0)	46.7% (14)	**50.0% (15)**	0.0% (0)	3.3% (1)	30
I more often find myself in the role of coach or advisor in the classroom.	6.7% (2)	30.0% (9)	**50.0% (15)**	10.0% (3)	3.3% (1)	30
Students get so wound up, it is difficult to get them to settle down.	**41.4% (12)**	**41.4% (12)**	10.3% (3)	3.4% (1)	3.4% (1)	29
I have gained skill in orchestrating multiple, parallel classroom activities.	3.3% (1)	23.3% (7)	**56.7% (17)**	13.3% (4)	3.3% (1)	30
Students can cheat more easily, e.g. by copying work and turning it in as their own.	10.3% (3)	**34.5% (10)**	**34.5% (10)**	17.2% (5)	3.4% (1)	29
					answered question	**30**
					skipped question	**0**

15. Please provide a general assessment of your students' technology skills.

	Most students have advanced skills	Most students have basic skills	Most students do NOT have basic skills	I don't know	Response Count
Computers in general	26.7% (8)	**73.3% (22)**	0.0% (0)	0.0% (0)	30
Word processing programs (e.g. Microsoft Word, Word Perfect, Apple Works)	33.3% (10)	**60.0% (18)**	6.7% (2)	0.0% (0)	30
Spreadsheet programs	0.0% (0)	**70.0% (21)**	23.3% (7)	6.7% (2)	30
Internet browsers	**56.7% (17)**	43.3% (13)	0.0% (0)	0.0% (0)	30
Email programs	**63.3% (19)**	33.3% (10)	3.3% (1)	0.0% (0)	30
OneNote and other tablet applications	21.4% (6)	**39.3% (11)**	35.7% (10)	3.6% (1)	28
Accessing the server	**46.7% (14)**	43.3% (13)	10.0% (3)	0.0% (0)	30
Using simulation software and applications	10.0% (3)	**50.0% (15)**	16.7% (5)	23.3% (7)	30
Presentation software (e.g., PowerPoint)	26.7% (8)	**60.0% (18)**	13.3% (4)	0.0% (0)	30
				answered question	**30**
				skipped question	**0**

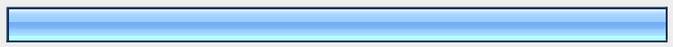
16. In the past 12 months, have you participated in any formal (classroom) or informal (video based, computer based, etc.) professional development activities that focused on uses of computers for instruction?

	Response Percent	Response Count
Yes	**66.7%**	20
No	33.3%	10
	answered question	**30**
	skipped question	**0**

17. In the past 12 months, how many hours did you spend on these technology-related professional development activities?

	Response Percent	Response Count
8 hrs or less	**60.0%**	12
9-16 hours	30.0%	6
17-32 hours	10.0%	2
33 hours or more	0.0%	0
	answered question	**20**
	skipped question	**10**

18. Overall, how useful were these activities to you?

		Response Percent	Response Count
Not useful		0.0%	0
Somewhat useful		**50.0%**	10
Useful		45.0%	9
Very useful		5.0%	1
	answered question		**20**
	skipped question		**10**

19. What as the most important thing you learned in the technology-related professional development?

	Response Count
	18
answered question	**18**
skipped question	**12**

20. Please indicate the extent to which you agree or disagree with the following statements about DSST.

	Strongly disagree	Disagree	Agree	Strongly agree	Response Count
The principal lets staff members know what is expected of them.	0.0% (0)	6.7% (2)	40.0% (12)	**53.3% (16)**	30
The school administration's behavior toward the staff is supportive and encouraging.	0.0% (0)	0.0% (0)	40.0% (12)	**60.0% (18)**	30
The level of student misbehavior in this school interferes with my teaching.	36.7% (11)	**50.0% (15)**	10.0% (3)	3.3% (1)	30
Necessary materials such as textbooks, supplies, and copy machines are available as needed by the faculty and staff.	3.3% (1)	13.3% (4)	**56.7% (17)**	26.7% (8)	30
I receive a great deal of support from parents for the work I do.	0.0% (0)	33.3% (10)	**63.3% (19)**	3.3% (1)	30
My principal enforces school rules for student conduct and backs me up when I need it.	0.0% (0)	3.3% (1)	30.0% (9)	**66.7% (20)**	30
Most of my colleagues share my beliefs and values about what the central mission of the school should be.	0.0% (0)	0.0% (0)	33.3% (10)	**66.7% (20)**	30
There is a great deal of cooperative effort among the staff members.	0.0% (0)	3.3% (1)	30.0% (9)	**66.7% (20)**	30
I am given the support I need to teach students with special needs.	3.4% (1)	34.5% (10)	**51.7% (15)**	10.3% (3)	29
I make a conscious effort to coordinate the content of my	0.0% (0)	17.2% (5)	**55.2% (16)**	27.6% (8)	29

courses with that of other teachers.					
The amount of student tardiness and class cutting in this school interferes with my teaching.	**46.7% (14)**	33.3% (10)	13.3% (4)	6.7% (2)	30
I am generally satisfied with being a teacher at this school.	0.0% (0)	3.3% (1)	46.7% (14)	**50.0% (15)**	30
				answered question	**30**
				skipped question	**0**

21. Please indicate the changes (or lack of change) you have noticed in students that may be related to increased use of educational technology.

	Decrease	Slight decrease	No change	Slight increase	Increase	Not Applicable/Don't know	Response Count
The breadth of students' understanding of the subjects taught.	0.0% (0)	0.0% (0)	6.7% (2)	**46.7% (14)**	36.7% (11)	10.0% (3)	30
The depth of students' understanding of subjects taught.	0.0% (0)	0.0% (0)	6.7% (2)	30.0% (9)	**56.7% (17)**	6.7% (2)	30
The amount of time students spend working with other students.	0.0% (0)	3.3% (1)	**33.3% (10)**	**33.3% (10)**	20.0% (6)	10.0% (3)	30
Students' independence as learners.	0.0% (0)	0.0% (0)	6.7% (2)	**46.7% (14)**	40.0% (12)	6.7% (2)	30
Students' engagement in activities.	0.0% (0)	3.3% (1)	10.0% (3)	30.0% (9)	**50.0% (15)**	6.7% (2)	30
The quality of products students are able to create.	0.0% (0)	0.0% (0)	10.0% (3)	26.7% (8)	**60.0% (18)**	3.3% (1)	30
The quality of students' writing.	0.0% (0)	0.0% (0)	26.7% (8)	**33.3% (10)**	26.7% (8)	13.3% (4)	30
The amount of initiative students							

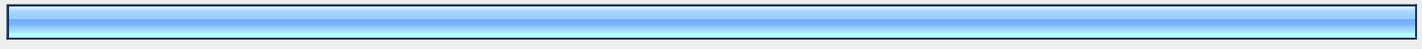
take outside class, e.g. doing extra research.	0.0% (0)	0.0% (0)	10.0% (3)	**50.0% (15)**	23.3% (7)	16.7% (5)	30
Students' achievement on state or district assessments.	0.0% (0)	0.0% (0)	6.7% (2)	13.3% (4)	**43.3% (13)**	36.7% (11)	30
Students' research skills.	0.0% (0)	0.0% (0)	6.7% (2)	**43.3% (13)**	33.3% (10)	16.7% (5)	30
Students' problem-solving skills.	0.0% (0)	0.0% (0)	**37.9% (11)**	31.0% (9)	13.8% (4)	17.2% (5)	29
The opportunity for students with special needs to participate meaningfully in the curriculum.	0.0% (0)	0.0% (0)	13.3% (4)	**40.0% (12)**	30.0% (9)	16.7% (5)	30
						answered question	**30**
						skipped question	**0**

22. Please indicate which of the following are major disadvantages of using educational technology in teaching.

	A major disadvantage	Not a major disadvantage	Response Count
The gap between "gifted" and other students is widening.	14.3% (4)	**85.7% (24)**	28
Students confuse quality of presentation with quality of content.	39.3% (11)	**60.7% (17)**	28
Students are able to hide their lack of knowledge in a subject with the aid of technology.	29.6% (8)	**70.4% (19)**	27
Students confuse finding information about a topic on the Internet with understanding of the topic.	**55.2% (16)**	44.8% (13)	29
English language learners (ELLs) are intimidated by the level of	25.0% (7)	**75.0% (21)**	28

English on the Internet.			
Students only want to focus on the area of the project that involves the Internet and computers.	44.8% (13)	**55.2% (16)**	29
Technology interferes with the teacher/student relationship.	10.3% (3)	**89.7% (26)**	29
It is difficult to monitor student activity on the Internet.	**62.1% (18)**	37.9% (11)	29
In general, teachers and students become too dependent on educational technology. When technology breaks down, they are lost.	34.5% (10)	**65.5% (19)**	29
Students without home Internet access are at a serious disadvantage.	**65.5% (19)**	34.5% (10)	29
	answered question		**29**
	skipped question		**1**

23. Are students allowed to use their laptops at any time during class, or only when specifically permitted to do so?

		Response Percent	Response Count
Any time		3.4%	1
Only when permitted		**96.6%**	28
	answered question		**29**
	skipped question		**1**

24. Which computer activities are discouraged in your classroom?				
	Forbidden	**Discouraged**	**Allowed**	**Response Count**
Instant messaging	**89.7% (26)**	10.3% (3)	0.0% (0)	29
Email	**51.7% (15)**	44.8% (13)	3.4% (1)	29
All activities not related to the course	**62.1% (18)**	37.9% (11)	0.0% (0)	29
			answered question	**29**
			skipped question	**1**

25. For a typical class, how often do you need to ask or tell a student(s) to stop using a computer for off-task activities?			
		Response Percent	**Response Count**
Never, or almost never		0.0%	0
About once a week		41.4%	12
About once each period		**44.8%**	13
More than once each period		13.8%	4
	answered question		**29**
	skipped question		**1**

26. Sometimes students do not have a working laptop with them when they come to class. How much of a problem has that posed for you as a teacher?

	Response Percent	Response Count
A serious problem	20.7%	6
A minor problem	**75.9%**	22
Hardly a problem at all	3.4%	1
answered question		**29**
skipped question		**1**

27. How many HOURS PER MONTH do you spend on each of the following activities?

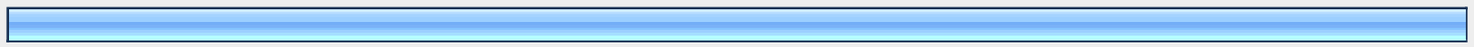
	Response Average	Response Total	Response Count
Maintenance activities such as backups, loading software, and organizing files on hard drives?	2.79	81	29
Developing applications for your own use, including scripting, writing macros, updating web sites etc?	**3.66**	**106**	29
Assisting students, staff, and administrators to solve their systems, applications, and network issues?	2.72	79	29
Receiving help from faculty, staff and students to solve systems, applications, and network issues?	1.48	43	29
Attempting to resolve your own			

system and application issues unaided (without service/service desk support or co-worker assistance)?		2.52	73	29
Casual learning such as reading manuals or using on-line help?		3.25	91	28
Downtime, service/service desk calls and associated time waiting for problems to get resolved? (Include network outage, application issues, email downtime, printer failures, and any other issues.)		1.00	29	29
			answered question	**29**
			skipped question	**1**

28. When a computer or network is down, what PERCENTAGE of time do you do the following? (Total should be 100.)

		Response Average	Response Total	Response Count
Work on other tasks		**55.89**	**1565**	28
Wait for problems to be resolved		7.22	195	27
Do the same task, but using manual, work around procedures		40.71	1140	28
			answered question	**29**
			skipped question	**1**

29. Do you have Internet access at home?

		Response Percent	Response Count
No		0.0%	0
Yes, slow speed (dial-up)		0.0%	0
Yes, fast speed (DSL, cable)		**100.0%**	29
	answered question		**29**
	skipped question		**1**

30. How important would it be for you to have a fast Internet connection at home?

		Response Percent	Response Count
Not very important		0.0%	0
Somewhat important		0.0%	0
Very important		0.0%	0
	answered question		**0**
	skipped question		**30**

31. How many years have you worked as an elementary or secondary teacher in a school? (Include this year as one full year)

		Response Average	Response Total	Response Count
Full time		**8.11**	**227**	28
Part time		1.58	19	12
	answered question			**29**
	skipped question			**1**

32. How many years have you worked at the Denver School of Science and Technology? (include this year)

		Response Average	Response Total	Response Count
Years		**1.90**	**55**	29
	answered question			**29**
	skipped question			**1**

33. What is the subject that you primarily teach?

	Response Percent	Response Count
Art	0.0%	0
Math	22.2%	6
English	18.5%	5
History	7.4%	2
Spanish	14.8%	4
Science	**33.3%**	9
Humanities	3.7%	1
Other (please specify)		2
answered question		**27**
skipped question		**3**

34. About how many students do you teach at each grade level?				
		Response Average	Response Total	Response Count
9th graders		**49.19**	**787**	16
10th graders		41.50	664	16
11th graders		45.23	588	13
12th graders		34.08	443	13
			answered question	**29**
			skipped question	**1**