# IMPACTFUL STUDENT LEARNING OUTCOMES
# OF ONE-TO-ONE STUDENT LAPTOP PROGRAMS
# IN LOW SOCIOECONOMIC SCHOOLS

A dissertation submitted to the faculty of
San Francisco State University
In partial fulfillment of
The Requirements for
The Degree

Doctor of Education
in
Educational Leadership

by

Matthew Joseph Harris

San Francisco, California

December 2010

Dedicated to my wife, Lisa.

Your unwavering love and support is the bedrock
for my drive to do meaningful work.

CERTIFICATION OF APPROVAL

I certify that I have read *Impactful Student Learning Outcomes of One-to-one Student Laptop Programs in Low Socioeconomic Schools* by Matthew Joseph Harris, and that in my opinion, this work meets the criteria for approving a dissertation submitted in partial fulfillment of the requirements for the degree: Doctor of Education in Educational Leadership at San Francisco State University.

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At present, a majority of one-to-one student laptop programs exist in schools that serve affluent communities, which denies low socioeconomic students the learning benefits of ubiquitous access to technology. Using a "Studying Up – Studying Down" paradigm, this multi-site case study collected mixed method data from program participants at five laptop programs to identify student learning outcomes of one-to-one student laptop programs, especially those with the greatest potential impact on low socioeconomic students. Findings showed that laptop programs affected all three levels of the Educational Digital Divide and that laptop students experienced transformed scholastic learning, changes to the learning environment, technology skills attainment, impacts on communication, and responsibility development. For low socioeconomic students, laptop programs impacted learning in the aforementioned areas to a higher degree than non-low socioeconomic students, while also improving career potential, expanding worldviews, and empowering communities through technology learning extended to students' families. Implications suggest that one-to-one student laptop programs can be effective educational investments for low socioeconomic schools.

I certify that the Abstract is a correct representation of the content of this dissertation.

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Chair, Dissertation Committee Date

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# Chapter One: Purpose of the Study

## *Statement of the Problem*

In recent years, schools across the country have implemented immersive technology education initiatives called one-to-one student laptop programs. In one-to-student laptop programs, schools provide each of their students with an Internet enabled laptop computer for use at school and at home. These programs offer students not only access to computers and the Internet, but also the promise of technology infused curriculum and ubiquitous access to digitized learning materials. However, since laptop programs are logistically complex and equipment intensive, they often require considerable resources and personnel to implement and maintain. As a result, a majority of one-to-one student laptop programs are found at public and private schools that serve affluent communities. This has created a situation where affluent students are realizing the benefits of ubiquitous access to technology while their low socioeconomic status (SES) peers are not. Such disproportionate access to laptop programs has replicated the Educational Digital Divide, thus denying low SES students, their families, and their communities access to the educational and social benefits of ubiquitous computing.

While this suggests that laptop programs should be established in low SES schools, mere implementation is insufficient. For these programs to be beneficial and sustainable, their pedagogic foundation needs to be grounded in student learning that has the greatest potential impact on low SES students and their communities. Further, this pedagogy must be based on reasonable and attainable student learning outcomes if it is to be effective and sustainable. However, a review of the literature has failed to identify (i) areas of impact of ubiquitous computing on low SES students or (ii) a list of student learning outcomes for one-to-one student laptop programs that could be used as a foundation for an impactful pedagogy.

### *Research Questions*

1. What are the student learning outcomes for existing one-to-one student laptop programs?
2. In what ways, if any, are these student learning outcomes different for low SES students?

### *Propositions*

I entered this study with two propositions:

1. Students in one-to-one student laptop programs experience learning outcomes in both academic and non-academic areas. These outcomes affect students' academic achievement, social and emotional growth, and their interactions with peers and the greater society. To address the full scope of student learning in one-to-one student laptop programs, student learning outcomes needed to be identified both inside and outside of the classroom.
2. The existence of the Educational Digital Divide, the material conditions of low SES students, and the incongruous entry skills low SES students would bring into

a one-to-one student laptop program suggested that student learning outcomes found at existing laptop schools, most of which serve high SES students, would not directly translate to low SES schools. As such, a list of student learning outcomes from existing laptop schools should only be used as a reference or springboard for the development of potential or realistically attainable learning outcomes for low SES students.

## *Conceptual Framework*

The conceptual framework for this study places the problem statement, purpose, justification, and methodology within the broad theoretical context of the Educational Digital Divide and sociological research theory. It draws upon two seminal works of scholarship to synthesize those theories and inform the overall research design: Hohlfeld, Ritzhaupt, Barron, and Kemker's (2008) conceptualization of the Digital Divide in U.S. Education and Laura Nader's (1972) "Studying Up – Studying Down" paradigm. The literature review in chapter 2 and the methodology in chapter 3 expound on these theories by investigating them in the available empirical research and contextualizing them for this study.

### *The Educational Digital Divide*

The theoretical basis for this study was grounded in Hohlfeld et al.'s (2008) multi-layered conceptualization of the Digital Divide in U.S. Education, herein referred to as the Educational Digital Divide to distinguish it from more general forms of inequitable distribution of technology resources. Holhfeld et al. show that the Educational Digital Divide is comprised of three levels of digital inequity: school infrastructure, the classroom, and the individual student.

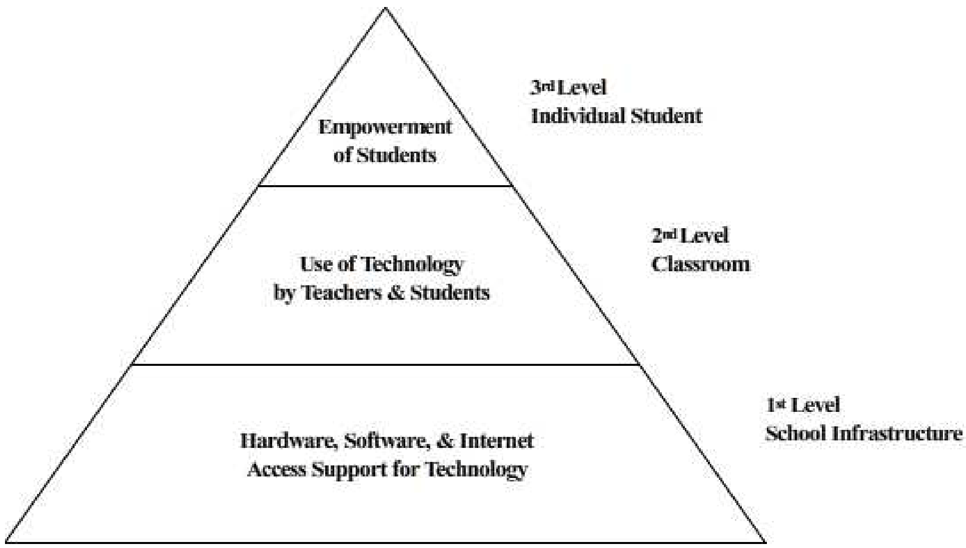


Figure 1. Levels of the Educational Digital Divide (Holhfeld et al., 2008)

As seen in figure 1, the foundation for the Educational Digital Divide originates in disproportionate access to school technology, which in turn results in inequitable classroom uses of technology. This resulting disparity of educational technology use is then realized by individual students, where those who have access to technology in school are more empowered than those who do not. When this paradigm is applied to one-to-one student laptop programs, we see that access to laptop programs is a replication of societal inequity and that pedagogic and student empowerment opportunities are missed by low SES students who do not participate in laptop programs.

*Access to Technology and Societal Inequity*

While the Digital Divide is a measure of access to technology both in society and in schools, it is also an indicator of greater societal inequity. Servon (2002) argues that the Digital Divide "is a symptom of a larger and more complex problem – the problem of persistent poverty and inequality." Through this statement, the Digital Divide can be viewed as a vehicle by which members of society are located within the stratification of social capital. Access to technology not only positions the poor at the bottom of the socioeconomic spectrum, but it also restricts their mobility within that stratum. The Digital Divide illustrates that technology access is a replicating, if not a exacerbating, factor of these societal inequities.

The current disparity of access to one-to-one student laptop programs mirrors and replicates the societal ills of the Digital Divide. With the current distribution of one-to-one laptop programs, high SES students have been given ubiquitous access to computing while their counterparts in low SES schools have experienced little or no access whatsoever. This disproportionate access positions students in an educational stratification that mirrors socioeconomic inequality where the affluent are the educational "haves" and the poor are the "have-nots". Further, the information literacy that accompanies participation in these programs illustrates that access to laptop programs is perpetuating the division of citizenry that is found in the greater society. High SES students who engage in ubiquitous computing have the ability to not only access information, but also to produce and disseminate knowledge. By contrast, lack of access to one-to-one student laptop programs relegates low SES students to the role of knowledge consumers, rather than producers, thereby denying them the opportunity to influence society. Yet without computers they cannot even fulfill this subverted role, which results in little or no access to digitized knowledge. But what is most egregious about this inequity is that it is found within the realm of education. By replicating the Digital Divide, and its associated social injustices, access to one-to-one student laptop programs have further incorporated societal divisiveness into the American educational complex.

Through application of Social Reproduction Theory (Bowles & Gintis, 1976), disproportionate access to one-to-one student laptop programs can be seen as a perpetuation of social stratification. However, this perpetuation is not merely a replication of social and economic strata or even an educational institutionalization of the Digital Divide, but rather an amplification of inequity. As our society moves deeper into the Information Age, the role of technology in society, equity, and social justice gains greater importance. Disproportionate access to technology through ubiquitous computing thereby becomes a means of utilizing education to increase social injustice. As members of the dominant class are provided access to one-to-one student laptop programs while members of the subverted class have little to no access, we will continue to see a widening of the Digital Divide, a growing division of labor, a larger disproportion of societal power, and a greater oppression of the poor.

*Missed Pedagogic Opportunities*

Beyond the replication of societal and institutional inequities, disproportionate access to one-to-one student laptop programs has resulted in missed pedagogic opportunities for low SES students. Laptop programs have been found to increase the potential for constructivism, Empowered Education, and Culturally Relevant Pedagogy, all of which have been shown to have academic impact on low SES students. Teachers in laptop classrooms have been found to utilize the personalized nature of individualized laptops to employ constructivist pedagogy where students' entry skills, developmental readiness, and prior knowledge are key in the design of instructional activities (Fosnot, 1996; Piaget, 1952). Similarly, access to laptops has been shown to empower students to a point where the authoritative division between teacher and student is moved to one of collaboration and mutual knowledge development. Ira Shor (1992) defines such a shifted classroom power dynamic as Empowered Education. Coupled with constructivism, this student empowerment would provide an ideal classroom environment for low SES schools to utilize laptops to implement Culturally Relevant Pedagogy. Ladson-Billings and Tate (1995) define Culturally Relevant Pedagogy as pedagogy that draws upon students' lived experiences and cultural heritage to construct their knowledge and to teach them to fight issues of social injustice and societal inequity, such as social reproduction and the Digital Divide. Unfortunately, the dearth of one-to-one student laptop programs in low SES schools exposes a missed opportunity to break free of mere potential in order to seize these beneficial and effective pedagogies that would come with laptop use.

*Student Empowerment*

Beyond the classroom, denial of access to laptops robs low SES schools of the opportunity to leverage ubiquitous computing to bridge the home-school divide and empower students for work in their own communities. A home-school bridge that would come from access to laptops outside of school could provide low SES communities with technology tools and competencies, such as Internet access, information literacy, and computer usage skills. This would develop student agency and community organization, which would empower students and their communities in their struggle against societal oppression, as described in Freirian Pedagogy and Critical Praxis. Freire (1970/2000) describes this type of empowerment, which he deems critical pedagogy, as one that "makes oppression and its causes objects of reflection by the oppressed, and from that reflection will come their necessary engagement in the struggle for liberation" (p.48). Laptops would provide low SES students, as the oppressed, access to digital resources such as the Internet and electronic communications, which could be used to mobilize community members to fight for improved conditions. The utilization of laptops to engage students in Freirian Pedagogy can be analyzed in greater detail through an examination of Critical Praxis. Critical praxis, as defined by Duncan-Andrade and Morrell (2008), is a cyclically recursive curriculum based on Freire's Problem Posing

Pedagogy. Through application of this curriculum, low SES students could use laptops to analyze the conditions of their oppression, develop a course of action to diminish the impact of those conditions, and evaluate the efficacy of those actions.

*Studying Up and Studying Down*

To encompass the breadth of the Educational Digital Divide and to advance a research design that had actionable and tangible results on those inequities, this study used Nader's (1972) "Studying Up – Studying Down" paradigm as a theoretical basis. The pairing of "Studying Up" and "Studying Down" was used to facilitate a cross-sectional comparison of knowledge about student learning in existing one-to-one student laptop programs in order to identify leaning outcomes that are most beneficial for low SES students (p. 289).

Nader describes "Studying Up" as a sociological research process where researchers study the conditions, characteristics, and influences of those in structural or societal power as a means of leveraging that knowledge to aid those out of power. "Studying Up" research seeks to indentify avenues for social improvement by investigating the privileged elements of a strata, then transferring that knowledge to the less privileged in order to facilitate upward mobility. Through this paradigm, research is conducted in an effort to study potential rather than deficiency. However, Nader also recognizes that "Studying Up" has little value unless paired with "Studying Down." This pairing then becomes the process by which conclusions drawn from "Studying Up" are used to benefit and empower participants in the “Studying Down” research. She claims this pairing is “serious in terms of developing adequate theory and description” (p. 290). Thus, both “Studying Up” and “Studying Down” must occur for valid and useful transfer of benefits from the privileged to the underprivileged.

This research project used “Studying Up” to investigate student learning at existing one-to-one student laptop programs. Yet, as Nader would note, this element of the research had no immediate value to underprivileged students. While the knowledge of student learning drawn from existing laptop programs has applicability to the high SES students who participate in those programs, it did not have direct application to low SES students who have different needs, skills, and histories. Thus, to transfer this knowledge for the benefit of low SES students, the study also utilized a “Studying Down” approach, where conclusions drawn from existing programs were combined with conclusions drawn from laptop participants at a low SES school. Through transfer and translation of knowledge, student learning outcomes were identified as impactful for one-to-one student laptop programs in low SES schools.

### *Key Terms*

Prior to the design and implementation of this research study, key terms were identified and defined. These terms will be used throughout the remainder of this report.

**One-to-One Student Laptop Program –** An educational program where the school or school district provides each student with access to an Internet enabled laptop computer for use at home and at school. Also known as *Ubiquitous Computing*.

**Student Learning Outcomes –** The skills, knowledge, or competencies students learn through participation in an educational program.

**Academic Learning –** Learning that occurs within curricular areas, often times at school, in the classroom, or at home during homework.

**Non-Academic Learning -** All learning outside of curricular areas, such as social, emotional, or personal learning.

**Socioeconomic Status (SES) –** An individual's or group's position within the societal hierarchy of economic and social class. Socioeconomic status depends on a combination of variables, most notably education and wealth (Cohen, 2009).

### *Statement of Delimitations*

The scope of this study was limited to a single area of inequity, an intentional focus on learning, and an investigation of perceived student learning outcomes.

While there are several documented constructs of societal and educational inequity, this study focused on socioeconomic status. As this study investigated one-to-one student laptop programs, which are resource intensive educational endeavors, and due to the fact that the Educational Digital Divide in its primacy is seen as a disparity of access to information technology resources, resource access inequity, namely socioeconomic status, was employed as a research focus. Though other factors of inequity were likely present within the research sites – racial, linguistic, geographic, and gender-based – socioeconomic status was used as the sole focus of inequality.

Within the context of one-to-one student laptops programs, this study's scope was limited to student learning outcomes. This included both the academic and non-academic learning outcomes experienced by students who participated in these programs. As this study was designed to look specifically at learning, program administration and logistics were neither foci of the research nor intended areas of analysis. These excluded areas included program implementation, funding, administration, teacher professional development, equipment maintenance, and logistical sustainability.

The measures of student learning were limited to perceived student learning outcomes. In order to attain the greatest breadth and depth of data collection and analysis, participant perceptions and opinions were used as data sources. As such, observable and quantifiable measures of student learning were beyond the scope of this study.

### *Role of the Researcher to the Field*

At the core of the validity for this research study and my qualifications as a researcher was my role within the field of one-to-one student laptop programs. This included my position within the field of one-to-one student laptops programs, my work in developing and transforming laptop programs, and my relationships with program stakeholders. Since 2003, I have served as the Director of Technology at two middle schools that have implemented one-to-one student laptop programs. In these positions, I have been responsible for administering and coordinating nearly every aspect of the laptop programs, including technical support, curriculum development, teacher professional development, student monitoring, parent education, technology instruction, and budgeting. I have worked closely with parents, students, teachers, and administrators to develop processes, build coalitions, and engage in strategic planning. Through my work with teachers and students, I have also developed and delivered a full technology curriculum for middle school students. Additionally, I have worked toward building parenting and communication skills for parents of students in these programs to help them meet the unique challenges they face with ubiquitous computing and Internet access in the home. I have also collaborated with middle school teachers to support the integration of technology into a variety of content areas.

While this may read as a self-congratulatory list of accomplishments, it is vital to recognize as it brings into question the validity of data I collected as a researcher. The degree to which my own bias as the primary actor within the research setting should be noted as a central factor in the authenticity of the data collection and analysis methods. My bias must be viewed as a possible cause for data skew and inclusion of confounding variation. To account for this, I have decided not to include either of the schools in which I have worked. However, while my deep involvement in laptop programs has made me the antithesis of the classic unbiased observer, it has provided me a level of intimacy and understanding of the research focus, discourse, and participants that very few researchers enjoy. My experience in both program administration and pedagogy has allowed for a depth of understanding and clarity of focus that provided greater validity to this study. Being both a practitioner and a researcher allowed greater richness and authenticity of the conclusions of this research study than would have been found if I were either just an academic or a laptop administrator.

### *Description of One-to-One Student Laptop Programs*

To provide clarity about the research context, an in-depth description of one-to-one student laptop programs is needed:

As previously stated, one-to-one student laptop programs are educational technology initiatives where a school provides its students with one-to-one access to Internet-enabled laptop computers. Beyond merely reducing the ratio of computers to students to 1:1, one-to-one student laptop programs provide students with individualized computers for use both at home and at school. In a majority of these programs, students use their assigned laptops throughout the school year. During the school day, students use their laptops in various classes and then take them home after school. Through participation in these programs, students assume responsibility for basic care of the computer and the accompanying digitized schoolwork.

While one-to-one student laptop programs share many characteristics, program administration policies can differ and are often defined by individual schools. For example, school administrators can have different policies regarding laptop ownership, whether students lease or buy their computers. Additionally, technological configurations of the laptops vary from program to program. These configurations include:

- **Laptop Type –** standard, tablet PC, or netbook
- **Operating System –** Mac OS, Windows, Linux, or some combination
- **Software Configuration –** the types and titles of software preloaded onto the laptops
- **Level of User Access –** the degree to which students have access to change or alter the laptop's software and operating system

Even though one-to-one student laptop programs can vary both in policy and technology, they all share the defining characteristic of continual access to individualized computing. Penuel (2006) defines the common characteristics of one-to-one student laptop programs as:

> (1) Providing students with use of portable laptop computers loaded with contemporary productivity software (e.g., word processing tools,

> spreadsheet tools, etc.), (2) enabling students to access the Internet through schools' wireless networks, and (3) a focus on using laptops to help complete academic tasks such as homework assignments, tests, and presentations. (p. 331)

Students in one-to-one laptop programs use their laptops at school and at home. With such access to their computers, laptop students are said to engage in ubiquitous computing. At school, students take their laptops with them from class to class, just as they would a textbook. However, unlike a textbook, laptops are far more engrossing, powerful, and complex. Researchers have shown that laptop students use their computers in a variety of subject areas (Rockman et al., 1997,1998, 2000; Silvernail & Lane, 2004). Often times in laptop classrooms, students can be found using a variety of software titles to accomplish instructional activities. Along with this, wireless access to the Internet and the associated connections to the online resources and digital communication media are accompanying tools that are standard on student computers. Outside of the classroom, students take their computers with them throughout the day, to and from home. By having ubiquitous access to their laptops, students are able to maintain, retrieve, and alter the digitized class work and personal data stored on their computers at any time. Given the responsibility of maintaining a laptop and the complexity of its use in schoolwork, a majority of one-to-one student laptop programs are found at the middle and high school levels.

The history of one-to-one student laptop programs can be traced back to three seminal initiatives:

First, in the late 1980s, Apple Computer, Inc. started the Apple Classrooms of Tomorrow project where they outfitted several classrooms with desktop computers for instructional uses (Dwyer, 1994). Students and their families who participated in the program were also given accompanying computers for use at home. In implementing Apple Classrooms of Tomorrow, program architects hoped to leverage the perceived benefits of ubiquitous computing to infuse technology into learning. Having seen the impact of computers on science, industry, and business, Apple Classrooms of Tomorrow was seen as a way to allow students to streamline their learning and increase their productivity through computer access both at home and at school. Being an experimental program, no clearly defined learning outcomes or competencies for students were every publicly defined.

Next, in the mid-1990s, Microsoft Corporation and Toshiba America Information Systems teamed up to create the Anytime Anywhere Learning initiative (Rockman et al., 1997). This was the first widespread ubiquitous computing program to provide laptops to schools across the nation. Through donations from Microsoft and Toshiba over 50 elementary, middle, and high schools received laptops and productivity software for use in school. Again, this program was implemented to study the potential of ubiquitous computing on student learning, without any clearly defined student learning outcomes or impacts on the Educational Digital Divide. Yet, the scope and ambitious nature of the

Anytime Anywhere Learning project are often seen as the springboard for the one-to-one student laptop program movement.

Lastly, in 2002, the state of Maine unveiled its ambitious Maine Learns Technology Initiative, in which every $7^{th}$ and $8^{th}$ grade student in the state was provided a laptop computer (Silvernail & Lane, 2004). Through this program, Maine was able to outfit nearly 20,000 students and teachers with computers in its first year. Along with this technology, the Maine Learns Technology Initiative included provisions for teacher training and curriculum development. Angus King, then governor of Maine, described the program as one that would transform the lives of Maine’s students, while also encouraging technology companies to migrate to the state. In an interview King said,

> For more than 100 years, Maine has always been in the bottom third of states – in prosperity, income, education, and opportunity for our kids. In my 30 years of working on Maine economic issues, no idea has had as much potential for leapfrogging the other states and putting Maine in a position of national leadership as this one – giving our students portable, Internet-ready computers as a basic tool for learning. (Curtis, 2003)

Though King’s comments seem to speak directly toward the reduction of Digital Divide, little research has been conducted to study the program’s impact on this area. Nevertheless, policymakers, educators, and researchers have cited the Maine Learns

Technology Initiative as a model for the implementation and administration of a large scale one-to-one laptop student laptop program.

With the broad scale and successful implementation of these seminal programs as examples, one-to-one student laptop programs have been implemented in schools across the country. At present, it is estimated that over 1000 schools and school districts have instituted one-to-one student laptop programs. Laptop schools can be found in every state in the union with several more to come. As of the completion of this study, 20 laptop schools and school districts were be found in the San Francisco Bay Area with several new ones in the early stages of planning.

However, only one of the SF Bay Area laptop schools was easily accessible by students from low SES backgrounds. Eighteen of the 20 Bay Area one-to-one student laptop programs were found at private schools with an annual tuition in excess of $16,000. Of the two public schools with laptops programs, one served an affluent community. This school resided in a Basic Aid district, which means the district was not reliant on state funding for operational costs due to the large amount of revenue they received from local property taxes. The other laptop school served a majority of low SES students and was included as a research site in this study.

### *Justification and Significance*

At present, one-to-one student laptop programs are primarily found in private schools and public schools in high SES communities. This condition exacerbates the

Educational Digital Divide by institutionalizing inequity of technology access within the educational context. To help alleviate this issue, students in low SES communities need to be given access to the beneficial academic and non-academic student learning outcomes of one-to-one student laptop programs. Yet, since low SES schools operate within tight budgets and limited resources, any laptop program implemented in low SES communities needs to be grounded in realistically attainable student learning outcomes to ensure broad scale benefit and program sustainability. To identify these student learning outcomes existing programs needed to be examined. By investigating, analyzing, and leveraging what has learning been found in existing programs, a model for implementation of ubiquitous computing in low SES schools can be based in realistic expectations and data-driven planning.

However, no literature could be found that a) explicitly defined the student learning outcomes for one-to-one student laptop programs or b) investigated the student learning that occurs outside of the classroom. Thus, both academic and non-academic student learning outcomes needed to be identified for existing laptop programs. Yet, this is a multi-dimensional research topic in and of itself that could include analysis of student entry skills, achievement data, classroom conditions, and much more. So, in order to gain the greatest depth and breadth of data with the greatest efficiency, this study investigated the perceptions of program participants, those who had direct experiential knowledge of student learning in these programs: administrators, teachers, and students. In line with this breadth of research participants, the study collected data at several sites to ensure the validity of its conclusions.

## *Overview of the Report*

This report is presented in five chapters. In Chapter One, the research problem, context, and justification are outlined as a framework for the study's purpose and intentions. Chapter Two presents a review of the Educational Digital Divide and one-to-one student laptop program literature. The study's mixed method research design, multiple site data collection methodology, and site and participant selection criteria are described in Chapter Three. Chapter Four reports on the study's research findings in the areas of the Educational Digital Divide, scholastic learning, changes to the learning environment, technology skills, communication, responsibility, and impacts on low SES students and their families. In Chapter Five, the research findings are linked back to the available scholastic literature as a means of identifying student learning outcomes that have the greatest potential impact for one-to-one student laptop programs in low SES schools.

# Chapter Two: Literature Review

## *Introduction*

In 1980, Seymour Papert wrote, “we are at a point in the history of education when radical change is possible, and the possibility for that change is directly tied to the impact of the computer” (Papert, 1980, p. 36). Since this statement was made three decades ago, Papert’s prediction seems to have come to fruition. Time spent on computers and the Internet has significantly changed the educational experiences for millions of American students. Over the past decade, the infusion of computing into education has radically evolved with the introduction of one-to-one student laptop programs. With ubiquitous access to laptops, students in these programs are not only learning on computers, but also taking their personalized computers with them wherever they go. Yet, as one-to-one student laptop programs are reliant on resources and personnel, a vast majority of them are found in private schools and public schools that serve high SES communities. This disproportionate access to ubiquitous computing denies low SES students Papert’s promise of radical educational change.

This review explores two areas of technology education scholarship related to the divergent access to one-to-one student laptop programs. The first section investigates the differences in access and usage of technology in U.S. education between low and high SES students, namely the Educational Digital Divide. This investigation of the Educational Digital Divide focuses on the manifestations and implications of digital inequity in greater society, then in U.S. education and specifically among low SES students. Using the Educational Digital Divide research as a means of identifying potential for ubiquitous computing to bridge the gap, the review then explores the available research on teaching and learning in one-to-one student laptop programs. Collectively, the review of these two areas of scholarship provided a basis for research into student learning in existing laptop programs that has the greatest potential impact on low SES students.

*Scope of the Review*

This review focused on the available research on (i) the Educational Digital Divide and (ii) the impacts of one-to-one student laptop programs on teaching and learning.

The context of the review was limited to public and private K-12 education in the United States. While research was found both in post-secondary education and in schools outside the United States, the majority of the research concerned U.S. K-12 schools. As such, the conclusions and implications from this review are intended to inform research involving U.S. K-12 schools.

The review of the Educational Digital Divide scholarship focused on the manifestations and impacts of digital inequity within U.S. education. This included empirical studies and syntheses of research on existing conditions, implications, and theoretical investigations of the divide. Though the scope of the review was limited to the

Educational Digital Divide in U.S. schools certain works were included that contained analyses on the broader societal Digital Divide.

The scope of the review of one-to-one student laptop program literature was limited to the impacts of ubiquitous computing on teaching and learning rather than program logistics. Research that focused on the design, implementation, maintenance, administration, financing, or evaluation of one-to-one laptop programs was excluded. Within the scope of teaching and learning, this review included literature on teacher preparation and practice, classroom conditions, and student learning. However, the review only sought to explore these teaching and learning impacts, not to evaluate them as positive or negative.

### *The Educational Digital Divide*

The Digital Divide was a term coined to describe the gap of access between those who use computers and the Internet and those who do not (Clinton & Gore, 1996). In its most simplistic and deterministic interpretation, the Digital Divide states that access to technology is binary: either people have access or they do not. However, the literature has illustrated that the divide is actually a far more complex issue that has direct ties to societal inequity. The Digital Divide has been shown to be a vehicle by which members of society are located within the stratification of social capital where access to technology not only positions disadvantaged members of society at the bottom of the social spectrum, but also restricts their mobility within that stratum. Theoretical analyses of the divide showed that technology access is a replicating, if not exacerbating, factor of societal inequities (Brown, 2002; Clark & Gorski, 2002; DiBello, 2005; Servon, 2002; Subramony, 2007; Warschauer et al., 2004).

The available literature has shown that resultant inequities of the Digital Divide have been perpetuated within the classroom. Researchers asserted that inequitable access to academic technology exemplifies the role of education in maintaining socioeconomic strata (Ba et al., 2001; Clark & Gorski, 2002; DiBello, 2005, Kalyanpur & Kirmani, 2005; Light, 2001, Subramony, 2007; Warschauer et al., 2004). High SES students, through access to school supplied Internet enabled computers, attained information literacy and societal influence, whereas low SES students, having little to no access to computers or the Internet, were denied these benefits (DiBello, 2005). The literature suggested that access to technology further entrenches high SES students in their positions within the dominant culture while low SES students are relegated to continued societal oppression (Subramony, 2007; Warschauer, 2003). Thus, researchers cite the Educational Digital Divide as evidence that education in the United States has institutionalized the Digital Divide en route to furthering societal inequality. Yet, the literature showed that digital inequity in schools has broad reaching impacts that encompass not only students' access to technology, but also the ways they use technology in the classroom and the resultant implications of that usage.

Hohlfeld et al. (2008) illustrated the multi-leveled complexity of the Educational Digital Divide in their seminal work on computer literacy. In their model, the Educational

Digital Divide has three levels: access, classroom use, and student empowerment. Each of these levels is the product of the one below it. The base level shows that all Educational Digital Divide inequity experienced by students is rooted in disproportionate access to computers, software, and the Internet. The second level illustrates the disparate ways in which technology is used in the classroom. On the top level, students experience inequitable empowerment opportunities obtained through computer access and the educational uses of technology. The manifestations of inequity progressively narrow as the Educational Digital Divide ascends through its three levels. In the first level, inequity is felt across the institution. It then moves into the classroom in the second level and ends with the students themselves in the top level.

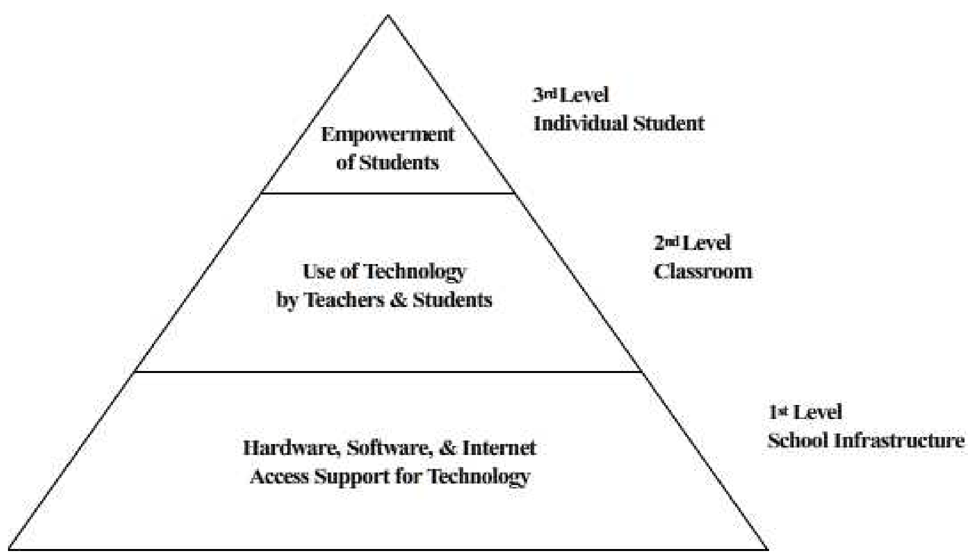


Figure 2. Hohlfeld et al.'s (2008) model of the Educational Digital Divide

Through empirical studies and research syntheses, the literature has shown that students are currently experiencing all three levels of Hohlfeld et al.'s (2008) model of the Educational Digital Divide.

### *Access to Computers and the Internet*

The first level of the Educational Digital Divide states there is a division in access to computing technology among U.S. schools. The division was found in schools' ability to provide and maintain academic technology infrastructure. This level of the Educational Digital Divide impacts students much like the Digital Divide affects social groups in greater society. Students from subverted groups have less access to technology infrastructure than their more-privileged peers. While this division was found between ethnic, racial, and linguistic groups, socioeconomic status was the most cited social group to experience the Educational Digital Divide (Ba et al., 2001; Clark & Gorski, 2002; Carvin, 2006; Garland & Wotton, 2002; Valadez & Duran, 2007). In their seminal article on the role of socioeconomic status in the Educational Digital Divide, Clark and Gorski argued that low SES students had the least access to computing because their communities of origin often housed resource poor schools that could not assume the continual costs of educational technology. The prevalence of this focus on socioeconomic status in the Educational Digital Divide literature suggests that any analysis of the manifestations of digital inequity in school must be based in the experiences of low SES students. As such, the remainder of this section of the review concentrates on the implications of disproportionate technology access for low SES students.

This divergent access to technology infrastructure was found to extend both to the quantity of technology access and the quality of the computers students used. Numerous studies showed that low SES students had less access to computing technology, whether measured by student-to-computer ratios (Attewell, 2001; Warschauer et al., 2004) or percentage of classrooms with access to the Internet (Moore, Laffey, Espinosa, & Lodree, 2002; Warschauer et al., 2004). The research showed this level of the divide not only manifested in the quantity of computers and the availability of Internet access, but also in quality. Low SES schools often housed inoperable computers, used out-dated software, and relied on slow and inconsistent Internet connections (Attewell, 2001; Moore, Laffey, Espinosa, & Lodree, 2002; Warschauer et al., 2004).

However, the literature has shown that over the last 15 years the divide in access to technology is actually closing. As a result of grant funding, the standardization of productivity software, and the decreasing costs of computers and broadband Internet, the gap between access for the low and high SES schools has shrunk (Goolsbee & Guryan, 2006; Hohlfeld et al., 2008; Subramony, 2007; Warschauer et al., 2004). Yet, researchers believed this decrease in access has done little to impact the other two levels of the Educational Digital Divide: classroom uses of technology and student and community empowerment. First, parallel to the Digital Divide found in society, mere access to technology is far too deterministic to measure the depth and breadth of digital inequity in schools (Light, 2001). Second, for computers to be transformative, there needs to be equitable educational uses of computers (Mouza, 2008). Just providing access to computers does not equate to similar methods of usage or resultant skills attainment. Lastly, increases in technology access don't address the needs or challenges of low SES schools. In one study, increased access to technology actually amplified existing forms of inequity in low SES schools because the increase was done in isolation of the broader context of the school and the surrounding community (Warschauer et al., 2004). Noting these discrepancies in the impact of technology access on inequity, a majority of researchers have shifted their focus away from access to the ways in which computers are used in the classroom.

*Classroom Uses of Technology*

The second level of the Educational Digital Divide states there is a disparity in the educational uses of computers and the Internet. Students in low and high SES classrooms use computers in vastly different ways, achieving vastly different outcomes. The measurements of this level of the Educational Digital Divide include: how often students and teachers use technology, for what purpose, and to what degree these activities are integrated into daily instructional activities.

As the first level of the divide – access to technology – heavily influences this level of the Educational Digital Divide, computer use in low SES classrooms was often infrequent. With limited access to computers, software, or the Internet, students and teachers in low SES classrooms found it difficult to consistently engage in meaningful educational uses of technology (Hohlfeld et al., 2008, Mason & Dodds, 2005a, 2005b). Researchers also found that when technology is available, the lack of reliable equipment and the dearth of technology support personnel resulted in infrequent computer use (Hohlfeld et al., 2008; Warschauer et al., 2004). According to Moore, Laffey, Espinsoa, and Lodree (2002) infrequent use of technology in low SES classrooms denied teachers and students the right to leverage the transformative potential of educational computing both on reducing inequity and improving learning.

Yet, frequency of use was secondary to the actual ways computers were used in the classroom. Researchers found that when school technology infrastructure was equal, high SES and low SES students still used computers in vastly differently ways. High SES classrooms used technology to transform learning whereas low SES classrooms simply used it as an additive (Attewell, 2001; Brown, 2002, Clark & Gorski, 2002; Moore et al., 2002; Subramony, 2007; Warschauer et al., 2004). Teachers in high SES classrooms used computers and the Internet in what Monroe (2001) calls “transformative” learning activities, where students interacted with content through dynamic learning curriculum. They used technology-based activities that focused on creation of knowledge, development of higher order thinking, and deeper understanding of content (Clark & Gorski, 2002). These activities helped high SES students develop skills that better prepared them for the digital global economy (Clark & Gorski, 2002; Swain & Pearson, 2002; Warschauer et al., 2004). Attewell (2001) believed that high SES students who participated in this type of educational computer use not only benefited from the resultant academic skill attainment, but they also learned ways to identify, develop, and leverage social and cultural capital.

Though researchers agreed this model of transformative computer use would be ideal for low SES classrooms, they found that low SES classrooms were using technology in ways that failed to realize these benefits. Most often low SES classrooms used computers to participate in drill and practice activities (Garland & Wotton, 2002). Researchers suggested reliance on these types of activities, coupled with the dearth of the transformative educational technology learning employed in high SES classrooms, may have actually aggravated inequity, most notably in the widening of the achievement gap (Attewell, 2001; Warschauer, 2004). Brown (2002) went so far as to say that this type of computer use was a tool for behavior management where teachers used repetitive activities to occupy large periods of time in which students were lulled away from interactivity or disruption.

Researchers also claimed computer use in low SES classrooms did not consistently create engaging learning opportunities because teachers often failed to draw upon students' cultural capital. Subramony (2007) identified students' family values, linguistic differences, and diverse backgrounds as frequently absent from the computer activities in which low SES students participated. Garland and Wotton (2002) exemplified this claim in their research on linguistic isolation in technology education. They showed that low SES students in their study, most which came from diverse linguistic backgrounds, participated in Internet activities that only visited English language websites.

This juxtaposition of computer usage between low and high SES students was often the result of teacher preparedness. Compared to their colleagues in low SES classrooms, teachers in high SES classrooms had more formal training and experience (Brown, 2002; Clark & Gorski, 2002; Warschauer & Lepeintre, 1997; Warschauer et al., 2004). Most teachers entered the classroom with more teaching experience, which resulted in better understanding of classroom instruction, pedagogy, curriculum development, classroom management, and assessment. They also completed technology education professional development courses and were versed in computing skills and Internet usage. In contrast, teachers in low SES classrooms were often less prepared to handle the complexities of developing and executing computer based curriculum. Additionally, many of these teachers had been in the profession for less than five years, which was too little time to develop the instructional skills exhibited by teachers who worked in high SES schools. Moreover, researchers discovered that many teachers in low SES classrooms lacked the cultural knowledge or experience needed to develop engaging and relevant computer learning activities that would draw upon students' cultural and social capital (Attewell, 2001; Brown, 2002; Clark & Gorski, 2002; Subramony, 2007).

As the literature has shown, the convergence of negative factors has created a barrier of technology use for low SES classrooms that is absent in high SES classrooms. Coupled with the divergence of access to school technology infrastructure, this barrier has created a divide of equitable use of computing in U.S. classrooms. The literature has shown this divide not only has impact within the classroom, but also lasting implications on students and their communities.

*Student and Community Empowerment*

The third level of the Educational Digital Divide further narrows the focus of inequity to those who are directly impacted by it: the students. Research has shown that technology and educational computer usage can provide students with tools to for self-empowerment, yet, low SES students are not realizing this potential. Holhfeld et al. (2008) described this inequity of student empowerment as whether "[students] know how to use [technology] for the betterment of their quality of life" (p. 1650).

Life skills development was the most common area of empowerment found in the literature. In describing these skills, researchers claimed that students who participated in dynamic computer use in schools developed critical competencies including academic content knowledge, depth of understanding, and problem solving skills (DiBello, 2005; Pearson, 2001; Warschauer, 2003). Specifically, researchers identified technology skills as the most prominent means of student empowerment. Students who utilized school technology to attain and develop technology skills were better "socialized into, and prepared for, the tech-heaviness of contemporary society" (Clark & Gorski, 2002, p. 29). The literature further suggested that divergent technology proficiency had long term consequences for low SES students in the form of gaps in future earnings tied to technology skills, gaps in civic involvement for those not proficient with Internet use, and gaps in influence on equity and civil rights issues (Clark & Gorski, 2002; DiBello, 2005; Subramony, 2007).

Some researchers claimed that the deepest impact of digital inequity on students came in the form of social capital development. When discussing technology use in education, Warschauer (2003) defined social capital as the accrual of benefits from personal relationships and memberships in social networks. Researchers believed that low SES students missed the opportunity to leverage computers and the Internet to create and cultivate social networks within their schools and communities, thus denying them digital tools to organize and facilitate social mobilization (Clark & Gorski, 2002; DiBello, 2005; Light, 2001). They noted that high SES students developed greater social networking skills through their educational technology use, which widened the gap of social capital.

In line with social capital development, researchers extended the scholarship of the third level of the Educational Digital Divide to include the impact of inequity on students' families and communities. Vail (2003) claimed efforts to address any or all levels of the Educational Digital Divide will fail as they don't account for the technology access in students' homes. He believed that to truly address educational technology inequity, educators must find ways to extend learning to students and their families. Clark and Gorski (2002) echoed these claims by stating equitable technology education, should it exist, would have to include collaboration efforts with families and communities to draw technology learning outside of the classroom. Other researchers concluded that the third level of the Educational Digital Divide denied tools for civic involvement and community development, which they claimed could reduce the prevalence of societal inequity (Clark & Gorski, 2002; DiBello, 2005, Garland & Wotton, 2002; Warschauer, 2003; Warschauer et al., 2004).

### *Potential Role of Ubiquitous Computing in the Educational Digital Divide*

A vast majority of the available literature on the Educational Digital Divide followed a deficit model of research. Researchers clearly illustrated the ways in which students experienced digital inequity, the root causes of that inequity, and the implications that inequity had on broader society. Yet, deficient from this scholarship was the concept of potential. Every deficit has an accompanying potential for improvement and in the case of the Educational Digital Divide that potential is large.

In examining the Educational Digital Divide's potential, the role of one-to-one student laptop programs is central as ubiquitous computing has the capability to influence digital inequity at all three levels of the divide. Yet, one-to-one student laptop programs are virtually absent from the Educational Digital Divide literature. In fact, the available research on one-to-one student laptop programs shows that a majority of laptop programs are found in private schools and high SES public schools, which suggests that ubiquitous computing is exacerbating the Educational Digital Divide by providing high SES students greater access to technology, educational computing, and student empowerment.

However, if some policy change were to arise to reverse this trend and every student across the country was given a laptop there would assumedly be significant impacts on the Educational Digital Divide. By definition, the first level of the divide would be reduced because all students would have equal access to technology. Yet, as the research has shown, equitable access may not result in equality on the second or third levels of the divide: classroom use of technology and student empowerment. This suggests that for one-to-one student laptop programs to be impactful in low SES schools, they must be tailored to address transformative computer use and student empowerment. This design would need to be grounded in how students use their laptops to learn and how teachers teach with a laptop in front of every student.

Yet, the Educational Digital Divide literature is largely speculative in this area. As previously noted, no research could be found that investigated the impacts of ubiquitous computing on low SES students. Even outside of one-to-one student laptop programs, few empirical studies were available that investigated the ways in which technology use differed between low and high SES schools. Of this available scholarship, little research focused on specific curriculum, teaching methods, pedagogy, or student learning outcomes. As such, an exploration of the impacts of one-to-one student laptop programs on teaching and learning is needed to define realistically attainable learning outcomes for laptop students. This would serve as the basis for identifying impactful student learning outcomes for one-to-one student laptop programs in low SES schools.

### *Impact of One-to-one Student Laptop Programs on Teaching and Learning*

One-to-one student laptop programs allow students to use computers across curricular areas while providing them an electronic repository and readily available access to online resources. Students in these programs are said to experience learning that is more engrossing, powerful, and complex. As such, the introduction of ubiquitous computing in a school environment invariably impacts students' educational experiences. This section of the review investigates those effects through an exploration of the available one-to-one student laptop program literature guided by the following question: What are the impacts of one-to-one student laptop programs on teaching and learning?

#### *Effects on Teachers*

The most widely researched impact of one-to-one student laptop programs was found in the effects on teachers. Dwyer, Ringstaff, and Sandholtz (1991) claimed that teachers in a ubiquitous computing environment experienced "change as an evolutionary process with stages we label: Entry, Adoption, Adaptation, Appropriation, and Evolution" (p. 47). Teachers entered this evolutionary process at different stages and progressed at different speeds based on their prior experience with technology education and their existing computing skills (Burns & Polman, 2006). Researchers claimed that regardless of evolutionary stage, involvement in a one-to-one student laptop program had considerable effects on teachers' attitudes and instructional practices.

*Helping Teachers Progress Through the Evolutionary Process*

Though teachers entered the evolutionary process at different stages and moved through at different speeds, researchers concluded that teachers could be helped along the process through professional development, collaboration, and involvement in program initiation and administration.

*Professional development.* Several researchers claimed that professional development was an important factor in moving teachers along the evolutionary stages of one-to-one student laptop programs. Dwyer et al. (1991) and Silvernail and Lane (2004) stated that professional development, specifically technology training, was necessary for teachers to overcome fears about technology and to improve practice. In a case study of the Maine Learns Technology Initiative, Garthwait and Weller (2005) linked professional development to laptop use in the classroom by juxtaposing the pedagogic impacts of training for two teachers. In the study, the teacher with limited technology training utilized laptops merely as a tool for supplementary instruction, whereas the teacher with extensive professional development credited the laptops for transforming his practice.

While some researchers stated that professional development in any form was requisite for teachers in one-to-one student laptop programs, others suggested the focus of the training must vary based on the needs of the teachers and their institutions. The literature suggested that teachers who were concerned about their own technological competency should concentrate on what Windschitl and Sahl (2002) described as "learning how" training that focused on technology skills development whereas teachers who exhibited a minimum level of skill and comfort should be trained in a "learning about" sessions where laptop utilization techniques for pedagogic and curricular development were showcased (p. 188).

*Collaboration.* In addition to professional development, researchers found that teachers progressed along the evolutionary process through informal collaboration with colleagues. Professional development needed to come not only in the form of computing skills instruction and technology integration into curriculum, but also in informal work with colleagues (Burns & Polman, 2006; Windschitl & Sahl, 2002). The most striking example of the effectiveness of teacher collaboration was found in Burns and Polman's (2006) study of three teachers where collaborative efforts through a professional learning community helped the teachers skip several evolutionary stages.

*Teacher involvement.* Involvement in the implementation and administration of the laptop program also helped teachers progress through the evolutionary process. The Maine Learns Technology Initiative was a landmark example of teacher involvement. Teachers were involved from the beginning in the program's design and development while also serving as site-level leaders during its implementation (Manchester, Muir, & Moulton, 2004). During the planning stages, they were involved in development of both the program architecture and decision-making procedures. At the site-level, teachers led the project as part of the Teacher Leader Network where they were responsible for advocating the program to other teachers at their school, monitoring the program's progress, and organizing professional development. As a result of this involvement, teachers were better prepared to integrate laptop use into their curriculum and were more engaged in the program overall.

*Attitude Toward Technology Use in Education*

The literature showed that teachers involved in ubiquitous computing classrooms assumed one of three attitudes toward technology use in education: supplementation, integration, or revolution.

A minority of teachers held the attitude that the laptop was only useful in supplementing existing curriculum without revolutionizing ways in which instruction was delivered (Garthwait & Weller, 2005; Windschitl & Sahl, 2002, Silvernail & Lane, 2004). On the other hand, a majority of teachers integrated some laptop activities into their teaching using computers both as direct and as supplementary instructional tools (Burns & Polman, 2006; Dwyer et al., 1991; Rockman et al., 1998; Windschitl & Sahl, 2002). While these teachers did not develop their own laptop activities, they did exhibit a more positive attitude toward the role of technology in education than those who merely used the laptops to supplement classroom instruction. A subset of teachers revolutionized their instructional practice to optimize the use of technology in their curriculum (Bebell, 2005; Burns & Polman, 2006; Garthwait & Weller, 2005; Silvernail & Lane, 2004; Swan et al. 2005; Windschitl & Sahl, 2002). Such teachers often served as on-site educational technology experts and advocates for their programs (Burns & Polman, 2006; Garthwait & Weller, 2005).

Interestingly, little research could be found regarding absences in or a worsening of attitudes toward technology use in education. Of the sources cited, only Windschitl and Sahl (2002) noted a decline in educational technology integration as a result of a laptop program, and this result was found in just one of the teachers they studied. This lack of negative findings could be attributed to what Grace-Martin and Gay (2001) call the "ostensible hegemony of the optimism regarding Internet technology and laptops in the classroom" (p. 95). In the available literature, researchers tended to base their studies on the belief that ubiquitous computing improved students' learning and teachers' pedagogy.

*Instructional Practice*

Though researchers illustrated that teachers experienced variable attitudinal change, they found that most teachers experienced similar impacts on instructional practice. Overall, the literature suggested that involvement in a one-to-one student laptop program tended to increase teacher workload and shift pedagogy toward constructivism, which changed teachers' instructional role in the classroom from direct teaching to guiding students' inquiry.

*Increased teacher workload.* In both qualitative case studies of initial implementations and mixed methods studies of large populations, researchers found a majority of teachers in one-to-one student laptop programs experienced an increase in workload (Bebell, 2005; Burns & Polman, 2006; Garthwait & Heller, 2005; Silvernail & Lane, 2004; Swan et al., 2005, Windschitl & Sahl, 2002). This increase came primarily in the form of lesson-planning, research, and preparation for class, but also included increased communication with parents and faculty. Researchers credited the added work to the introduction of ubiquitous computing's complexity into teachers' preparation, delivery, and assessment of instruction. However, the degree to which teachers experienced increases in workload correlated negatively to their educational technology knowledge prior to entry into the program, where teachers with the greatest knowledge experienced the lowest increase in workload (Burns & Polman, 2006).

Interestingly, the research did not indicate the increase in workload had a negative impact on teachers' attitude toward the laptop program (Bebell, 2005; Burns & Polman, 2006; Garthwait & Weller, 2005). Similar to the lack of research on negative attitudes toward educational technology, this absence of data should by no means be viewed as conclusive, but rather a tendency of the researchers to focus on the positive effects of ubiquitous computing.

*Movement toward constructivism.* Researchers listed a move toward constructivism as the most noticeable impact of ubiquitous computing on teachers.

Constructivism is a theory of epistemology that argues that knowledge is generated through experience and is based upon the learner's foundation of prior skills and knowledge (Fosnot, 1996; Piaget, 1952). While constructivism is not a form of pedagogy, per se, but rather a model for understanding how people learn, it is often associated with active learning practices or learn-by-doing instruction (Brooks & Brooks, 1994).

The literature showed that teachers in both large laptop initiatives and small school programs experienced increases in constructivist practices. Teachers across all 29 laptop schools in the Anywhere Anytime Learning initiative showed movement toward constructivism (Rockman et al., 2000). In studies of smaller implementations, teachers were found to employ constructivist instructional practices at higher frequency once laptops were introduced despite the wide variance of laptop integration into their curriculum (Bebell, 2005; Burns & Polman, 2006; Silvernail & Lane, 2004). In contrast, Windschitl and Sahl (2002) concluded that the mere presence of ubiquitous computing did not move teachers toward constructivism. Yet the data they presented did not support this claim as their subjects either implemented constructivist practices, showed increased positive attitudes toward constructivism, or explicitly credited their laptop program with facilitating a move toward constructivist teaching practices.

*Changing roles.* As a result of shifting pedagogy, teachers found their roles changed where they became "more 'facilitators of learning' in the ubiquitous computing classroom and less ‘disbursers of knowledge’” (Swan, Van ‘T Hooft, Kratcoski, & Schenker, 2007, p. 506). Researchers observed that a portion of the instructional content in laptop classrooms could be delivered through electronic means, which allowed students to construct their own knowledge and reduce the content responsibilities for the teacher (Burns & Polman, 2006; Dwyer et al., 1991; Garthwait & Weller, 2005; Penuel, 2006; Swan et al., 2005; Swan et al., 2007). Rockman et al. (1998) noted that when students had laptops teachers spent less time lecturing, teachers took on the role of facilitator, and students directed their own learning.

## *Changes to the Classroom Environment*

Researchers found that ubiquitous access to computers significantly changed the classroom environment in one-to-one laptop schools. Technology use in curriculum increased, which was linked to changes in social roles and interactions for both students and teachers. Studies also credited laptops with increasing student motivation, engagement, and attendance. However, the complexities of technology-infused instruction also resulted in classroom management issues, increased distraction, and instructional interference from computer-related issues.

### *Increased Technology Use*

The most widely noted and perhaps most obvious conclusion researchers drew about the impact of one-to-one laptops programs was that technology use in the classroom increased. In Rockman et al.'s (1998) landmark study of the Anytime Anywhere Learning initiative, researchers reported increased technology use at all 29 school sites. They amplified this finding by claiming, "Seventh grade laptop students used computers as much in a day as non-laptop students used them in a week. Tenth grade laptop students used computers in school more than two hours per day, over nine times as much as the non-laptop students" (p. 5). Other researchers drew similar conclusions during statewide studies conducted in Maine (Silvernail & Lane, 2004; Mitchell Institute, 2004) and New Hampshire (Bebell, 2005). While this conclusion was found in most of the research, it was hardly groundbreaking as increased technology use was a logical of one-to-one student laptop programs.

More revealing was the finding that the amount of increased technology use varied by curricular area. The largest increase was found in language arts, specifically writing. A number of researchers noted that students spent a large portion of their computer time writing and editing papers (Bebell, 2005; Lowther et al., 2003; Mitchell Institute, 2004; Owston & Wideman 2001; Rockman et al., 1997, 1998, 2000; Russell, Bebell, & Higgins, 2004; Silvernail & Gritter, 2007; Warschauer, 2005). Russell et al. (2004) noted that "students in the 1:1 classrooms viewed laptop computers as their primary writing tool" (p. 322) and that students experienced "nearly universal use of technology for writing" (p. 313). To a lesser degree, researchers also found increases in technology use in humanities (Rockman et al., 1998; Russell et al., 2004; Van Hover et al., 2004) and science (Burns & Polman, 2006; Garthwait & Weller, 2005; Rockman et al., 1998; Russell et al., 2004). The increase in technology use in math was the least conclusive. Russell et al. (2004) noted that while technology use in math for laptop students was greater than that of non-laptop students, the degree of increase was noticeably less than that of science, language arts, or humanities.

Beyond specific subject level increases in technology use, researchers also found that students used technology more often in normal day-to-day academic practices. Penuel (2006), in his research synthesis of one-to-one computing initiatives, said, “Across a wide range of studies, students use laptops primarily for writing, taking notes, completing homework assignments, keeping organized, communicating with peers and their teachers, and researching topics on the Internet” (p. 340).

*Student-Centered Activities*

When describing the characteristics of a ubiquitous computing classroom, Swan et al. (2007) noted that “teaching and learning was more student-centered, more collaborative, more project-oriented, more constructivist, and more flexible” (p. 509). Parallel to the shift toward constructivism, students often assumed a larger role in the development and execution of learning activities. These student-driven activities were characterized by greater individualization of instruction and increases in collaborative work through project-based learning.

*Individualized instruction.* The literature showed that laptop students experienced an increase in individualized learning, as the laptops allowed teachers to differentiate instruction, individualize pacing, and provide timely feedback (Dunleavy et al., 2007; Rockman, 2003; Russell et al., 2004). Rockman (2003) summarized this individualization by stating, "[Laptop] students can do more work on their own and at their own pace, and the teachers can act more as consultants to them, offering individualized suggestions, mid-course corrections, and more frequent assessments of individual and group progress" (p. 26).

Researchers found that laptop students often guided the construction and execution of many of these individualized instructional activities. Rockman et al. (1998) reported that students took initiative to use their laptops in active learning strategies to accomplish complicated activities. In other studies, laptop students were found to choose both their own research topics and the methods in which to present their findings (Dunleavy, et al., 2007; Mitchell Institute, 2004; Rockman et al., 1998; Russell et al., 2004; Swan et al., 2007).

*Collaborative work.* In addition to individualized instruction, researchers found that students in ubiquitous computing classrooms participated in more collaborative, project-based learning. Case study analyses showed that students experienced increased collaboration with peers through shared group work and digital communications (Dunleavy et al., 2007; Swan et al., 2007). Lowther et al. (2003) found that laptop students engaged in collaborative learning 65% of the time they were observed by researchers. Other studies amplified this finding by claiming that students spent less time in group lecture and more time working as collaborative teams to accomplish complex tasks (Dwyer, 1994; Lowther et al., 2003; Rockman et al., 1998; 2004; Rockman, 2007).

### *Changing Roles and Interactions*

Researchers observed that the movement toward student-centered learning was often accompanied by changing classroom roles for students. Along with these changing roles, and in concert with their increased participation in instruction, students also experienced changes in their interactions with teachers and peers.

*Students as teachers.* Given the amount of technology knowledge needed to fully integrate laptops into the curriculum, teachers turned to several sources for training and technical support. Professional development, as previously mentioned, was the primary means of training teachers on the use of technology in classroom. However, such professional development did not account for just-in-time learning, where teachers needed training in specific technology skills during class time (Penuel, 2006; Rockman et al., 1997; Schrum, 1999). Researchers found that students often filled this void by being content experts and thereby assuming a teaching role in the classroom. The Maine Learns Technology Initiative formalized this role by creating student “iTeams” in many schools where groups of students were available to help troubleshoot routine computer problems and teach teachers specific technology skills (Silvernail & Lane, 2004, p. 30).

*Student-teacher interactions.* The literature also suggested that student-teacher interactions improved as a result of participation in one-to-one student laptop programs. Researchers used pre- and post-survey data (Bebell, 2005) and experimental designs (Lowther et al., 2003; Rockman et al., 1997; 1998; 2000; 2004; Russell et al., 2004) to conclude that ubiquitous computing generally improved students' interactions with their teachers. However, a clear definition of improved interaction was absent from these findings. Researchers failed to clarify what metrics they used to identify these improvements and whether improved student-teacher interactions meant increases in communicative quantity or quality.

*Interactions between students.* Ubiquitous computing was found to affect interactions between students and their peers in ways comparable to the improvements in student-teacher interactions. As opposed to the vagueness of findings related to student-teacher interactions, researchers clarified their claims about student peer interactions with explanation and examples. During collaborative work projects, students' classroom interactions with peers increased both in quantity and quality (Dunleavy et al., 2007; Dwyer, 1994; Lowther et al., 2003; Russell et al., 2004; Swan et al., 2007). Social dynamics also changed as peer interactions shifted toward increased inclusion.

Researchers showed that students who had previously been shunned by peers experienced greater prominence in the social hierarchy of laptop classrooms due to their technical knowledge (Dunleavy et al., 2007; Russell et al. 2004; Windschitl & Sahl, 2002).

*Increased Motivation and Enthusiasm for School*

Researchers found that students in one-to-one student laptop programs exhibited increased motivation and engagement in classroom activities. Large scale studies claimed that students in laptop programs across displayed not only more engagement in classroom activities, but also greater enthusiasm for school in general (Bebell, 2005; Rockman et al., 1997, 1998, 2000; Silvernail & Lane, 2004). As an indicator of this increased motivation and enthusiasm for school, researchers reported that student attendance increased in laptop schools. Drawing upon his extensive research of laptop schools, Rockman (2007) asserted that increased attendance was a noted benefit of one-to-one student laptop programs. To support this assertion, he drew upon his own frequently cited research synthesis that stated students in laptop programs experienced greater enrollment and attendance (Rockman, 2003). Other studies used self-reported data to support similar findings (Bebell, 2005; Silvernail & Lane, 2004). Though this evidence suggested that attendance improved, no corroborating quantitative data could be found to show changes in actual attendance figures.

*Disadvantages of Ubiquitous Computing in the Classroom*

Researchers found that the use of laptops introduced detractive complexities into the classroom environment. Teachers who taught in laptop schools found classroom management was more difficult, laptops presented opportunities for distraction and inappropriate behavior, and their teaching was over-reliant on uncertain technology dependability.

*Classroom management.* Dunleavy et al. (2007) and Windschitl and Sahl (2002) found that classroom management became more difficult for teachers in laptop environments. They attributed this difficulty to the complexity of laptop-based curriculum and the increase in individualized instruction. Thus, the same factors that were seen as positive impacts of ubiquitous computing also provided classroom management problems for the participants who were on the ground level of program implementation.

*Distraction and inappropriate computer use.* A large portion of these classroom management issues were attributed to the Internet access included with students' laptops. Such access provided students opportunities for distraction and inappropriate behavior. Several studies found that laptop students were distracted more often, and therefore disengaged in class as a result of Internet enabled computing (Bebell, 2005; Rockman et al., 2004; Tan & Morris; 2006). The Mitchell Institute (2004) and Rockman (2007) both claimed that along with distraction, instances of inappropriate computer use increased in laptop classrooms. Rockman (2007) defined this harmful computer use as “an adult-defined dark side, in which illegal and inappropriate content becomes available and circulates with alarming speed and without apparent restraint” (p. 24). However, some researchers found that the levels of distraction and inappropriate use could be reduced through clear definition of rules and by keeping students on task. Rockman (2007) explained this claim by stating, “When a well-constructed 1:1 program is in place, students learn the difference between appropriate and inappropriate use of the computer” (p. 23). He went on to claim that well-constructed programs have clearly defined rules and guidelines and have “devised various ways to monitor students” (p. 23).

*Over-reliance on technology.* While researchers lauded the impacts of technology-infused pedagogy on the classroom environment, they also noted that such reliance on computers could be troublesome, especially during computer failures. Researchers found a positive association between computer reliability and student learning, noting that decreased reliability had detrimental impacts on instructional effectiveness (Penuel, 2006; Silvernail & Lane, 2004). They found that computer failures took time away from curriculum and, in some cases, halted instruction completely (Burns & Polman, 2006; Mitchell Institute, 2004; Windschitl & Sahl, 2002).

## *Impacts on Student Learning*

In the shadow of the No Child Left Behind Act of 2001 (Public Law 107-110), one-to-one student laptop programs have often been implemented with the promise that they will help improve standardized test scores through differentiation of instruction and increased access to academic resources. However, researchers have been unable to conclude whether one-to-one student laptop programs positively or negatively impacted test scores. In fact, the research strongly suggested that ubiquitous computing had no effect whatsoever.

### *Impact on Standardized Test Scores*

Several researchers have attempted to establish a link between participation in one-to-one student laptop programs and standardized test scores. Research was found that presented findings supporting both sides of the issue; some studies found that students in laptop programs experienced increased test scores, while others found decreases. Since these results were both compelling and contradictory, the literature was ultimately inconclusive as to the true impact of ubiquitous computing on standardized test scores.

*Increased test scores.* As far back as the Apple Classrooms of Tomorrow (ACOT) project, researchers have claimed that ubiquitous computing has improved standardized test scores. Dwyer (1994) stated, “Two years in a row the district reported significantly higher scores on the California Achievement Test [for ACOT students] than students in non-ACOT classrooms in vocabulary, reading comprehension, language mechanics, math computation, and math concept/application" (p. 5). Silvernail and Lane (2004) reported that laptop students showed improved performance in class and that laptops helped students meet Maine's statewide learning standards. Through case study analysis, Warschauer, Grant, Del Real, and Rousseau (2004) concluded that technology-infused learning activities, as part of a one-to-one student laptop program, increased test scores for students in a "culturally and linguistically diverse" urban school (p. 532). Yet, none of these studies provided actual test score data to support their claims.

Other studies, however, were able to show statistically significant increases in test scores for laptop students. In a three-year study, Grimes and Warchauer (2008) tracked test scores for two cohorts of middle school students: one cohort of laptop students and one cohort of non-laptop students. They found that laptop students experienced increases in math scores on a standardized assessment relative to their non-laptop peers. In a similar study of classrooms with different student-computer ratios, the class with a 1:1 ratio outscored both the 4:1 ratio class and the class with no access to computers in a standardized writing assessment (Owston & Wideman, 2001).

*Decreased test scores.* Contrary to the aforementioned findings, several studies found that students who participated in one-to-one student laptop programs experienced a decrease in standardized test scores. Wenglinksy (2006) reported that high school students in a one-to-one student laptop program scored lower on the National Assessment of Educational Progress (NAEP) after the introduction of laptops. He concluded there was a negative correlation between laptop use and test scores stating, “The more time [students] spend on computers in school, the lower they were likely to score on the NAEP” (p. 31). In the same study in which Grimes and Warschauer (2008) found math scores increased, English/Language Arts scores for laptop students decreased by 7% compared to non-laptop students.

*Inconclusive results.* In response to these contradictory results, prominent researchers postulated that the impact of ubiquitous computing on standardized tests scores was inconclusive. In their culminating report on the Anytime Anywhere Learning initiative, Rockman et al. (2000) found that comparisons of standardized test scores across the schools they studied yielded inconclusive findings. Rockman (2003), in his frequently cited position paper said, “Those administrators and board members who insist on a specific test score gain as the return on investment are, more likely than not, going to be disappointed” (p. 25). Penuel (2006) amplified this claim by stating, “The expectation that one-to-one initiatives will improve achievement scores bears further investigation, and it is likely that to expect achievement gains, one-to-one initiatives would need to be part of a larger, more comprehensive effort to improve instruction” (p. 341).

*Insufficient Measure of Student Learning*

The literature suggested, then, that standardized tests are not an ideal metric for evaluating student learning, as these tests fail to assess the skills and competencies students learn during participation in one-to-one student laptop programs (Grimes & Warschauer, 2008; Rockman, 2003). These findings illustrate that authentic evaluation of student learning in one-to-one laptop programs must be grounded in an assessment of the skills and competencies students learn through participation, which begs the question: what do students learn by participating in a one-to-one student laptop program?

Researchers found that students who participate in one-to-one student laptop programs experienced improved work quality in core curriculum areas, most notably in writing. Outside of core curriculum learning, students also developed skills in technology usage, data processing and representation, and higher order thinking. Interestingly, the degree to which students learned these skills and competencies was negatively correlated to their academic achievement prior to their participation in ubiquitous computing.

*Improved Work Quality*

The literature suggested that student work quality improved through ubiquitous computing. In landmark multiple site, mixed methods studies, Silvernail and Lane (2004), Rockman et al. (1998), and Grimes and Warchauer (2008) listed improved work quality as a student learning outcome for the one-to-one student laptop programs. Case study research also corroborated this conclusion (Mitchell Institute, 2004; Rockman et al., 2004, Swan et al., 2007), as did Penuel (2006) in his research synthesis.

However, the type of data used to draw this conclusion raises some validity issues. For the most part, researchers cited teachers' opinions as their basis for drawing the conclusion that ubiquitous computing improved student work quality. While these opinions came from practitioners who had direct experiential knowledge of students' work, the data was self-reported and therefore not immune to bias. Similarly, authors failed to present a comparative analysis of student work, nor did they draw any explicit links between improved work quality and learning in core curriculum areas. Still, the number of studies that listed improved student work quality as a conclusion must be noted as it provides a degree of credence to the finding.

*Writing*

One core curriculum area researchers explicitly discussed as being impacted by ubiquitous computing was writing. The literature showed that ubiquitous computing increased both the quantity of student writing and the frequency of peer review, along with improving students' writing quality. Researchers cited the ease of editing and redrafting through writing on a computer to support this claim (Bebell, 2005; Mitchell Institute, 2004; Penuel, 2006; Rockman et al. 1997, 1998, 2000, 2004; Russell et al., 2004; Warschauer, 2005). In conjunction with increased writing and editing, students in one-to-one student laptop programs also engaged in peer review at a higher frequency (Bebell, 2005; Owston & Wideman, 2001).

Most notably, researchers found that laptop students experienced an improvement of writing quality (Bebell, 2005; Grimes & Warschauer, 2008; Lowther et al., 2003; Owston & Wideman, 2001; Rockman, 2003; Rockman et al. 1997, 1998, 2000, 2004; Silvernail and Gritter, 2007; Warschauer, 2005). Two studies supported this finding by evaluating laptop students' writing quality through standardized assessments. Owston and Wideman (2001) found that students in a one-to-one laptop environment scored higher and showed a greater amount of improvement on the writing subtest of the California Test of Basic Skills than did non-laptop students. Silvernail and Gritter (2007) found that students who participated in the Maine Learns Technology Initiative showed a 32% increase in writing scores on state administered tests over non-laptop students.

*Learning in Non-Core Curriculum Areas*

Rockman (2003) said, "Computers don't provide content, they offer the tools to access, manipulate, and organize content." (p. 25). Through the use of these tools, researchers found that students developed competencies in several non-core curriculum areas, including: the acquisition of technology skills, information literacy, and improved higher order thinking skills.

*Acquisition of technology skills.* A majority of the literature claimed that laptop students acquired technology skills through ubiquitous access to their computers. Some researchers merely listed computer proficiency as a student learning outcome without providing data to support their claims (Burns & Polman, 2007; Swan, et al., 2005, 2007; Warschauer, 2005). Other researchers supported their claims with self-reported data, such as comparative data of laptop students' confidence with technology against data collected from non-laptop students (Lowther, et al., 2003) and students' self-rating of computer skills (Mitchell Institute, 2004). Still other researchers noted the specific technology skills students acquired, with word processing, Internet use, and electronic communication being the most frequently noted skills (Dunleavy et al., 2007; Dwyer, 1994; Rockman et al., 1997, 1998, 2000, 2004; Warschauer et al., 2004; Windschitl & Sahl, 2002).

*Information literacy.* Beyond technology skills attainment, the literature suggested that students in one-to-one student laptop programs developed information literacy, which included skills in the accessing, processing, and presentation of information. Grimes and Warschauer (2008) define information literacy as "the ability to locate, recognize, evaluate, and synthesize information across a wide range of media using electronic resources and other technology" (p. 317).

Within this information literacy, students first learned how to access information using their laptops, mostly through Internet use (Dunleavy et al., 2007; Mitchell Institute, 2004, Rockman et al., 2004). Next, students learned how to organize, validate, and process information (Grimes & Warschauer, 2008; Silvernail & Lane, 2004). Finally, they learned how to present their findings using electronic tools (Rockman, 2003; Rockman et al., 1997; Swan et al., 2007; Warschauer et al., 2004).

*Higher order thinking skills.* In concert with information literacy skills, researchers concluded that students developed higher order thinking skills through the learning activities they engaged in as part of their one-to-one student laptop programs. Higher order thinking skills included critical thinking, causal reasoning, and problem solving. Rockman et al. (1998) found that laptop students who participated in the Anytime Anywhere Learning initiative demonstrated higher order thinking skills at a greater degree than non-laptop students, crediting the laptops with positively impacting students' thinking processes. In their case study of a high school laptop program, Mitchell Institute (2004) claimed curricular rigor had been increased as a result of higher order thinking skills attained through laptop use.

*Degree of Learning Impact*

Researchers found that the degree of learning impact of ubiquitous computing was inversely related to students' academic performance prior to participation in the laptop program. High achieving students experienced the smallest learning impact, while low achieving and special needs students experienced the greatest impact (Bebell, 2005;

Penuel, 2006). The literature suggested that the individualized instruction and increased access to resources available through ubiquitous computing accommodated the needs of low achieving and special needs students (Bebell, 2005; Mitchell Institute, 2004; Rockman et al., 1997; Russell et al., 2004; Swan et al., 2005). Russell et al. (2004) described this phenomenon as "a leveled playing field" between traditional and special needs students (p. 322). Traditional and high achieving students also experienced the impacts of ubiquitous computing, but to a lesser degree than low achieving students.

### *Summary*

The Educational Digital Divide is a complex issue of inequity that manifests in three areas: access, usage, and empowerment. A chasm of access to school technology infrastructure exists between low SES and high SES students, where low SES students do not have access to the computing and digital communication resources requisite for meaningful educational computer use. Yet, the divide in educational computer use itself is representative of educational digital inequity. Students in high SES classrooms have been shown to use technology in ways that encourage cognitive development, creativity, and deeper understanding of content. This divergence of use has resulted in a gap in learning outcomes. Low SES students who have not had the opportunity for meaningful educational computer use have been unable to leverage those experiences for personal empowerment, thus replicating social inequity.

Yet one-to-one student laptop programs were an area of scholarship noticeably absent from the Educational Digital Divide literature. What if every low SES student was given equal access to technology for use at home and at school? Would this reduce the Educational Digital Divide? The literature suggested that one-to-one student laptop programs would simultaneously reduce and perpetuate the divide. By providing all students equal access to the technology, the first level of the divide – access – would be significantly reduced. However, equitable usage of computers would not automatically emerge. Instead, research shows that laptop use and the resulting student empowerment would continue to diverge. To avoid this potential consequence, this study was warranted; an investigation of computer usage in one-to-one student laptop programs that determined how ubiquitous computing impacts the learning aspects of the Educational Digital Divide.

The literature showed that one-to-one student laptop programs have appreciable impacts on teaching and learning in the areas of effects on teachers, changes to the classroom environment, and impacts on student learning. Teachers experienced changes in their progression through the evolutionary process of integrating laptop use into their curriculum by means of professional development, collaboration, and involvement in program development and administration. They also experienced changes in their attitudes toward technology and education, shifted instructional roles, and movement toward constructivist practices. Within the classroom environment, the shift toward constructivism was paralleled by increases in student-centered activities, collaboration, and individualized instruction. Students in these classrooms showed greater motivation and enthusiasm for school, while experiencing improved interactions with teachers and peers. Not surprisingly, the influx of technology resulted in greater use of technology in instruction. Yet, researchers also found negative effects of technology: increases in distraction, inappropriate computer use, and time spent managing classroom behavior. As for student learning, the literature suggested that laptop students experienced an increase in work quality, specifically in writing. They also develop skills and competencies in technology use, information literacy, and higher order thinking. The research illustrated an inverse relationship between the learning impact of ubiquitous computing and prior academic achievement, with the greatest learning found among low-achieving students. However, the research was inconclusive as to whether ubiquitous computing had any effect, either positive or negative, on standardized test scores.

The breadth of these impacts implies that ubiquitous computing has the potential to fundamentally change pedagogy. However, the depth of these impacts also exemplifies the level of complexity ubiquitous computing can impart on instruction and curriculum. These confounding influences suggest that authentic assessment of student learning is needed to determine the educational value of one-to-one student laptop programs. Yet at present, standardized testing, rather than authentic assessments, are the requisite means for measuring student learning.

Although standardized testing has become the pervasive form of educational assessment, the use of test score data as a gauge of student learning in one-to-one student laptop programs is insufficient. As such, alternate measures and definitions of student learning outcomes in one-to-one student laptop programs must be applied. Yet, no such measures or definitions could be found. The literature did make allusions to student learning outcomes such as information literacy and technology skills acquisition, but these links were indirect and vague. In order to truly assess the impacts of ubiquitous computing on student learning, research was needed to explicitly define the learning outcomes students attained through participation in a one-to-one student laptop program.

Moreover, to fully examine the impact of laptop programs on student learning, this research could not merely focus on school-related student learning. Within the scope of the currently available published literature, little research could be found that investigated student learning outside of the classroom. Since laptop students have ubiquitous access to their computers, they undoubtedly experience learning outcomes in non-academic contexts, such as computer use for social interaction or recreation. As a result, the research into student learning outcomes had to include a comprehensive scope, focusing on academic and non-academic learning.

Not surprisingly, the greatest deficiency in the one-to-one student laptop program literature was the absence of empirical research into the learning impacts of ubiquitous computing on underserved populations. Much of the available research either investigated schools in affluent communities or completely omitted population demographics. For the most part, the literature has failed to take into account the influence of the material conditions of low SES students and the presence or lack of entry skills and behaviors. Most importantly, the literature has ignored the impacts of ubiquitous computing on the second and third levels of Educational Digital Divide. Thus, the conclusions drawn from the existing research may not directly translate to schools that serve low SES communities.

However, this dearth of literature presented an opportunity for this research. This study investigated existing one-to-one student laptop programs to identify the breadth of student learning attained through ubiquitous computing and to identify which of those learning outcomes had the greatest impact on low SES students. By identifying the breadth of student learning outcomes – both academically and non-academically – for one-to-one student laptop programs, researchers and practitioners will have a strong empirical basis for program assessment and improvement. These data provide views into meaningful computer usage and realistically attainable learning outcomes that can influence laptop programs in low SES communities, thus addressing the second level of the Educational Digital Divide. Moreover, by identifying student learning outcomes that have the greatest potential impact on low SES students, program administrators can tailor their programs to specifically target the third level of the divide: the use of computer skills and knowledge for student and community empowerment.

# Chapter Three: Methodology

## *Introduction*

The purpose of this exploratory multi-case study was to identify student learning outcomes from existing one-to-one student laptop programs, particularly outcomes that had direct impacts on low SES students. The research was designed to investigate perceptions around student learning and the impact on low SES students from program participants – students, teachers, and administrators – at five laptop schools. However, as there was only one laptop program in the SF Bay Area that served low SES students, data were collected not only at the low SES laptop school, but also at four other laptop schools, all of which served high SES students. These five schools were classified as individual cases, then divided into two groups. In group A, qualitative research was conducted at the four high SES schools to investigate the academic and non-academic learning that students experienced through participation in one-to-one student laptop programs. By investigating this breadth of data sources and participants, a comprehensive list of students learning outcomes was developed from these high SES schools. In group B, research was conducted at the public high school that served a majority of low SES students. This data collection paralleled that of group A, but refined the focus from student learning found in laptop programs to those experienced by low SES students. Data were also collected to identify the existence and persistence of the Educational Digital Divide between participants at the five research sites.

*Research Questions*

1. What are the student learning outcomes for existing one-to-one student laptop programs?
2. In what ways, if any, are these student learning outcomes different for low SES students?

*Variables*

The variables of analysis for this research were drawn from my experiences as a laptop program administrator, my research into one-to-one student laptop programs, and conclusions drawn from the Educational Digital Divide and one-to-one student laptop program literature. In what follows, variables are identified and defined with references to the literature and their sources of data. Data sources are leveled by primacy – primary, secondary, tertiary – based on their perceived value toward investigating the variable.

**The Educational Digital Divide –** The ways in which disproportionate access to technology impacts the educational and personal lives of students (Hohlfeld et al., 2008). Modeled around Hohlfeld et al.'s (2008) three-tiered conceptualization of the Educational Digital Divide, this variable focused on (i) access to computers and the Internet, (ii) the use of educational technology, and (iii) student empowerment. Since this variable measured the direct impact of technology access on students, students were used as the primary data source. Teachers and administrators were the secondary and tertiary data sources, respectively.

**Socioeconomic Status –** The degree to which students, their families, and their communities reside within the stratum of access to social and economic resources (Cohen, 2009). This variable sought to measure ways in which financial and educational factors impacted social and economic conditions. Publicly available data from the California Department of Education on students' eligibility for Free and Reduced Price Lunch and parent education levels were used as the primary data source. Administrators served as the secondary source and students as the tertiary.

**Teaching –** The ways in which ubiquitous computing impacts teaching methodology and instruction delivery (Burns & Polman, 2006; Dwyer et al., 1991; Windschitl & Sahl , 2002). Based on conclusions from the literature, the focus of this variable ranged from changes to instructional practice – integration of technology in instruction and movement toward constructivism – to impacts on teaching roles and collaboration. As this variable focused on teaching directly, teachers were the primary source of data, with administrators, as their direct supervisors, being the secondary source.

**The Classroom Environment –** Ways the learning environment of the classroom is changed through the introduction of laptops (Lowther et al., 2003; Rockman et al., 1997).

Student empowerment, motivation, and engagement were the central foci of this variable, along with the increase in collaborative and project-based learning. Since teachers have such as central role in creating the classroom environment, they were the primary source of data. Students were the secondary data source and administrators were the tertiary.

**Student Learning –** The areas, manifestations, and degrees of impact laptops have on what students learn, both academically and non-academically (Grimes & Warschauer, 2008; Rockman et al., 1998; Silvernail & Lane, 2004). Guided by my personal experience and conclusions from the literature, this variable explored a range of student learning, including core curriculum learning, information literacy, personal growth, communication, high order thinking, and accommodation. Students were used as the primary source of data, with secondary and tertiary data coming from teachers and administrators, respectively.

Table 1

*Variables for analysis and their sources of data*

| *Variable* | *Primary Data Source* | *Secondary Data Source* | *Tertiary Data Source* |
|---|---|---|---|
| The Educational Digital Divide | Students | Teachers | Administrators |
| Socioeconomic Status | Public Data | Administrators | Students |
| Teaching | Teachers | Administrators | |
| The Classroom Environment | Teachers | Students | Administrators |
| Student Learning | Students | Teachers | Administrators |

*Research Design*

This study employed a multi-case mixed methods design (Creswell & Plano Clark, 2007; Yin, 2009) guided by Laura Nader's (1972) "Studying Up – Studying Down" paradigm. Using Nader's paradigm of studying privilege as a means of informing research that intends to benefit subverted groups, this study was designed to analyze what high SES laptop students learned through participation in ubiquitous computing, then couple that knowledge with research in a low SES laptop school in an effort to identify impactful student learning outcomes of one-to-one student laptop programs in low SES schools.

Group A was organized as the "Studying Up" phase of the overall research. For this group, a breadth of data sources and research sites was used to aggregate the learning outcomes experienced by students in existing one-to-one student laptop programs, all of which were found in high SES schools. This phase of the research employed a multiple case study (Yin, 2003; 2009) in which program participants from four laptop schools were studied. Data collection utilized interviews and focus groups with students, teachers, and administrators to investigate program participants' perceptions of student learning. Using these data, student learning outcomes for one-to-one student laptop programs were identified.

Group B was designed as the "Studying Down" phase. Similar methods to those for group A were used, but redefined to focus on the role of socioeconomic status in laptop learning. Opposed to the breadth of data sources used in group A, a depth of data at a single research site were investigated.

For both groups, students were surveyed to measure (i) their degree of technology access, (ii) uses of computing in the classroom, and (iii) student home use of technology, thereby measuring the manifestation of the three levels of the Educational Digital Divide between low SES and non-low SES laptop students.

### *Role of the Researcher*

For the research conducted with the group A schools, I maintained a colleague/peer relationship with the technology directors at these schools through my participation in the Bay Area Independent Schools Network (Chan, 2010). However, within each institution, my relationships with administrators, teachers, and students fell under the classic researcher-participant paradigm. Similarly, in the group B school, the only relationships I had with participants prior to data collection came in my solicitation of their participation. However, as the group B research was designed to engage participants in greater depth than group A, relationship development was key in establishing an open, honest, and productive data collection environment. I established these relationships with introductory conversations that included “get to know you” content and full descriptions of my research interests, my experience, and my long-term research agenda.

## *Research Sites*

The research sites included in this study consisted of five schools – four private schools and one public school – located in the San Francisco Bay Area that had implemented and sustained one-to-one student laptop programs. The four private schools were used as the group A research sites, with the public school serving as the group B research site. In table 2, the names, types, levels, and research groups of the five schools has been listed. All school names are pseudonyms.

Table 2

*Types, levels, names, and groups for the five laptop schools*

| *School Name* | *School Type* | *School Level* | *Research Group* |
|---|---|---|---|
| Chavez High School | Public | High School | Group B |
| Gibson Middle School for Girls | Private | Middle School | Group A |
| Hemings High School | Private | High School | Group A |
| Twain Middle School for Boys | Private | Middle School | Group A |
| Ulysses High School | Private | High School | Group A |

### *Site Selection*

To begin the site selection process, 20 laptop schools in the San Francisco Bay Area were identified and investigated. During this preliminary research, each school was contacted to assess information about their laptop programs, learn more about the schools themselves, and to solicit preliminary permission to conduct research. From this list, the five school sites were selected using a process that was developed to account for program and participant variability.

While all one-to-one student laptop programs share certain characteristics, such as the distribution of laptops to each student in the program, the ways in which laptop programs are implemented and administered vary from school to school. This study's site selection process accounted for such variances by including multiple sites that represented a cross section of variables.

This site selection process accounted for the following variables:

- **Type –** public or private
- **Grade level –** middle or high school
- **Number of students** – small programs ($n < 200$), medium programs ($200 < n < 500$), or large programs ($n > 500$)
- **Year started –** programs that were established (started prior to 2005) or new (started in 2005 or later)
- **Laptop ownership –** whether the school or the student's family owned the computer
- **Level of student access –** whether the student has restricted or full administrative access to their laptop's software and operating system
- **Operating system platform –** Macintosh Operating System, Windows Operating System, or cross-platform (Note: Linux was used at certain sites, but the percentage of users using Linux was so small that it was excluded from the study)

Table 3

*Research sites with school and laptop program characteristics*

| *School Name* | *Type* | *Grade Level* | *No. of Stud.* | *Year Started* | *Owner-ship* | *Access Level* | *Operating System* |
|---|---|---|---|---|---|---|---|
| Chavez High School | Public | High | 1100 | 2004 | School | Restricted | Mac |
| Gibson Middle School for Girls | Private | Middle | 150 | 2006 | School | Admin | Mac |
| Hemings High School | Private | High | 685 | 2001 | Student | Admin | Cross |
| Twain Middle School for Boys | Private | Middle | 200 | 1999 | Student | Admin | Windows |
| Ulysses High School | Private | High | 350 | 2001 | School | Admin | Mac |

As seen in table 3, this study included schools that represented all of the aforementioned potential variation among laptop programs: two middle schools and three high schools; two large programs, two medium programs, and one small program; four established programs and one new program; two student owned computer models and three school owned; four administrative level access programs and one restricted access; three Mac programs, one Windows program, and one cross-platform program. By including this breadth of variation in the site selection process, potential confounding influence of these variables was removed.

It should be reiterated that the four group A research sites were all tuition-based private schools that served high SES students. This distribution of one-to-one student laptop programs is indicative of laptop programs in the San Francisco Bay Area being available primarily at high SES schools. Of the 20 schools found that had laptop programs, 18 of them were private schools with an annual tuition in excess of $16,000. One of the remaining laptop schools was a public school that served an affluent community. This school resided in a Basic Aid district, which means the district was not reliant on state funding for operational costs due to the large amount of revenue they received annually from local property taxes. During the site selection process, this Basic Aid laptop school was also identified as a potential research site, but despite being asked to participate in this study the school declined involvement. The second Bay Area public school that employed a one-to-one student laptop program was included as the group B research site.

Chavez High School was selected as the group B research site because it provided greater depth of data toward the overall research goal of investigating the impact of ubiquitous computing on low SES students. Chavez High was a public school that both maintained a one-to-one student laptop program and served a majority of low SES students.

According to definitions of low SES by the California Department of Education (CDE) and Cohen (2009), Chavez High's student body consisted of a majority of low SES students. Both the CDE and Cohen (2009) defined socioeconomic status as a function of income and education. The CDE operationalized this definition by stating that students are considered "socioeconomically disadvantaged" if neither of the student's parents has received a high school diploma or the student is eligible for Free or Reduced Price Lunch (FRPL), also known as National School Lunch Program (USDA, 2009).

Under this definition, Chavez High School's student body served a majority of students who were "socioeconomically disadvantaged," herein referred to as low SES students. As seen in table 4, of Chavez High's 1100 students, 620 were eligible for FRPL. This portion of the student body amounted to 56.36% of Chavez High students meeting one of the criteria for CDE's definition of low SES student.

Table 4

*Chavez High School's student population and eligibility for Free or Reduced Price Lunch*

| | |
|---|---|
| *Total population* | 1100 |
| *Number of students eligible for FRPL* | 620 |
| *Percent of students eligible for FRPL* | 56.36% |

Parent education levels reinforced this statement that Chavez High School served a high percentage of low SES students. Table 5 shows that nearly one quarter of Chavez High parents who responded with their highest level of education stated they did not graduate high school. The CDE reported that after assigning each education level with a numeric value ("1" for "not a high school graduate" through "5" for "graduate school") the Average Parent Education Level (APEL) for Chavez High was 2.58. This value was the seventh lowest APEL for large urban high schools in the SF Bay Area.

Table 5

*Parent education levels for Chavez High School*

| *Parent Education Level* | *No. of Responses* |
|---|---|
| Not a high school graduate | 24 |
| High school graduate | 23 |
| Some college | 27 |
| College graduate | 20 |
| Graduate school | 5 |
| *Average Parent Education Level (APEL)* | *2.58* |

Chavez High School's one-to-one student laptop program also provided characteristics that further accounted for variance among the laptop schools. Chavez High's laptop program was considered large (greater than 500 students) and established (started prior to 2005). It was also the only high school that restricted administrative access to its users.

Table 6

*Chavez High School laptop program characteristics*

| *School Name* | *Type* | *Grade Level* | *No. of Stud.* | *Year Started* | *Owner-ship* | *Access Level* | *Operating System* |
|---|---|---|---|---|---|---|---|
| Chavez High School | Public | High | 1100 | 2004 | School | Restricted | Mac |

Additionally, Chavez High's inclusion accounted for the influence of public versus private schools. Though this division of public versus private schools aligned with the division of socioeconomic status, in that Chavez High School represented was both a public school and a low SES school, socioeconomic status was isolated from institution type by asking administrators and teachers for attribution of this factor and by dividing students into research groups based on their eligibility for Free or Reduced Price Lunch.

*Description of the Sites*

In addition to the site selection criteria, each of the five research sites had unique cultural, historical, administrative, and programmatic characteristics that influenced the data they provided.

*Chavez High School.* Chavez High School was a public high school that served approximately 1100 students. Participants identified it as the most diverse school in the school district. One administrator explained this claim by describing the school as having "true diversity" in that there was no racial majority – greater than 50% of the population – among the student body. The student population had risen in recent years, which one administrator credited to increased test scores, improved reputation, and the school's laptop program. The laptop program itself had been at the school since 2004, but due to budget cuts had been reduced to grades 10-12 only for the school year during which this research was conducted. Each laptop student's family assumed financial responsibility for the laptop and was offered insurance at the cost of $100. However, given this cost and the potential financial liability of losing the laptop – around $1000 – some families opted out of the program.

*Gibson Middle School for Girls.* Gibson Middle School for Girls was a private, all girls middle school that opened in 1998. The student body, which consisted of 150 students, was made up of girls that came from and would matriculate to both public and private schools. The school's mission was to provide girls a focused single-sex education during their critical adolescent years. Their educational philosophy was founded on constructivist practices that utilized project-based and experiential learning. The school's laptop program was started in 2006 to supplement existing curriculum and to solve the need for a technology lab on campus when no space was available.

*Hemings High School.* Hemings High School was a private high school that served 685 students. The school was part of a K-12 private school system that spanned three divisions – elementary school, middle school, and high school – each of which occupied a separate campus. The overall school system was founded over 100 years ago, but the high school itself was only 12 years old. Hemings High School's curriculum had a strong focus on academic rigor, providing both college preparatory and college equivalent coursework. The laptop program was started in 2001 to meet aspirations of the math department that felt one-to-one access to technology was needed to facilitate changes to pedagogy and curriculum. In 2006, Hemings High School's feeder middle school also implemented a one-to-one student laptop program.

*Twain Middle School for Boys.* Twain Middle School for Boys was part of an all boys K-8 private school, which opened in 1939. The school was located in an affluent section of a major San Francisco Bay Area city. The middle school had a population of 200 students. Its laptop program, started in 1999, was the oldest laptop program in the San Francisco Bay Area. Unlike other middle school laptop programs that started at grade 6, the program at Twain Middle School for Boys started at grade 5 and ran through grade 8. During data collection, the school's administration was in the process of evaluating the program to decide if changes were needed to the program's curriculum, administration, financing, or technology.

*Ulysses High School.* Ulysses High School was a private high school located in a major urban area. The school served 350 students, a majority of which matriculated to private colleges and universities across the country. The school implemented non-traditional scheduling, assessment methods, and teaching styles. Ulysses High Students only received traditional marks in grade 12. In grades 9-11, they received rubric-based narratives. The school's pedagogy and curriculum was grounded in constructivist theory. The laptop program at Ulysses High School was started in 2001 as a means of furthering the school's educational mission. The laptop program had won numerous awards and been nationally recognized by both educational and corporate bodies as a program of distinction.

## *Population and Sample*

At each of the five research sites, data were collected from administrators, teachers, and students. These research participants were selected based on their experience within the laptop program and, in the case of group B participants, their experiences as or working with low SES students. As seen in table 7, a total of 10 administrators, 35 teachers, 35 students, and 162 student survey-takers participated in this study.

Table 7

*Number of participants by group and school*

| *School* | *Administrators* | *Teachers* | *Students* | *Survey Takers* |
|---|---|---|---|---|
| Chavez High School | 2 | 6 | 8* | 58** |
| Gibson Middle School for Girls | 2 | 7 | 9 | 25 |
| Hemings High School | 2 | 8 | 7 | 31 |
| Twain Middle School for Boys | 2 | 6 | 6 | 22 |
| Ulysses High School | 2 | 8 | 5 | 26 |
| *Total* | 10 | 35 | 35 | 162 |

***** = Includes participants from both student focus groups
(4 eligible for FRPL and 4 not eligible for FRPL)
** = Includes all student survey takers
(30 eligible for FRPL and 28 not eligible for FRPL)

At each site, two administrators were selected based on their positions relative to the administration of the laptop program and other educational programs at the school. The inclusion criteria called for one administrator directly responsible for administration of the laptop program and one administrator responsible for curriculum or instruction. Most often this included the school's educational technology coordinator or laptop program administrator and a division head or vice principal. Table 8 shows the job titles by school for each administrative research participant. Other than job responsibilities, no other inclusion criteria were used in the selection of administrator participants.

Table 8

*Job titles for the administrator research participants*

| *School* | *Administrative Positions* |
|---|---|
| Chavez High School | Assistant Principal of Guidance<br>Assistant Principal of Instruction |
| Gibson Middle School for Girls | Director of Technology (former)<br>Academic Dean |
| Hemings High School | Director of Technology<br>Head of the Upper School |
| Twain Middle School for Boys | Director of Technology<br>Upper School Director |
| Ulysses High School | Director of Technology<br>Assistant Head for Academics |

Additionally, at each research site, between six and eight teachers and five and nine students were included in the qualitative data collection. These participants were selected based on their experience with the laptop program, their perceived potential for providing thoughtful and informed responses, and, in the case of teachers, the subject they taught. Inclusion was also contingent on a minimum experience with the program of one year. In group B, teachers were also selected based on their experience working with low SES students. Group B student focus group participants were divided into two groups. One group included students that were eligible for Free or Reduced Priced Lunch and the other group included students that were not eligible. Beyond this, no other inclusion criteria were used.

The identification and selection of teacher and student research participants began with meetings with a school administrator from each research site. During these meetings, the administrator and I developed lists of potential participants based on the aforementioned criteria. These lists included 8-10 teachers and 10-14 students. From the lists, I contacted the prospective participants to solicit their participation and attain their consent. The first nine participants to respond were included in the research. In cases where nine participants did not respond, the first four to eight were included. At Chavez High School, sixteen total participants consented to participate in the two focus groups, but only four students actually attended each focus group, for a total of eight student focus group participants.

At each site, between 22-58 students completed the survey; 22-31 at the group A schools and 58 at the group B school. Survey takers were identified and solicited using a similar process to that of the qualitative research participants. With help from a school administrator, I identified and solicited participation from potential student survey takers. These students were selected based on a minimum of one year of experience in the laptop program and their identification by the administrator as participants who would provide thoughtful and informed responses. From this list of potential participants, surveys were distributed to students at each school and collected from those who chose to return them. Students who were identified as potential survey takers did not participate in the student focus groups. At Chavez High, two groups of students completed the survey: one group of students eligible for FRPL and the other not eligible.

Though the socioeconomic status of students was central to the research design, demographics for participants were not applicable and thus not collected. Participants' ethnic backgrounds, socioeconomic status, gender, and age were not considered in the inclusion criteria, data collection, or data analysis. There were three exceptions: (i) group B students were identified as low SES or non-low SES through their eligibility for FRPL, (ii) all research participants had to be located in the San Francisco Bay Area, and (iii) all students had to be K-12 age appropriate.

### *Data Collection*

Data was collected during visits to each of the five research sites. During each site visit three types of data collection were employed: interviews, focus groups, and a survey.

The two administrators at each site participated in semi-structured formal interviews (Fontana & Frey, 2000). These interviews were guided by interview protocols (see appendices B and C), but deviated from those protocols when greater depth of investigation was needed. All interviews lasted 45-60 minutes and were held on site at the school campus. All of the interviews were audiotaped and later transcribed.

At each site, six to eight teachers and five to nine students participated in semi-structured formal focus groups (Berg, 2004). These focus groups were held separately. The focus groups were guided by focus group protocols (see appendices D-F), but deviated from the protocols when greater depth of investigation was needed. The focus groups lasted 45 minutes and were held on site at the school campus during the school day. All of the focus groups were audiotaped and later transcribed.

The interview and focus group protocols were designed as a framework for identifying potential, intended, and actual student learning outcomes. The group B protocols were also designed to identify the role of socioeconomic status in laptop learning. These protocols were based on conclusions from the literature and my experiential knowledge as a laptop program administrator. To ensure that the protocols were researching the impacts of laptops rather than other school conditions, each interview and focus group began with introductory questions about school quality then made explicit shifts toward questions about the learning effects of the laptop programs (see appendices B-F).

As a tool for comparison between non-low SES laptop students and the low SES students who participated in group B, a short survey was distributed to gauge students' level of technology access and usage (see appendix A). This survey was developed to assess the manifestation and persistence of the three levels of the Educational Digital Divide. It was administered at each school during my site visits. Completion of the survey took 5-10 minutes and was completely anonymous.

Attached to each of the data collection instruments in the appendices are full descriptions of the data collected, rationale, and links to the literature for each question. Please refer to appendices A-F.

*Differences Between Group A and Group B Research*

Though similar data collection methods were employed for both group A and group B research, there were distinct differences in research focus, participants, and instrumentation.

Since identifying student learning outcomes of one-to-one student laptop programs in low SES schools was the main research focus for this study, the group B data collection was refined to investigate student learning at a low SES school. As opposed to group A, the research focus for group B shifted away from general student learning to the learning outcomes experienced by low SES students. This was accomplished by implementing changes to the research design and instrumentation that isolated the role of socioeconomic status in student learning for Chavez High's one-to-one student laptop program.

To begin, the number of participants and the inclusion criteria for group B student participants were expanded. As opposed to group A data collection which included one student focus group, group B consisted of two focus groups. The two groups were held in parallel, with one group including low SES students and the other including non-low SES students. An inclusion criterion was added that identified participants as eligible for FRPL for the low SES group and not eligible for the non-low SES group, thereby creating a research scenario where socioeconomic status was isolated between the two groups. The same research protocol that was employed for the group A focus groups was used in both of the group B student focus groups (see appendix D). Additionally, the survey was distributed to 27 more students at Chavez High than at any of the other research sites. Again, students were divided into low and non-low SES groups as identified by their eligibility for FRPL. Both groups were given the same survey that was distributed to the group A students.

The protocols for the teacher focus group and the administrator interviews in group B were altered from the protocols used at the group A schools to explicitly focus on the role of socioeconomic status in student learning (see appendices C and F). While group B teachers and administrators were asked similar questions about student learning as the group A participants, they were also asked how socioeconomic status influenced that learning and how low SES students experienced different learning outcomes than their non-low SES peers. The added questions resulted in data collection sessions that lasted roughly 20 minutes longer than those in group A.

## *Validity*

As this study employed a multi-case study design that used participant perceptions as primary data sources for the investigation of multiple variables, validity of sources and design were paramount. For group A, validity was ensured through breadth of data, the inclusion of multiple sites, and multiple participant groups. For group B, validity was attained through depth of data at a single site while also using multiple participant groups.

### *Group A Validity*

To ensure validity of the research design and data collection methods for the group A research, a breadth of sites and participants was included. This breadth of data sources provided varying levels of experience and conditions that accounted for potential confounding variation.

As described earlier in this chapter, the site selection criteria accounted for six variables found in laptop programs. Both middle schools and high schools were included as well as programs of differing sizes, ages, and levels of student control. By conducting research at four schools, the breadth of data collected from these dissimilar configurations of laptop programs minimized the research effects of this variation. By investigating all of these schools this study was able to identify a more exhaustive list of student learning outcomes.

Triangulation of data sources was another tool used to validate the research. By investigating administrators, teachers, and students, three different participant groups were included, each of which had separate areas of expertise, knowledge, and motivation for learning. Through comparison of data from these three groups this research was able to develop more accurate conclusions.

Moreover, at each school site, breadth was employed as a validity measure in participant selection. Administrators, teachers, and students were all included to investigate student learning outcomes from a cross-section of program stakeholders. Each participant group offered insight into the spectrum of student learning outcomes. As seen in figure 3, administrators were chosen because they were seen to possess greater knowledge of intended academic outcomes, whereas students had direct knowledge of actual non-academic learning outcomes.

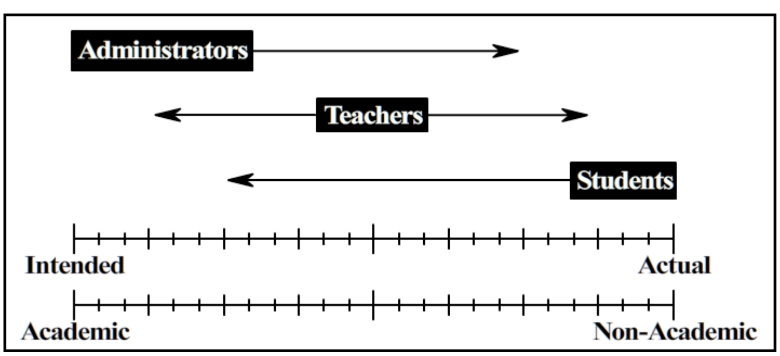


Figure 3. Distribution of participant group knowledge of student learning

This breadth of knowledge across participants groups helped ensure validity by accounting for variances among these groups. Moreover, research participants were selected based on their experiential knowledge of laptop programs. Administrators were selected based on their knowledge of laptop program design, administration, deployment, and integration into curriculum and instruction. Teachers and students were included if they had taught or participated in their laptop program for at least one year. This minimum experience helped ensure that the included teachers and students possessed valid opinions and knowledge. The range of research sites and participants, coupled with the practical, theoretical, and experiential knowledge of the research participants accounted for the variances of opinions among participants and the aforementioned programmatic variables found in one-to-one student laptop programs.

To ensure that the research evaluated the effects of laptops as opposed to existing school conditions, availability of resources, and the educational quality that resulted from serving high SES students, introductory questions were included to establish baseline information regarding the educational conditions within each institution. Once this baseline had been established, questions shifted to the educational influence of laptops so participants would focus specifically on the impact of access to laptops on student learning.

*Group B Validity*

As opposed to group A, where a breadth of data sources were used to account for potential variation, depth of investigation at a single research site was used to ensure group B validity. Depth of knowledge and investigation were tools used to ensure the results were accurate and valid, and to effectively answer the second research question: In what ways, if any, are these student learning outcomes different for low SES students?

To begin, the research site was selected based on the socioeconomic demographics of students and the experience levels of administrators and teachers. Within this school, research participants were selected based on their experiential knowledge of working and attending schools in low SES communities. Teachers and administrators were included based on their knowledge of pedagogy, curriculum, and the impact of ubiquitous computing on low SES students. Students were included based on their classification as low SES or non-low SES as identified by the California Department of Education. The school environment, coupled with the depth of research involving participants who possessed large amounts of experiential knowledge, helped ensure that the study's conclusions were applicable to identifying impactful student learning for one-to-one student laptop programs in low SES schools.

However, this research was conducted at only one low SES site suggesting that the conclusions may not be transferable to similar schools. This issue was mitigated through the site selection process that targeted participants with a depth of experiential knowledge. Specifically, the school site was selected based on the socioeconomic conditions of its students being representative of the definition of low SES. Cohen (2009) states, “In research on socioeconomic status and social class, these are commonly operationalized as combinations of variables such as income, education, and occupational prestige” (p. 197). Based on Cohen’s model, the selection process took into consideration family income and educational attainment of parents when determining whether the student population was considered low SES. The sources of knowledge and the depth of investigation utilized in group B further reduced the threats to validity by providing multi-dimensional results that could be tailored to other school settings.

### *Protection of Human Subjects*

To ensure the safety of participants, this research study was subjected to numerous types of evaluation throughout its conception, design, and execution. During the two years I worked conceiving and designing this study, every aspect of the research was vetted through professors, colleagues, and peers. Just prior to my defense of the dissertation proposal, I presented this study to a panel of professors and one-to-one student laptop program practitioners for evaluation. Through their insights, I made additional improvements to reduce the potential risks to participants. Additionally, the San Francisco State University Committee for the Protection of Human Subjects conducted an extensive review of my research prior to my data collection, including a faculty committee review. Through their recommendations and approval, I implemented additional safeguards to further minimize participant risk.

The safeguards utilized in this project included clear inclusion criteria, protection of recorded data, and full confidentiality for participants. As previously stated, participants were included based on their experiences with laptop programs or with low SES schools. No other inclusion criteria were used or discussed. All recorded data were kept under lock and key, visible only by my dissertation committee and myself. All participants' identities were kept confidential through either data protection – the use of pseudonyms for both participants and research sites – or, in the case of the survey, a complete absence of recorded names or personal information.

## *Data Analysis*

Data analysis was a continual procedure throughout the data collection process. While the interview and focus group protocols were written prior to collecting data, thematic analyses (Ryan & Bernard, 2000) were used from each school site's data to inform data collection at subsequent sites. The data analyses used for both groups were based upon deductive and inductive analyses, thematic analysis, and statistical analyses.

### *Statistical Analysis*

The survey data from all five schools were entered into Microsoft Excel and Statistical Package for the Social Sciences (SPSS), both of which served as statistical software packages. Descriptive and inferential statistics were generated from these data to identify the areas of disproportionate access and usage of technology between low and non-low SES laptop students. These data were used in the quantification of the

Educational Digital Divide and as a basis for analysis of the student learning outcomes identified in the qualitative phase of the study.

*Thematic Analysis for Student Learning*

From the qualitative data collected at the five research sites, a three-tiered thematic analysis was conducted. First, from each site, emergent themes were identified among data from the interviews and the focus groups. Through this analysis, codes were developed that were tied to school related conditions, as described by the set of variables discussed earlier in this chapter. Second, data were combined across schools for each participant group – administrators, teachers, and students – and then subjected to another thematic analysis. During this session, emergent codes were found that linked participant groups' area of involvement. For example, curricular level student learning was often tied to codes that emerged from teacher focus groups. Lastly, all the data were aggregated and subjected to a final thematic analysis. Using triangulation (Ryan & Bernard, 2000) among the codes developed in the three analyses, five major areas of student learning were identified that will be presented in Chapter Four.

*Group B Thematic Analysis*

Group B data were processed using both inductive and deductive analyses to identify the role of socioeconomic status in learning. Using grounded theory (Glasser & Strauss, 1967), inductively generated themes were developed from data among the individual participant groups and across all groups. These themes were further reduced to isolate the role of socioeconomic status in student learning and the specific student learning outcomes that had the greatest impact on low SES students.

# Chapter Four: Findings

## *Introduction*

The purpose of this study was to determine student learning outcomes for existing one-to-one student laptop programs and to identify which of those outcomes had specific impacts on low SES students. The data showed that all laptop students experienced learning outcomes in the following areas: scholastic learning, changes to the learning environment, technology skills, communication, and responsibility. Low SES students experienced the same learning outcomes, but to a greater degree. They also experienced an expanded worldview, community empowerment, and career development. In terms of addressing inequity, the data showed that access to laptops impacted all three levels of the Educational Digital Divide: access to technology, classroom uses of technology, and student and community empowerment.

In this chapter, findings are presented in three major sections that align with the three sections of the conceptual framework presented in Chapter One. The first section describes the variance in the three levels of the Educational Digital Divide for one-to-one student laptop programs within this local context, by drawing comparisons based on socioeconomic status using quantitative data. The second section presents the five areas of student learning that emerged from the qualitative data collection based on Laura Nader's (1972) "Studying Up – Studying Down" paradigm. The third section further draws upon Nader's work by identifying the impact those areas of student learning had on low SES students at Chavez High School.

*Existence of the Educational Digital Divide*

To investigate the Educational Digital Divide for one-to-one student laptop programs, a total of 162 students from the five research sites completed a survey that investigated their technology access and usage. Respondents were divided in two ways to focus on the divide between low SES and non-low SES students, identified by eligibility for Free or Reduced Price Lunch. In the first comparative set, the respondents from all five schools were divided into two groups: those eligible for Free or Reduced Price Lunch (FRPL) and those not eligible. The former group (N = 30) included the group B students eligible for FRPL. The latter group (N = 132) included all students from the four group A schools – the private schools – and students from the group B school – Chavez High School – not eligible for FRPL. The second comparative set also divided students into two groups based on eligibility for FRPL. However, this set only included low SES (N = 30) and non-low SES (N = 28) respondents from Chavez High School. Data analysis used both descriptive and inferential statistics to identify the existence or absence of the Educational Digital Divide within each comparative set. For all inferential statistics, equal variance was not assumed.

As the survey was designed to collect data across the three levels of the Educational Digital Divide, the results in this section are presented by level.

*Access to Computers and the Internet*

At the first level of the Educational Digital Divide – access to computers and the Internet – students' participation in their laptop programs presupposed a reduction in digital inequity. However, statistics showed that the divide persisted between the Chavez High School students eligible for FRPL and all students not eligible for FRPL. Hereafter, these two groups will be referred to as Chavez High School low SES students (CHS low SES), and all non-low SES students (All non-low SES). The divide existed between these groups in the areas of (i) number of computers to which students had access, (ii) the frequency of access to school computers, and (iii) the quality of school computers. Statistics showed the divide in student access to the Internet at home was not present. Between CHS low SES and Chavez High School student not eligible for FRPL, hereafter referred to as Chavez High School non-low SES students (CHS non-low SES), the Educational Digital Divide only existed in the number of home computers and not in any of the other aforementioned areas. The divide was less accentuated between CHS low SES and CHS non-low SES students than CHS low SES and all non-low SES students because both students groups at Chavez High School came from similar communities and geographic areas, despite their socioeconomic differences. Conversely, the all non-low SES group included a majority of students who attended private schools.

Table 9

*t-test results for access to computers at home between comparative groups*

| *Comparative Groups* | *T* | *d.f.* | *p* |
|---|---|---|---|
| *All non-low SES vs. CHS low SES* | 6.07 | 57 | 0.01 |
| *CHS non-low SES vs. CHS low SES* | -2.29 | 43 | 0.03 |

In the area of student access to computers at home, independent samples t-tests for both comparative sets showed the differences between the groups were statistically significant at the 0.05 level. Descriptive statistics further identified these differences. CHS low SES students had home access to a mean of 1.87 computers (SD = 1.14). Their non-low SES counterparts at Chavez High had access to roughly one more computer at home per student. The gap was larger between CHS low SES and All non-low SES students where the All non-low SES students had access to a mean of 3.38 computers per student (SD = 1.55), which were more than one and a half additional computers per student.

Similarly, Pearson chi-square analyses of access to school computers showed the difference between All non-low SES and CHS low SES students, $\chi^2(1, N = 162) = 6.17$, $p = 0.01$, was statistically significant, while the difference between CHS non-low SES and CHS low SES students, $\chi^2(1, N = 58) = 0.28$, $p = 0.60$, was not statistically significant. To reduce the probability of type 1 errors, those which result in false positives, responses for this survey question were combined into two groups: always and often/rarely/never.

Table 10

*Counts and expected counts for frequency of access to school computers*

| | | All non-low SES | CHS low SES |
|---|---|---|---|
| *Always* | *Count* | 93 | 14 |
| | *Expected Count* | 87.2 | 19.8 |
| *O/R/N* | *Count* | 39 | 16 |
| | *Expected Count* | 44.8 | 10.2 |

*O/R/N = Often, Rarely, or Never.*

Table 10 shows the divergences of counts and expected counts for All non-low SES and CHS low SES students' frequencies of access to school computers. For the All non-low SES group, students responded "always" at a rate higher than expected, whereas the CHS low SES group had a significantly lower rate of "always" responses than expected.

Descriptive and inferential statistics showed that the divide did not exist in the areas of Internet access at home. All three groups had home access to the Internet in excess of 93%: All non-low SES 99.22%, CHS non-low SES 96.43%, and CHS low SES 93.10%. Though CHS low SES students had the highest percentage of students without home Internet access at 6.90%, this percentage translated into only two respondents.

An independent samples t-test, $t(47) = -2.15$, $p = 0.04$, did show the existence of the Educational Digital Divide in the perceived quality of school computers between CHS low SES and All non-low SES students. However, the descriptive statistics only showed a minor difference in student responses. On a 5 point Likert scale, where "1" corresponded to "Strongly Agree" and "5" corresponded to "Strongly Disagree", CHS low SES had a mean of 2.43 (SD = 0.97) for the reliability of their school computers, their All non-low SES peers only scored their computers better by .43 points at a mean of 2.00 (SD = 1.10). Moreover, both groups maintained the same median score. The independent samples t-test between CHS low SES and CHS non-low SES students, $t(52) = .635$, $p = 0.53$, showed no significant difference in the area of school computer reliability.

*Classroom Uses of Technology*

Inferential statistics showed that the Educational Digital Divide did not exist, for the most part, between groups in either of the comparative sets for the second level of the divide. As table 11 shows, independent samples t-tests showed that the differences between All non-low SES and CHS low SES student responses were insignificant at the 0.05 level of significance for three of the four areas. Interest in school computer use was the only area that showed statistical significance, $t(39) = -2.011$, $p = 0.05$. Between these groups, the CHS low SES students scored this area higher on the aforementioned 5 point Likert scale, and thus more negatively ( $\bar{X}$ = 2.53, SD = 1.20) than the All non-low SES students ( $\bar{X}$ = 2.06, SD = 0.99).

Table 11

*t-test results for classroom use of technology between All non-low SES and CHS low SES*

| *Question focus* | *T* | *d.f.* | *p* |
|---|---|---|---|
| *Teachers' technology knowledge* | -1.019 | 45 | 0.31 |
| *Frequency of computer use at school* | -1.624 | 39 | 0.11 |
| *Computers enhance learning* | -.988 | 43 | 0.33 |
| *How interesting is school computer use* | -2.011 | 39 | 0.05 |

Table 12 further shows that between CHS low SES and CHS non-low SES students responses were not statistically significant at the 0.05 level.

Table 12

*t-test results for classroom use of technology between CHS non-low SES and CHS low SES*

| *Question focus* | *T* | *d.f.* | *p* |
|---|---|---|---|
| *Teachers' technology knowledge* | .264 | 50 | 0.79 |
| *Frequency of computer use at school* | .750 | 56 | 0.46 |
| *Computers enhance learning* | -.439 | 54 | 0.66 |
| *How interesting is school computer use* | .979 | 56 | 0.33 |

*Student and Community Empowerment*

At the third level of the divide – student and community empowerment – statistical analyses showed the Educational Digital Divide was present between All non-low SES and CHS low SES students in the areas of (i) self assessed increase in academic performance, (ii) frequency of Internet communication, and (iii) desire for changes in the frequency of computer use. Between CHS low SES and CHS non-low SES students, the divide was only present in the area of desire for changes in the frequency of computer use. All other areas showed no statistically significant differences at the 0.05 level.

An independent samples t-test, $t(42) = -2.35$, $p = 0.02$, showed that the differences between All non-low SES and CHS low SES students' self assessment that school computers have improved their academic performance was statistically significant. The descriptive statistics showed moderate differences as the responses from All non-low SES ( $\overline{X}$ = 2.64, SD = 1.06) was slightly lower, and thus more positive, than those from CHS low SES ( $\overline{X}$ = 2.13, SD = 1.07). The t-test between CHS non-low SES and CHS low SES students for self assessed increases in academic performance was not statistically significant, $t(54) = .971$, $p = .34$.

The Educational Digital Divide was absent in four areas of student self-assessment of technology skills. As seen in table 13, inferential statistics showed no statistically significant differences, at the 0.05 level of significance, between either All non-low SES and CHS low SES students or CHS non-low SES and CHS low SES students in the areas of basic computer skills, Internet usage skills, productivity software skills, and Internet research skills.

Table 13

*t-test results for students self rating of technology skills*

| *Rating area* | *t* | *d.f.* | *p* |
|---|---|---|---|
| *All non-low SES vs. CHS low SES* | | | |
| *Basic computer skills* | -1.703 | 42 | 0.10 |
| *Internet usage skills* | -1.403 | 41 | 0.17 |
| *Productivity software skills* | -.718 | 47 | 0.48 |
| *Internet research skills* | .105 | 36 | 0.92 |
| *CHS non-low SES vs. CHS low SES* | | | |
| *Basic computer skills* | 1.044 | 56 | 0.30 |
| *Internet usage skills* | -.019 | 56 | 0.99 |
| *Productivity software skills* | .045 | 52 | 0.97 |
| *Internet research skills* | .937 | 53 | 0.35 |

Inferential statistics showed the Educational Digital Divide was present in the areas of frequency of Internet communication and desire for changes in frequency of computer use. Pearson chi square analyses showed a strong statistical significance, $\chi^2(1, N = 162) = 10.26$, $p < 0.01$, in the differences in responses about Internet communication between All non-low SES and CHS low SES students where All non-low SES students used Internet communications more frequently than the CHS low SES students. Yet, the differences between CHS non-low SES and CHS low SES students were not statistically significant, $\chi^2(1, N = 58) = 1.37$, $p = .24$, in this area.

In the area of desire for changes in frequency of computer use, Pearson chi square analyses showed statistical significance for both All non-low SES and CHS low SES students, $\chi^2(2, N = 162) = 23.98$, $p < .01$, and CHS non-low SES and CHS low SES students, $\chi^2(2, N = 58) = 8.35$, $p = .02$. As seen in table 14, 56.67% of CHS low SES students indicated they would like to use computers more often as compared to 25% for CHS non-low SES and 15.15% for all non-low SES students. The represented a reverse divide, where CHS low SES were interested in a greater frequency that either the All non-low SES and CHS non-low SES students.

Table 14

*Counts for responses to desire for change in frequency of computer use*

| | | *All non-low SES** | *CHS non-low SES*** | *CHS low SES**** |
|---|---|---|---|---|
| *Less Often* | *Count* | 24 | 2 | 4 |
| | *Percent* | 18.3% | 7.1% | 13.3% |
| *More Often* | *Count* | 20 | 7 | 17 |
| | *Percent* | 15.3% | 25.0% | 56.7% |
| *Neither* | *Count* | 87 | 19 | 9 |
| | *Percent* | 66.4% | 67.9% | 30.0% |

* N = 131
** N = 28
*** N = 30

*Summary*

The data showed that Educational Digital Divide existed between CHS low SES students and both their non-low SES peers at Chavez High and all the non-low SES peers across the five research sites. Within each comparison set, the divide was found at all three levels, though mostly at the first level – access to technology – and the third level – student and community empowerment – as seen in table 15. This suggested that there was little divide between the students' educational uses of technology, but more in students' access to computers and their resultant empowerment. The divide was also found in a greater number of areas between the CHS low SES group and All non-low SES group than between CHS low SES and CHS non-low SES students. Undoubtedly, this increased persistence of the Education Digital Divide was the result of the higher socioeconomic statuses of students at the group A research sites. Their collective technology access and student empowerment was invariably more prominent than those of the CHS non-low SES students when compared to the CHS low SES students.

Table 15

*Areas where the Educational Digital Divide was found*

| *Rating Area* | *CHS low SES vs. All non-low SES* | *CHS low SES vs. CHS non-low SES* |
|---|---|---|
| *Access to Computers and the Internet* | | |
| *No. of computers to which students had access* | X | X |
| *Internet access at home* | | |
| *Frequency of access to school computers* | X | |
| *Quality of school computers* | X | |
| *Classroom Uses of Technology* | | |
| *Teachers' technology knowledge* | | |
| *Frequency of computer use at school* | | |
| *Computers enhance learning* | | |
| *How interesting is school computer use* | X | |
| *Student and Community Empowerment* | | |
| *Self assessed increase in academic performance* | X | |
| *Self rating of basic computer skills* | | |
| *Self rating of Internet communication skills* | | |
| *Self rating of productivity software skills* | | |
| *Self rating of Internet research skills* | | |
| *Frequency of Internet communication* | X | |
| *Desire for changes in frequency of computer use* | X* | X* |

* Reverse divide where CHS low SES students exhibited this behavior to a higher degree

### *Areas of Student Learning*

The qualitative phase of this study was informed by Laura Nader's (1972) "Studying Up – Studying Down" research paradigm. As such, findings from the qualitative data are presented in two major sections: the overall areas of student learning that emerged from the data and the areas of learning that specifically impacted low SES students. For overall student learning, the data showed that laptop students experienced learning in both academic and non-academic areas. Within academic learning, students experienced impacts to scholastic learning and changes to the learning environment. For non-academic learning, students learned technology skills, communication, and responsibility. In terms of specific impacts on low SES students, the data showed that low SES students experienced all of the aforementioned learning to greater degree than the non-low SES students. Access to laptops also extended learning into low SES students' homes, improved their academic performance, and taught them vocational skills.

### *Scholastic Learning*

Students at the five research sites experienced numerous changes to their scholastic learning as a result of educational laptop use. The degree of change, the affected content areas, and the resultant impact on academic performance was contingent on a number of factors, specifically teacher knowledge and experience.

#### *Teacher Dependent Tool for Learning*

Participants across the five research sites believed that the laptops, in of themselves, did not teach content or affect student learning. While adamant that the laptops had no impact in isolation, participants agreed the laptops were powerful tools for facilitating content delivery. Repeatedly, students, teachers, and administrators discussed examples of how teachers used laptops to teach content through dynamic learning exercises. Participants described laptops as tools of entry, providing students a gateway to a rich set of digital resources, including numerous software titles, Internet content and applications, and collaborative Web 2.0 tools. Teachers in particular showed great enthusiasm for resources and activities they had created or discovered. The Director of Technology at Ulysses High School also identified other technology resources available at the school that were accessible through the students' laptops: interactive whiteboards, data repositories, and asynchronous communication services.

Overall, participants agreed that the laptops and the associated tools and resources provided teachers opportunities to create innovative instruction. The teachers at Twain Middle School for Boys described their innovation as a function of using specific tools to teach content in ways they had never been considered before. An administrator at Twain Middle School for Boys called this type of instruction "cutting edge learning." Yet none of the participants provided a clear definition, beyond isolated examples, of "innovative instruction." Interestingly, a subset of teachers at Chavez High School questioned the value of this laptop-based innovation, claiming it fell short of its promise of transformative learning and that it did not always align with the curriculum standards. One Chavez High School teacher said, "I tried to embrace laptops, but I actually find them to not be useful. My sophomores have to take [a standardized test] in April and I can't find a way to integrate them into that timeline." Despite these opinions, a majority of teachers, students, and administrators at the five research sites identified innovative instruction as a byproduct of the laptop program.

Teachers identified increases in interactivity and dynamic instruction as a form of instructional change that came about because of the laptops. They said students were able to engage in experiential learning in these activities, which included real time feedback from either the laptop or the teacher. Teachers also said they were less reliant on scripted activities because the tools and resources available on the laptops allowed them to be more dynamic in their instruction. They could alter lesson plans in the middle of class based on the students' interests or instructional needs. Additionally, the digitization of instructional materials and student work allowed teachers to use instructional progress and student performance as formative measures to influence classroom instruction.

Within this dynamic instruction, participants believed that teachers were better suited to use the laptops for differentiation of learning. They claimed laptops allowed teachers to tailor instruction, curriculum, and activities toward the learning needs and styles of each student. This differentiation was found across several curricular areas and in both group work and individual activities. When talking about differentiation, teachers stated that the laptops facilitated individualized instruction, where students could be taught at a depth and pace that was independent of their peers. A foreign language teacher at Hemings High School provided an example of this instruction:

> When we are recording in class, [students] will use their computers. It is an interesting experience because they use muffled headsets when they're

> all talking at the same time. Or they could do the same thing at home while they are reviewing for a big test or using a multitude of online drills. [With both of these activities, students are] studying and getting personalized feedback on their mistakes.

Interestingly, teachers and administrators did not feel this laptop-enabled differentiation and individualized instruction resulted in an increase in accommodation. They felt that laptops provided equity of access to resources, but not necessarily a trend toward equality of performance.

Overall, the data showed that the laptops, in of themselves, had potential to enhance instruction by providing supplementation, differentiation, and real-time feedback, but the actual learning impacts of the laptops were completely teacher dependent. Participants across the research sites believed that all academic learning tied to student laptops was the direct result of the teachers' skill in using the laptops in their teaching. As one teacher at Gibson Middle School for Girls said, "The laptops don't teach anything. The teachers do." Since teachers were responsible for developing curriculum, delivering instruction, and deciding how and when the students would use their computers, they were seen as the lynchpins for learning, just as they would have been in classrooms without laptops.

However, the effectiveness of this laptop-enhanced instruction was also tied to teachers' understanding of pedagogy, their desire to develop curriculum, and their willingness to explore the technology. The identification of these characteristics came from teachers' self-assessments, their descriptions of other teachers, and data drawn from students and administrators regarding quality laptop teaching. These data showed that teachers who had an understanding of effective pedagogy and a thought out educational philosophy seemed to have the greatest success in using the laptops to facilitate scholastic learning. The converse was also true, where seemingly ineffective teachers who had mediocre or poor understanding of pedagogy showed little facility or desire to leverage the laptops as tools for dynamic instruction. These data suggested that the laptops amplified teachers' skills, where strong teachers were able to further improve and mediocre or poor teachers made little to no improvement.

Yet, pedagogic knowledge and teaching skills were not enough to ensure teacher success in utilizing the laptops for learning. Teachers also needed an interest in using the tools and a lack of trepidation with the technology. Two teachers at Chavez High School exemplified this in their attitudes toward classroom laptop use. The two teachers – one a foreign language teacher and the other a history teacher – had both been in the field for more than 15 years and were regarded by their peers in the focus group as excellent teachers. The foreign language teacher was passionate about using the laptops to develop the foreign language skills of her students through interactive activities that included immediate feedback and to use laptops to expose the students to a diverse range of foreign cultures. The history teacher, on the other hand, stated that she had a mistrust of the students using their laptops in class because she felt they would spend more time using social networking sites and not paying attention to her lectures. As a result, she disallowed computer use altogether in her class.

*Content Understanding and Academic Performance*

The data showed that laptops strongly influenced students' understanding of content. Laptop students experienced impacts in a variety of subject areas, while learning a broader range of content to a deeper degree. Yet, this influence on content learning did not result in significant changes students' academic performance.

Participants at Gibson Middle School for Girls and Ulysses High School believed strongly that laptops did not improve student performance, instead crediting their schools' educational philosophies, which emphasized dynamic learning, differentiation, and innovation. In contrast, administrators and teachers at Chavez High School and Twain Middle School for Boys – both of which employed less progressive educational philosophies – were more inclined to credit increases in student performance to the laptops, but the degree of such increases was small and inconsistent. Students at Chavez High believed that their grades had increased slightly because of the laptops, but not to a large degree. The low SES group at Chavez High School was the most adamant that their grades had improved because they had access to laptops. Conversely, teachers at Hemings High School believed that laptop use resulted in a reduction in retention of instructional content because students had ubiquitous access to notes and online resources, which reduced their need to memorize information.

Not surprisingly, improvements in student performance within content areas varied from school to school based on their faculties and school cultures. Increases in performance in specific content areas were directly tied to the teachers who taught those subjects, where the pedagogic knowledge and interest in technology seemed to have the greatest impact on learning. To a lesser degree, the school's culture, academic focus, and impetus for starting their laptop programs also influenced the content areas where students saw the greatest performance increases. For example, the laptop program at Hemings High School was implemented to facilitate pedagogic changes in math and science and as such Hemings students showed the largest degree of performance increase in those areas.

In line with the variation in student performance, the data showed that access to laptops had noticeable impact on an array of content areas, but the degree of change within those subjects varied considerably.

Writing showed the greatest impact of access to laptops. Participants across all five research sites noted that students' ability to articulate an argument and write a cohesive essay was noticeably improved because students were able to write, revise, and peer edit at a higher frequency using their laptops. Similarly, participants at all five sites claimed media studies – such as digital photography, video production, or desktop publishing – were heavily impacted from students' ubiquitous access to laptops. In these classes, students were involved throughout the creative process, from design to production and distribution. Participants also noted the media skills students learned on their laptops were transferable to instructional activities in other content areas, such as humanities, language arts, and science. Foreign languages also showed strong effects of student laptops. Teachers at four of the research sites – Chavez High School, Hemings High School, Twain Middle School for Boys, and Ulysses High School – said they used the laptops to record students speaking, which allowed them to give students individualized feedback.

The data also showed impacts on mathematics and science instruction, but those impacts were localized to Hemings and Ulysses High Schools where teachers displayed expertise in the use of specific software titles and online resources. Furthermore, administrators and teachers at these schools claimed curriculum and pedagogy in mathematics had been transformed by laptop access to mathematics software and online resources, which also resulted in improved student performance. As an administrator at Hemings High School said, "[Laptops allow our teachers] to teach students about mathematics, rather than how to do mathematics." Similarly, Ulysses and Hemings students experienced transformed science instruction via software titles and peripheral data capture devices connected to the students' laptops. Similar instructional transformations in math and science were not found at the three other schools.

Interestingly, the data showed that laptops actually had a negative impact on learning in humanities. One teacher at Chavez High School felt that students merely used their laptops for notetaking, rather than the transformative instruction found in other subjects. The teachers at Hemings and Ulysses High Schools agreed that humanities offered fewer opportunities for dynamic, technology-based instruction. Instead, they saw the primary use of laptops was to access static information on the Internet. Conversely, one administrator at Hemings High School, who was a former humanities instructor, claimed that laptops completely transformed his teaching. He said that US Government websites, cia.gov in particular, provided students the most up-to-date information on international politics and geography. Yet this was an isolated claim from a single administrator and thus did not sufficiently refute the collective opinions of the other humanities teachers who felt the laptops had been of little help in transforming instruction and learning.

Interestingly, administrators at multiple research sites believed that while the effects of laptop learning on content areas varied and student academic performance changes were inconclusive, standard forms of educational assessment were insufficient in measuring the true learning impacts of one-to-one student laptop programs. They stated that academic assessment was often focused on content knowledge and recitation when learning in laptop programs frequently centers on cognitive abilities, access to content, and understanding. They believed authentic assessment of student learning in laptop programs would have to focus on content understanding as opposed to content retention. An administrator at Twain Middle School for Boys said, “The computers have broadened the spectrum of assessments needed to assess what students are learning in the classroom.”

In line with this call for authentic assessment, a majority of participants claimed the laptops provided students a deeper understanding of content. Teachers at Hemings High School believed the individualized instruction and dynamic learning activities provided students greater depth of content understanding regardless of subject area. They were reluctant to credit the laptops more than the teachers, but they recognized the laptops' role in facilitating instruction. One administrator at Ulysses High School cited the increased quality of student conversations as evidence of this depth of understanding, stating:

> Because there's all of these additional avenues to both exchange information as well as to dialogue with each other, whether it's formalized in the class or informal, what's happening is that kids are exchanging a lot more ideas. [As a result], there's a greater depth of ideas that are being discussed and shared.

Only the teachers at Gibson Middle School for Girls disagreed that laptop students attained a deeper understanding of content. Yet, this was an isolated opinion. The majority of the data showed increased depth of content understanding was a relevant finding.

In addition to depth of understanding, data showed that students learned a greater breadth of content within and across subject areas. Teachers and students provided examples of in-class learning that moved away from the core area of content to cover tangential areas. In these situations, students would be called upon to use their laptops to conduct just-in-time research, find supplemental information, clarify statements, or settle disagreements. Additionally, this research often extended to other content areas. For example, one teacher at Hemings High School talked about an ethics class where he would make statements or use vocabulary in lectures that would require students to use the Internet for definitions and clarification. These activities often extended into history, current events, and language arts.

Beyond content learning, participants at Twain Middle School for Boys and Ulysses High School said laptop students learned higher order thinking skills in the form of problem solving and increased learning capacity. At Twain Middle School for Boys, the administrators and teachers explicitly stated that their students were better problem solvers because of the school's laptop program. They noted that students had to problem-solve and address computer maintenance issues when help was not immediately available. Similarly, the students and administrators at Ulysses High School believed that laptops helped students develop problem-solving skills and increase their learning capacity. As one Ulysses student said, "Physically having the laptop is like learning a sort of psychological competency [that gives me] the ability to dig deeper and perform more complex tasks." Further, the Ulysses High School students agreed that the activities they completed on their laptops had helped them gain a deeper grasp of ideas and an increased capacity for abstract thought, which had shown up in their in-class and online discussions.

Table 16

*Summary of findings for* Scholastic Learning

*Teacher Dependent Tool for Learning*

- The effectiveness of laptop instruction was tied directly to teachers' pedagogic knowledge and interest in educational technology
- Laptops were tools of entry to resources, software, and the Internet
- Teachers were provided opportunities for innovative and dynamic instruction
- Students experienced more individualization, differentiation, and supplementation of instruction while enjoying quicker and more personalized feedback

*Content Understanding and Academic Performance*

- Laptop-based instruction did not improve academic performance for all students
- Improvement in student performance varied within content areas, mostly tied to the teachers who taught those subjects
- Writing and media studies were the only areas where improved performance was consistent across research sites
- Standard assessment measures were insufficient in measuring student learning
- Students learned greater breadth and depth of content
- Students learned high order thinking skills and increased learning capacity

## *Changes to the Learning Environment*

Data showed that laptop students experienced changes to the learning environment in ways that paralleled those found in the literature. As with prior research, laptop students used technology quite often in learning. However, in this study the value of that technology connected most strongly with better resources access than simply the laptops themselves. Students in these schools also frequently engaged in dynamic learning activities, both collaboratively and individually, while experiencing impacts on their motivation, engagement, and distraction. Participants viewed school culture and teacher quality as the prime factors in changing the learning environment

*Access to Resources*

Access to resources was the hallmark feature of the laptop learning environment at all of the five research sites. These resources spanned computer hardware, software, Internet resources, communications, and students' digitized work. Further, laptops provided equal access to these resources for all students. Regardless of socioeconomic conditions, each student had access to similar academic technology resources, both at home and at school.

Yet, participants believed the real value of this access to resources came in its immediacy. By having the laptops, students could access resources in real time, which changed instructional planning and pacing. Teachers at Hemings High School and Twain Middle School for Boys said that the introduction of laptops changed the way they prepared lesson plans. A Hemings High teacher said,

> [Laptop use] really enhances the curriculum; that takes time and patience to manage and build what you want. [This requires] a kind of experimentation because [all of the students and teachers] are in a different place [when they enter laptop learning].

The teachers at Ulysses High School also claimed that the laptops, and their access to the Internet in particular, allowed for tangential instruction and deeper content exploration, where the class would suspend its current lesson to research and discuss a topic. As one teacher stated, “[With laptops, students] are more apt to discover and explore content than they might be with pencil and paper.”

Administrators, teachers, and students also said the immediacy of resources, such as access to productivity software and the Internet, altered instructional pacing. At times, teachers would slow down instruction to achieve deeper understanding of content or to bring in supplemental resources, while at other times, they would increase pacing, which allowed them to cover a greater breadth of content. With increased pacing, teachers spent less time clarifying concepts for individual students because each student’s laptop provided personalized resources and instruction that did not slow or modify the instructional pacing for the rest of the class. However, administrators and teachers noted that increased pacing was rare. One Hemings High teacher claimed that it made her uncomfortable because she worried about content retention for students learning a quick pace.

Participants also believed the immediacy of resources extended learning outside of the classroom. Since students had access to the same resources at home as they did at school, teachers felt they could include more long term projects. Similarly, teachers at Twain Middle School for Boys found the distinction between class work and homework had been reduced because of the resources available on the laptops, which in turn allowed for continuity of instructional activities in and out of the classroom. A Twain student gave an example of this type of continuity in talking about essay writing on his laptop. He said,

> Laptops offer greater convenience because you always have [them]. If you forget your paper at school, it's okay because your essay is on your computer, which is always with you. So, you can finish it and you won't get marked down.

Students at both Gibson Middle School for Girls and Twain Middle School for Boys agreed that their homework assignments utilized the laptops quite often and as a result were less repetitive, rote, and finite in scope. A Gibson Middle School for Girls student said, "[Having laptops] is really positive because you can do fun, educational things with the computer. Before I used to get frustrated with homework." Students at the three high schools echoed this statement, but a lesser degree. A Ulysses High student said, "I think having the laptop has potential to take away so much of the boring stupid work I don't think I should be doing."

Participants at Gibson Middle School for Girls also provided an interesting example of the immediacy of resources bridging the home-school gap in real time. Students and teachers described a class session where students were working on a group project. One of the group members was ill and had stayed home from school. She had been responsible for a critical element of the project that was due that day, so in the morning she emailed her work to the teacher and to her group mates. However, during class the students were supposed to combine their work and plan the next phase of the project. Instead of suspending the activity or proceeding without the sick student, the group members used video chat and instant messaging to include her in the discussion. As a result, the group was able to complete their task and stay on schedule.

*Impacts on Learning Processes*

The data showed that laptops allowed for a variety of learning processes, including collaborative learning, individualized instruction, multi-tasking, asynchronous learning, and cross-curricular learning.

Administrators and teachers at the four private schools mentioned collaborative learning through project-based instruction as an intended outcome of their laptop programs. While all of these schools were already utilizing this pedagogy, they felt that the implementation of laptop programs facilitated greater student collaboration. Teachers at Chavez High School found that they, too, had implemented more collaborative learning, although to a smaller degree. They believed that this was due to fact that they were constrained by standards and testing while their private school colleagues enjoyed more academic freedom. One Chavez High School teacher said,

> I wish I had more freedom. If I had more time I could integrate the computer in my classes more, but I just don’t use it enough. I will say [the little amount I have been able to use the laptop] has improved my teaching.

Students across the five research sites also credited the laptops with making them more collaborative. However, instead of structured project-based learning, they mentioned collaboration in the form of study groups and information exchanges. Students said that while working on homework, they were in contact with peers and teachers to give and receive help. They described these interactions as being part of learning community that blurred academic and social topics. A Chavez High student explained,

> Sometimes you just talk to teachers [using Facebook] and they may ask you how you're doing or about something you posted [online about your social life] or you can ask them what homework they gave. It depends on the situation.

In addition to collaborative learning, administrators and teachers found that laptops provided opportunities to individualize instruction. Participants found that the individualized access to resources through students' laptops translated into potential for differentiated instruction and individualized learning. Students were able to learn at their own pace, stop and start, and receive individualized assessment and supplemental instruction. A Chavez High teacher summed this up by stating, "[Laptops allow us] to cover all of Bloom's taxonomy because we're reaching [students] in all different ways in all the different learning styles." However, other administrators and teachers were cautious to credit the laptops for such improvements in instruction. They believed the laptops could erroneously be seen as a silver bullet tool for differentiation and accommodation. Instead, they felt the laptops had potential to offer this type of learning, but only when orchestrated by skilled teachers. It should be noted that very few teachers mentioned accommodation for special needs or low performing students whatsoever, despite their opinions that laptops provided opportunities for differentiation.

One type of learning that was mentioned across participant groups was multiple task learning, or multi-tasking. In multi-tasking, students worked on multiple tasks simultaneously, switching their focus quickly and frequently. Students claimed to multi-task on their computers quite often at home, working on schoolwork in multiple subject areas while maintaining digital communications with peers. Administrators and teachers found multi-tasking to be prevalent at school as well, where students worked on classroom work while simultaneously accessing personal content on the Internet. Teachers and administrators viewed multi-tasking negatively as they felt students needed to focus in order to develop understanding. The teachers were especially frustrated with multi-tasking in the classroom as they believed it was (i) disrespectful to them as instructors because students were not focused on their teaching, (ii) detrimental to students' retention of content, and (iii) a disguise for disallowed computer use, such as gameplay or plagiarism. Students for the most part agreed that multi-tasking was a negative outcome of access to their laptops, but they showed little desire to stop. They felt the ability to multi-task was a skill they needed to learn, as it was becoming a cultural norm among college students and in the workforce.

Participants at Hemings and Ulysses High Schools mentioned asynchronous learning as an impactful instructional process found within their laptop programs. They claimed the Web 2.0 tools and learning management systems, specifically Moodle, that were accessible through their laptops allowed them to review content and participate in instructional activities at different times of day. Using these tools, student learning was less reliant on class sessions and in-person meetings. Students were still able to discuss concepts and explore material, just at their convenience. The participants did not go so far as to describe this learning as online classes, but they did feel that the laptops opened up the school to potentially offering such classes in the future.

Lastly, participants at the two middle schools found that students engaged in more cross-curricular learning as a result of their laptops. Teachers at both schools believed this was result of faculty collaboration. They claimed that the introduction of laptops had generated a level of complexity in instruction that required teachers to work together. One Gibson Middle School for Girls teacher said, “I put in most of my work ahead of time, which is a lot of work coming up with a plan, but I work with [colleagues] to put together presentations that the kids will be able to use.” This collaboration resulted in curriculum that either focused on multiple content areas or drew upon skills and knowledge learned in other classes. As an example, Gibson Middle School for Girls students described an entrepreneurial learning project where they worked in groups to design and run a fictional business. Teachers said this project was purposively designed to teach concepts across multiple curricular areas. They noted that although this project was implemented prior to the introduction of the laptop program, the project's pacing, length of time, and scale had grown because of the laptops.

*Engagement and Distraction*

In terms of students' attitudes toward learning, participants had conflicting opinions about the effects of laptops on engagement. Interestingly, these conflicts arose both within participant groups and within schools. At Hemings High School, administrators believed the laptops promoted greater engagement in learning for students, but the individual impacts were teacher dependent. They claimed that teachers who were the most effective in creating interactive technology curriculum experienced the greatest improvement in student engagement. The Hemings teachers identified negative effects on engagement, claiming that the laptops provided too many opportunities for distraction. The Hemings students themselves could not come to consensus. Some believed potential distractions impaired engagement, while others felt the immediacy of resources made them more engaged. At Chavez High School, the teachers and the Assistant Principal of Instruction described the students as less engaged in classroom activities, while the students and the Assistant Principal of Guidance found them to be more engaged. The students at Ulysses High School had a unique perspective. They believed that while engagement in classroom uses of technology was teacher dependent, their overall motivation for learning was completely independent of the laptops. They said that they drew their motivation from intrinsic and extrinsic factors that were unaffected by access to laptops. A Ulysses High School student said, “[My laptop] doesn’t give me motivation to do schoolwork. I have internal motivation that pushes me to do my work.”

Participants agreed that the greatest deterrent to student engagement was the distractions available on their laptops. Distractions were a key point of discussion in all 21 interviews and focus groups. Participants claimed distractions were a perpetual issue within all of their laptop programs that required constant and vigilant attention. Interestingly, the types of distraction listed by participants matched several of the areas they identified as non-academic learning areas: gaming, social networking, access to Internet resources, and digital communication.

Teachers were most adamant about the impact distractions had on their teaching and on student performance. As a group, they believed that instructional efficiency and productivity had decreased in the classroom because teachers had to mitigate distractions while also providing engaging curriculum. However, some teachers found that if they were clear and consistent about behavioral expectations, the issues related to distraction decreased, but were not eliminated. Others found that clear expectations only worked when coupled with engaging, interactive learning activities.

Administrators also found that distractions were impediments to instruction and learning, however they saw these issues as endemic across many laptop classrooms within their schools. They felt the responsibility to deter distractions fell to all participants in their laptop programs: administrators, students, and teachers. At a school wide level, they believed administrators needed to install monitoring systems and school policies to address the problem. As a result, all five schools had installed content filtering on their local networks, computer monitoring software, or both. Additionally, they all had written computer usage policies that had been distributed to students, teachers, and parents. Within the classroom, administrators agreed that teachers needed to be explicit with rules and behavioral expectations, while also providing engaging instructional activities. However, they claimed that these classroom and school wide anti-distraction endeavors were only partially effective. They believed students had to take responsibility for their actions and consciously work to avoid distraction.

Students themselves identified numerous ways in which laptop distractions had affected their academic performance, but they believed the degree of effect varied by individual. They claimed games and social networking distracted some students to the point where their grades had slipped significantly. Others found distractions were a periodic problem, varying in impact from day to day. Still others claimed that distractions had been a diminishing problem because their interest in such activities was waning. As a group, they believed that all laptop students experienced some degree of distraction each day. Students also stated that they experienced most distractions while outside of the classroom. They found that games, social networking, and digital communications were the greatest impediments to their efficiency and productivity when they were working on homework. For the most part, they found this to be true at home when teachers and administrators were not monitoring them and their academic work was less structured.

Parallel to students' claims that interest in distracting activities waned over time, administrators and students explained that the distractions impacted entry students the most. Those students who started the program – either as entering $5^{th}$/$6^{th}$ grade students at the middle schools or as $9^{th}$ graders at the high schools, as well as new students in other grades – were the most distracted and inefficient with their computers. Students at both middle schools claimed they had the most problems with gaming and digital communication when they first received their laptops, but as they progressed to $8^{th}$ grade those distractions were less of a problem. The Director of Technology at Ulysses High School claimed he and his staff had to ramp up monitoring of $9^{th}$ graders during their first six months of each school year. During that time, he frequently had to pull $9^{th}$ graders aside to discuss their uses of the computers and the potential outcomes. He also noted that after the first marking period, issues with distraction dropped significantly and that they continued to decrease in severity and frequency as students advanced through the grades.

*School Culture*

Participants at all five schools found a direct link between their laptop programs and their school's culture. In some instances, the school culture heavily influenced the educational uses of the laptops, while at others the introduction of laptops transformed the culture of the school.

Participants at Gibson Middle School for Girls, Hemings High School, and Ulysses High School all claimed the laptop programs at their schools were implemented to further realize their schools' educational philosophies and cultures. At Gibson Middle School for Girls, the school used the laptops to expand the project-based curriculum they had been using since the school's inception. Similarly, Hemings High School started their program to implement specific pedagogic changes that were driven by teachers. At Ulysses High School, they had been using constructivist practices and technology-infused learning for years and had implemented their laptop program mostly because it seemed like the next logical step. While these laptop programs only enhanced the pedagogic cultures of their schools, they did change each school's social culture by encouraging a greater sense of community through digital communication.

Conversely, the participants at Chavez High School identified significant changes in school culture – both socially and educationally – that arose as a result of the introduction of their laptop program. They noted that the school culture had evolved to one of community and exploration, where students and teachers were more connected, extra curricular activities were better organized, and parents felt more comfortable interacting with one another and the school staff. Additionally, the laptops encouraged students to explore areas of study that were previously under-emphasized at the school. One of the administrators credited the laptops with being a key factor in improving the school's reputation in the community, as evidenced by the school's increase in enrollment since the laptop program had been implemented.

At Twain Middle School for Boys, participants claimed the laptops had introduced a technology-based culture. In describing the educational elements of this culture, teachers said they frequently worked together to explore new electronic resources and develop technology-infused curriculum. The administrators described this technology culture as one of "tinkering.” Students used their computers to explore new technologies, develop problem-solving skills through experimentation, and test the limits and capabilities of school software. Interestingly, participants also mentioned the role of gaming in the school’s technology culture. According to them, the students’ primary recreational use of their laptops was playing video games. Through gaming, students shared interests and engaged in competition. The administrators and teachers believed these gaming interactions facilitated social connections with peers, which in turn built a sense of community among the students.

Table 17

*Summary of findings for* Changes to the Learning Environment

*Access to Resources*

- Resources include hardware, software, Internet, communication tools, and digitized student work
- The real value of access was in immediacy of resources
- Immediacy resulted in altered pacing and learning outside the classroom

*Impacts on Learning Processes*

- Laptops encouraged collaborative learning through project-based instruction
- Students experienced greater individualization of instruction and feedback
- Students engaged in more multi-tasking
- Laptops enabled asynchronous learning through digital tools and online discussions
- Student experienced greater cross-curricular learning

*Engagement and Distraction*

- Teachers were the primary agents in student engagement in laptop classrooms
- Laptops provided numerous distractions that could impede learning
- Distractions affected entry students most

*School Culture*

- The effectiveness and implementation of laptop-based instruction was often heavily influenced by existing school culture
- At some schools, laptops introduced changes to the social and educational environments, most notably in the community developed at Chavez High School

## *Technology Skills*

The largest area of non-academic student learning that emerged from data was in technology skills attainment. Across the five schools, the data showed that laptop students learned computer usage skills and information literacy, similar to findings in earlier research. However, earlier research did not describe the breadth of computer skills, nor the depth of information literacy found in this study. Moreover, students at these schools learned Internet Safety skills, in the form of personal conduct and computer safety, which were absent from the available literature.

*Computer Usage Skills*

Not surprisingly, computer usage skills were the largest area of non-academic learning across all five research sites. Participants believed students developed knowledge in computer hardware, software, Internet usage, and media skills.

In terms of computer hardware, participants agreed that students uniformly learned the basic operation of their laptops' components. Beyond basic operation, few students expressed interest in or knowledge of advanced usage of their computer hardware. At Chavez High School and Gibson Middle School for Girls, teachers claimed the students had developed typing skills, but they did not provide any metrics – such as accuracy or words per minute – to substantiate this claim. Participants at all sites agreed this hardware knowledge was mostly attained through student experimentation and experiential learning, rather than explicit instruction.

Students also learned software and Internet skills through similar types of experiential learning. However, this knowledge development was more often guided and task oriented than that of hardware learning. Teachers at all five sites mentioned software titles and Internet resources students had learned through participation in academic activities. The students also mentioned other titles and Internet skills that they had developed through personal activities outside of academic work.

Teachers and administrators noted that students were able to apply and transfer this knowledge to other tasks. Once students had developed a rudimentary knowledge of an application they were able to apply that knowledge to other activities and projects. Students also developed these skills at such a quick pace and high degree that they became sources of knowledge for teachers and peers. Teachers at both Gibson Middle School for Girls and Chavez High School cited examples of students providing just-in-time instruction and advice on software use for specific classroom projects.

There were conflicting data on the need to explicitly develop students' software knowledge. Teachers at Twain Middle School for Boys encapsulated this issue in discussing productivity software. Three teachers believed that students in the 7$^{th}$ and 8$^{th}$ grade had developed sufficient knowledge of word processing, spreadsheet, and presentation software to accomplish any academic tasks required them. They believed the students had attained these skills through class projects on their laptops in 5$^{th}$ and 6$^{th}$ grade. However, one of the other teachers noted that his students had very little knowledge of spreadsheet software and only a basic understanding of presentation software. He found that he had to spend instructional time explaining specific functions of these applications for students to complete their projects. This started a discussion about implicit versus explicit software instruction. While some teachers believed experiential knowledge and just-in-time training was sufficient, others felt that students needed explicit instruction in application functionality to be productive with their computers.

The use of explicit technology instruction varied from school to school. Some schools provided no software instruction whatsoever, while others utilized computer resource specialists to teach students about applications and Internet resources. The schools that provided explicit instruction experienced a higher and more uniform level of student software skills. Gibson Middle School for Girls, Twain Middle School for Boys, and Ulysses High exemplified this finding in their employment of technology skills classes and the perceived technology skill level students, as described by teachers, administrators, and the students themselves. Both in their self-assessments and in teachers' perceptions of them, students at these schools showed a clearer understanding of technology skills than students at the other two schools. Further, these three schools were less reliant on assumed and experiential student software knowledge than the other two schools. These higher skill levels allowed teachers to spend less time focusing on building computer skills, allowing more time for content exploration and instruction. Conversely, Chavez and Hemings High School teachers complained that they had to spend instructional time teaching technology skills because their schools did not offer explicit instruction.

In terms of organized curriculum, students at all five schools participated in, or had the option to participate in, computer science and media classes. Participants at Chavez High School, Gibson Middle School for Girls, and Hemings High School prided themselves on their schools' computer science classes. While teachers and administrators at these schools claimed computer science could be taught without their laptop programs, they all agreed that student engagement and retention of class content was notably higher because students could use their computers to store data and work from home. Media classes were also available at all five sites. In these classes, students learned about media consumption and production. Teachers again noted that these classes were not reliant on the laptops, yet students' laptop access provided deeper understanding of content and increased work quality. Beyond academic work, students claimed that personal activities on their laptops also taught them media literacy skills. Teachers and students linked such personal uses of media to development of creativity, though only to a small degree.

Participants rated the value of these technology skills very highly, considering them requisite for success in school and the workforce. Participants believed that technology skills were baseline competencies in college and that the skills they developed in their laptop programs gave them an advantage. This finding emerged from all three high schools, most notably from Chavez High School. Participants at all three schools believed that college coursework was more reliant on technology. They explained that a vast majority of the colleges and universities their graduates attended had de facto one-to-one student laptop programs as nearly every student owned a computer. They believed laptop students would, therefore, more easily adapt, as these students would be technologically skilled and comfortable using computers for academic purposes. Beyond academia, students also identified technology skills as needed for success in the workforce. To land higher paying and more interesting jobs, they would be expected to navigate computers and the Internet easily. While students believed they would be able to attain some of these vocation technology skills without their laptops, they believed their comfort and skill levels were significantly higher because of their laptop programs. As one Chavez High School teacher said, “The laptop program acculturates students to the digital world.”

In line with this acculturation, students became more interested in technology through participation in laptop programs. Several students at both middle schools said their access to laptops had engendered an overall interest in technology. Girls at Gibson Middle School for Girls claimed that they spent more time exploring technology than their peers at other schools. They also noted an increase in comfort with technology, both in computing and personal electronics. At the high school level, participants credited laptops with exposing students to potential careers and areas of study they otherwise would not have known about prior to entering college, most notably STEM careers: Science, Technology, Engineering, and Math. Teachers and students at Chavez High School claimed that a portion of college bound seniors were choosing media studies, software development, and engineering as their college majors because they had developed interests in these subjects through the school’s laptop program. Of course, they believed the laptops were only partially responsible. They saw the laptops as facilitating and supplementing the academic programs that were ultimately responsible for encouraging these interests. Conversely, a handful of students at Gibson Middle School for Girls, Twain Middle School for Boys, and Hemings High School expressed a decrease in interest in technology. They claimed that the inundation of technology in academic and home lives had turned them off to computer usage and technology-centric careers. Yet these cases should be noted as counter-examples, as a vast majority of participants believed access to laptops increased students' interest in technology.

*Information Literacy*

Information literacy was also a key learning outcome for students at the five research sites. Through use of their computers and the Internet, students learned to access, search, collect, and present information. Participants agreed that student laptop access afforded them the opportunity to practice and develop these skills anytime, both at home and at school. While participants agreed that students understood the procedural elements of information access, they disagreed about students' understanding of information processing.

For the most part, administrators and teachers found that students used the Internet as their primary source of data. The unregulated nature of Internet information brought the issues of synthesis and validation of sources into the information literacy discussion. Some teachers and administrators believed students failed to scrutinize or integrate sources in reaching conclusions. In fact, they claimed that students often drew conclusions from the first source they came upon, without comparison with other sources. Chavez High School teachers in particular felt their students were engaging in plagiarism because they often failed to demonstrate the difference between formulating conclusions based on cited sources and regurgitating ideas and knowledge verbatim. Yet Chavez High School did not have a formal information literacy program, while the other schools in this study educated students on the difference between plagiarism and source citing.

At Gibson Middle School for Girls, Hemings High School, and Twain Middle School for Boys, students participated in some form of information literacy instruction. At the two middle schools, students spent time with librarians who provided instruction on information access, synthesis, and source validation. Hemings High School students spent time with librarians learning information processing skills both on the Internet and with a number of databases to which the school subscribed. Additionally, Hemings High School students who came from its feeder middle school had received similar instruction while participating in the laptop program at that school, and as a result, showed a deeper understanding of information literacy. At all three of these schools, teachers and students believed laptop students needed explicit instruction to develop a strong understanding of information synthesis and source validation.

The development of presentation skills was variable among schools and content areas. For the most part, all schools and participant groups agreed that laptop students learned how to present findings via multiple media. Yet the frequency and efficacy of those presentations varied. Both Twain Middle School for Boys and Gibson Middle School for Girls made concerted efforts to focus on presentation skills and articulation of findings and, as such, all participants at these schools claimed their students could skillfully present ideas and conclusions. Other schools mentioned various media students used to present data, but they did not focus on presenting data as a primary information literacy skill. Some mentioned knowledge of presentation software or application of technology skills in completing research assignments, but few participants focused on the mechanics of actually presenting findings. As with information literacy skills in general, the data showed that explicit instruction was the best way to teach students how to present ideas and analyses.

*Internet Safety*

One of the main concerns expressed by teachers about student access to laptops and the Internet came in Internet safety. Administrators and teachers worried that ubiquitous access to unregulated Internet resources posed a threat to students' academic success and their personal well-being. However, students believed their laptop programs taught them Internet safety skills.

When asked about specific Internet safety skills, students mentioned protection from strangers, bullying, permanency of data, and malicious software. First, students believed the Internet safety skills they learned revolved around contact with strangers. They talked about incidents they had heard about, either first or secondhand, where someone had been assaulted or inappropriately contacted via Internet communication. A Chavez High School student said, "There's some scary stories I've heard where girls get kidnapped [because of people they meet online]." They recognized the need to limit such communications and to disclose any potentially dangerous contact to peers and adults. Second, students saw an increase in online bullying, where peers felt that online anonymity gave them license to say whatever they wanted without repercussions. Again, students talked about getting help from peers and adults to protect themselves from such attacks. Third, students had a rudimentary understanding of the openness and permanency of online information, though only a few students from Chavez and Ulysses High Schools grasped the repercussions. Some provided examples of online conduct affecting real world reputations. Lastly, students understood the dangers of viruses and other malicious software, though the degree and relevancy of that understanding varied among the schools with students from Twain Middle School for Boys showing the clearest grasp of these dangers.

High school students clearly believed they had learned self-protection skills over the course of their educational careers, with a specific focus during their laptop program experiences. They received this knowledge through experiential learning, interactions with teachers, and specialized Internet safety instruction. Students at Chavez and Ulysses High Schools felt that Internet safety information had been “shoved down their throats” for so long that they often disregarded further instruction.

Students at all three high schools discussed examples of Internet dangers and incidents they or their peers had experienced. They identified these experiences as difficult and dangerous, but not completely avoidable. They felt they had learned to make good choices and rely on friends for support. At Chavez High School, students mentioned their relationship with teachers on social networking sites as a means of self-protection. At the same time, they felt that teachers were both scrutinizing their activities and available for protection if needed. Teachers and students at the three high schools also mentioned Internet safety seminars and materials they had been given as part of their laptop programs.

Conversely, middle school students seemed less skilled in self-protection on the Internet, though still knowledgeable about Internet safety concepts. Students at both middle schools presented a more cavalier attitude toward safety, often laughing or joking about issues their peers had experienced. Moreover, their limited knowledge seemed immature, in that students only understood about extremes related to online dangers, rather than the spectrum of potential issues. Teachers felt this immaturity of knowledge and attitude was due to developmental issues as most middle school students had limited life experiences.

Similar to the effects of distraction, participants noted that entry students displayed the lowest amounts of Internet safety understanding. Regardless of whether they were $5^{th}$ or $6^{th}$ grade students, $9^{th}$ grade students, or transfer students, those new to laptop programs ran into problems at higher frequencies than their more experienced peers.

Table 18

*Summary of findings for* Technology Skills

| |
|---|
| *Computer Usage Skills* |
| Student developed knowledge in computer hardware, software, Internet usage, and media skills |
| Explicit computer usage instruction resulted in uniform student skill levels and reduced the need for in-class skill development |
| Participants valued computer usage skills highly |
| Laptops acculturated students to computers and encouraged interest in technology |
| *Information Literacy* |
| Students learned the procedural elements of conducting online research |
| The Internet was students' primary source of data |
| Validation and synthesis of information was lacking |
| Students who received information literacy instruction experienced a stronger understanding of source validation |
| Laptops afforded students multiple media in which to present information |
| *Internet Safety* |
| Laptops informed students' knowledge about protecting personal information on the Internet |
| Students learned to avoid and report cyberbullying |
| Secondhand knowledge taught students the permanency of online information and the repercussions of Internet postings on real life interactions |
| Students learned how to protect their computers from malicious software |
| Entry students had the lowest understanding of Internet safety |

## *Communication*

Similar to technology skills attainment, the area of communication development was a widely discussed area of non-academic student learning. Participants felt the laptops impacted students' knowledge of communication media as well as their communicative quality and quantity. Additionally, the notion of community development and social networking emerged as key learning outcomes of students' access to laptops. This was mostly a new area of learning for laptop research as the available literature failed to investigate communication beyond media skills attainment.

*Communication Media*

Participants at all five schools credited the laptops with exposing students to a variety of digital communication media. They specifically mentioned email, instant messaging, video chatting, blogging, podcasting, Web 2.0 tools, and social networking. Participants believed students had some experience with these media prior to participation in their laptop programs, but a majority of those experiences came through social interactions. The teachers and administrators claimed the laptops allowed students to learn all of these tools for academic purposes.

While all students were exposed to this range of media, the communication medium of choice varied from school to school. At Gibson Middle School for Girls, students were required to use email to communicate with teachers, and as a result used email quite a bit with parents and peers. Similarly, Chavez and Hemings High students used email as their primary communication tool with teachers, but not with peers. At Twain Middle School for Boys and Ulysses High School, email was used sparingly. At schools where email use was in decline, students preferred to use Web 2.0 tools and instant messaging. Students at Hemings and Ulysses High Schools preferred to communicate using Moodle and iChat. Their teachers claimed it was often difficult to exchange information over email because the students checked their email accounts so infrequently. In fact, for communications with peers, students preferred instant messaging, video chatting, and social networking. Many students associated email with formal communication, while others believed it was a dying medium.

Moreover, students described peer-to-peer communication as distinct from communication with teachers. First, it rarely covered a single topic, instead it would begin with academics or social interactions, then move seamlessly back and forth amongst multiple topics, without losing any threads. Similarly, students said it was not uncommon to be simultaneously engaged in several different conversations. One Gibson Middle School for Girls student described a typical evening where she would be video chatting with one to two friends, instant messaging with three to four more, and accessing Facebook and doing her homework, all at the same time.

For academic purposes, students and teachers seemed to be moving toward archived asynchronous communication. At Ulysses High School, students and administrators described the prevalence of teacher blogging, podcasting, and Web 2.0 communication. Students often discussed academic topics through these media by posting comments, starting threads, or creating their own material. Students and administrators claimed the real value of such communication was its asynchrony, meaning that students and teachers did not have to communicate in real time to hold discussions. An administrator at Ulysses High School said,

> [Students and teachers] are having much more discussions [online] that are asynchronous. There are some practices in various departments of online commentary and discussion about student writing or about content or literature where [students and teachers] can spend a lot of time talking about examples without being on at the same time.

The other four schools were also in the process of integrating more asynchronous tools into their academic communication, each at a different stage of integration.

Beyond these trends regarding laptop communication, three interesting cases emerged from the data. At Twain Middle School for Boys, teachers and administrators believed that gaming was another form of valuable communication using laptops. They described situations where students exchanged information, shared experiences, and developed a common vernacular through online gaming worlds. While they believed this was irrelevant to academic communication, they saw it as a medium students used to build social circles. At Hemings High School, one of the teachers used instant messaging to discuss academic concepts and provide test preparation advice to his students outside of school hours. He had found that making himself available via the Internet allowed his students to be more open and expressive in academic discussions. At Chavez High School, students and teachers maintained connections via Facebook. They had "friended" each other and were using Facebook as a primary communication tool to discuss academic topics. They also used Facebook to hold real-time and asynchronous discussions outside of class time, both during and after school hours.

*Quantity and Quality*

According to participants across all five research sites, students communicated at a higher frequency because of their laptops' resources and their ubiquity of access. Students credited their laptops with allowing them to maintain contact with friends throughout the day, which was a substantial increase from their communicative frequency prior to entering their laptop programs. A Gibson Middle School for Girls student said, "[Since I joined the laptop program in sixth grade] I check my email and talk to friends more all the time." Teachers and administrators echoed this statement by noting the increase in collaboration they had observed among the students.

Additionally, teachers said that their communication with students had increased. Citing the ability to use multiple media, asynchronous technology, and the relative anonymity of digital communication, they felt students were more open and communicative because of their laptops. One teacher at Hemings High School felt his most fruitful interactions with introverted students occurred via laptop use. He believed the laptops allowed students to ask more questions and hold more in-depth discussions despite being physically separated from their peers. Students also expressed an increased comfort in communicating with teachers. Students at Chavez High School described how Facebook allowed them to talk with their teachers on a regular basis, which decreased the need to wait until the next class period to ask questions. Students at Gibson Middle School for Girls and Ulysses High School identified similar increases in student-teacher interactions when they discussed their use of email and asynchronous communication tools.

While participants agreed on the laptops' effect on communication quantity, they disagreed on the effects on quality. Most administrators and teachers believed the laptops had a negative impact on the quality of students' communication. They claimed that the colloquial and jargon-filled nature of electronic communications, coupled with the increase in frequency, had adversely affected students' grammar, vocabulary, and ability to communicate formally. Teachers at Chavez High School, Twain Middle School for Boys, and Hemings High School supported these claims by citing examples of poorly written emails and incidents of "IM speak" showing up in academic work. Overall, they feared that this decrease in quality would hinder students in college and the workforce.

To battle this adverse effect, two schools implemented policies and curriculum to help students improve digital communication quality. At Chavez and Hemings High Schools, the faculty adopted informal policies to correct errors or informalities in students' digital communication with teachers and administrators. They decided to respond to these communications with the errors highlighted along with requests for correction and resubmission. At Gibson Middle School for Girls, the librarian taught a full instructional unit on electronic communication etiquette, where he highlighted a variety of communicative elements: tone, audience, articulation, formality, and expression. Despite these efforts, teachers still felt laptop students were communicating at a lower quality – being less articulate, using “IM speak”, and utilizing limited vocabularies – due to the increase in digital communication quantity.

Yet students at four of the five research sites disagreed with this claim, stating that their communicative competencies had actually improved. Except for Twain Middle School for Boys, students believed that the increase in quantity had taught them to manage multiple streams of communication with diverse audiences. They claimed they had learned to code-switch, where they could identify their audience and tailor their content and tone accordingly. Students acknowledged that the use of “IM speak” was prevalent among their peers in social communication, but did not see this an indicator of decreased communication quality due to their laptops. Rather, “IM speak” seemed to them the result of increased cell phone texting. In fact, students at Chavez High School and Gibson Middle School for Girls claimed their peers at non-laptop schools used “IM speak” more frequently than they did. The students recognized that “IM speak” occasionally appeared in academic writing and communication with teachers, but these were isolated incidents that were usually handled swiftly by their teachers.

Since teachers only described general trends and failed to present examples, while students were able to identify both potential communicative quality issues and their resultant behaviors to mitigate those issues, these data suggest communication quality was not adversely affected by access to laptops.

*Community Development and Social Interaction*

The social impacts of laptops were significant for students in social and school communities. Students stated that their computers facilitated community development through the ubiquity of access to digital communication tools and the overall increase in communication with teachers and peers. Participants at Chavez High School claimed communication using the laptops, specifically email and social networking, had encouraged closer relationships between students and teachers, which allowed them to freely discuss academic work and other school related topics. Administrators at Hemings and Ulysses High Schools claimed that their community development extended beyond graduation because teachers were using digital communication tools to maintain contact with students for longer periods of time. It should be noted that students at Hemings and Ulysses keep their laptops after graduation.

Among peers, data showed that community development was a significant outcome of access to the laptops. Administrators and teachers at all five sites found that students were more interactive and open with one another because they could stay in contact for longer periods of time, both in terms of days and years in school. Students said their digital interactions with peers had created local social networks where they would discuss schoolwork and social topics as well as organize recreational activities. They also noted the ease at which they could coordinate communication with peers using their laptops. Moreover, participants claimed that student social communities had grown beyond the school. Students at Hemings High School, Twain Middle School for Boys, and Ulysses High School said they used their laptops to maintain friendships with students from other schools whom they had met through social activities or school field trips. Administrators and teachers also believed the laptops provided students with a "wider circle" of friends, where students were exposed to school and social cultures different than their own, which in turn increased their social awareness. One teacher said, "I think [the laptops provide students] a lot of exposure to people and things that have expanded their view of the world."

Interestingly, these expanded communities seemed to have little impact on students' social behavior or personalities. Some teachers said they were initially apprehensive about the possibility of students becoming reclusive and anti-social because of the laptops, yet they did not find ubiquitous computing had such an impact. Teachers at Gibson Middle School for Girls claimed that the students who would have been reclusive without their computers were the ones who were reclusive with their computers. In describing one particular student who had difficulties with social interactions, a Gibson Middle School for Girls teacher said, "[This student] has bigger issues for her to handle in her life regardless of the technology." Similarly, the teachers at Twain Middle School for Boys dismissed the influence of the laptops on confrontation and conflict, stating, "[With or without technology] boys will be boys." Ulysses High School students similarly believed their increased quantity of communication and their expanded social communities did not function any differently than they would have without the laptops. One student said, "[Digital communication and social networking] is a complicated thing, but it doesn’t really concern me. It hasn’t changed the way I talk to people or affected other people with me.” Of all the administrators and teachers, only one administrator at Gibson Middle School for Girls provided a counter example. She described a socially isolated student who was adept at computer use and digital art. The administrator claimed the student was able to better interact with her peers through demonstrating computer skills and sharing her artwork, both of which were facilitated through her laptop. However, the administrator said the rest of the student’s social interactions had remained unchanged.

*Social Networking*

Online social networking, primarily through Facebook, was the most widely discussed area of communication development. Nearly all participants mentioned the use of Facebook, both at home and at school, as an outcome of access to Internet enabled laptops. They claimed that students spent a significant portion of their computer time on Facebook to (i) send messages to friends, (ii) view photos and video, and (iii) play video games. Participants believed these three uses facilitated the aforementioned community development, as each involved interaction with peers. In fact, most students identified Facebook and its associated tools and resources as their primary medium for communicating with friends.

Yet, the value of Facebook as an instructional tool was disputed among participant groups. Teachers at the four private schools believed that Facebook was designed for recreation and social interaction with little value in academic discourse. The academic administrators at Hemings and Ulysses High Schools claimed that the plethora of information on Facebook had the potential to overload students, which could adversely affect their academic performance. Conversely, the students and Directors of Technology at these schools were ambivalent about Facebook's value. Some claimed the site was an overwhelming distraction, while others found it to be a powerful networking source that could be used to develop community and facilitate communication between teachers and students. Overall, data showed the academic value of Facebook was inconclusive.

While the opinions of participants at the four private schools were mixed, their policies toward Facebook use were consistent. At each of the schools, Facebook use during class time was discouraged, prohibited, or blocked through the school's content filtering system. At these schools, administrators and teachers were not allowed to "friend" students and, in some cases, not even their parents. These policies ranged from tacit agreements among the faculty to explicit written policies signed by all teachers and administrators.

Chavez High School was the exception as members of the school community used Facebook as a means of interaction inside and outside of the classroom. Students and teachers used a variety of the site's tools, including messaging, wall posts, and chatting, to communicate about academic, extracurricular, and personal topics. According to the students, Facebook had become ingrained into multiple aspects of the school's culture; every student club maintained a Facebook group, numerous events were organized through the site, and the career counseling center used Facebook to post college admissions information. Students also felt their Facebook access to teachers during exam study periods was invaluable, while teachers felt they could maintain a degree of parental oversight by reviewing their students' Facebook posts.

Regardless of their attitudes about Facebook, a majority of participants agreed that social networking was an emergent area of student learning for laptop programs. Even though student usage of Facebook was already significant, many administrators and teachers expected usage to increase in years to come because student laptops facilitated near ubiquitous access to the site. Students saw Facebook as an increasingly relevant tool for information exchange and peer contact. Many of the Directors of Technology expected to see more inclusion of social networking in curriculum delivery in the near future. Participants also agreed they had little understanding of Facebook's true potential for educational use or its long-term implications for academic learning.

Table 19

*Summary of findings for* Communication

*Communication Media*

Laptop access taught students a variety of digital communication media
The medium of choice varied from school to school based on school culture
Peer-to-peer communication often spanned multiple topics simultaneously
Academic communication was moving toward asynchronous Web 2.0 tools

*Quantity and Quality*

Laptops encouraged students to communicate at a high frequency
Students felt more open and communicative because of their laptops
The effects of laptops on communication quality were conflicting
Students felt they understood contextual and audience reliant communication and therefore had the ability to code-switch
Teachers believed "IM Speak" had diminished students' communication quality

*Community Development and Social Interaction*

Digital communication on laptops facilitated community development for both social and academic purposes
Expanded communities had little impact on social behavior or personalities

*Social Networking*

Social networking, specifically Facebook, is an emergent area of learning and community development
Students spent a large portion of time on social networking sites as they viewed it as a portal to friends
Opinions on the academic value of social networking sites varied
Chavez High students also viewed social networking as a means of interaction and supplementary instruction with teachers

## *Responsibility*

By agreeing to participate in laptop programs, students assumed responsibility for the well-being, operation, and data stored on their computers. Yet, the development of responsibility, much like other areas of non-academic learning, was largely absent from the available literature. However, in this study, responsibility development was a clear area of student learning. Data showed that laptop students developed responsibility in the areas of possession responsibility, data responsibility, maintenance responsibility, and personal responsibility.

*Possession Responsibility*

The most prominent type of responsibility students developed in their laptop programs came in the area of possession responsibility. By having ubiquitous access to their laptops, students assumed responsibility for the physical possession of their computers and the associated financial value. This responsibility had a variable impact on the students based on their socioeconomic status and each of the school cultures.

At each of these schools, students and their families assumed financial liability for their laptops. So if the laptops were damaged or lost, the students' families would be responsible for the value of the laptop or some portion thereof. At most schools, families had the option of purchasing insurance, thereby reducing their liability. However, for some families the cost of insurance and the potential loss of the computer were still too large of a burden. Thus, students developed responsibility for maintaining possession and care of their laptops. At all schools, students were clear about the need to know where their computers were at all times, whether at school or at home. They were also concerned, for the most part, with the condition of their laptops, making sure their laptops were carried in padded bags, stored in safe locations, and monitored when being used by someone else. Teachers and administrators compared this type of responsibility development with the “flour babies” they had to care for when they were in middle and high school. In “flour babies” programs, students cared for a bag of flour for a fixed period of time – usually a week – to emulate the responsibility of caring for a real baby. Administrators and teachers felt that ubiquitous access to laptops taught students similar “care and feeding” of this valuable piece of equipment.

Conversely, some students questioned this type of responsibility development. These students postulated that instead of becoming more responsible they were actually becoming paranoid. One Chavez High School student believed that having her laptop had not made her cognizant of its location and care, but rather worried about it. She claimed to focus constantly on making sure the laptop was secure and accessible, which made her uncomfortable. She said,

> I just get scared when I go to [sporting events] and I can’t leave my laptop out. I just remember last year. Everyone got [their laptop] stolen. It was an epidemic and it was horrible and it [has made] me worried.

A subset of students at each of the three high schools agreed with this opinion, but the majority of students, including all the middle school students, believed they were gaining a positive sense of responsibility, not paranoia.

Regardless of emotional impact, the degree to which students learned responsibility around loss or theft seemed to vary both by school and by socioeconomic group. At Chavez High School, students were heavily concerned with loss and theft of their laptops at school and at home. Students in both the low SES group and the non-low SES group recounted stories of peers who had left their laptops in classrooms or on public transportation and subsequently had them stolen. Low SES students in particular were aware of the potential for loss or theft of their computers. They worried about the financial liability to their families and the academic impacts of not having their computers. In contrast, the non-low SES students were equally concerned about theft and loss, but less concerned about academic impact as all of them had access to computers at home. The impact was even less at the four private schools. At Gibson Middle School for Girls and Twain Middle School for Boys, students did develop responsibility related to concerns about loss and theft, but these were mostly related to transportation of their computers to and from school. They were also concerned for their computers on campus as teachers and administrators would confiscate them if left unattended, but this concern was only loosely connected to responsibility around loss and theft. At Hemings High School and Ulysses High School, students and teachers mentioned loss and theft, but only in passing. They claimed that their schools' cultures were trusting and secure to the point where students rarely worried about losing their computers. The Directors of Technology at both schools said that students left their laptops unattended in classrooms and hallways every day, but they could not remember an incident of a lost or stolen computer within the past five years. As might be expected, each of these schools served a majority of high SES students.

Nonetheless, students at all five sites expressed concern for possible damage to their computers. This concern came in the form of potential loss of access to resources and time away from their computers. Students noted that mishandling their laptops could cause damage that would impede their academic and personal uses. As such, participants found that their laptop programs taught students responsibility around the care and use of their laptops by the students themselves and when others used them.

Interestingly, possession responsibility was the only form of responsibility that participants discussed as having transferability outside of the laptop programs. Students claimed their experiences with laptops taught them to be more responsible with other possessions, although this learning transfer seemed to only extend to other electronics. Teachers and administrators found that students were more concerned with the operation and care of their MP3 players and cell phones, but no more attentive to other possessions such as clothing or books. As one administrator described, “Kids know where their electronics are all times, but our campus is [filled] with lost sweatshirts and lunch boxes.” Students at Chavez High School claimed to be more responsible with their cars, backpacks, and lockers, but only in response to securing their laptops throughout the day.

### *Data Responsibility*

Participants also claimed that students developed data responsibility through laptop usage. They noted that students stored large amounts of critical data on their computers, both for academic and personal purposes. They claimed students learned to be responsible for that data through organization and back-ups.

With regard to organization, students learned how to manage the data housed on their laptops. For computer files, students felt responsible to organize data by using the folders to group files, choosing naming schemes that were appropriately descriptive, and learning how to use the operating system’s search functions. This organization allowed students to easily access files when needed. Beyond data files, participants also believed students learned data responsibility in maintaining their electronic communications and keeping their digital calendars up-to-date.

The most powerful element of data responsibility came in data redundancy or “backing up” information. All participants recognized that students’ data were entirely reliant on the availability and function of their laptops. As such, all five schools taught their students to be responsible with their data, especially their critical academic data, by making regular back-ups to external devices. Several students demonstrated understanding of the value of data back-ups by recounting secondhand stories of peers who had suffered consequences from losing their data to lost computers or computer malfunctions. These consequences ranged from lost music and photos to lost projects and college applications. Even though students understood the procedural steps and need for making back-ups, surprisingly few of them did so on a regular basis. Claiming they forgot or did not have the time, no student in any of the focus groups had backed-up their data within the past month. It should be noted that none of them had personally experienced a loss of critical data to computer malfunction or loss.

*Maintenance Responsibility*

In line with data responsibility, students also learned maintenance responsibility: the responsibility for keeping the laptop in good working order. While participants stated that their schools had technical support available for students in the event of large problems or catastrophic damage, students were responsible for day-to-day computer maintenance. Students identified these skills as keeping their computers clean, software up to date, and free space in their hard drives large enough to maintain functionality. Beyond this, teachers and administrators also identified troubleshooting and seeking help as elements of this type of responsibility. At Twain Middle School for Boys, administrators actively taught students troubleshooting and repair techniques in order to teach them technology skills, problem-solving skills, and maintenance responsibility.

Teachers noted that most students developed maintenance responsibility through experimentation and experience with their laptops. However, similar to data responsibility, students only exercised this knowledge when large problems arose, as opposed to using such skills as preventative measures. In fact, several participants claimed that many students would not learn this responsibility without experiencing some form of computer failure. At Hemings High School, a teacher recounted a story where one of his students came into class with an inoperable computer, which precluded the student from participating in class. This student had saved so much digital music and video on his laptop's hard drive that the applications on his computer could not function. The teacher said this event taught the student that managing his computer's maintenance and data were critical for participating in academic activities.

*Personal Responsibility*

Personal responsibility was the final area of responsibility development that emerged from the data. Participants claimed that students learned this responsibility through their responses to distraction, their personal conduct on the their computers and on the Internet, and their focus on completing tasks and meeting deadlines. Students seemed to acquire this responsibility primarily through experiential learning. Those who had been in the program the longest learned the most personal responsibility related to laptop access. Yet there was a wide range of personal responsibility attainment among students, which varied from student to student and day to day. Administrators and teachers claimed that this variation was the result of different experiences and dissimilar stages of adolescent development.

One Hemings High School administrator was adamant that his school's laptop program offered students the opportunity to learn what he called "self-discipline." He said that students were forced to develop some level of discipline, citing the opposing forces of academic responsibilities and distractions along with the potential dangers of online communication. He believed that the laptops had facilitated Hemings High students developing this discipline, but was reluctant to say it would be a learning outcome for other laptop schools. He claimed that the school's use of the laptops, along with its culture of focusing heavily on academic achievement, helped move students toward this discipline.

Regardless of school culture, the most prominent area of personal responsibility came in personal conduct on the Internet. Administrators, students, and teachers claimed that laptop use, coupled with the Internet safety knowledge they had learned, taught students to be responsible for the information they posted on the Internet. This was a major topic at both Chavez High School and Ulysses High School, where students discussed the consequences of posting personal data on the Internet and sharing too much with information with strangers. At both schools, students recounted personal stories of experiential learning in this area, primarily involving social networking sites.

Students also appeared to have developed responses to the large amount of potential distraction that came with access to their laptops. They claimed to know when to bilk temptation in order to complete academic tasks. To accomplish this, they would exercise personal willpower, close applications, or disable their Internet connections. Interestingly, at Ulysses High School, the Director of Technology described a grassroots effort by students to install distraction-mitigating software on their laptops. Students had identified, researched, and recommended that software be installed that would disable all games and heavily filter content on the computers during certain hours. However, teachers and administrators did not agree that students as a group exercised this responsibility. At Chavez High School and both middle schools, teachers felt that students had actually regressed in this area. Overall, it appeared that students understood the tenets of distraction avoidance, but application of that knowledge was inconsistent.

Teachers and administrators agreed that students used their laptops to develop strategies for managing tasks and responsibilities. They provided numerous examples of students using software tools for organization and time management. Students believed their data management skills were also applicable to the organization of assignments, events, and extra-curricular activities. They used calendaring software for time management, reminders, and social organization. Teachers found that ubiquitous access to these resources helped students learn to take responsibility for keeping them up-to-date. Students also noted that the laptops provided external motivation to take responsibility for organization, time management, and maintenance of data as their teachers understood enough about the capabilities of their laptops that they accepted fewer excuses for late or missing work.

Table 20

*Summary of findings for* Responsibility

*Possession Responsibility*

Students developed responsibility for the physical well-being of their laptops
Possession responsibility extended to loss, theft, and damage
Schools' policies on financial liability and lost data were key in the efficacy of this learning
Some students, primarily low SES students, experienced a high level of worry rather than responsibility development
Possession responsibility had moderate transferability to other electronic possessions

*Data Responsibility*

Students learned data organization and file maintenance
Secondhand information taught students the value of backing-up data, but few students exercised that knowledge on a regular basis

*Maintenance Responsibility*

Responsibility for laptops taught students the required behaviors for basic computer maintenance
Similar to data responsibility, students did not exercise this knowledge regularly

*Personal Responsibility*

Students learned to manage the potential impediments to productivity and learning that came through laptop accessible distractions
Some students developed self-discipline
Coupled with Internet safety knowledge, students learned the consequences of online actions and the need to regulate personal conduct
Laptops taught students strategies for time and task management

### *Impacts on Low Socioeconomic Status Students*

The data showed that access to laptops had specific impacts on low SES students and their communities. Laptops affected low SES students in the aforementioned areas of academic and non-academic learning to a higher degree than their non-low SES peers. Similarly, the laptops provided students and their families with resources for career advancement, social capital development, and community empowerment. However, none of the research sites, including Chavez High School, described any explicit intention to leverage these impacts to address inequity among their low SES students.

*Addressing Inequity*

Of the five research sites, only one school stated that its laptop program was implemented with the intent of addressing digital inequity. According to the Director of Technology, the laptop program at Gibson Middle School for Girls was implemented to meet the needs of low SES students by providing them equal access to computing tools and resources. To accomplish this, students on financial aid would receive discounted prices for technology resources commensurate to their level of tuition aid. However, the school's focus on socioeconomic status ended there without mention of computer usage or student empowerment. Outside of Gibson Middle School for Girls, none of the participants at the other three private schools mentioned any explicit or implicit focus on socioeconomic status or digital inequity.

Surprisingly, administrators and teachers at Chavez High School claimed that addressing inequity was not an explicit outcome of their program, though they believed the program did have a major impact on technology access for low SES students. Teachers claimed that the laptop program created a "level playing field" of access to resources for low SES students in the classroom. Administrators stated that every student, regardless of socioeconomic status, was provided access the same educational tools, both for use in the classroom and at home. Chavez High teachers and administrators believed the laptop program moved the student body toward greater parity of resources while at school. However, the students claimed reality was not this sanguine. The low SES students agreed that opportunities for access to academic technology were equal, but the financial liability associated with the laptops was a barrier to realizing true equality. Some families could not afford the potential financial cost of a lost computer or even the premium for the school-provided insurance and thus opted out of the laptop program. Moreover, differences between the two Chavez High School student groups showed that the equality of access did not extend beyond the classroom. While a majority of the low SES students claimed their school laptop was the only computer available to them at home, each of the non-low SES students claimed they had access to at least three other computers outside of school. Consequently, low SES students felt they would be at an academic disadvantage if their laptops were lost or damaged, whereas the non-low SES students believed they would be able to cope.

*Effects on Student Learning*

Teachers stated that while the laptops provided equal access to resources at school, they did not see corresponding equality in academic achievement. They found that the laptops did little to affect the achievement gap or improve academic performance for low SES students when compared to non-low SES students. However, they did believe low SES students received a deeper and broader understanding of content because their laptops provided them access to resources that expanded their worldviews. Anecdotally, the low SES students also felt the laptops had affected their content understanding and that they had experienced a corresponding improvement in academic performance. Conversely, the non-low SES students did not credit their laptops with improving their performance or grades.

Beyond resources and academic performance, low SES students were most impacted in the area of technology skills development. The low SES students mentioned a broad list of computer usage skills, information literacy skills, and Internet safety skills they had learned through access to their laptops. As a group, the low SES students at Chavez High School discussed these skills at greater length, depth, and enthusiasm than any other student group in this study. They said the laptops helped teach them skills they believed were critical for success outside of school. Some low SES students identified these technology skills as needed for vocational pursuits, while others believed they were requisite for college acceptance and post-secondary academic success. Moreover, two of the students described the application of these skills in finding after school jobs while still in high school. They both said they found their jobs, applied online, and communicated to their future employers through use of their computers, all of which would not have been possible without their school laptops or the technology skills they had learned. Additionally, some of the low SES students said they had overcome fears of computers and had developed intrepid attitudes toward new technology, both inside and outside of school. Though low SES students seemed to progress further in this area, they still fell behind the technology skills of the non-low SES students. Yet the Chavez High teachers claimed this illustrated that the laptops were moving students toward equality, as they believed the low SES students entered the program far behind their non-low SES peers and the laptops helped them close that gap.

In terms of communication and responsibility, the laptops had mixed results for low SES students. Low SES students at Chavez High School credited the laptops and their teachers' use of the technology with exposing them to communication media they had not used before. Beyond this, they experienced communication effects no different than the rest of the laptop students. They experienced increases in communication quantity, Facebook use, communication with teachers and peers, and an uncertain effect on communication quality. Conversely, their responsibility development was quite dissimilar to their non-low SES peers. The low SES students did develop responsibility in the four aforementioned areas, but they heavily skewed toward possession responsibility. The low SES students were especially cautious with the whereabouts and conditions of their laptops. They provided several examples of peers who had lost, damaged, or had their laptops stolen and the accompanying financial and academic repercussions. In fact, they were the first to identify the juxtaposition of responsibility versus paranoia in caring for their laptops. The low SES students also mentioned data responsibility and personal responsibility, but at much shallower depths.

*Implications for Home and Family*

The impacts of the laptop program at Chavez High School extended beyond the low SES students to their homes and families. As previously noted, some of the low SES students claimed their school laptop was the only computer available in their homes, which resulted in low SES students' family members using their laptops and realizing similar learning outcomes.

Participants believed this home use of school laptops provided families appreciable technology skills development and access to online information. One student claimed her family had purchased Internet connectivity at home so her parents and siblings could use her school laptop to access the Internet and communicate with extended family members. One administrator discussed two low SES students whose parents and siblings were logging significant time on the school laptop at home. He claimed the skills they learned through this usage were important for the parents in monitoring their students' use of the computer at home and in overseeing their students' academic progress through the school's online grade reporting system. Another teacher told two similar stories of students' parents who experienced career advancement using school-supplied laptops. In both instances the parents came into school to ask the teacher for help with Internet research and job searches. The teacher provided them and their students with a list of online resources to access at home. In one case, a parent used his student's laptop to research, apply for, and secure a new job. The other parent used the laptop to research salary scales for his profession, which he used to attain a promotion and a raise.

Chavez High School administrators and teachers also believed the laptops were beginning to break the cycle of social reproduction by providing skills and developing social capital. In terms of technology skills, teachers felt the laptops were teaching students and their families vocational skills – in the form of digital communication, computer usage, and Internet research skills – that could secure them better paying jobs. Moreover, administrators and teachers believed the laptops helped students and their siblings break from the parent education cycle as evidenced by the low SES students at Chavez High School beginning to exceed their parents' educational attainment. The administrators and teachers credited the laptops with providing students access to resources, skills, and exposure to career paths that encouraged them to set higher aspirations in their academic and vocational goals than they would have without laptops.

Chavez High teachers also felt home access to the Internet and digital communications allowed families to build social capital amongst themselves and within their communities. The teachers believed that by using school laptops, students and their families were able to access information on other cultures, communities, and countries, which expanded their worldviews and developed their social capital. Specifically, one teacher found that her students were able to see that the belief that their neighborhood was the beginning and ending of their community was, in fact, a narrow view. Other participants agreed that this expansion of worldview offered families, and students in particular, a vision of greater potential for their futures.

Table 21

*Summary of findings for* Impacts on Low Socioeconomic Status Students

| |
|---|
| *Addressing Inequity* |
| Schools rarely implemented their programs to explicitly address inequity |
| The laptop program at Chavez High only provided equal access, not equal use |
| *Effects on Student Learning* |
| Low SES students experienced learning outcomes to a greater degree |
| Equal access to resources did not result in equality of academic achievement |
| Access to digital resources resulted in expanded worldviews for low SES students |
| Technology skills development was particularly important to low SES students as it gave them a leg up in post-secondary education and vocational opportunities |
| *Implications for Home and Family* |
| Laptop access extended computer access and technology learning to low SES families |
| Access to technology skills and online resources developed community, built social capital, and provided vocational advancement for low SES families |
| Laptop use helped begin to break the cycle of social reproduction |
| Access to digital resources at home expanded worldviews for students and families |

*Summary of Findings*

Students at the five research sites experienced academic and non-academic learning outcomes in the areas of scholastic learning, changes to the learning environment, technology skills, communication, and responsibility.

Across the academic areas – scholastic learning and changes to learning environment – the data showed that laptops had the potential to provide dynamic instruction and offer deeper and broader understanding of content. However, the actual realized impacts of the laptops were teacher dependent. Teachers' knowledge of pedagogy, interest in technology, and ability to design and deliver engaging curriculum were the only true measures of the laptops' impact on students' academic learning. In terms of non-academic learning, students learned how to use technology and the Internet effectively and safely. They learned various communication media, experienced increases in communicative quantity, and built communities, primarily through social networking tools. Students also developed a range of responsibility from computer usage responsibility – possession, data, and maintenance – to personal responsibility.

Laptop access had direct impacts on low SES students and the Educational Digital Divide. Statistics showed that student access to laptops had failed to bridge the Educational Digital Divide in the areas of access to technology and student and community empowerment. Yet the divide was mostly absent within the area of classroom uses of technology, suggesting that laptops had the potential to offer similar educational experiences for low SES and non-low SES students. Qualitative data echoed this finding. These data showed that low SES students experienced all of the aforementioned academic and non-academic learning as well as an increase in access to educational resources. In fact, low SES students experienced these learning outcomes to a greater degree than their non-low SES peers. Outside of school, ubiquitous access to laptops also extended learning to students' families. Low SES students and families experienced career growth, skill development, community development, and a broader worldview, all of which had the potential to reduce social and educational reproduction.

Table 22

*Synopsis of findings*

| |
|---|
| *Educational Digital Divide* |
| Access to laptops appeared to reduce the divide between low SES and non-low SES students at Chavez High School, but not between low and non-low SES students across the research sites. |
| *Scholastic Learning* |
| Teachers, not laptops, were responsible for scholastic learning impacts, but access to laptops did encourage deeper and broader understanding of content. Impacts to learning were found across several content areas. |
| *Changes on the Learning Environment* |
| Students had immediate access to resources, which resulted in more collaboration, individualized instruction, multi-tasking, asynchronous learning, and distraction. |
| *Technology Skills* |
| Access to laptops taught students computer usage skills, information literacy, and Internet safety skills. |
| *Communication* |
| Laptops exposed students to a variety of communication media, increased their quantity of communication, and developed community through social networking. |
| *Responsibility* |
| Students developed responsibility in the following areas: possession responsibility, data responsibility, maintenance responsibility, and personal responsibility. |
| *Impacts on Low SES Students* |
| Low SES students experienced learning outcomes at a greater depth and socially impactful learning extended home to students' families and the communities. |

# Chapter Five: Discussion and Recommendations

## *Interpretation of Findings*

Through a combination of qualitative data drawn from program participants and quantitative data that targeted the Educational Digital Divide, this study showed that one-to-one student laptop programs had significant student learning outcomes, some of which had particular impacts on low SES students. By having a computer at home and at school, students learned academic content more deeply and broadly. They engaged in dynamic forms of instruction that drew them in as primary agents in their own learning, thereby enhancing content relevancy and retention. They learned content that exceeded the bounds of traditional classroom instruction, which provided them skills and experience requisite for an increasingly technology-centric post secondary education system and workforce. Laptops also engaged students in social and emotional learning that progressed their interpersonal growth and adolescent development. And most encouragingly, one-to-one student laptop programs taught low SES students skills and competencies they used to reduce all three levels of the Educational Digital Divide.

### *The Educational Digital Divide*

In terms of the Educational Digital Divide, one-to-one student laptop programs helped reduce the division of computer usage and student empowerment through equitable skills and resources. Equal access to computing through school provided laptops – which, by definition lessened the first level of Hohlfeld et al.’s (2008) conceptualization of the Educational Digital Divide – allowed low SES students to utilize technology for learning in ways similar to their non-low SES peers. This finding was in contrast to the literature, which stated that when technology access was equal low SES students would engage in computer use that was less dynamic and transformative (Attewell, 2001; Garland & Wotton, 2002; Warschauer, 2004). Most likely this finding was the result of the ubiquity of access and student agency available through participation in one-to-one student laptop programs. In prior literature, research was conducted among educational technology classes where students only had finite access to computers and the activities in which they engaged were often heavily controlled by their teachers. Yet, in the one-to-one student laptop programs in this study, students had greater access to technology and control over instruction, which allowed them to drive and alter the educational uses of computers. Moreover, students enjoyed equal levels of influence on computer usage and instruction despite differences in their socioeconomic statuses. This finding is encouraging as it paints an optimistic picture of the potential impact of one-to-one student laptop programs in low SES schools. Data from Chavez High School showed that ubiquitous computing delivered on the promise of equal access resulting in equal usage, which means equity of learning can be attained.

Outside of computer usage, this study showed that one-to-one student laptop programs nearly eliminated the divide of student and community empowerment attained through academic technology use. Whereas the literature suggested that students in low SES communities used technology less effectively for technology skill development

(Clark & Gorski, 2002; Warschauer et al., 2004), this study found the opposite. Again, this is likely the result of the increased influence on learning afforded low SES students through the greater access and agency they attained in their in one-to-one student laptop programs. This study showed that ubiquitous computing provided equal attainment of technology skills and student empowerment to the point where low SES students were more interested in leveraging the use of their computers for social, educational, and vocational advancement than their non-low SES peers. This was an especially valuable finding as it showed laptops not only provided equitable learning outcomes, but also encouraged attitudes and behaviors that can reduce inequity.

However, not all of the effects of laptop programs on the Educational Digital Divide were optimistic. The data showed that ubiquitous computing significantly impacted all three levels of the Educational Digital Divide, but this transformation was localized to one school site. Among students at Chavez High, the divide nearly disappeared at all three levels, but when compared with the rest of the research sites the divide was present, particularly within access and student empowerment. This was quite revealing about the true potential of one-to-one student laptop programs. Laptop programs appeared to appreciably reduce inequity between proximal socioeconomic levels like those found at Chavez High, but when applied to more disparate levels, such as between the low SES students at Chavez High and the high SES students at the other sites, the impact of laptop programs was less significant. Higher socioeconomic students still had access to greater amounts of technology that were more reliable and more frequently used. They also realized greater increases in Internet communication and academic performance. Yet, their academic computer usage was not divergent. This shows that while laptop programs have a long way to go to significantly reduce the first and third levels of the Educational Digital Divide between low and high SES students, they do provide learning opportunities to both cohorts of students that are equally impactful. It is within this learning where this study offers the most valuable conclusions by identifying the academic and non-academic student learning outcomes for one-to-one student laptop programs and illustrating which of those learning outcomes were most impactful for low SES students.

*Academic Student Learning Outcomes*

Laptop students experienced academic learning that spanned content areas and fundamentally changed the ways in which they interacted with knowledge, but the realization of this learning was directly tied to the pedagogic skills and attitudes of teachers. However, if we account for the moderating effects of teacher quality, then this study shows that participation in one-to-one student laptop programs resulted in several student learning outcomes, all of which have considerable academic implications. Laptop students learned content at deeper, broader, and more interconnected levels. They experienced greater relevancy and retention of instruction, while developing an improved capacity for learning. Laptops also made students better writers and provided them an increased ability to process information.

*Deeper understanding of content.* Laptop students learned content to a deeper level as a result of the instructional activities they engaged in through access to their computers. The findings showed that the immediacy of learning materials, the personalized nature of laptop-based instruction, and the ubiquitous access to computers helped teachers develop curriculum that taught students multiple facets of the content, which resulted in a deeper understanding. Interestingly, the literature indirectly supported this conclusion in its discussion of student work quality. Researchers found that students in laptop programs produced better quality work because of the instruction they received using their computers (Penuel, 2006; Rockman et al., 1998; Silvernail & Lane, 2004). Researchers implied that improved quality was a reflection of students' increased depth of content knowledge. The combination of this study's findings and the prior literature show that laptops facilitated student learning that exceeded the bounds of curriculum standards by offering depth of investigation into the nuances and implications of the content being studied.

*Wider breadth of content knowledge.* Parallel to depth, this study also showed that students gained a wider breadth of content knowledge. Through dynamic instruction, multi-modal teaching, just-in-time learning, and the availability of electronic resources, laptops facilitated students' content learning that was broader than the subject areas they were studying. Laptop based instruction allowed expansion beyond isolated curricular units, which built students' content knowledge and broke free of the constrictions of standards based curriculum. Thus far, the literature has not identified greater breadth as a learning outcome of one-to-one student laptop programs.

*Integration of content areas.* Academic learning was further influenced by laptops in students' experience of integrated content area learning. Within this student learning outcome, laptops facilitated cross-curricular instruction that resulted in students understanding content as interconnected, as opposed to subject areas being discrete and isolated silos of learning. The literature supported this conclusion by illustrating various laptop-based instructional projects that covered multiple subject areas (Dunleavy et al., 2007; Swan et al., 2007). Prior research also implied this student learning outcome in its identification of increased teacher collaboration and joint professional development, where teachers from mixed disciplines worked together to create instructional units (Garthwait & Weller, 2005; Windschitl & Sahl, 2002). This study amplified this conclusion by showing that the integration of content areas had strong implications in the use of knowledge. As a result of cross-curricular projects and the technology skills they attained, laptops students were better able to connect knowledge from a variety of subjects, thereby integrating content areas and further deepening and broadening their understanding.

*Greater relevancy of learning.* This study showed that access to laptops and the resulting impacts to content knowledge provided students greater relevancy of learning.

The increases in constructivist teaching practices found in this research and in the literature illustrated how students were involved in generating the methods and outcomes of laptop infused scholastic learning (Bebell, 2005; Burns & Polman, 2006; Silvernail & Lane, 2004). Through this type of instruction, laptops enabled students to take primary agency within their learning. This agency allowed instruction to be personalized, variable in pacing, and dynamic, which made learning more relevant for laptop students. Increased relevancy also helped students draw greater connections between scholastic learning and their personal interests, beliefs, and family histories. This more relevant curriculum was especially impactful for low SES students. In fact, the inclusion of cultural and family knowledge into academic work, described by researchers as Culturally Relevant Pedagogy, has been shown to increase low SES students' academic retention and performance (Gay, 2002; Ladson-Billings & Tate, 1995).

*Improved capacity for learning.* Due to the instructional activities and resources found in laptop classrooms, students experienced an improved capacity for learning. Both this study and the literature showed that students in one-to-one student laptop programs participated in a variety of instructional activities, such as project-based learning (Swan et al., 2007), individualized instruction (Rockman, 2003; Russell et al., 2004), asynchronous learning, dynamic instruction, and just-in-time learning. Students also utilized a host of online resources to facilitate and supplement their learning. Through exposure to these varied activities and resources, laptop students developed a higher capacity for learning. They were able to tailor their actions, modify their behaviors, and alter their involvements in learning because of their experiences using laptops. Yet, prior researchers did not advance their studies toward this conclusion. They only identified the variety of activities and resources available to students without investigating the resultant learning outcomes of those educational changes. Yet this research showed that students were able to comfortably participate in a range of instructional activities because of their laptop learning experiences. Still, both this study and literature showed that this greater capacity of learning, along with the changes to content and relevancy, did not consistently affect students' academic performance (Penuel, 2006; Rockman, 2003). As a result, greater capacity for learning was a student learning outcome for one-to-one student laptop programs while increases in academic performance was not.

*Increased ability to process information.* One-to-one student laptop programs taught students an increased ability to process information. This student learning outcome was found in three areas: the increase in higher order thinking skills, the attainment of information literacy skills, and the improvement of students' writing abilities. First, laptop students in this study and in the literature developed higher order thinking skills, which included the ability to think abstractly by taking in and utilizing information to effectively complete tasks or solve problems (Mitchell Institute, 2004; Rockman et al.,1998). In this study, higher order thinking was evidenced by the increase in problem solving at Twain Middle School for Boys and Ulysses High School. Through the development of higher order thinking skills, laptop use seemed to increase students' cognitive ability. Second, access to laptops taught students information processing through information literacy (Rockman, 2003; Rockman et al.,1997; Swan et al., 2007; Warschauer et al., 2004). Whereas higher order thinking skills were based on the intake of stimuli, information literacy skills included the abilities to seek out information, validate it, synthesize findings, and present conclusions. Information literacy was a key technology skill attained by laptop students, particularly at Gibson Middle School for Girls and Twain Middle School for Boys, both of which taught information literacy classes. This type of information processing was more procedural than cognitive, but it did teach students the valuable skills of digital research, data scrutiny, and information dissemination. Lastly, students became better writer through use of their laptops as evidenced by improved prose, articulation, and argumentation. Both this study and the literature showed that frequent writing and multiple drafts, along with the ease of revision and peer editing, made improved writing skills a clear learning outcome of one-to-one student laptop programs (Bebell, 2005; Mitchell Institute, 2004; Penuel, 2006; Russell et al., 2004). The combination of these three skills – higher order thinking, information literacy, and improved writing skills – shows that laptops inculcated students with a constructive ability to process information, which was critical for them as they conducted a majority of their information exchanges electronically.

*Realization of these academic student learning outcomes.* The academic student learning outcomes identified above show the potential learning that can be attained through participation one-to-one student laptop program. However, for this study, the actual laptop learning found at the research sites was as varied as the schools in which the laptop programs were housed. Across the five research sites, data showed variance in the types of instructional activities, content areas effected, and degree of student content retention. This finding was not unique to this research as numerous prior studies identified an array of instructional practices and academic outcomes for one-to-one student laptop programs (Garthwait and Weller, 2005; Silvernail & Lane, 2004; Windschitl & Sahl, 2002). While this variation initially paints laptop learning as inconsistent and unpredictable, it in fact illuminates a valuable conclusion that one-to-one student laptop programs hold the *potential* for powerfully transforming education. Laptop learning can be dynamic, individualized, and multi-modal, which can improve student engagement, content retention, and skills attainment. For low SES students, laptop-based instruction has particular potential for improving academic achievement. Yet this study showed that access to laptops neither guaranteed nor precluded these transformative changes or the realization of the aforementioned academic student learning outcomes. In fact, students learned very little academically as a direct result of access to their laptops. Findings from all five research sites showed that laptops were tools for instruction, but not primary agents in learning. Rather, laptops merely introduced the potential for the transformative change into the learning environment. This was evidenced by students' and teachers' claims that the efficacy of laptop learning was the result of teachers' dynamic use of computing, not the laptops themselves.

Furthermore, the realization of academic student learning outcomes was neither content specific nor the direct result of the introduction of laptops. It was in fact teacher centric. Prior to this study, the literature hinted at this conclusion by illustrating the importance of teachers in implementing laptop programs (Manchester, Muir, & Moulton, 2004), the value of targeted professional development (Windschitl and Sahl, 2002), and attitudinal shifts experienced by teachers (Garthwait & Weller, 2005; Rockman et al., 1998; Silvernail & Lane, 2004). However, this study solidified the central role teachers played in laptop learning by showing the effectiveness of laptop use in education was directly tied to the attitude, aptitude, and skill of the teachers who designed and delivered this technology-infused curriculum. As opposed to directly influencing instructional impact, laptops amplified the pedagogic skills of teachers, where the best teachers outside of laptop learning were also the best inside. As such, the depth, value, and relevancy of student learning on laptops was directly tied to the experience, training, and passion teachers possessed, not the resources or technological configurations that accompanied the laptops themselves.

The critical role of teachers also extended into management of the overall learning environment. Since laptops fundamentally changed the learning environment to one of dynamic tension, readily available resources, and distractions, teachers' skill in managing such unpredictability was key. For learning to be truly effective, teachers had to orchestrate their classrooms and facilitate learning, as described by Rockman et al. (1998). Through such responsibilities, teachers were even more valuable in influencing student learning. They set the cultural standards for their classrooms, where their actions, behaviors, and attitudes toward laptop learning drove students educational experiences and directly influenced the effectiveness of those experiences. The Spanish teacher at Chavez High was a clear example of this influence. Through her pedagogic knowledge and desire to use technology to transform learning, her students were exposed to a variety of Latin American cultures and dialects, which expanded their understanding of language and culture while increasing their engagement in learning.

The sum total of these influences shows that academic learning in laptop programs starts and ends with teachers. Under a skeptical view, this conclusion can be seen as putting tremendous onus on administrators. If schools are to see appreciable improvements in the academic student learning outcomes identified in this study, then administrators need to hire and cultivate strong teachers. Alternately, this conclusion provides a valuable opportunity for laptop programs in low SES schools as it shows that school resources can be targeted to improve student learning. Since teachers hold the central role in laptop learning, then the allocation of resources for professional development and teacher support would improve student learning.

Independent of the direct influence of teachers' pedagogic skills, both this study and the available literature showed that laptop students participated in student driven learning activities to a significantly higher degree than non-laptop students. Whether these activities were described as constructivist practices (Bebell, 2005; Burns & Polman, 2006; Silvernail & Lane, 2004), student-centered activities (Swan et al., 2007), or the dynamic and project-based learning found in this research, both the literature and this study showed that laptops encouraged instruction that drew upon students as the primary agents for learning. For example, the low SES students at Chavez High School discussed research projects where they selected their topic, conducted individual research, then synthesized that work with group members. All of this academic work and collaboration was facilitated through students' laptops. This type of learning was characterized by individualization, collaboration, and drawing up students' sources of knowledge. Such practices have been shown to be impactful on learning for low SES students, as these types of curricula allow students to realize the pedagogic promises of Ira Shor's (1992) Empowered Education and Ladson-Billings and Tate's (1995) Culturally Relevant Pedagogy. Shor describes Empowered Education as an educational environment where the authoritative division between teachers and students is moved to one of collaboration and mutual knowledge development, which is representative of the student driven nature of the laptop-infused instruction found in this study and in the literature. Also, the personalized and resource-enabled functionality of laptops allowed teachers to employ Culturally Relevant Pedagogy, which is a pedagogy that draws upon students' sources of cultural knowledge and family histories as a basis for instruction. Low SES students at Chavez High School experienced Culturally Relevant Pedagogy in their Spanish class when the teacher used Internet resources to compare students' communities and cultures with those found in other Latin American countries. Thus, one-to-one student laptop programs, through facilitation of Empowered Education and Culturally Relevant Pedagogy, can be used to increase the impact, relevancy, and retention of academic learning for low SES students.

However, the prevalence of dynamic instruction and constructivist learning activities raises a key pedagogic dichotomy for laptop learning: consumptive education versus creative learning. In consumptive education, students are taught discrete skills and knowledge based on standards and milestones. They process and store information delivered to them for future recitation and task application. This type of instruction is often criticized for its focus on outcomes as student achievement is gauged through the recitation of knowledge rather than the depth of understanding. Conversely, creative learning teaches pupils to build knowledge and understanding through shared experiences, project-based learning, and individualized instruction – all of which were found within laptop learning activities. Teachers working with a creative learning model rarely deliver curriculum that directly instructs skills or knowledge, instead believing that the process of creation provides added meaning and relevancy to content. Yet, this type of learning often fails to align with curriculum standards and standardized testing. As such, it is not surprising that ubiquitous computing, which encourages creative instruction, shows inconclusive effects on academic performance and standardized test scores.

The findings for both this study and the available literature show that one-to-one student laptop programs have heavy pedagogic leanings toward creative instruction. This can have long-term impacts on laptop students, specifically low SES students. On the one hand, creative learning has the potential to add meaning and validity to academic learning for low SES students by drawing upon their funds of knowledge and social capital, which are often absent from standardized curriculum. It can also provide them a greater depth and breadth of content knowledge that can develop more meaningful and lasting understanding. On the other hand, the abandonment of consumptive learning may deny low SES students critical skill development needed for academic success beyond their laptop programs, specifically on standardized tests. This juxtaposition suggests that teachers need to account for a balance in creative and consumptive education if they are going to maximize the scholastic benefits of one-to-one student laptop programs for low SES students.

*Non-Academic Student Learning Outcomes*

Outside of scholastic learning and dynamic instruction, this study showed that one-to-one student laptops programs had significant impacts on non-academic skill attainment and developmental growth. One-to-one student laptop programs taught students computing skills, affected their communicative abilities, and impacted the pace of their development. Contrasted to academic student learning outcomes, this area of learning had little prior research from which to compare. Non-academic student learning is, therefore, an emergent area of study with strong potential for illuminating the full impact of one-to-one student laptop programs.

*Technology proficiency.* Perhaps the most obvious non-academic student learning outcome for one-to-one student laptop programs was students' development of technology proficiency. As seen throughout the literature, technology immersion in laptop programs taught students a variety of hardware, software, and Internet skills (Burns & Polman, 2007; Swan, et al., 2005, 2007; Warschauer, 2005). Parallel to prior research, laptop students in this study learned technology proficiency that extended beyond skill attainment to comfort and curiosity, where students learned to explore technology without trepidation. However, the findings from pre-existing scholarship ended at this point, whereas this study has advanced the field by illustrating ways that laptop programs encouraged longitudinal technology learning. Prior to this study, researchers merely identified discrete skills – such as software titles and types of hardware – in which laptop students became proficient. Yet, these skills were often outdated by the time the research was published due to the ever-evolving nature of computing technology. This study showed that laptop programs also provided students the capacity and comfort with computing to learn new technology skills quickly and efficiently, as exemplified by the learning experienced at Chavez High School. Through access to laptops, low SES students at Chavez High learned computer usage skills and experienced increased interest and aptitude for technology. This shows that laptop programs had long-term impacts on students' ability to engage in new and unfamiliar technologies, which should serve them well as they enter a post-secondary education system and workforce heavily reliant on computer technology.

*Attainment of Internet safety skills.* Access to laptops prepared students for the complexities of Internet use by teaching them Internet safety skills. Though previous literature was unavailable in this area of student laptop learning, this study showed that laptops taught students the dangers of accessing and posting information online while sheltering them within a controlled environment. Laptop programs gave students critical experiential knowledge that will help protect them as they spend increasing amounts of time researching information, downloading software, and interacting with others using the Internet. This study also showed Internet safety skills attainment was particularly valuable for low SES students. These students demonstrated the least amount of entry knowledge in this area and, as a result, experienced the greatest amount of Internet safety learning. This was a particularly valuable finding for low SES students because the aforementioned Internet dangers can be especially problematic for novice Internet users as they can hamper educational achievement and social development, as well as open users up to physical, emotional, and legal problems. Therefore, by learning these skills, ubiquitous computing taught low SES students ways to avoid risky and potentially catastrophic behavior.

*Communication media aptitude.* Students learned a variety of communication media that built their repertoire of information exchange and processing tools. Such tools included email, instant messaging, video chatting, blogging, podcasting, Web 2.0, and social networking. This conclusion was moderately supported by the available literature, but only in the identification of communication media knowledge students attained as part of their technology skills development (Dunleavy et al., 2007; Rockman et al., 1997, 1998, 2000; Warschauer et al., 2004; Windschitl & Sahl, 2002). Whereas the available literature failed to investigate the implications of communication media literacy, this study showed that the communication media skills students learned were part of a greater communicative aptitude. Thus, students not only learned the procedural uses of various digital communication tools, but also the appropriate application of those tools and the etiquette of their use, which was especially powerful for low SES students.

*Improved communication quality.* In line with communication media aptitude, increased communication quality was a student learning outcome for one-to-one student laptop programs. Again, this area of non-academic student learning was void of available literature to either refute or support this conclusion. However, this study showed that laptop access taught articulation and argumentation skills through students' frequent use of digital communication tools. Along with these skills, laptop students learned how to tailor message, tone, and word choice based on their audience and the media they used. Though data from teachers provided counter-examples to this conclusion, the overall research showed that students experienced an improvement in communication quality. In fact, these counter-examples reinforced this conclusion of improved communication quality by showing that students learned to code-switch; they developed the ability to switch between communicative styles based on audience, media, or situation. However, this study also showed that laptop communication was often too informal and thus schools needed to establish and enforce communicative norms and guidelines to fully realize this student learning outcome.

*Community development.* Two interesting student learning outcomes emerged from this study that suggested that one-to-one student laptop programs affected students' adolescent development. The first of these outcomes was found in social growth and learning through community development. Across the five research sites, students used their computers to establish connections with peers and teachers as part of digital communities that served both social and academic purposes. These communities emerged from the data in several ways, such as the Facebook network at Chavez High School, the expansion of social networks beyond the student body at Ulysses High School, and the video game culture at Twain Middle School for Boys. Yet, regardless of the methods or tools used to create these communities, students connected and cultivated their personal networks through use of their laptops. Ubiquitous access to laptops not only facilitated the development of these communities, but also enabled community expansion. Students learned to identify and connect with people who resided outside of their geographic area, most of whom would not have been included in their social communities if they did not have access to laptops. This experiential learning helped build students' social skills by making them comfortable interacting with a variety of audiences. It also informed their social growth by teaching them the value of broadened social groups and cultivated personal networks. Prior scholarship failed to identify any changes of students' development as a learning outcome for one-to-one student laptop programs.

Social growth through community development was especially valuable for low SES students. Community development within the social boundaries of school helped low SES students feel closer and more trusting of their teachers, which encouraged them to more frequently look to their teachers for instructional guidance, mentorship, and camaraderie. This in turn created an environment that promoted academic achievement and personal growth. Outside of school, digital communities exposed low SES students to social content from a wider circle of peers, which further impacted their social development by broadening and strengthening their social capital. Warschauer (2003) said social capital development was a critical area of educational technology learning denied to low SES students by the Educational Digital Divide.

*Responsibility.* The second student learning outcome that illustrated ubiquitous computing's impact on adolescent development came in students' attainment of responsibility. Through access to, liability for, and care of laptops, students learned various types of responsibility. They learned the attentiveness needed to care for and maintain a possession with high monetary and academic value. Also, they learned their actions, even in the digital space, had real and lasting repercussions. This learning outcome showed that access to laptops impacted students' maturity and emotional growth by teaching them socially and fiscally appropriate attitudes and behaviors.

Interestingly, this student learning outcome's unique impact on low SES students supported the conclusion that laptops positively affected student development. While low SES students experienced similar levels of responsibility as non-low SES students, they were more susceptible to excessive worry about financial liability because the relative impact on their families' finances due to loss or breakage was proportionally more significant. Though this increased worry should be seen as a negative potential learning outcome for low SES students, it shows that laptops did have an appreciable effect on students' attitudes and actions, which illustrates the power of this learning on influencing developmental growth. However, this conclusion clearly demonstrates the imperative for teachers and administrators to recognize the developmentally influential power of laptop access and mitigate it so that low SES students experience responsibility development that is beneficial and healthy. This outcome would best be accomplished by minimizing the financial liability assumed by low SES families.

*Impacts on Low SES Students and Their Families*

Low SES students not only experienced each of the aforementioned academic and non-academic student learning outcomes, but they also experienced them to a greater degree of impact than the rest of the program participants. Thus, while ubiquitous computing assumed a powerfully influential role in learning for all students, it was especially transformative for low SES students. Low SES students experienced greater relevancy of content, greater breadth and depth of learning, and more ownership of instruction as well as deeper attainment of technology skills and greater impacts on adolescent development. Yet this study also showed that ubiquitous computing had specific impacts for low SES students and their communities that suggest one-to-one student laptop programs have long-term potential in reducing societal inequity.

*Reduction in the opportunity gap.* In the area of computer usage – the second level of the Educational Digital Divide – this study showed that low SES students experienced similar types and frequencies of educational technology use as their non-low SES peers. Laptops normalized the educational opportunities for all students, regardless of socioeconomic status, and thereby encouraged educational equity. As such, the opportunity gap in access and uses of educational technology, as described in the previous literature (Clark & Gorski, 2002; Hohlfeld et al., 2008, Mason & Dodds, 2005a, 2005b), was significantly reduced for low SES students through participation in a one-to-one student laptop program.

*Academic improvement.* In line with the reduction in the opportunity gap, low SES students reported experiencing improvements in academic achievement and increases in college-going rates due in part to their laptop program. This, along with the academic student learning outcomes, suggests that well orchestrated one-to-one student laptop programs have the potential to reduce the achievement gap. Yet low SES students in this study did not experience a reduction in the achievement gap because such a reduction was not included in their laptop program's design. While Chavez High School's one-to-one student laptop program had appreciable academic impacts for low SES students, such improvements were not explicitly intended outcomes of the program. Instead, the program architects at Chavez High designed their laptop program to reduce the opportunity gap by providing equality of access to resources – in the form of equal access to laptops – rather than focusing on equity of academic achievement. This lack for purposive design is a key counter example that reinforces this student learning outcome. It shows that improved academic performance can be a student learning outcome for one-to-one student laptop programs in low SES schools if program administrators focus on low SES students' academic achievement in their curriculum design and delivery. As this study's academic student learning outcomes show, this can be accomplished through implementation of Culturally Relevant Pedagogy and Empowered Education and the employment of both creative and consumptive learning.

*Extension of learning into the home.* One of the most promising student learning outcomes for laptop programs in low SES schools was the extension of laptop learning beyond students to low SES families and communities. Through access to laptops and the accompanying skills attainment, low SES students' families were able to reduce socioeconomic reproduction, develop community, and increase their influence on greater society. This illustrated ubiquitous computing's potential for reducing the third level of the Educational Digital Divide – student and community empowerment – as it showed schools can use laptops as a positive force for impacting societal equity and empowering local communities.

*Career advancement.* Both low SES students and their families reported experiencing career advancement through home and school access to computers. At home, low SES students' families identified increased vocational skills and improved career opportunities as an outcome of access to their students' school-issued laptop. This exemplifies the transformative potential of school laptops on low SES communities. When school laptops are taken into students' homes, learning outcomes for low SES families extend beyond technology skills and communication media literacy to impact earning potential and standard of living. Yet this element of career advancement was somewhat shortsighted as it only affected families' immediate job prospects and salaries. More encouraging was the impact of laptop programs on students' career opportunities. Access to laptops not only improved students' academic achievement, which increased their post-secondary opportunities, but also exposed them to career paths that would have been otherwise more challenging to enter, such as those in STEM fields – science, technology, engineering, and math. In contrast to the immediate impacts on low SES families, the career advancement learning for low SES students had potential longitudinal impacts on students' academic learning, which in turn had long term potential to significantly reduce social reproduction and the third level of the Educational Digital Divide.

*Decrease in social inequity.* Ubiquitous computing had concrete effects on factors of societal inequity for low SES students and their families. Low SES students developed technology skills, experienced career advancement, and broadened their worldviews through home usage of school provided laptops. All of these areas were identified in the Educational Digital Divide literature as measures of digital inequity (Clark & Gorski, 2002; Warschauer et al., 2004). Thus, participation in one-to-one student laptop programs helped reduce inequity by providing students and their families tools for empowerment. Further, ubiquitous computing equipped low SES students with tools to break free from the constraints of parental educational attainment and social reproduction, which was evidenced by the finding that more low SES students from the laptop program at Chavez High were attending college and pursuing higher paying jobs because of the skills they learned through participation in their laptop program. The tools and skills afforded to low SES families through school laptops also enabled transformative community development in line with the societal and financial empowerment outlined by Clark and Gorski (2002).

Table 23

*Student learning outcomes for one-to-one student laptop programs*

| |
|---|
| *Academic Student Learning Outcomes* |
| Deeper understanding of content |
| Wider breadth of content knowledge |
| Integration of content areas |
| Greater relevancy of learning |
| Improved capacity for learning |
| Increased ability to process information |
| *Non-Academic Student Learning Outcomes* |
| Technology proficiency |
| Attainment of Internet safety skills |
| Communication media aptitude |
| Improved communication quality |
| Community development |
| Responsibility |
| *Student Learning Outcomes Specific to Low SES Students and Their Families* |
| Reduction in the opportunity gap |
| Academic improvement |
| Extension of learning into the home |
| Career advancement |
| Decrease in social inequity |

*Discussion of Limitations*

While this study identified a broad list of academic and non-academic student learning outcomes for one-to-one student laptop programs, and identified which of those student learning outcomes were most unique and had the greatest impact for low SES students (see table 23), its limitations warrant discussion.

First, the dearth of available research sites brings into question and reinforces the conclusions presented in this study. Throughout the entire San Francisco Bay Area, only one low SES school could be found that housed a one-to-one student laptop program. This brings into question the generalizeability of these student learning outcomes. One low SES school was insufficient to draw applicability of these conclusions to other low SES schools. Yet this scarcity of available sites also supports the value of these conclusions. It shows that the student learning outcomes identified as unique and impactful to low SES students are valid as they were drawn from participants, including students who had experiential knowledge of a one-to-one student laptop program in a low SES school. Of the limited prior research on ubiquitous computing in low SES schools, most conclusions were conjecture with little data collected from low SES students themselves.

Second, the use of self-reported data limits the applicability of these conclusions. Since data were drawn from participants' perceptions of learning rather than from observed outcomes, these conclusions may be influenced by participant bias. However, to account for this bias, a breadth of participant groups and research sites were included, which reinforced the validity of these student learning outcomes. To further hone these conclusions, future research should directly measure student learning outcomes attributable to one-to-one student laptop programs.

Third, this study did not measure the magnitude of student learning found in one-to-one student laptop programs. Though this research was designed to identify student learning outcomes, the degree of learning found within these areas was not investigated. For example, deeper understanding of content was an identified student learning outcome, but the depth of that understanding was not researched. As such, future research will need to investigate how impactful one-to-one student laptop programs are in achieving these student learning outcomes.

Lastly, this study had geographic limitations that may have reduced the generalizeability of its conclusions. All five research sites were located within fifty miles of San Francisco. This area had distinctive economic, political, and historical features that likely influenced the laptop learning experienced by students within this study. This influence may not be present in other geographic areas. Moreover, the proximity of the Silicon Valley, with its focus on computing research and development, may also have influenced the student learning outcomes found at the research sites. Future research will need to include geographically diverse laptop programs to ensure that the student learning outcomes identified in this study are not unique to students in the San Francisco Bay Area.

## *Implications*

The student learning outcomes identified in this study show that one-to-one student laptop programs have appreciable effects on student learning. These outcomes are both impactful and realistically attainable for low SES students, which implies that one-to-one student laptop programs are effective academic investments for low SES schools.

This finding has implications at every level of laptop program administration, from educational policy to design, implementation, and instructional practice. It also has specific implications in the reduction of the Educational Digital Divide that can improve the lives of low SES students and their communities.

This research shows educational policymakers should consider the implementation of one-to-one student laptop programs in low SES schools as an effective way to realize the student learning outcomes identified in this study. Ubiquitous computing has the potential to impact student learning across curricular areas as well as reduce societal inequity, both of which align with the core mission of U.S. public education and, specifically, the tenets of No Child Left Behind. However, policymakers will need to make a full commitment toward addressing digital inequity across all socioeconomic groups if one-to-one student laptop programs are going to have a lasting impact on all three levels of the Educational Digital Divide.

This study also implies that the design of budgeting, administration, and accountability processes for one-to-one student laptop programs in low SES schools should be reflective of the student learning outcomes listed above, specifically the critical roles students and teachers play in affecting educational impact. Without focus on these outcomes and roles, programs will fail to achieve true impact. As one-to-one student laptop programs in low SES schools are resource dependent programs in resource challenged environments, impact is paramount for success. Further, implementation of these programs must account for and leverage potential community development and extension of learning into the home to realize the full breadth of potential learning benefits. Program architects and administrators should draw upon the conclusions of this study to design educational programs and policies that encourage partnerships with students' families and communities while extending laptop education to them. Of course this will require further examination of budget allocations in order to pay for such programs.

Within instructional practice, the student learning outcomes identified in this study provide clear milestones and guidelines for curriculum development and instruction, such as focus on depth, breadth, relevancy, and integration of content. Teachers in one-to-one student laptop programs in low SES schools should examine these outcomes at depth to identify how they can transform practice to maximize the educational impact of laptops for low SES students. Further, these outcomes have specific implications in the evaluation and assessment metrics of ubiquitous computing. They show that assessment of learning needs to be both formative and summative, focusing simultaneously on authentic learning measures as well as those based in content standards.

Outside of policy and practice areas, these impactful student learning outcomes for one-to-one student laptop programs in low SES schools have significant implications on the Educational Digital Divide. They illustrate tangible measures within one-to-one student laptop programs that can be taken to reduce all three levels of the divide. Students can be given ubiquitous access to laptops that will increase their access to technology, which addresses the first level of the divide. They can use that technology in ways that will move schools toward equality, thereby affecting the second level of the divide. The skills and competencies they learn through this usage can build empowerment opportunities for them and their families that have the potential to diminish social reproduction among low SES communities, thus reducing the third level of the divide. Further, these measures can be built upon both educational research and practice, which would reinforce their validity, relevancy, impact, and sustainability.

This study also has specific implications for low SES students and their communities. It shows that ubiquitous computing is at a crossroads. At present, access to laptop programs is worsening societal inequity because a majority of programs are located in schools that serve high SES communities. Yet this study has shown that one-to-one student laptop programs can actually be agents to improve the lives of low SES students and their communities. This study’s conclusions show that ubiquitous computing can improve students’ academic performance, increase their understanding of content, develop skills that can give them entree into our global digital economy, and empower them in their own learning. Further, it implies that low SES students themselves must be agents in realizing these impacts. As such, the conclusions of this research should serve as a rallying cry for low SES students and their families in demanding that a one-to-one student laptop program based on the aforementioned student learning outcomes be implemented at their school.

*Recommendations for Action*

The results of this study inform action for both existing one-to-one student laptop programs and potential programs in low SES schools. For existing programs in low SES schools, administrators should use these student learning outcomes to establish evaluation criteria for their programs' impact on teaching and learning. They could identify areas of improvement for their programs, which would inform resource allocation and professional development. Specifically, administrators should identify the skills and attitudes of their programs' teachers in relation to pedagogy and technology-infused instruction. With such information, professional learning communities among teachers could be created where teachers with the greatest pedagogic skill could collaborate with less experienced teachers to improve instructional quality. Within these groups, dynamic instructional activities and classroom management practices could be exchanged among teachers to elevate the skill levels for all teachers within the program. Moreover, administrators, teachers, and students should work collaboratively to utilize the resources available through student access to laptops to draw upon students' funds of knowledge and cultural experience to fully realize the potential for Culturally Relevant Pedagogy and Empowered Education (Bowles & Gintis, 1976, Ladson-Billings & Tate, 1995, Shor, 1992).

Equally important as academic student learning outcomes, this study demonstrated the non-academic learning potential of one-to-one student laptop programs. As such, existing program administrators should develop educational policies and programs within their schools to leverage the non-academic learning potential of student access to laptops. First, they should use the non-academic student learning outcomes to identify specific technology skills they would like students to learn, then modify their instructional programs to ensure those skills are attained. Second, they should create policies for communication and responsibility standards that challenge students without putting them under undue pressure. Lastly, they should work with students to identify potential career paths and areas of academic study that could be developed through laptop use.

Community development and extension of learning to low SES families should also become explicit goals of existing programs. Schools should follow Chavez High School's model of using social networking to connect teachers and students to encourage increased communication, mentorship, and camaraderie. However, use of social networking will need to be accompanied by clearly defined policies for acceptable usage and appropriate student-teacher interactions. Additionally, schools should formalize technology-infused learning for students' families by providing after school educational programs in technology skills development, electronic resource usage, and digital communication. Further, they should help facilitate community development outside of school by hosting digital communication resources within the schools' technology infrastructures. However, these programs would be external to the core mission of schools, which would necessitate additional resources and personnel that would need to be funded outside of schools' budgets. Such resources could be attained from philanthropic organizations or through grant funding.

For new programs in low SES schools, all the aforementioned actions could be accomplished by purposively integrating the impactful student learning outcomes identified in this study into the implementation and administration of those programs. By doing this during the design and development phases, student learning, the needs of low SES communities, the focus on teachers in academic learning, and on students in non-academic learning could be embedded in the programs' cultures. Thus, programs' missions and decision-making structures would intentionally work to realize realistically attainable student learning for low SES students, as well as reduce the second and third levels of the Educational Digital Divide.

### *Recommendations for Further Study*

This study has shown that one-to-one student laptop programs have immense potential in impacting learning for low SES students and their communities and in reducing all three levels of the Educational Digital Divide. However, if laptop programs in low SES schools are to fully realize the depth of this potential then the level of impact on learning must be researched. Researchers will need to build upon this work by investigating the degree of learning students experience through participation in one-to-one student laptop programs. Such research should utilize observed behaviors, classroom performance, and assessment data to quantify and qualify these depths of learning.

In order for this research to improve practice in one-to-one student laptop programs in low SES school this study's conclusions must be codified in a manner that is actionable and sustainable. Researchers should use this work to develop an effective pedagogy for one-to-one student laptop programs in low SES schools. This pedagogy should draw upon the existing literature and the findings from this study to outline educational procedure and philosophy for impactful laptop programs in schools that serve primarily low SES students.

The development of this pedagogy presents an exceptional opportunity for valuable future research. Through participatory action research, one-to-one student laptop programs based on this effective pedagogy could be implemented and studied in schools with high percentages of low SES students. Such research would not only yield empirical data that would aid in the refinement of the student learning outcomes identified in this study while further developing this effective pedagogy, but also extend the opportunity for low SES students to experience the social, curricular, and skills-based impacts of ubiquitous computing.

However, the substantial cost, complexity, and administrative commitment required for implementing one-to-one student laptop programs are often insurmountable barriers for low SES schools. Yet a synthesis of the existing literature on the impacts of ubiquitous computing, along with the conclusions from this study could help other researchers or policymakers develop a cost-reducing model of effective implementation, administration, and accountability for one-to-one student laptop programs in low SES schools. This model would allow laptop programs to be tailored to and initiated in any school setting, thereby offering the potential learning impact of ubiquitous computing to any and all students.

### *Reflections on the Research Process*

Having been a long time practitioner in the field of one-to-one student laptop programs, I entered this research believing that laptops had the potential to transform instruction and learning. Yet during this process, I came to see the value of laptops in learning is insignificant if not coupled with adept teachers and engaged students. All the same, the teachers and students did not work in isolation of their environments and their communities. Their school cultures heavily influenced their attitudes toward the technology, and by extension, the usefulness of that technology in learning. It showed me that the success of any educational program, be it a small educational programmatic adjustment or a large scale change in pedagogy, rests first and foremost in the efforts and skills of the participants, not in the resources or administration of that program.

This led me to examine the vast inequity in access to ubiquitous computing. Across the nation, a significant majority of one-to-one student laptop programs are found in public and private schools that serve high SES communities. Yet this study has shown that low SES students and their families have the most to gain from access to laptops. In fact, given the argument that participants drive educational success, the only elements missing from the implementation of sustainable and impactful one-to-one student laptop programs in low SES schools are appropriate planning and opportunity. The conclusions from this study serve as a basis of such planning, by describing student learning outcomes that would guide the resource allocation and administration of such programs. This just leaves opportunity. Given the opportunity to engage in ubiquitous computing, coupled with the aforementioned planning based on realistically attainable student learning outcomes, low SES students and their families will experience improved academic achievement and reduced societal inequity. The students and teachers at Chavez High embodied this in their passion and pride for what they had accomplished through their laptop program.

## *Conclusion*

In the near future, can you imagine a U.S. classroom where students do not have some form of personalized learning technology, be it a laptop or some other device? It seems hard to fathom, but if this reality were not to come to fruition for all students, what would happen to those without access? Presumably, if a group of students were to be denied personalized educational technology then undoubtedly they would come from subverted social groups, most likely from low SES communities. Such division of access would further exacerbate an already gaping divide in access to educational technology, which would in turn widen the gaps between the second and third levels of the Educational Digital Divide: educational technology use and student empowerment. As such, it is imperative to reduce barriers to success for one-to-one student laptop programs in low SES schools. However, at this point in time, success of a one-to-one student laptop program in any school is ill-defined, as researchers and practitioners have not identified accountability metrics. As such, the best we can hope for is impact on learning and program sustainability. This study has shown that learning impacts rely primarily on the actions of teachers and the mentorship of students, and further, that sustaining a program requires constant examination and refinement of that learning.

This reveals a striking conclusion about laptop programs. If we consider that the impact of any educational program is the result of a combination of resources and personnel, then we can formulate a basic equation for the realized learning impacts of one-to-one student laptop programs. Within this equation, the inputs would be teachers, students, and laptops, while outputs would be the academic and non-academic student learning outcomes described in this research. Interestingly, this study has shown that learning in one-to-one student laptop programs is most directly related to the teachers and students, not the laptops. This suggests that regardless of the type of laptop – whether a Macintosh computer, Windows-based computer, Netbook, tablet PC, or some other personal computing device – one-to-one student laptop programs can still impact students to similar degrees, as long as students have access to some form of personalized computing and teachers are well supported. This conclusion has serious implications for the implementation and administration of potential one-to-one student laptop programs in low SES schools. If the type of device itself does not carry primary influence on student learning, program administrators could allocate fewer funds on expensive technology, which would make program sustainability less reliant on financial factors. Instead, administrators could direct what funds were available to teacher training and community development, which would have greater and longer lasting impacts on both student learning for low SES students and on all three levels of the Educational Digital Divide.

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# Appendices

Appendix A: Student Technology Survey

## Student Technology Survey

**1. How many computers do you have access to at home?** ____________________

**2. Do you have Internet access at home?** Yes No

**3. How often do you have access to computers at school?** Always Often Rarely Never

| In this section, please rate the following statements: | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree |
|---|---|---|---|---|---|
| **4. The computers provided by my school work well.** | 1 | 2 | 3 | 4 | 5 |
| **5. My teachers know how to use computers and the Internet.** | 1 | 2 | 3 | 4 | 5 |
| **6. I often use computers and the Internet at school.** | 1 | 2 | 3 | 4 | 5 |
| **7. At my school, computers and the Internet are used to enhance what I learn.** | 1 | 2 | 3 | 4 | 5 |
| **8. The way my school uses computers and the Internet is interesting.** | 1 | 2 | 3 | 4 | 5 |
| **9. I am a better student because of my school's use of computers and the Internet.** | 1 | 2 | 3 | 4 | 5 |

Please rate your abilities in the following areas:

| | | | | | |
|---|---|---|---|---|---|
| **10. Basic computer use** | Expert | Advanced | Average | Below Average | Novice |
| **11. Internet communications (email, web, IM, etc.)** | Expert | Advanced | Average | Below Average | Novice |
| **12. Using productivity software (e.g. MS Word, Powerpoint, etc.)** | Expert | Advanced | Average | Below Average | Novice |
| **13. Using the Internet for research** | Expert | Advanced | Average | Below Average | Novice |

**14. How often do you use the Internet to communicate with friends and family?** Daily Weekly Monthly A few times a year Never

**15. Do you wish you were able to use computers:** More Often Less Often Neither

## *Explanation of Survey Questions*

This survey was designed to measure various facets of the Educational Digital Divide. It’s organization and question selection was informed by the Educational Digital Divide literature, specifically the role of education in impacting or exacerbating the Educational Digital Divide. The survey was intended to measure students’ access to and uses of educational technology. It was designed to collect data around (i) existing conditions at home and at school, (ii) student perceptions of those conditions, (iii) and their own abilities and competencies.

### *Organization of Questions*

The questions in this survey were designed to cover the three areas of the Educational Digital Divide. The breakdown of questions is as follows:

- Questions 1-4 – Level 1 – Access to Hardware, Software, and the Internet
- Questions 5-8 – Level 2 – Use of Technology by Teachers and Students
- Questions 9-15 – Level 3 – Empowerment of Students

Within each section, questions were designed to measure elements within each level of the Educational Digital Divide as identified in the literature review.

### *Level 1 – Access to Hardware, Software, and the Internet*

*Question 1.* Home access to computers, including hardware and software. Though the focus of much of literature was on school access to computing, several researchers found positive correlations between home access to computers and the availability and quality of school computers.

*Question 2.* A simple binary question seeking to determine student access to the Internet at home. Researchers noted that Internet access at home was a common and simple measure of the binary interpretation of the Educational Digital Divide (the haves vs. the have nots)

*Question 3.* Beyond mere access, the quantity of access to computers is also found to be a measure of inequity in the first level of the divide. It was expected that laptop students would answer this question "Always", but group B students could have shown greater variation in their responses. The comparison of those responses was designed to provide data around frequency of computer access and use.

*Question 4.* Researchers noted that the first level of the Educational Digital Divide could be measured in the quality and reliability of computers to which students had access.

*Level 2 – Use of Technology by Teachers and Students*

*Question 5.* As a basis for the second level of the divide, the ability of teachers to use technology was considered a requisite for effective use of computers in the classroom.

*Question 6*. This question was designed to measure the frequency of technology use by students in the classroom. As opposed to educational technology quality, this question focused on quantity.

*Question 7*. This was the first of two questions that focused on quality. This question investigated whether educational technology was used to enhance teaching and learning. It was intentionally left as a broad question so that students had to decide whether they believed technology was used effectively to improve learning overall as opposed to focusing on specific subject areas or technology skills development.

*Question 8*. This question measured the quality of technology use in the classroom by focusing on how interesting those uses were separate from their educational impact. In the literature, several researchers drew connections between interesting and thought-provoking uses of technology in the classroom to the second level of Educational Digital Divide.

*Level 3 – Student Empowerment*

*Question 9.* This question measured the summative academic impact of technology access. Researchers believed that one of the primary characteristics of the third level of the Educational Digital Divide was student self-perception of their abilities as learners.

*Questions 10-13.* These questions measured students' technology skills. Technology skills have been linked to student interaction, personal growth, and self-empowerment within the Educational Digital Divide literature. The subject matter was based on the International Society of Technology Educators National Educational Technology Standards for Students (International Society for Technology in Education, 2010).

*Question 14*. The use of the Internet to maintain contact with friends and family was seen as the hallmark of technology's role in community organization and student empowerment in developing social capital.

*Question 15*. This question determined whether students felt their technology needs were met. This self-identified need was an indicator of both student empowerment and effective technology use.

# Appendix B: Group A Administrator Interview Protocol

WARM-UP

What is your role in the laptop program?

GROUNDWORK

How would you describe the educational culture of your school? What are the key characteristics of your educational programs?

Probes:
1. Pedagogy
2. Resources
3. Mission/Goals
4. Student Achievement
5. Matriculation

INTRODUCTION OF LAPTOPS

Has the introduction of laptops impacted your educational programs?

…If so, in what ways?

…If not, why do you think it has not had an impact?

PROBES

TEACHING

**Yes** In what ways has teaching changed as a result of student access to laptops?

**No** In what ways, if any, had you expected teaching to change as a result of student access to laptops?

CLASSROOM ENVIRONMENT

**Yes** How have laptops changed the classroom environment?

What specific impacts do you see on student behaviors and interactions?

**No** How had you expected laptops to change the classroom environment, if at all?

What specific impacts, if any, did you expect to see on student behaviors and interactions?

STUDENT LEARNING

**Yes** What do you believe students learn through participation in your laptop program?

**No** What did you expect students to learn through participation in your laptop program, if anything?

## *Explanation of Interview Questions*

### *Warm-up*

The warm-up question was designed to establish rapport with the interview subject by providing an objective, factual question that focused on personal information and involvement in the laptop program.

### *Groundwork*

This question was designed to put the interview subject in the frame of mind of the educational conditions of the school overall, without focusing on the role of laptops. By establishing these educational conditions, the following was used to focus on the specific impacts of laptops as opposed to blurring the line between existing conditions and laptop use. To provide greater clarity and depth in this question, the interview subject was asked to focus on the areas listed under probes.

### *Introduction of Laptops*

This question built upon the previous question. After asking the interview subject to think about the educational conditions of the institution, this question sought to investigate the impact of laptops on those conditions. This question had one of two answers: yes or no. From the subject's responses, the follow-up questions were asked to investigate why and how such impacts were or were not present.

*Probes*

These questions were used to guide the interview should the interview subject not touch upon these topics in his/her explanation of the impact of laptops on teaching and learning. These three probe areas were derived from the areas of impact on teaching and learning found in the literature review.

# Appendix C: Group B Administrator Interview Protocol

WARM-UP

What is your role in the laptop program?

GROUNDWORK

How would you describe the educational culture of your school? What are the key characteristics of your educational programs?

Probes:

1. Pedagogy
2. Resources
3. Mission/Goals
4. Student Achievement
5. Matriculation

INTRODUCTION OF LAPTOPS

Has the introduction of laptops impacted your educational programs?

…If so, in what ways?

…If not, why do you think it has not had an impact?

In what ways, if any, does students' socioeconomic status affect what they learn by having a laptop?

PROBES

TEACHING

**Yes** In what ways has teaching changed as a result of student access to laptops?

**No** In what ways, if any, had you expected teaching to change as a result of student access to laptops?

How does students' socioeconomic status influence these changes/expectations?

CLASSROOM ENVIRONMENT

**Yes** How have laptops changed the classroom environment?

What specific impacts do you see on student behaviors and interactions?

Do students with differing socioeconomic statuses experience these changes in different ways? If so, how?

**No** How had you expected laptops to change the classroom environment, if at all?

What specific impacts, if any, did you expect to see on student behaviors and interactions?

Did you expect students with differing socioeconomic statuses to experience changes to the classroom environment in different ways? If so, how?

STUDENT LEARNING

**Yes** What do you believe students learn through participation in your laptop program?

Does socioeconomic status impact this learning? If so, how?

**No** What did you expect students to learn through participation in your laptop program, if anything?

Did you expect socioeconomic status to impact learning? If so, in what ways?

*Explanation of Interview Questions*

*Warm-up*

The warm-up question was designed to establish rapport with the interview subject by providing an objective, factual question that focused on personal information and involvement in the laptop program.

*Groundwork*

This question was designed to put the interview subject in the frame of mind of the educational conditions of the school overall, without focusing on the role of laptops. By establishing these educational conditions, the following was used to focus on the specific impacts of laptops as opposed to blurring the line between existing conditions and laptop use. To provide greater clarity and depth in this question, the interview subject was asked to focus on the areas listed under probes.

*Introduction of Laptops*

This question built upon the previous question. After asking the interview subject to think about the educational conditions of the institution, this question sought to investigate the impact of laptops on those conditions. This question had one of two answers: yes or no. From the subject's responses, the follow-up questions were asked to investigate why and how such impacts were or were not present.

The question about socioeconomic status was designed to investigate the role of socioeconomic status in learning, whether it was a factor, to what degree, and in what ways it manifested itself.

*Probes*

These questions were used to guide the interview should the interview subject not touch upon these topics in his/her explanation of the impact of laptops on teaching and learning. These three probe areas were derived from the areas of impact on teaching and learning found in the literature review.

A discussion about the role of socioeconomic status accompanied each of these probes. These discussions were designed to have the interview subject think about how socioeconomic status impacted learning or would have impacted learning if they had found it.

# Appendix D: Student Focus Group Protocol

GROUNDWORK

Thinking of what you learn and how you learn here at XXXXX, how would you describe your school to someone who has never been here?

INTRODUCTION OF LAPTOPS

How have laptops changed the way you learn?

CLASSROOM ENVIRONMENT

How have laptops changed the way you feel about school?

STUDENT LEARNING

What do you think you learn by having your laptops?

### *Explanation of Focus Group Questions*

#### *Groundwork*

This question was designed to put the participants in the frame of mind of the educational conditions of the school overall, without focusing on the role of laptops. By establishing these educational conditions, the following questions were able to focus on the specific impacts of the introductions of laptops as opposed to blurring the line between existing conditions and laptop use.

#### *Introduction of Laptops*

This question built upon the previous question. After asking the participants to think about the educational conditions of the institution, this question sought to discover the impact of laptops on those conditions. This question had one of two answers: yes or no. From these responses, questions were asked to investigate why and how such impact was or was not present.

#### *Classroom Environment and Student Learning*

These questions were used to guide the focus group when the participants did not touch upon these topics in their explanations of the impact of laptops on teaching and learning. These three probe areas were derived from the areas of impact on teaching and learning found in the literature review.

# Appendix E: Group A Teacher Focus Group Protocol

## WARM UP

How long have you been a teacher here at XXXXX? What grades/subjects do you teach?

## GROUNDWORK

How would you describe the educational culture of your school? What are the key characteristics of your educational programs?

Probes:
1. Pedagogy
2. Resources
3. Mission/Goals
4. Student Achievement
5. Matriculation

## TEACHING

How has the introduction of laptops changed your teaching?

…If so, in what ways?

…If not, why do you think it has not had an impact?

## PROBES

TEACHING

**Yes** In what ways has your teaching style changed as a result of the students having laptops?

**No** In what ways, if any, had you expected teaching to change as a result of student access to laptops?

CLASSROOM ENVIRONMENT

**Yes** How have laptops changed the classroom environment?

What specific impacts do you see on student behaviors and interactions?

**No** How had you expected laptops to change the classroom environment, if at all?

What specific impacts, if any, did you expect to see on student behaviors and interactions?

STUDENT LEARNING

**Yes** What do you believe students learn through participation in your laptop program?

What do you believe students learn outside of academic areas?

**No** What did you expect students to learn through participation in your laptop program, if anything?

What, if anything, had you expected students to learn outside of academic areas?

*Explanation of Focus Group Questions*

*Warm-up*

The warm-up question was designed to establish rapport with the focus group participants by providing an objective, factual question that focused on personal information, involvement at the school, and experience as educators.

*Groundwork*

This question was designed to put the participants in the frame of mind of the educational conditions of the school overall, without focusing on the role of laptops. By establishing these educational conditions, the following question was able to focus on the specific impacts of the introduction of laptops as opposed to blurring the line between existing conditions and laptop use. To provide greater clarity and depth in this question, the participants were asked to focus on the areas listed under probes.

*Introduction of Laptops*

This question built upon the previous question. After asking the participants to think about the educational conditions of the institution, this question sought to discover the impact of laptops on those conditions. This question had one of two answers: yes or no. From these responses, questions were asked to investigate why and how such impact was or was not present.

*Probes*

These questions were used to guide the focus group when the participants did not touch upon these topics in their explanations of the impact of laptops on teaching and learning. These three probe areas were derived from the areas of impact on teaching and learning found in the literature review.

# Appendix F: Group B Teacher Focus Group Protocol

<u>WARM UP</u>

How long have you been a teacher here at XXXXX? What grades/subjects do you teach?

<u>GROUNDWORK</u>

How would you describe the educational culture of your school? What are the key characteristics of your educational programs?

Probes:

1. Pedagogy
2. Resources
3. Mission/Goals
4. Student Achievement
5. Matriculation

<u>TEACHING</u>

How has the introduction of laptops changed your teaching?

…If so, in what ways?

…If not, why do you think it has not had an impact?

In what ways, if any, does students' socioeconomic status affect what students learn by having a laptop?

<u>PROBES</u>

TEACHING

**Yes** In what ways has your teaching style changed as a result of students having laptops?

**No** In what ways, if any, had you expected teaching to change as a result of student access to laptops?

How does the socioeconomic status of your students influence these changes/expectations?

CLASSROOM ENVIRONMENT

**Yes** How have laptops changed the classroom environment?

What specific impacts do you see on student behaviors and interactions?

Do students with differing socioeconomic statuses experience these changes in different ways? If so, how?

**No** How had you expected laptops to change the classroom environment, if at all?

What specific impacts, if any, did you expect to see on student behaviors and interactions?

Did you expect students with differing socioeconomic statuses to experience changes to the classroom environment in different ways? If so, how?

STUDENT LEARNING

**Yes** What do you believe students learn through participation in your laptop program?

What do you believe students learn outside of academic areas?

Does socioeconomic status impact this learning? If so, how?

**No** What did you expect students to learn through participation in your laptop program, if anything?

What, if anything, had you expected students to learn outside of academic areas?

Did you expect socioeconomic status to impact learning? If so, in what ways?

*Explanation of Focus Group Questions*

*Warm-up*

The warm-up question was designed to establish rapport with the focus group participants by providing an objective, factual question that focused on personal information, involvement at the school, and experience as educators.

*Groundwork*

This question was designed to put the participants in the frame of mind of the educational conditions of the school overall, without focusing on the role of laptops. By establishing these educational conditions, the following question was able to focus on the specific impacts of the introduction of laptops as opposed to blurring the line between existing conditions and laptop use. To provide greater clarity and depth in this question, the participants were asked to focus on the areas listed under probes.

*Introduction of Laptops*

This question built upon the previous question. After asking the participants to think about the educational conditions of the institution, this question sought to discover the impact of laptops on those conditions. This question had one of two answers: yes or no. From these responses, questions were asked to investigate why and how such impact was or was not present.

The question about socioeconomic status was designed to investigate the role of socioeconomic status in learning, whether it was a factor, to what degree, and in what ways it manifested itself.

*Probes*

These questions were used to guide the focus group when the participants did not touch upon these topics in their explanations of the impact of laptops on teaching and learning. These three probe areas were derived from the areas of impact on teaching and learning found in the literature review.

A discussion about the role of socioeconomic status accompanied each of the probes. These discussions were designed to have participants think about how socioeconomic status impacted learning or would have impacted learning if they had found it.