ABSTRACT

Title of Document:	TESTING THE DIGITAL DIVIDE: DOES ACCESS TO HIGH-QUALITY USE OF TECHNOLOGY IN SCHOOLS AFFECT STUDENT ACHIEVEMENT?
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This study investigates the relationship between access, use of technology and student achievement in public middle schools in Maryland. The objective of this study was to determine whether a digital divide (differences in access and utilization of technology based on student characteristics of race, socioeconomic status, and gender) exists among schools, and whether those differences relate to mathematics and reading achievement. More specifically, the study uses school data on technology access, students' instructional uses of technology, and teacher technology proficiency from the 2007 Maryland Technology Inventory. This study analyzes student demographic data and assessment results from the 2007 Maryland School Assessments in reading and mathematics obtained from the Maryland State Department of Education. The data

analyses use descriptive and multivariate statistics to determine the existence of digital divides and their effects on reading and mathematics achievement.

Analysis of these data described patterns of technology access and use in order to determine whether differences in access and use resulted in a digital divide. Differences in access and use were then examined to determine their impact on reading and mathematics achievement levels.

Findings indicated that digital divides exist in the student-to-computer ratio and the number of teachers with classroom computers, and digital access was positively associated with eighth-grade mathematics and reading proficiency scores. However, student classroom computer ratios were negatively associated with achievement, controlling for other factors. Digital divides in students' use of technology for publishing text, organizing information, and communicating information were identified, with access to technology for these tasks/skills and positively associated with mathematics and reading scores, but connecting language to words had a negative impact. Teachers' use of technology for creating instructional materials had a positive impact on reading scores but a negative impact on mathematics achievement, when the researcher controlled for other factors. Findings suggest that differences exist in several areas of technology access and use when considering student characteristics of race, socioeconomic status, and gender. This study contributes to existing research on the effects of technology on instruction and informs state and local policy on instructional technology implementation and practice.

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Dedication

This dissertation is dedicated to my wife, Rhonda Jean Talley, whose steadfast love, moral support, and confidence fulfill my life and make it possible to fulfill my dreams.

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Chapter 1: Introduction

A major priority of the federal No Child Left Behind Act of 2001 (NCLB; PL 107-110) and the State of Maryland's Bridge to Excellence Act (Maryland State Department of Education [MSDE], 2008) is improving achievement for all students and closing achievement gaps among student groups. These policies focus on meeting the needs of low-achieving students, and NCLB's intent is to impact all schools in closing the achievement gap between minority and nonminority students. In conjunction with these achievement goals, both federal and state education technology policies support the effective uses of technology to improve student academic achievement.

The Maryland education technology plan indicates that all students should have access to technology resources to prepare them for the future.   However, the plan notes that high-poverty schools lag behind more affluent schools in student use of technology. This phenomenon of difference in access to and use of technology, based on demographics of race, ethnicity, socioeconomic status (SES), and gender, is referred to as the *digital divide*. The digital divide has also been a policy concern for eliminating these gaps in technology access and use in society and in schools. In a society becoming increasingly dependent on technology, schools face challenges in preparing children for life in an information-driven, competitive global society. For schools to meet these challenges, it is critical that adequate access to technology is available and that students learn effective use of technology to ensure that all students have technological opportunities to learn.

During the late 1990s, federal and state legislation focused on implementing technology in schools and addressing social inequities associated with technology access.

The realization of policy makers and educators was that technology had potential as a learning resource. As a result, there was an influx of computers and Internet connections into schools; at the same time, schools were implementing major reforms across the nation, so that schools faced the challenge of dual technology and reform implementation. Today, most students and teachers are routinely engaging with technology in their schools.

Since its inception in education, technology has been the focus of extensive research. Studies of technology's impact on students' and teachers' learning and attitudes have produced an extensive knowledge base and differing views of technology's role in education. To address policy concerns about employing technology to improve achievement and closing the digital divide, ongoing research is needed, particularly on how technology is distributed in schools and how students and teachers are using technology for instructional purposes.

To explore the possibility of a digital divide, this study provides a description of the patterns of technology access and use in schools with respect to race and class to determine the relationships of access and use with student academic achievement in mathematics and reading. To explore these issues more clearly, I begin with a discussion of learning theories that relate to technology and background information on technology access, teachers' technology efficacy, the use of technology in schools, the digital divide issue, and the impact of technology on student achievement.

Technology and Learning

Richey (2008) defined *educational technology* as "the study and practice of facilitating learning and improving performance by creating, using and managing

appropriate technological processes and resources" (pp. 24–25). Technology is usually associated with equipment, but technology also means the designs and environments that engage learners (Jonassen et al., 1999). The terms *information technology* and *information communication technology* (ICT) are often used interchangeably to refer to both instructional and administrative functions supported by computer and telecommunications resources (Cradler & Cradler, 2003; Partnership for 21st Century Skills, 2008).

Developments in learning theory have identified ways that technology can support learning. In addition to evidence of effectiveness in supporting behaviorist learning approaches, there is also evidence that technology is effective in facilitating constructivist theories of learning (CGTV, 1996; Tamin et al., 2011). Constructivism describes learning as an active and social process whereby learners create their own knowledge through organizing new knowledge into their existing framework of experiences (Papert, 1993). Constructivists contend that learning is greatest when it occurs in authentic or real-world environments with an emphasis on problem solving and collaboration (Jonassen, Mayes, & Maleese, 1993).

With the interactive and communications capabilities of technology, curricula can be enhanced through lessons based on real-world problems (Bransford, Brown, & Cocking, 2000). Technology's visualization capabilities through multimedia and graphics provide "scaffolded" learning experiences that can guide learners through complex simulations and models to develop deeper understanding of curricular content. The ability of technology to access information and to analyze data provides opportunities for feedback, reflection, and revision for learners. Technology's

networking capabilities connect students and teachers to communities outside the classroom to share ideas, to stimulate conversation, and to interact with groups to build knowledge and understanding (Bransford et al., 2000).

Technology Access in Schools

A number of technology resources are available in schools: computers, the Internet, handheld mobile devices, televisions, network devices, projectors, white boards, and so on. This study focuses on access and use of computers and the Internet. Coley, Cradler, and Engler (1999) defined *technology access* as the availability of various technology resources for teaching and learning. Similarly, this study defines technology access as the availability of computers, the Internet, and technology-trained teachers in a teaching and learning environment.

Technology access is generally expressed as the number or percentage of resources in a location or as a ratio of units to the number of students or teachers. In the case of ratio measures, the smaller the ratio, the greater the level of access. Although there are no specifications for determining an optimal level of access, policy initiatives often establish goals for student-to-computer ratios and Internet access for schools and classrooms. For example, in 2000, Maryland established a goal of five students per computer and 90% of classrooms equipped with Internet access.

National trend data show a rapid deployment of technology in schools over the past decade and a leveling off in the past few years. In 2009, the national average student-to-computer ratio was 3.1:1, and the ratio of students to classroom computers increased to 5.3:1. Also in 2009, 97% of teachers had one or more computers in their classrooms. Internet access was available in 93% of all classrooms (Gray, Thomas, &

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Lewis, 2010). Despite these national figures, there are significant variations in the student-to-computer ratios among states.

Several factors can influence technology access. The goal of policy initiatives and funding allocations at federal, state, and local levels has been to encourage increased access in schools. One major influence is the demand of educators, parents, and the community for greater access in schools for instructional and administrative use. On the supply side, manufacturers are producing technology at lower costs and developing targeted marketing efforts for the education sector. Other influences are the reduction in the cost of technology and the development of portable computers and mobile devices that provide flexibility and convenience of use. The result is an unprecedented level of access in terms of computers and the Internet in schools across the nation (Trotter, 2007). At the same time, the Internet is not free from concern for the safety of children. Protecting children from inappropriate material is paramount in schools. Most schools have established acceptable-use policies for students and provide software filters to block material deemed offensive, inappropriate, and unwarranted.

A consensus among researchers is that technology access is a necessary but not sufficient condition for improving student learning (Becker, 2000; Cuban, 2001; Wenglinsky, 2005).

Teacher Technology Efficacy

Teachers play a critical role in the implementation of technology. They are expected not only to teach with technology but also to guide students' experiences with technology as part of routine classroom activities. Accomplishing these tasks requires the knowledge and skills that will facilitate use of technology designed to enhance

instruction and promote student learning (Becker, 2000; Cradler, Freeman, Cradler, & McNabb, 2002; Cuban, 2001). This capacity is referred to as *teacher efficacy*. Teacher efficacy is "a teacher's expectation that he or she is able to bring about student learning—a belief in one's 'capabilities to organize and execute the courses of action required to produce given attainments' (Bandura, 1997, p. 2) directed toward the teacher as an agent of student achievement" (Ross & Bruce, 2007, p. 50). This study developed a unique composite measure of teacher technology efficacy.

As part of school reform efforts, most states have adopted technology standards to encourage teachers to use technology in more meaningful ways. Standards provide expectations of what teachers should be able to do with technology. For example, teachers are expected to use technology as part of their routine instruction, to develop lesson plans that incorporate technology, to evaluate instructional software, to design technology-based student assignments, and to assist students in developing their technology skills. At the fundamental level, teachers need to understand computer operations and file structures, have the ability to use the Internet as a reference resource, and have skills to use applications such as word processing software, spreadsheets, and presentation tools (ISTE, 2007).

In addition to these skills, another often-cited goal for a teacher's use of technology is to integrate technology into curriculum and instruction. A definition of technology integration was provided in the Technology in Schools Task Force (2003) report:

> The incorporation of technology resources and technology-based practices into the daily routines, work, and management of schools. Technology resources are computers and specialized software, network-based communication systems, and other equipment and infrastructure. Practice includes collaborative work and

communications, Internet-based research, remote access to instrumentation, networked-based transmission and retrieval of data, and other methods. This definition, however, is not in itself sufficient to describe successful integration. It is important that integration be routine, seamless, and both efficient and effective in supporting school goals and purposes. (Lawless & Pellegrino, 2007, p. 557)

These reforms have been met with positive results. Teachers have increased opportunities to gain technology skill and knowledge through professional development programs aimed at helping teachers feel comfortable using technology. Indeed, a growing number of teachers appear to be feeling more confident in their technology expertise. A 2008 survey of teachers found that the majority of teachers (85%) reported that they were "somewhat well prepared" to use technology in the classroom, an increase from a previous survey reporting a figure of 53% (Tuck, 2008).

Providing professional development on effective integration of technology into curricula and instruction continues to be a challenge for both preservice and in-service programs. Congress, under NCLB legislation, requires states to allocate a minimum of 25% of federal technology funding to professional development and to document its impact. The research on professional development using technology suggests three strategies for improvement. First, teacher demonstration and modeling of technology integration are effective strategies for both preservice and practicing teachers. Second, the integration of technology standards with professional development programs is a strategy for meeting teacher technology standards. Third, mentoring preservice and practicing teachers by a technology-proficient teacher, then providing for collaborative learning and practice helps to build teacher confidence in using technology in instructional practice (Cradler, Freeman, Cradler, & McNabb, 2002).

To the extent that professional development strategies do work and accomplish the desired goals, technology advocates often promote technology as a means to reform teaching pedagogy. Critics, conversely, argue that technology is underutilized because teachers either lack the knowledge and skills needed to use technology effectively or do not believe technology will benefit their students. In summary, this study views teachers as a vital component in the effective use of technology for learning.

Technology Use

A major focus of this study is the instructional use of technology in K–12 schools. This study defines *technology use* as the ways in which students and teachers engage technology to accomplish an instructional purpose, objective, or task.

The attributes of technology facilitate a variety of uses in schools. The combination of text, pictures, graphics, audio, full-motion video, animation, telecommunications, computation, and file storage provides variations in how technology can be used. Computers and the Internet are used for instructional, administrative, and, more recently, assessment purposes.

The most effective instructional use of technology remains undefined or at least debated (Schachter & Fagnano, 1999; Wenglinksy, 1998, 2005). Technology can support basic skill development by engaging students in drill and practice applications that focus on specific skills, providing simulations that display complex phenomena to students and tutorials that guide students through content, and administering programs that allow students to create computer applications. Technology also supports, however, constructivist-learning approaches. Computers and the Internet can support knowledge construction using application and presentation tools. These technologies can provide

active, student-centered learning environments for students to search, process, and reflect on information. The Internet provides a social medium to support communications, collaboration, and the sharing of knowledge and ideas. Technology can be used for developing problem-solving skills through authentic and real-world artifacts (Schacter & Fagnano, 1999).

Many factors influence technology use. These include the availability of computers; the inventory of appropriate software that correlates to the curriculum objectives; the knowledge and preparation of teachers; the level of motivation to integrate technology into the curriculum; the assessment program; and the school context in which technology implementation occurs (Becker, 2000; Hedges, Konstantopoulos, & Thoreson, 2000).

Measuring technology use is a challenging endeavor. Researchers typically define *use* as a variable based on frequency and application. The frequency of use is measured on a time continuum (daily, weekly, monthly, yearly) to determine how often technology is used. Frequency is oriented to quantity without regard to quality of use (Becker, 2000). Moreover, research evidence shows that frequent use of technology can have negative effects on learning if used inappropriately (Wenglinksy, 1998, 2005). Several studies have observed the kinds of applications (word processing, spreadsheets, simulations, learning games, e-mail, etc.) that students and teachers use as an indicator of purpose for technology use. Despite these findings, critics have also found that technology is underutilized in schools (Cuban, 2001).

Whereas some studies focus on teachers' use of the technology, or the specific software or program used in the classroom, this study uses measures of student use in the

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classroom as an indicator for the various uses of technology in schools. This approach may offer clearer perspectives on the nature of student use.

Prior research showed that Maryland teachers identified barriers to technology use such as limited access to technology in the school building, inadequate training, and the lack of sufficient time in the school schedule (MSDE, 1999). However, these teachers were increasingly more confident in using computers and the Internet and in their ability to help students use these resources (MBRE, 1999). Technology use is a critical element in the learning process. The multifaceted capabilities of technology provide potential variation in how and why technology is used in schools. This study investigates many of the variations in instructional use by students.

Digital Divide

The term *digital divide* refers to differences between those who have access to technology and those who do not, often cited as the technology "haves and have-nots." These differences are multifaceted. Variations in access have been based on individual demographics of race, income, education, gender, age, and disability status (NTIA, 1995).

The digital divide has been a policy concern for more than two decades. It was highly publicized first during the late 1990s and continues to receive public attention. Research has well documented that it is both a national and international problem. The digital divide has been categorized as a complex and dynamic phenomenon (Van Dijk & Hacker, 2000). Concerns over the digital divide in education reflect the problem of differentiated access and use of technology among students based on race, SES, gender, location, content, literacy skills, physical abilities, and language (Attewell, 2001; Becker,

2000; Bushweller & Fatemi, 2001; Carvin, 2000; DiMaggio & Hargittai, 2001; Harrell, 1998; Natreillo; 2001; Novak & Hoffman, 1998; Swain & Peason, 2003). A recent term, *digital equity*, defined as equal access to and opportunity to use digital tools, resources, and services to increase digital knowledge, awareness, and skills has emerged in the literature (ISTE, 2007).

Prior to the emergence of the digital divide terminology, the issue of equity of computers in schools was widely researched. In the late 1980s, studies found that inequalities existed in access, use, curriculum content, and student interactions with technology based on race, socioeconomic conditions, and gender. Recommendations were made for further research to examine differences between schools and to focus on poor and minority children (Harrell, 1998; Sutton, 1991). The majority of research on the digital divide centers around differences in access and use based on demographics of race and family income. In the same manner, this study uses adequacy as a premise for studying the impact of the digital divide. Adequacy refers to providing "a specific set of inputs to accomplish a particular set of outcomes" (Thornton Commission, 2002, p. 5). This study examines race, SES, and gender as factors that determine the digital divide and its impact on student achievement.

The question of whether the digital divide in schools still exists or has closed is strongly debated among researchers, educators, and policy makers. Schools have made progress in closing the digital divide by increasing the level of student access. However, gaps exist in technology access at home (Trotter, 2007). Some researchers, using only student-computer ratios and Internet connections to schools, have suggested that the access divide in schools based on race and socioeconomic conditions closed by 2003

(DeBell & Chapman, 2006; Vigdor & Ladd, 2010). Nonetheless, a more detailed look at technology access and use in schools, using additional measures, suggests that the digital divide is still prevalent for disadvantaged students (Education Week, 2008). This study explores several measures of access and use to determine the existence of the digital divide in Maryland schools.

Examples of recent digital divide findings include a National Center for Education Statistics (NCES) 2009 national survey of teachers that found differences in student use of technology based on poverty levels. This survey found that students (66%) in low-poverty schools used technology more often to prepare written text than students (56%) in high-poverty schools. For use in practicing basic skills, the low- and high-poverty school comparison results were 61% and 83%, respectively (Gray, Thomas, & Lewis, 2010). A 2008 National Education Association (NEA) national survey found differences among teachers' perceptions of the proficiency in technology use based on their schools' poverty levels. The results show that 74% of teachers in low-poverty schools feel they are sufficiently trained to use technology compared to 62% in high-poverty schools. Similarly, 67% of teachers in low-poverty schools felt that they were sufficiently trained to integrate technology into classroom instruction, but 56% of teachers in high-poverty schools felt that they had received sufficient training (NEA, 2008). NCES also conducted a national survey in 2003 that indicated that the divide in technology access in schools had closed; however, differences based on family income still exist (DeBell & Chapman, 2003).

Research at the state level indicates that in Maryland differences exist in students' access to and use of computers and the Internet based on demographics (Education Week,

2007). The Maryland State Department of Education (2007) noted that high-poverty

schools lag behind other schools in student use of technology and require additional

resources to close the digital divide. Despite these documented inequalities, little

empirical analysis has explored the magnitude of the digital divide and its implications

for achievement. Given this lack of evidence, this study addressed the effects of the

digital divide and its impact on achievement in Maryland schools.

Technology and Student Achievement

A major goal for technology utilization in schools is to improve learning. Two

outcomes associated with technology use are academic achievement and technology

literacy. As mentioned previously, academic achievement is the impetus for both federal

and state education and technology policies, with a particular focus on improving

achievement among student groups. The Enhancing Education through Technology Act

(2001) supports effective use of technology in schools to improve student academic

achievement. A goal of these policies is to close the achievement gap. The *achievement*

gap is defined as the differences in achievement among student groups based on

demographics. For example, Asian and White students continually outperform African

American and Hispanic students in mathematics assessments. Similarly, students from

higher income families have better mathematics scores than students from lower income

families (Barton & Coley, 2010; National Assessment of Educational Progress [NAEP],

2007).

Since the introduction of technology in schools during the 1970s, educators,

researchers, and policy makers have debated an important policy question: does

technology enhance student learning? The research on technology's impact on learning,

although mixed, shows evidence of improving student learning if used effectively (Becker, 2000; Coley, Cradler, & Engel, 1997; Kulik, 2003, 1994; Liao, 1992; Means, 1995; Parr, 2000; Rochelle, Pea, Hoadley, Gordin, & Means, 2000; Schacter & Fagnano, 1999; Sivin-Kachala & Bialo, 1999; Wenglinsky, 1998, 2005). Educators are also placing emphasis on improving technology literacy for students as a means of developing 21st-century learning skills to prepare students to participate in a global technological society (Trotter, 2007).

Technology literacy skills involve using technology to acquire and process information, to develop creative ways of self-expression, and to communicate and share ideas. The Partnership for 21st Century Skills (2008), a public–private organization, suggests that students and teachers need to incorporate strong academic thinking, teamwork, and technology proficiency skills to ensure that America remains competitive in the information-based global economy. Because NCLB includes a goal to have every student technologically literate by the eighth grade, this study investigated the variety of literacy skills through analyzing data on student use for Maryland, middle-school students.

Research Problem

One of the many challenges to conducting research on the impact of technology in the school environment occurs because technology is a rapidly changing phenomenon. Schools have multiple and often competing instructional goals that influence how technology is implemented, making it difficult to isolate the effects of the technology as opposed to other interventions. In addition, technology use by students is not well documented (Fadel & Lemke, 2006). The problem that this study addresses is that for

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technology to be deployed as a strategy to improve student learning, as identified in the state's technology policy, a thorough knowledge is needed of its adequate availability and utilization for all students and teachers and its relationship to student achievement.

Purpose of the Study

The purpose of this research is to describe how technology is distributed and used in public middle schools in Maryland, based on race and SES, and to compare patterns of access and use to levels of student achievement. Specifically, this study will answer five questions:

1. How is technology distributed in schools?

2. Are the patterns of access equitable in terms of race, class, and gender?

3. How do students and teachers use technology?

4. Are the patterns of use equitable in terms of race, class, and gender?

5. How are differences in distribution and utilization of technology related to student performance?

To answer the preceding five research questions, this study will test eight of the following hypotheses:

$H_0 1$: There is no difference between minority students and nonminority students in terms of access to school technology for middle schools in Maryland.

$H_0 2$: There is no difference between low-SES students and high-SES students in terms of access to school technology for middle schools in Maryland.

$H_0 3$: There is no difference between female students and male students in terms of access to school technology for middle schools in Maryland.

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$H_0 4$: There is no difference between minority and nonminority students in terms of their use of school technology in middle schools in Maryland.

$H_0 5$: There are no differences between low-SES students and high-SES students in their use of school technology in middle schools in Maryland.

$H_0 6$: There is no difference between female and male students in terms of their use of school technology in middle schools in Maryland.

$H_0 7$: There is no relationship between students' level of access to school technology and their academic achievement scores on the Maryland School Assessment for eighth-grade reading or mathematics.

$H_0 8$: There is no relationship between students' level of use of school technology and their academic achievement scores on the Maryland School Assessment for eighth-grade reading or mathematics.

Importance of the Study

This study complements the extensive body of research on educational technology by describing patterns of technology access, distribution, and utilization in public schools in Maryland. The research on the digital divide in public schools is limited. This study fills voids in this area. This study extends the analysis of the digital divide to investigate multiple measures of access and use for students. Finally, this study describes access and use based on levels of student achievement using state standardized assessment data to describe relationships of technology to school performance.

As mentioned earlier, NCLB includes technology literacy as a goal for all eighth-grade students. This study explores how middle school students in Maryland use technology in their classes and therefore provides insight into assessing students'

progress toward meeting Maryland's goals for technology literacy. Furthermore, this investigation can inform state policy for instructional technology by addressing an objective of Maryland's Education Technology Plan that seeks to improve the instructional uses of technology by analyzing patterns of access and utilization and their relationship to student achievement in middle school reading and mathematics in Maryland public schools (MSDE, 2007).

It is important to note that technology updates are generally reported annually to the Maryland State Board of Education (MSBE). Particularly, in April 2007, the Committee on Technology in Education (COTE) presented the 13th annual progress report on technology to the MSBE using data from the Maryland Technology Inventory (MTI). Discussions focused on the increases in computer and Internet access, the digital divide issue, the minimal progress in higher level thinking activities associated with classroom use, and the use of the Internet by students for research. Recommendations included maximizing technology integration into the curriculum, the need to correlate classroom use of technology to student performance, and providing high-quality professional development. This discussion provided the impetus for this study.

This study represents an expanded and more detailed analysis of the COTE report and uses the data compiled by the MSDE's MTI survey. The study relates the survey findings to actual student achievement data, that is, the Maryland School Assessments (MSA). Therefore, this study provides a more comprehensive approach to describing Maryland's capacity to deploy technology to improve student learning.

Organization of the Dissertation

This dissertation is organized into five chapters. Chapter 1 has introduced the topic of educational technology; stated the research problem; and explained the issues, significance, and relevance of educational technology from a policy perspective. The chapter also stated the purpose, research questions, and hypotheses developed for the study. Chapter 2 presents a review of the literature that defines educational technology access and use and the context of the digital divide in education. The chapter concludes with an explanation of the analytical model used for the study.

Chapter 3 provides a description of the methodology used in conducting the research study, the participants of the study, the instruments used to obtain the data and the data sources used, and the statistical methods and procedures used for data analysis. Next, Chapter 4 presents the research findings of the study. The results of the hypothesis testing are reported in detail, first for access and use based on race and SES, then for access and use based on mathematics and reading achievement. The last and final chapter, Chapter 5, provides a discussion of the research findings. Conclusions are drawn from the research results and relevant literature to inform educational technology policy for the K–12 community. The chapter concludes with recommendations for further research.

Chapter 2: Literature Review

This chapter provides an overview of research on educational technology that relates to the digital divide, technology access and use, and student achievement. First, I provide background information on technology policies. Next, I review the literature on access and use of technology. Finally, I review information that pertains to the question, is there a relationship between the digital divide and the achievement gap?

Rooted in the psychology, sociology, and philosophy of education research literature, this study informs technology's role in education. This study is also grounded in the research that addresses issues of educational equality, social stratification, and differences in opportunities to learn (Becker, 1990; Bidwell & Friedkin, 1988; Light, 2001, Sutton, 1991). This study is influenced by the literature on critical theory as it relates to societal privilege and multiple forms of oppression as a rationale for the digital divide phenomenon (Kincheloe & McLaren, 2000).

The literature that relates to technology equity stems from the early implementation of technology and the education reform efforts targeted toward educational excellence. When researchers began evaluating levels of technology in schools, many found a tendency for urban, poor, and large schools to have less access to technology and to use technology in less sophisticated ways. These schools tended to have higher enrollments of African American and Latino children. Additionally, the research included information on how girls often feel excluded from participating in computer clubs and after-school computer activities.

One argument asserts that if technical skills develop based on the individual's use of technology, then minorities' limited access will result in fewer learning opportunities

and less employment potential (Picciano, 1998). Coupled with these equity concerns is the view among many researchers that technology is a potentially valuable instructional resource to facilitate teaching and learning, supporting the assumption that all children can learn. If that assumption is true, then all students should have access to and the opportunity to use technology in ways that benefit their learning. In addition, the same literature views technology as a resource of promoting equity of learning opportunities in schools and policies that seek to close the digital divide in education. However, the digital divide is a complex and dynamic social issue (Dijk & Hacker, 2000). Analyses of technology implementation may indicate patterns of educational technology access and use in schools that often mirror and reinforce existing societal inequalities rather than alleviating them (Schofield & Davidson, 2003).

Background on National Technology Policies

Historically, the federal government has provided widespread support for technology in schools. Computer technology was introduced in schools during the early 1970s as a result of support by federal Title I funding and was used primarily for computer-assisted drill and practice applications in elementary mathematics and reading programs (Jamison, Suppes, & Wells, 1974). In 1980, Seymour Papert developed Logo, a programming language designed for young children, and set the groundwork for using computers as a tool for developing thinking skills at the elementary school level, which extended computer-programming instruction in schools (Papert, 1993). The marketing of low-cost personal computers by Apple and IBM for the education market resulted in extensive acquisition of computers in both schools and homes, expanding technology access and experiences for students. In 1983, the *A Nation at Risk* report called for

increased computer competency for students in an effort to prepare a more technologically skilled workforce to compete in the information age. In 1986, the National Assessment of Educational Progress (NAEP) conducted the first national assessment of students' computer competence to learn how students across the nation were using computers in schools (NAEP, 1988). The assessment found that the major uses of computers were for programming and literacy, with very little use in core subject areas.

In 1996, federal support encouraged large-scale technology implementation in schools. It was during this time that *digital divide* became a popular term. For example, the Clinton administration established the Technology Literacy Challenge Fund, a $2 billion grant program to equip schools with computers, software, and teacher training programs. Also, in 1996, Congress authorized the E-Rate program to provide discounts for school networking and Internet connections. These programs supported widespread improvement in computer and Internet access in schools.

The U.S. Department of Education's (2005) current education technology plan, "Toward a New Golden Age in American Education: How the Internet, the Law and Today's Students Are Revolutionizing Expectation," "expands the concept of eLearning, offering students greater learning opportunities, through their access to online courses and learning resources available from school and at home." (p. 25).

Background on Maryland Technology Policies

Maryland developed its first Maryland Plan for Technology in Education in 1995 to encourage the effective use of technology in schools. The Glendening administration's Maryland Connected for Learning initiative funded computers, networking, Internet

access, software, and teacher training. To monitor the progress of the plan, the first MTI

survey was conducted in 1997 with 90 participating teachers. Currently the survey is

conducted annually and includes all schools in Maryland to ascertain technology

implementation in terms of access, use, and teachers' technology competency statewide

(MSDE, 1999). Survey results from the MTI will be used as primary data for this study.

Similar to federal technology policy, Maryland's Plan for Technology in

Education (MSDE, 2007) establishes the goal to "improve student learning in all content

areas and in the technology-related knowledge and skills critical to students' ability to

contribute and function in today's information technology society" (p. 1). To accomplish

this goal, the plan seeks to improve student learning through technology, improve

equitable access to appropriate technologies among all stakeholders, and improve the

instructional uses of technology through research and evaluation (MSDE, 2007).

Local school systems have developed their own technology policies. One

example of a local district policy, Baltimore City's Information Technology Plan 2006–

2008, includes a strategy to integrate the use of technology to improve student

achievement. The plan (Baltimore City Public Schools, 2006) notes, "Because

technology enables learning activities to be personalized to individual student needs, it

represents a significant strategy for raising learner productivity" (p. 29).

Technology and School Reform

One question raised in the research literature asks, how does technology fit into

education reform efforts? Means (1993) found that technology's role in education reform

is to "support superior forms of learning" (p. 1), particularly higher-level skills such as

student exploration, interactive instruction, collaboration, and authentic work, and with

teachers as facilitators. Cuban (2001), a technology critic, identified three major goals for technology use in education reform:

1. Technology will make schools more efficient and productive. Based on the productivity gains experienced in the private sector, the expectation is that schools can also improve productivity through technology utilization.

2. Technology will transform teaching and learning into an engaging and active process connected to real-world experiences. In efforts to promote more constructivist learning strategies in the classroom, technology is used to motivate students to engage in more problem-solving, collaborative learning that is linked to real-world concepts.

3. Technology will prepare students for the future workforce, which will require more technological skills.

Cuban (2001) also outlined several assumptions about technology deployment in schools:

1. Increased technology availability in the classroom, along with a technologically skilled teaching staff, would lead to increased use.

2. The resulting increased use would lead to improvements in teaching practice, making instruction more effective and resulting in improved student learning (increased test scores, improved workforce skills).

3. Improved teaching and learning would produce more knowledgeable graduates with technological skills that enable them to compete successfully in the global workplace.

Researchers tend to agree that technology, as a school improvement strategy, is often difficult to implement and evaluate. Problems associated with technology

evaluation stem from differing and often competing goals for using technology. In addition, there is a lack of consensus among educators as to which goal is most important. Schools tend to select multiple goals for technology implementation, which makes the evaluation process more complex (Education Week, 1997). Each goal represents variations in implementation and measurement that add to the complexity of determining technology's effectiveness (Cuban, 2002; Trotter, 1998). For example, a study by Cisco Systems and the Metiri Group cited six purposes for educational technology in schools (Fadel & Lemke, 2006): to (a) improve learning (increase test scores); (b) increase student engagement in learning; (c) improve the economic viability of students; (d) increase the relevance and real-world applications of academics; (e) close the digital divide by increasing technology literacy for all students; and (f) build 21st-century skills, including critical thinking, global awareness, communications skills, information and visual literacy, scientific reasoning, productivity, and creativity. This example reveals the complex and multifaceted nature of educational technology in schools. These multiple approaches influence levels of access and use, instructional practice, and assessment and program evaluations.

Digital Divide

The term *digital divide* first appeared in a 1995 report released by the Department of Commerce titled, "Falling Through the Net: A Survey of the Have-Nots in Rural and Urban America." The term created a metaphor of separation within society of different groups' access to computers and the Internet, thus combining Cervantes's depiction of the rich and poor segments of society as the "haves and have-nots." The term quickly became widespread in the literature to describe differences in computer and Internet

access based on various demographic factors. These technology gaps have been expressed as both a global and national concern and as an issue that affects education.

The digital divide issue evolved over the years as a result of more informed inquiry into the nature of the problem and further investigation of various segments of society (Eamon, 2004; Reid, 2001), shifting from an earlier focus on differences in computer ownership between wealthy and poor households to a more in-depth focus on race, gender, and ethnicity (Novak & Hoffman, 1998) and on differences in school and home access among students (Becker, 2000). Subsequently, sociology research literature described two distinct digital divides. One described the differences in technology access as the access divide, and the other showed differences in technology use as the utilization divide. The access divide has been the focus of most federal policy initiatives, and evidence indicates that progress is being made to close the access divide. The utilization divide is more challenging from a policy perspective because of many factors such as the changing nature of technology; the content available; and the variation in individuals' technological skills, abilities, and motivation (Attewell, 2001; Natreillo, 2001).

Measuring the digital divide. Most studies of the digital divide use descriptive measures to show differences in one or more technology variables based on demographics. For example, many studies determine the digital divide in access by using student-to-computer ratios to calculate the median ranking of schools. Schools above the median level would be ranked as high-access schools, whereas schools ranked below the median would represent low-access schools. With schools grouped in terms of technology access, other variables could be examined to determine their effects in those low- and high-technology-access schools (Becker, 2000).

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Determining the digital divide in technology use is a more complex endeavor. For example, one study of technology use in schools used high-minority and low-minority student enrollment as independent variables and use of computers to learn reading, writing and spelling, math, social studies, science, keyboarding skills, art, music, games, and means of access to information as the dependent variables. To determine whether a statistically significant difference was present, a multivariate analysis of variance (MANOVA) revealed a digital divide in student use based on race and ethnicity (Juarez & Slate, 2007). Variables generally included in digital divide studies include independent variables of race or ethnicity, physical disability status, school enrollment, parental educational attainment, family or household type, household language, family income, poverty status, and metropolitan status, which are related to the dependent variable computer–Internet use, while other independent variables are held constant or are statistically controlled (DeBell & Chapman, 2006).

Racial divide. The racial divide has been well documented in the research literature, which affects African American, Hispanic, and American Indian students, who tend to have less computer and Internet access and to use technology in less sophisticated ways when compared to their White and Asian counterparts. A little more than half of all Black and Hispanic students have access to a computer at home, and only about 40% have Internet access at home (Fairlie, 2005). Minority students are more likely to use technology for drill and practice, whereas White students have higher level experiences designing Web sites and presentations (Fairlie, 2005; Sutton, 1991). There is no clear explanation for the racial divide. Discrimination, lack of exposure of minority students to technology, lack of culturally significant content, and low priority for technology use

among minority populations are cited as possible reasons for the racial digital divide (Reid, 2001).

Socioeconomic status divide. A 2007 Education Week report shows little variation in whether students have used computers in schools based on income. Using NCES 2006 data, 86% of students from families with high incomes ($75,000 and over) used computers at school, and 80% of students from families with low incomes (under $20,000) also used school computers. These data do not indicate the frequency of computer use or the types of computer use by students; rather, they are only a dichotomous measure of whether the student had used a computer.

Maryland defines high-poverty schools as those with a percentage of students enrolled in free and reduced meal programs (percentage FARMS) greater than 70%. Low-poverty schools are those with a percentage FARMS less than 11% (MSDE, 2007). The gap was significantly greater for computer use at home. For low-income students, only 37% used computers at home, while 86% of students from high-income families used computers at home (Bausell & Klemick, 2007; DeBell & Chapman, 2006). Most differences in access to resources were reflected in the different tax bases between poor and wealthier communities (Schofield & Davidson, 1998).

Gender divide. The research literature is rather conclusive that gender differences in access and use of computers and the Internet in schools have diminished (Cooper, 2006). Several studies have shown that boys play computer games more often than girls but that girls use e-mail communication more frequently. In terms of attitudes toward technology in general, girls are less positive than boys, however, they are more enthusiastic about using word processing and graphics (Volman et al., 2005). Prior

studies have shown that girls prefer games and applications that facilitate cooperation as opposed to competition. Girls also like applications that appeal to creativity more than tools that require dexterity, and they like detailed and colorful images in games and educational software (American Association of University Women, 2000).

Technology Access in Schools

    Measuring technology access. Technology access in schools is viewed as a necessary but not sufficient condition for school improvement (Becker, 2000). A number of terms are used to describe access such as *availability*, *capability*, *density*, *ownership*, *penetration*, and *presence*. These terms for access are often used interchangeably (Anderson, 1997). In the literature, typically, measures of access are at the national, district, and school levels and by location in the schools, that is, classroom, computer lab, media center, and at home (Education Week, 2007; Market Data Retrieval, 2001; National Assessment of Educational Progress in Mathematics, 1996; Wenglinsky, 1998). *Access* is also a term used to describe a variety of technology-related resources, computers, the Internet, software, technology-trained teachers, and technical support.

    Computer access measures. A widely used metric for describing computer access is the ratio of students to computers. The student-to-computer ratio will be used in this study to measure access. The ratio is calculated by dividing the total number of students by the total number of computers. Simply stated, the lower the ratio, the greater the number of computers available to students. The trend in access shows that the ratio has dropped significantly over the years, indicating an increase in the number of computers being placed in schools.

The student-to-computer ratio is a more useful measure than penetration because it takes into account the number of students who will have potential computer access. Since the student-to-computer ratio is calculated based on the total student population within the school, it does not indicate how many students share a computer in a given setting. School-level student-to-computer ratios are aggregated to provide district-level ratios. State-level access would be the average (mean) and median student-to-computer ratios calculated across all schools. When the median is less than the mean, it represents large ratios that skew the distribution away from a normal distribution. Student-to-computer ratios provide a mechanism to systematically compare levels of access among various schools (Anderson, 1999). For example, ratios can facilitate comparisons of computer access between elementary, middle, and secondary schools across the state or comparisons of middle schools within the state and comparisons with national averages or with schools in other states.

There is no consensus among researchers on the optimum student-to-computer ratio and no definitive specifications for an appropriate level of computer access in schools and classrooms (Mann, 1999). More recently, the National Education Association (2008) found that the number of computers in classrooms was not adequate to support instruction.

In 2001, the U.S. Department of Education's Office of Educational Research and Improvement (2001) suggested a student-to-computer ratio of 5:1 as a level for effective use in schools. Maryland and many other states have surpassed this level. This is a difficult issue to resolve because of the lack of evidence to show how incremental increases in numbers of computers result in measurable student outcomes. Issues related

to access are whether current access is sufficient to support instruction, whether the available technology can support the instructional application, and whether more access produces greater learning gains. Several research studies have indicated that without sufficient access to technology, effective integration into instruction will not be possible (Becker, 2000; Mann et al., 1999; Ringstaff & Kelly, 2002).

Others argue that the frequency-of-use metric can also be a measure of access (Wenglinsky, 1998). Frequency of use may represent a more accurate indicator for student access, but accurate data on frequency of use in schools are difficult to obtain. The student-to-computer ratio reflects the schools' ownership of computers; however, many computers may be unused. In addition, the level of technology spending can also serve as an indicator of access; however, this measure also reflects school ownership of technology while not accurately reflecting access for student use (Wenglinsky, 1998).

A popular measure of access includes the number of computers in classrooms (Education Week, 2008). The presence of technology in the classroom has significant implications for instructional use. Teachers can more readily direct student technology– related activities as opposed to scheduling computer lab time.

A number of national surveys of school technology access have been conducted and widely used in research studies by the NCES, Quality Educational Data (QED), and Market Data Retrieval (MDR). For example, MDR surveys samples of over 86,000 schools across the nation, asking questions about access and use of computers, networking, and the Internet. MDR's annual publication contains year-to-year comparisons and analyses of trends over time. The data reported by MDR have been used in several technology publications, including Education Week's annual *Technology*

Counts. However, there have been criticisms of QED's and MDR's data collection due to flawed methodologies that result in undercounting and inconsistent response rates (Trotter, 1999).

Other indictors of technology access in schools include technology penetration, computer capacity, computer location, technology-intensive schools, software, Internet access, and Internet penetration. These measures have also been used to determine opportunities for learning (Anderson, 1993). Each indicator is briefly listed below:

- *Technology penetration* is an inventory of the total number of devices or connections within the school or classroom, often indicated as a percentage of schools, classrooms, and other locations within the school that have computers or Internet access.

- *Computer capacity* is an indicator of the processing power as determined by the type of processor equipped in the computer. Older processors are relatively slower and are often incapable of running newer, more sophisticated software. High-end computers run faster; are capable of running the latest versions of software applications, including graphics-intensive programs; and provide faster access to Web-based applications.

- *Computer location* has a significant influence on student and teacher use. Computers can be located in classrooms, computer labs, media centers, or designated areas in the school. Computer labs of 20 or 30 networked computers provide access to more students and teachers, but locating computers outside the classroom can make it more difficult to integrate computer activities into classroom instruction (Becker, 1998). Lab use must

be a scheduled activity, and student access is usually limited to specific class times. Conversely, one or two computers distributed in each classroom would make it difficult for teachers to integrate computer activities for the entire class of students.

- In addition to computers in classrooms, computer labs, and media centers, schools are acquiring laptop computers to increase access for individual students' use both in school and at home (Mouza, 2008; Roschelle et al., 2000). Several states have incorporated laptop computers in schools to lower student-to-computer ratios to 1:1.

Internet access. In addition to the increasing trend of computers in schools, access to the Internet in schools has also flourished. Several initiatives have supported increasing Internet access, including federal funding such as the Technology Literacy Challenge program, the E-Rate program, state and local funding, and grassroots public–private partnerships like Net Day/Net Weekend events, which bring volunteers into schools to assist in wiring and providing connectivity of classrooms to school networks.

Internet access can be measured in a similar manner to computer access by the ratio of students to Internet-connected computers. A more recent measure is the number of classrooms with Internet access. Other Internet measures include the type of access and the relative connection speed, such as digital subscriber line (DSL), T1, or cable modem.

Home access. A large part of student access to computers and the Internet occurs outside of school, primarily in homes. Recent reports have indicated that the digital

divide is greater for home access as compared to school access (Education Week, 2009).

Access to home computers has also increased rapidly over the past several decades. Key

predictors of access to home computers are income, education, and ethnicity (Fairlie,

2005). A majority of the research on the digital divide is based on home access and its

relationship with household demographics. Students from low-income families are less

likely to have a home computer compared to students from high-income families.

Similarly, students from parents who had not graduated from high school were less likely

to have a home computer as compared to students with a parent with a master's degree.

Black and Hispanic students were less likely to have a home computer compared to

White and Asian students (Becker, 2000).

Home access is an important variable when investigating technology access and

use as it relates to the digital divide. However, the focus of this study is on the digital

divide in schools.

Software access. Software access is an important variable in the analysis of

overall technology access in schools; however, this is a difficult variable to measure

because of the limitations on collecting data on software acquired by schools.

Educational technology policies show a general focus on increasing hardware and

telecommunications capabilities in schools, while less attention has been paid to specific

software, use across curricular areas, and instructional practices (Office of Technology

Assessment [OTA], 1995; Zehr, 1998).

Educational software can be classified in two ways, based on instructional

strategies: open ended and remediation (drill and practice). Open-ended software

emphasizes problem solving and higher order thinking skills, which support

constructivist-teaching approaches. In contrast, drill and practice software generally supports basic skills instruction, where the software design presents a concept, provides students with practice, and then assesses their progress in concept mastery. This strategy formed the basis for computer-assisted instruction (CAI) and integrated learning systems used in schools during the 1990s. A national experimental study analyzed the effects of drill and practice software on reading and mathematics test scores and found no significant effects (Dynarski et al., 2007).

Teachers find it difficult to obtain quality software, which often impedes technology use. Acquiring good software that supports instruction can be complex and time consuming. Ideally, teachers review and select software based on the instructional needs of their students, but generally, teachers select software based on their teaching styles and preferences. The demand for quality software is heavily driven by state learning standards (Education Week, 2000).

Software is an important component in technology implementation. However, no data are available on the software used in public schools in Maryland, so this study will not address software access or use issues.

Current trends in access. Over the past decade, significant progress has been made in providing computer and Internet access in schools across the nation. A comparison of 2005 and 1998 data shows that the national average ratio of students to computers with Internet access in 2005 was 3.8:1, down from the 1998 ratio of 12.1:1 (National Center for Education Statistics [NCES], 2007). In addition, the ratio of Internet-connected computers is 3.7:1, also down from the 1999 ratio of 13.6:1. Maryland has followed a similar trend in access, with a student-to-computer ratio of

4.5:1, down from the 1999 level of 6.6:1. The ratio of Internet-connected computers is 4.4:1, compared to a ratio of 16.5:1 in 1999. This increasing trend has leveled off in the past several years as schools have more computers and virtually all schools have Internet access (Education Week, 1999, 2008; NCES, 2006). Almost one-half (49.5%) of students nationally have computers in their classrooms. Maryland has slightly less than the national average (45%) of students with computers in their classrooms. Among eighth-grade students nationally, only 83% had computer access, whereas 86% of Maryland eighth graders had computer access, slightly above the national average (Education Week, 2007).

For the past decade, Education Week's *Technology Counts* publication has served as a major source of national and state technology trend data as well as reviews of major issues related to educational technology. Education Week's focus has been to chart access, use, and capacity to use technology among states on an annual basis. The 2008 publication included a State Technology Report Card, which assessed each state's progress in implementing technology. Maryland's assessment received an overall grade of C+, a D grade for access to technology, an A− for use of technology, and a B− grade for capacity to use technology.

Technology Use in Schools

There are many ways to define how students put technology into action and for what purposes. The multifaceted nature of technology lends itself to a variety of uses, which include individual and group learning, information processing, communications, instructional management, and assessment (Glennan & Melmed, 1999). Patterns of use

consist of the percentage of a group of students using technology at specific grade levels, in different content areas, and for various activities or applications.

Several classifications of technology use appear in the research literature such as CAI, integrated learning systems, simulations, tutorials, and tool applications. These classifications provide a way of describing technology use in terms of low-level and high-level uses. An example of a low-level application is a CAI program, in which the computer presents the instructional content to the student. This is typical of drill and practice and many remedial programs. In contrast, a high-level use would include tool applications, consisting of word processors, spreadsheets, databases, and e-mail applications, in which the student searches for information to solve a problem, interprets the information, writes a report or creates a presentation, and then communicates the report to others (Means, 1993; Reeves, 1996; Taylor, 1980).

Scott, Cole, and Engel (1991) described strategies for using computers based on a schema developed by Makrakis (1988) to present a comparative perspective of computer use on a scale from low to high levels of learning interaction. Scott et al. (1991) stated that, "Makrakis proposed a schema of the relation between interaction and cognition that provides a useful index of the various 'modes' of computer-assisted teaching and learning in different parts of the curriculum" (p. 204). The Makrakis model for measuring relative computer use and learning interaction is shown in Figure 1 as a rating mechanism for technology use.

Drill and practice, tutorials, instructional games, and simulations were at the low end of the scale, while problem solving, spreadsheets, word processing, and database management were at the high end. There is general agreement that drill and practice CAI

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uses reflect traditional teaching practices and support basic skills learning objectives, whereas simulations and tool applications tend to support more constructivist teaching practices and higher order learning strategies (Cognition and Technology Group at Vanderbilt, 1996; Means, 1993; Scott et al., 1991). Using the Makrakis model, this study will determine high-level and low-level technology use by evaluating data included in the MTI.

Figure 2.1: Makrakis model of rating computer use and learning interaction in schools

Level of Learning/Computer Interaction							
Low --- High							
Drill and Practice	Tutorial	Instructional Games	Simulation	Problem Solving	Spreadsheet	Word Processing	Database Management
Low --- High Level of Cognitive/Mental Thinking							

(Scott, Cole, & Engel, 1992, p. 204)

Technology Use Measures

Generally, technology use can be measured in several ways:

1. The frequency of use is how often technology is used in a given period of time (Coley, Cradler, & Engel, 1997).

2. Type of use is described as drill and practice applications, tutorials, simulations, word processing, data collection, exploration, communications, and presentations.

3. Low-level and high-level uses evaluate how technology is used in an instructional context. Low-level uses include skills reinforcement and remediation, whereas high-level uses emphasize real-world problem solving, collaboration, and processing information (Means, 2000).

4. Direct observation is used to determine skill levels, such as observing an individual or group performing a technology-related task, then measuring the individual's or group's ability to complete the task. In this case, measuring the skill of completing an online task was more important than the binary measures used in most digital divide research, which considers whether a person uses the Internet (Hargittai, 2002). Direct measures in schools are more desirable measures than availability but are also more difficult to obtain (Wenglinsky, 1998).

5. Several studies have used student-to-computer ratios as a proxy for technology use (O'Dwyer et al., 2005).

Surveys and case study observations are methods often used to determine how often teachers and students use technology and in what contexts the use occurs. The variations in the patterns of technology use are a critical part of this study because they lay the groundwork for determining whether a digital divide in use exists in Maryland schools. The data from the MTI survey consist of frequency data for several types of student and teacher use.

Technology use by students. Most research on technology use consists of survey data reported by administrators, teachers, parents, and students or through case studies that involve classroom observations. Generally, schools do not document or report technology use in systematic ways.

One strategy to increase technology use in classrooms is through the development of technology standards (ISTE, 2002). Technology standards outline the expectations of what students should be capable of doing with technology, and most all states have established technology standards (Education Week, 2007). In 2007, the MSBE adopted the Maryland Technology Literacy Standards for Students, which consist of six student expectations: (a) to demonstrate their knowledge of technology systems; (b) to evaluate how technology affects individuals and society; (c) to select and use technology tools to enhance learning and encourage collaboration; (d) to use technology for communication and expressing ideas; (e) to use technology to locate, evaluate, gather, and organize information; and (f) to use technology to solve problems and make decisions (MSDE, 2007).

Maryland, as well as several other states, is beginning to assess student progress toward meeting technology standards. One goal of Maryland's Educational Technology Plan is that by the year 2012, all students will show mastery of the technology standards by the end of the eighth grade, which aligns with NCLB's goal for technology literacy. Baseline data show that 50% of seventh graders are proficient users of technology (MSDE, 2009).

Students are engaging in technology experiences both inside and outside school. Schools report using the Internet for conducting research, word processing to write

papers, and PowerPoint for making presentations. Students are using blogs (online journals) to discuss class work, are conducting online searches, are using school Web sites to review and discuss their work, are publishing online newspapers, and are developing podcasts (audio files on the Internet) to review lesson notes and prepare for tests. These applications may be accessible outside school through a variety of personal devices such as cell phones, MP3 players, and iPods (Education Week, 2007).

Between 1999 and 2003, most middle and high schools were using Microsoft's Office software suite (word processing, spreadsheet, database, electronic presentation, publishing, Web editing, and e-mail programs) and the Internet. The most-used applications were electronic presentation (81%), word processing (68%), and the Internet (50%), while spreadsheets (6%), databases (<1%), and e-mail (<1%) were the least used applications. Spreadsheets and databases are conceptually and technically more difficult to use but tend to develop more higher order thinking skills (Burns, 2006).

There is little evidence in the literature on technology assessment of higher order technology skills. One assessment of students' technology skills using the Web showed variations in higher order skills, where 80% of students were able to complete an organizational chart based on e-mailed information, while only 40% could enter multiple search items to narrow the results of a Web search (Educational Testing Service, 2006).

The Educational Testing Service's assessment found that students were highly skilled at organizing information from e-mails but showed less skill in evaluating information, conducting Web-based searches, and developing new information based on research obtained from their Web searches.

Digital Divide in Technology Use

There is a general consensus that low-SES and high-minority schools are more likely to use computers more often for drill and practice, while high-SES and low-minority schools are more likely to use computers less often but to use them for challenging assignments (Education Week, 2001; Juarez & Slate, 2007). Education Week's *Technology Counts 2002* publication provides some background data on instructional uses of technology by states in terms of high-poverty and high-minority enrollment schools. In the 2002 report, nationally, only 24% of eighth graders used a school computer for mathematics at least once or twice a week. Only 25% who were eligible for the school-lunch program used computers for mathematics, while those who were not eligible were at 22% usage. For Maryland, the figures were 16% statewide, 18% for those students eligible for school lunch, and 15% for those not eligible. A comparison of national and Maryland data for use showed for drill and practice (16% nationally, 21% in Maryland); simulations/applications (12% nationally, 22% in Maryland); playing mathematics games (13% nationally, 9% in Maryland); and not using computers (51% nationally, 37% in Maryland). Education Week is no longer providing state data on technology access and use, which limits making comparisons that are more recent.

NCES's 2003 report also found evidence of a digital divide in computer and Internet use among students based on demographics and SES. Technology use was higher among White students when compared to Black and Hispanic students. In addition, students who live in higher income families were more likely to use computers and the Internet. The report noted that schools serve as "bridges" in the digital divide by

offering significant opportunities for technology access and use for many disadvantaged

students (DeBell & Chapman, 2006).

Earlier, Wenglinsky's (1998) landmark technology study found that how

technology is used matters in student learning. The study found that frequent use of

technology is negatively related to achievement and also confirmed the results of

previous research in that eighth-grade Black students are more likely to use computers for

low-order applications and are less likely to use computers for higher order use than are

White students.

Teachers in lower minority enrollment schools are more likely to assign their

students to use technology for multimedia presentations and research as compared to

teachers in the higher minority enrollment schools. In addition, teachers in schools with

smaller proportions of minority enrollments are more likely to use computers or the

Internet for research assignments (Smerdon et al., 2000). Computer use is also based on

ability level. Whereas low-achieving students tend to use technology for drill and

practice and remediation, more challenging applications, such as problem solving and

simulations, are used among high achievers (Becker, 2000; Manzo, 2001).

Internet use. The Internet is used by students and teachers primarily as a tool for

gathering information. As with computer use, the evidence shows that Internet use is

infrequent among most teachers. Shiveley and VanFossen (2005) identified five types of

Internet use: (a) increasing access to information; (b) creating the opportunity for students

to learn and apply critical thinking skills; (c) facilitating collaboration and

communication; (d) increasing availability to diverse resources and perspectives, leading

to better research; and (e) assisting students in the construction of meaning for

themselves. The effective use of the Internet requires teachers to have more planning

time and additional skills and practice, as compared to traditional instruction (Shiveley &

VanFossen, 2005).

The Pew Internet and American Life Project's (2002) national study found that

the majority of public middle and high school classrooms are connected to the Internet

and that 60% of America's children under 18 years of age have used the Internet. In

addition, 94% of 12- to 17-year-olds use the Internet for school research, 58% use Web

sites, 34% download study aids, and 17% create Web pages for school activities (Levin &

Arafeh, 2002).

Another method used for measuring Internet use involves observing an individual

performing a technology-related task, then measuring the individual's ability to complete

the task successfully or the amount of time necessary to complete the task. Hargittai

(2002) argued that measuring the skill of completing online tasks is more important than

the typical binary measures used in most digital divide research, which considers whether

a person has Internet access (Hargittai, 2002).

Teachers' technology experiences. Research on the digital divide and teachers is

very limited. Evidence suggests that wealthier schools tend to have more teachers who

are technologically trained than poorer schools (Becker, 2000). In addition, teachers tend

to use technology more often with their high-achieving students than with their lower

performing students (Education Week, 2001).

The literature shows a consensus that teachers play a critical role in using

technology to enhance learning (Becker, 2000, 2001; Cuban et al., 2001; O'Neill, 2003;

OTA, 1995). However, the evidence shows that instructional use of technology among

teachers is rather limited and that technology has had little effect on teaching practices (Cuban, 1993, 2003; Scott, Cole, & Engel, 1992). Education Week (2002) reported the percentage of schools in which at least half the teachers use a computer daily for planning or teaching nationally as 78%, in high-poverty schools as 73%, and in high-minority schools as 69%. In Maryland, the figures are similar, at 73%, while they are 60% in high-poverty schools and 67% in high-minority schools.

Teachers reported that one reason for low technology use is the lack of technology access for students in their classrooms (Becker, 2001; Education Week, 2000). Teachers also report time constraints for planning as a reason for limited use. To use technology for instruction, teachers have to plan how to use technology in their lessons, then preview and select appropriate software that matches the curricular objectives, and finally, orchestrate student assignments with the available technology in their classrooms or schedule access in the school's computer lab. These are time- and labor-intensive processes that often inhibit technology integration into teaching practices (Education Week, 2000).

Another rationale for low usage could be that many teachers are unprepared to use technology in their content areas (Coley et al., 1997; NCES, 1997). While only 20% of teachers report feeling prepared to integrate technology into their teaching, teachers who receive more technology training tend to use it more frequently for instruction and use it in more higher order thinking tasks (Ringstaff & Kelley, 2002; NCES, 1999).

A key component to increasing teacher technology expertise is professional development (Coley et al., 1997; OTA, 1995; Sandholtz, 2001). A survey of over 300 studies found that students of teachers with more than 10 hours of training significantly

outperformed students of teachers with five or fewer training hours (Sivin-Kachala & Bialo, 2000). West Virginia's Basic Skills/Computer Education program found that teacher training was a key factor in the achievement gains of eighth-grade students in problem solving and critical thinking (Mann et al., 1999). In addition, NAEP mathematics data revealed that students of teachers who received professional development on computers showed gains in mathematics scores of up to 13 weeks above grade level (Wenglinsky, 1998).

Apple Computer's Apple Classroom of Tomorrow (ACOT) research project developed a continuum of technology training stages based on teachers' needs. The five stages of teacher use of technology are entry, adoption, adaptation, appropriation, and invention. *Entry* involves rudimentary training on how to set and operate the technology. *Adoption* occurs when teachers begin using technology for administrative and record-keeping activities. *Adaptation* occurs when teachers start using technology for instructional applications. *Appropriation* is the stage in which teachers use technology in project-based activities as part of their teaching practice. *Invention* occurs when teachers create new technology applications or combine several technology strategies to enhance instruction as part of their pedagogy (Sandholtz et al., 2001).

Teachers often develop their technology skills on their own time, and many report that they are self-taught (Mann et al., 1997; Statham & Torell, 1999). The ACOT project found that the professional development programs that were effective in helping teachers to integrate technology into their instruction included opportunities for exploration, reflection, collaboration with peers, activities with authentic learning tasks, and engagement with hands-on, active learning (Sandholtz et al., 2001).

The issue of teacher technology training is a concern for preservice programs. Research on preservice programs has found that the content of technology preparation focuses on fundamental computer operations rather than on how to use technology as a teaching tool and how to integrate it across the curriculum (Sandholtz, 2001). Student teachers often do not have the opportunity to use technology during their field experiences or to have support from experienced teachers to help them integrate technology into their instruction (Moursund & Bielefeldt, 1999). This study will investigate teacher data from the MTI that provides percentages of teachers at the novice, intermediate, and advanced levels.

Technology and Effects on Student Achievement

This study is not an attempt to test technology effectiveness on student achievement. The objective of this study is to determine if differences exist between technology access and use (digital divide) and student achievement based on race and class.

Research on the effectiveness of educational technology tends to be inconclusive, but the majority of published studies have shown small but positive results for improving learning. Unfortunately, the research is also limited in determining which technologies have the greatest impact on learning, under which conditions, and more importantly, for which students (Education Week, 2007). Results have shown that technology has increased student achievement, student motivation, teacher–student interaction, learning efficiency, and cognitive skills (Baker, Gearhart, & Herman, 1994; Cuban, 1999; Kulik, 1994; Mann et al., 1999; Parr, 2003; Rochelle et al., 2000; Scardamalia & Bereiter, 1996; Sivin-Kachala, 1999; Trotter, 1997; Wenglinsky, 1998). There is evidence that

technology can have a positive impact on learning for low-income students (Kosma &

Croninger, 1992; Signer, 1991). A review of technology research found that

technology's role in education was multifaceted, capable of supporting both traditional

and constructivist approaches to curriculum, instruction, and assessment (Cognition and

Technology Group at Vanderbilt University, 1996). The research shows rather consistent

results for improving basic skills using drill and practice applications but less conclusive

results for constructivist learning applications (Education Week, 1998, 2007).

Technology access and student achievement. Researchers' attempts to examine

the relationship between increased technology access and student achievement usually

consist of large-scale national, state, or regional studies. These studies are generally

nonexperimental, ex post facto in design, and rely on various multivariate statistical

analyses to control for confounding variables to isolate the technology variable, and they

usually use traditional measures of achievement (Fouts, 2000).

There is consensus among researchers that access alone will not influence

learning (Becker, 2000; Fuchs & Woessmann, 2004). The research on the effects of

access on student achievement is extremely limited. One study found no significant

differences in achievement, however, the study did show that student groups sharing 5–7

and 8–10 computers scored above the state average in reading, math, and science. There

is no reference to how the computers were used, how often they were used, or whether

the study controlled for other achievement effects (Alsapaugh, 1999).

Research on the effectiveness of programs that provide ubiquitous computer

access with laptop computers is emerging. A synthesis of research on students in one-to-

one computer programs showed positive effects in technology use, in literacy, in

mathematics and writing skills, and in using productivity and design tools (Mouza, 2008; Penuel, 2006). Students using laptop computers in a middle school program showed significantly higher achievement in English, mathematics, and writing after 1 year (Gulek & Demirtas, 2005).

CAI used for drill and practice in basic skills instruction is the oldest and most researched computer application. The consensus in the research literature on CAI is that drill and practice applications produce small, positive gains in reading and mathematics achievement (Coley, Cradler, & Engel, 1999).

In earlier reviews, CAI had an effect size of .24 and ranked i[n] the 59th percentile (Walberg, 1984). A series of meta-analyses on CAI found positive effects on student learning, with students learning more, in less time, liking their classes with computers more, and having positive attitudes about computer use (Kulik, 1994; Kulik & Kulik, 1991). Kulik (2003) noted "that programs which rely heavily on tutorial instruction have been producing positive results in mathematics for decades and the effect sizes of this review were between 0.14 and 1.05" (p. 36). One meta-analysis reviewed eight content areas and found a mean effect size of .17 for mathematics achievement (Christmann, Badgett, & Lucking, 1997).

Studies are emerging on the effectiveness of laptop programs on learning, with some results showing small positive effects of laptop use in improving student achievement (Lowther et al., 2003; Penuel et al., 2002). West Virginia's Computer Basic Skills Program showed positive results for fifth-grade students in reading and mathematics. Variables analyzed in the study included student prior achievement, SES, demographics, teacher training, and teacher and student attitudes. Gains in student test

scores on the SAT-9 (950 fifth graders in 18 schools) were attributable to the alignment

of technology, teacher instruction, and assessment (Cradler & Cradler, 2003; Mann et al.,

1999; Schacter, 1999).

Research has indicated that technology can support higher order thinking,

analysis, and inquiry skills (Roschelle, Pea, Hoadley, Gordin, & Means, 2000). Based on

new theories of how children learn, technology can support school reform goals that

focus on higher order skills such as problem solving and real-world applications

(Bransford, Brown, & Cocking, 1999; Culp, Hawkins, & Honey, 1999; Means, 1994;

Sandholtz et al., 1997).

Examples of technology's effectiveness in higher order skills include research of

the intelligent tutor program designed to enhance ninth-grade algebra instruction in

Pennsylvania schools. The intelligent tutor focuses on mathematical analysis of real-

world problems using computational tools (Koedinger et al., 1999).

A program that has demonstrated significant results with disadvantaged students

is the Higher-Order Thinking Skills (HOTS) program. The HOTS program combines

technology with drama and Socratic dialogue. Students in Grades 4–7 achieved twice the

national gains on reading and mathematics test scores (Coley et al., 1997; Pogrow, 1996).

A survey study of technology use in schools in Massachusetts found that the relationship

between teachers' use of technology for instruction and students' geometry scores was

small but positive (O'Dwyer et al., 2008).

Not every study finds positive outcomes for all uses of technology. For example,

Apple Computer's ACOT longitudinal study project reported that students in the ACOT

program were more engaged when the technology was integrated into project-based,

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interdisciplinary instruction than were those students who did not participate in ACOT; however, ACOT students did not show increased performance on standardized tests (Baker, Gearhart, & Herman, 1994; Sandholtz, Ringstaff, & Dwyer, 1997).

Wenglinsky (1998) found that the frequency of computer use in schools and computer use for lower order skill development were negatively related to achievement, as measured by NAEP eighth-grade mathematics scores, but computer use for higher order skill development was positively related to NAEP eighth-grade mathematics scores.

Hedges, Konstantopoulis, and Thoreson (2003) argued that Wenglinsky (1998) failed to use "the best available SES variable: free or reduced price lunch eligibility" (p. 3), confounding results by social class. In addition, computer use and achievement are related to race and ethnicity, again confounding the results of negative relationships between use and achievement. However, Hedges et al. were unable to make any conclusions about the relationship of computer use and achievement due to the limitations of the NAEP data (a cross-sectional survey design limits inferences for causality, and measurements of nonachievement variables are weak). NAEP's (2000) mathematics assessment measures five content strands (number sense, properties, and operations; measurement; geometry; data analysis, statistics, and probability; and algebra and functions) and three mathematics abilities (conceptual understanding, procedural knowledge, and problem solving).

Research on the effects of technology on learning often fails to relate technology use to improved standardized test scores because of limitations in the measures of technology and achievement. One limitation cited is measuring technology use by using student-to-computer ratios as a proxy for use. Another limitation noted concerning

Wenglinsky's (1998) study of the relationship of technology use and achievement is that it used NAEP data as the achievement measure, which is designed to measure achievement trends over time (O'Dwyer et al., 2008).

Is There a Relationship Between the Digital Divide and the Achievement Gap?

This study raises the question of whether a relationship exists between the digital divide and the achievement gap. This section will explore aspects of the achievement gap.

Although some progress is being made, the achievement gaps are still prevalent among students based on race and SES. The Center for Education Policy reports that more than 20 points still separate the scores of White and non-low-income students from those of African American, Latino, and low-income students (Center for Education Policy, 2009). For 2009, NAEP reported modest gains for eighth-grade mathematics for most student groups, yet the achievement gap did not narrow. Maryland reduced its rates of below-basic achievement for African American, Latino, and low-income fourth graders (Education Trust, 2009).

Similar to the digital divide, there are differences in student achievement that are based on race and class. A comparison of the digital divide and the achievement gap is missing from the research literature.

Measuring the achievement gap. One way that the achievement gap can be measured is by calculating the difference between the average scores on standardized assessments of the higher performing group and the lower performing group, an approach used by NAEP (Anderson, 2006). Another way to measure the achievement gap is to

compare the highest level of educational attainment for student groups. Graduation rates

and college enrollments also reflect gaps in attainment based on race and class.

The federal NCLB legislation requires schools to demonstrate progress on

improving student test scores with a focus on helping students from underserved

populations (poor, minority, students with disabilities, and limited English proficiency)

improve academic performance. For example, in Table 1, the numbers indicate that

Maryland's student proficiency for eighth-grade mathematics finds over 43% of students

scoring at the basic level, and for reading, over 31% score at the basic level.

Table 1

2007 MSA Proficiency Levels for Grade 8 Reading and Mathematics by Percentage

Maryland	Advanced	Proficient	Basic
Reading	23.9	44.3	31.8
Mathematics	25.0	31.7	43.3

Note. Data are from MSDE (2008).

One of the difficulties associated with technology impact studies is that

standardized tests often are not aligned with the objectives of technology use strategies to

develop skills and knowledge. For example, mathematics tests may test problem-solving

skills through word problems or may require the student to define a function that

represents the relationship described, enter the appropriate number, and perform the

computations. Problem solving on the computer may require students to critically assess

data, to discover relationships and patterns, to compare and contrast, or to transform

information into something new (O'Dwyer, Russell, Bebell, & Seely, 2005).

The research questions are used here to summarize the literature review:

How is technology distributed in schools? Schools have experienced a major influx of technology over the past decade, in the form of personal computers, laptops, Internet connections. This influx is the result of both public and private support. A huge portion comes from federal funding and subsidies. Computer and Internet access is distributed in classrooms, computer labs, library-media centers, and other instructional areas.

Are the patterns of access equitable, in terms of race, class, and gender? The patterns of access are different among students based on race, class, and gender. The literature suggests that progress is being made in narrowing these differences due to federal funding to provide greater access, particularly for less wealthier schools.

How do students and teachers use technology? Students use computers in a variety of ways, using software, tool applications, simulations, educational games. Word processing and Power Point presentations are popular applications. The Internet is used to gather information and conduct research. Some students use email to communicate with other students or information providers. Teachers use technology for both instructional and administrative functions. For instruction, teachers use technology to demonstrate concepts, research topics for lesson plans, and review software for student use. For administration, teachers use technology for attendance, grading, and record-keeping.

Are the patterns of use equitable, in terms of race, class, and gender? The literature provides evidence that variations in student use are related to race and class. Data from 2003 indicate computer and Internet use is higher for non-minority students compared to minority students. Students from households with higher family incomes use technology more than those from lower income households. In addition, students of more

educated parents use technology more than those of less well-educated parents. Finally, technology use among boys and girls are about the same.

How are differences in distribution and utilization of technology related to student performance? There was no definitive information in the literature to relate distribution and student performance. For example, Maryland has surpassed its goal provide reasonable student access for instructional use, which was a student to computer ratio of five to one. This goal was not related to student performance.

The literature does address the relationship of computer use and student achievement. The evidence suggests that student use of technology applications for higher-order thinking and problem solving skills have a positive impact on student achievement. Low-level uses, such as drill and practice, tend to have negative effects on student achievement.

Chapter 3: Methodology

The literature review in Chapter 2 shows that the results of previous studies involving the digital divide and the effects of technology on achievement are rather mixed. Significant progress has been made in closing the access digital divide, and the instructional use of technology appears to hold some promise for improving student academic achievement. Consequently, this study focuses primarily on filling in the gaps in existing research and provides more conclusive answers regarding the digital divide in schools as it relates to technology access and use. A secondary goal of this study is to address the relationships between technology access and use and their impact on school academic achievement in mathematics and reading.

Simply put, the main objective of this study was to determine whether and to what degree a digital divide condition was present in Maryland schools and to examine its relationship to student achievement. The research design compares the levels of technology access and use in schools based on race, SES, and gender. The study also analyzes the relationships of technology access and use to school-level performance in mathematics and reading by predicting achievement scores using access and use variables, while controlling for race, SES, and gender.

This study consisted of two phases. Phase 1 of this study was designed to test whether differences in technology access and use exist across schools based on the demographics described earlier. Phase 2 of this study examined the relationship between technology access and use in schools and student achievement in reading and mathematics.

This chapter is divided into five sections. The first section specifies the research hypotheses examined by the study. The next section describes the study participants. The third section describes the instruments and data collection methods used, followed by a fourth section, which discusses how the variables examined by the study have been operationalized. The last section describes the data analysis procedures used to examine the data.

Research Hypotheses

As outlined earlier in Chapter 1, this study will test eight hypotheses. The digital divide study compared schools by dividing them into three groups based on the percentage of minority, FARMS, and female enrollment. Based on the results of previous studies relating to the digital divide discussed in Chapter 2, the following null hypotheses relating to the digital divide were formulated:

$H_0 1$: There is no difference between minority students and nonminority students in terms of access to school technology for middle schools in Maryland.

$H_0 2$: There is no difference between low-SES students and high-SES students in terms of access to school technology for middle schools in Maryland.

$H_0 3$: There is no difference between female students and male students in terms of access to school technology for middle schools in Maryland.

$H_0 4$: There is no difference between minority and nonminority students in terms of their use of school technology in middle schools in Maryland.

$H_0 5$: There are no differences between low-SES students and high-SES students in their use of school technology in middle schools in Maryland.

$H_0 6$: There is no difference between female and male students in terms of their

use of school technology in middle schools in Maryland.

Past studies that examined the effects of technology on student achievement

indicated that how technology is used in schools appears to have a greater impact on

student achievement than access (Mann et al., 1999; Wenglinsky, 1998, 2005). Based on

the results of these studies, the following null hypotheses related to access and use on

achievement were formulated:

$H_0 7$: There is no relationship between students' level of access to school

technology and their academic achievement scores on the Maryland School

Assessment for eighth-grade reading or mathematics.

$H_0 8$: There is no relationship between students' level of use of school technology

and their academic achievement scores on the Maryland School Assessment

for eighth-grade reading or mathematics.

Participants

The participants in this study included 229 public middle schools in Maryland that

provided responses to the 2007 MTI. Four middle schools were missing in the MTI data

set. The 229 schools represented 178,143 students and 12,617 teachers. This study

focuses entirely on the students' responses. Out of the total number of students, 86,551

(49%) were girls and 91,592 (51%) were boys. Of those students, 87,144 (49%) were

minority students and 55,732 (31%) were eligible for free and reduced-price lunch

programs. School enrollment data were obtained from the MSDE's 2007 Grade 6–8

enrollment database.

For the 2007 school year, the number of public schools in Maryland totaled 1,444 schools in 24 local school districts. Student enrollment totaled 851,640 students and 59,322 teachers. Of the total number of schools, there were 233 middle schools with 66,332 middle school students enrolled in the eighth grade. Student enrollment by race consisted of 0.4% American Indian/Alaskan Native; 5.4% Asian/Pacific Islander; 38.1% African American; 8.3% Hispanic; and 47.8% White. Students from a family of four were eligible for free school meals if family income was below $28,665 (at or below 130% of the poverty level). To be eligible for reduced-price meals, students' family income had to be between $28,665 and $40,793 (between 130% and 185% of the poverty level; MSDE Fact Book, 2006–2007).

Instruments and Data Collection

Written requests were submitted to the MSDE for data sets from the 2007 MTI and for data sets of student scale scores for the 2007 MSA for mathematics and reading. Student scale scores were not available; however, data for the percentage of students scoring at the basic, proficient, and advanced levels were provided.

Maryland Technology Inventory. To measure the technology access and use characteristics in schools, this study used data from the 2007 MTI. The MTI surveyed all public schools and school districts in Maryland. The survey was first conducted in 1995 and is distributed to schools annually by MSDE. The questionnaires are mailed to each school, with instructions requesting completion by the principal or technology specialist at the school. The questionnaires are returned to MSDE for compilation and reporting purposes. Excerpts from the compiled data are posted on MSDE's Web site and are archived by reporting year.

The data from the 2007 MTI contains self-reported, school-level data for 1,404 public schools in Maryland. The overall response rate for all schools was 97.2%, and the response rate for middle schools was 98.3%.

The MTI's 25-page questionnaire has 10 sections. The school profile section contains information on the number of students, teachers, classrooms, media centers, and computer labs. The equipment section provides the number of computers in various locations in the school. The network access section describes the level of Internet and local area network access within the school. The teacher expertise section describes the level of teachers' personal computer use, Internet use, and integration of technology into curriculum and instruction estimated by the percentage of teachers in three skill categories of novice, intermediate, and advanced. The student use section describes students' technology use, which consists of 19 questions also using a 4-point Likert scale. The MTI frequency data for student use consisted of four Likert-scale responses ranging from 0 (*never*) to 3 (*every day or almost every day*). Not included in the analysis were the sections for assistive technologies, support maintenance and professional development, administrator use, teacher use, and home access. The MTI survey is provided in Appendix A.

Maryland School Assessments. Student achievement data used in this study were compiled from the results of the 2007 MSA for eighth-grade reading and mathematics. The MSA are tests given annually for Grades 3–8 in the content areas of mathematics, reading, and science. In 2007, the Stanford Achievement Test Series, 10th edition (SAT10) provided norm-referenced and criterion-referenced test results.

For the 2007 MSA eighth-grade mathematics, 65,085 students were tested: 16,275 (25%) at advanced level, 20,625 (32%) at proficient level, and 28,185 (43%) at basic level. For eighth-grade reading, 65,075 students were tested: 15,576 (24%) at advanced level, 28,846 (44%) at proficient level, and 20,653 (32%) at basic level. Individual student scale scores were not available for this study. Table 1 showed the proficiency levels for Grade 8 reading and mathematics for 200.

Operationalized Variables

Dependent measures. Once the data were compiled, several new variables were created. The total number of computers was calculated by adding the various computers listed by type and location. The student-computer ratio was calculated by dividing the number of computers by the number of students. Similarly, the student–classroom computer ratio was calculated by dividing the number of computers per classroom by the number of students. Percentages for student enrollment as minority, FARMS, and female were also calculated.

In the first part of the study, the dependent measures of access and use were compared based on variations of minority, FARMS, and female enrollment. The six dependent measures for technology access were (a) student-to-computer ratio (computed by dividing the number of students by the total number of computers); (b) student-to-classroom computer ratio (computed by dividing the number of students by the number of computers in classrooms); (c) number of teachers with computers in their classrooms; (d) number of classrooms with Internet access; (e) number of classrooms with five or more computers; and (f) teacher technology efficacy (measures of teacher technology skills were reported at three levels: novice, 1; intermediate, 2; and advanced, 3; each level

was summed and averaged to produce a composite measure). The teacher technology efficacy variable resulted from a weighted transformation of three reported measures. Teachers' level of technology proficiency was reported in three categories: personal computer skill, Internet skill, and integrating technology into the curriculum. For each category, percentages of teacher technology proficiency were rated at three levels: novice, intermediate, and advanced. A multiple of 1 was applied to the novice-level ratings, 2 to the intermediate level, and 3 to the advanced level. The resulting transformations were averaged, and then standardized to provide a single measure for teacher expertise.

The technology use measures were also compiled from the MTI. There were a total of 14 measures (13 student-related measures and one teacher-related measure). The measures included the following: (a) gather information and data; (b) organize and store information; (c) perform measurements; (d) manipulate data; (e) communicate and report information; (f) display data; (g) publish text; (h) create graphics; (i) perform calculations; (j) understand complex material; (k) connect language to written words and graphic; (l) support individualized learning and tutoring; (m) remediate basic skills; and (n) teacher creates instructional materials. The use measures were rated on a 4-point Likert scale ranging from 0 (*never*) to 3 (*daily*).

The technology use variables selected from the student use questions contained in the MTI were identified with the state's instructional goals for eighth-grade reading and mathematics and are listed in Figures 3.1 and 3.2. The matching of student use questions to instructional goals provides a framework for evaluating the importance of specific technology uses that may influence instructional outcomes.

Figure 3.1: Maryland Reading Goals and MTI Items.

Eighth-Grade Reading Goals	MTI Questions: Student Use
General reading processes—Read and develop vocabulary Controlling language Listening Speaking	Communicate/report information, conclusions, or results of investigations (e.g., in word processing documents, e-mail, online discussion areas, multimedia presentations, or on a Web site): Question #5
Comprehension of informational text—Analyze text and electronic media	Gather information/data from a variety of sources (e.g., via Internet, World Wide Web, online services, CD-ROM-based reference software): Question #1
Comprehension of literary text—Analyze text	Develop a more complete understanding of complex material or abstract concepts (e.g., through visual models, animations, simulations): Question #14
Writing—Composition, revision	Plan, draft, proofread, revise, and publish written text: Question #8

In the multivariate analyses for achievement, the dependent measures were (a) mathematics achievement, as measured by the percentage of students scoring at proficient and advanced levels on the MSA eighth-grade mathematics assessment, and (b) reading achievement, as measured by the percentage of students scoring at proficient and advanced levels on the MSA eighth-grade reading assessment. The access and use measures were used as independent variables (predictors) to predict mathematics and reading achievement, while controlling for minority, FARMS, and female enrollment.

Figure 3.2: Maryland Mathematics Goals and MTI Items.

Eighth-Grade Mathematics Goals	MTI Questions: Student Use
Knowledge of algebra, patterns, and functions	Develop a more complete understanding of complex material or abstract concepts (e.g., through visual models, animations, simulations): Question #13
Knowledge of geometry	
Knowledge of probability	
Knowledge of measurement	Perform measurements and collect data in investigations or lab experiments: Question #3
Knowledge of statistics—Organize, analyze, and display data	Display data/information (e.g., using charts, graphs, maps): Question #5
Knowledge of number relationships and computation/arithmetic	Perform calculations (e.g., graphing calculators or spreadsheets): Question #12
Processes of mathematics	Manipulate/analyze/interpret information or data to discover relationships, generate questions, and/or reach conclusions (e.g., sorting databases or spreadsheet files, using electronic graphic organizers): Question #4

Independent Variables

In comparing differences in school access and use, the three independent

measures used in the study were minority enrollment, FARMS enrollment, and female

enrollment. Minority enrollment included the percentage of minority students (African

American, Asian/Pacific Islander, Hispanic, American Indian) in each school. FARMS

enrollment was the percentage of students participating in FARMS programs (a measure

of SES). Gender was represented by the percentage of female student enrollment in each

school.

For the multivariate achievement analyses, the percentage of students scoring at

the proficient or advanced levels on the mathematics and reading assessments from the

2007 MSA was used. In the regression analyses, the demographic measures (minority,

FARMS, and female enrollment) were control variables for studying the effects of access

and use on mathematics and reading achievement. A condition or treatment in the study

was to group demographic measures (minority, FARMS, female student enrollment) and achievement measures (mathematics and reading assessment performance) into three levels (high, medium, and low).

The minority, FARMS, and female enrollment measures and mathematics and reading achievement scores were grouped into three percentile ranges: 0–33.33%, 33.34%–66.65%, and 66.66%–100%. For the achievement analyses, the schools were also divided into three groups based on the percentage of advanced and proficient scores on MSA mathematics assessments and three groups based on the percentage of advanced and proficient scores on MSA reading assessments. The mathematics and reading groups were 0–33.33%, 33.34%–66.65%, and 66.66%–100%. Mathematics and reading groups were coded as 1 = low, 2 = medium, and 3 = high.

Table 2 shows the school groupings for the 2007 enrollment and MSA proficiency levels by percentage and totals. For the multivariate analyses, minority, FARMS, and female enrollment measures were dummy coded: (0–40%) – 0 = low and (40%–100%) – 1 = high.

Table 2

School Grouping for 2007 Enrollment and MSA Proficiency Levels by Percentage

School group	Low (1)	Medium (2)	High (3)	Total
Minority enrollment	0–29.92% = 75	29.93%–65.79% = 76	65.80%–100% = 78	229
FARMS enrollment	0–19.41% = 75	19.42%–43.66% = 76	43.67%–100% = 78	229
Gender enrollment	0–48% = 76	48%–50% = 76	50.5%–100% = 77	229
Math achievement	0–50.92% = 76	50.93%–68.32% = 77	68.32%–100% = 76	229
Reading achievement	0–64.56% = 76	64.57%–77.73% = 77	77.74%–100% = 76	229

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Data Analysis Procedures

The unit of analysis for this study was schools. Technology resources, such as computers, the Internet, and software, are typically allocated at the school level for student use and are not individually assigned to students. The technology inventory and student assessment data were compiled and reported at the school level. One outlier for the variable number of classroom computers was removed from the data set. Thus schools would be the unit where the treatment is distributed. This study focused on the variability between middle schools.

Descriptive analyses. To address the hypotheses that differences in access and use are influenced by school demographics, descriptives for school-level access and use were calculated. Group means and standard deviations for each variable based on the three demographic groups (low, medium, high minority; FARMS; and female student enrollments) provided a description of central tendencies and variations. Each access and use variable was compared by the three demographic groups, and differences in access and/or use based on demographics would denote the presence of a digital divide.

Correlations were calculated to examine relationships among access, use, the control variables, and achievement. The correlations illustrated no problems of multicollinearity.

Multivariate analyses. For the multivariate analyses, ordinary least squares multiple regression techniques were selected to analyze the relationship between the access and use variables (predictor variables) and minority, FARMS, and female enrollment. Subsequent analyses compared access and use with mathematics and reading achievement (criterion variables), while controlling for school demographics of minority

(race), FARMS (SES), and female enrollment (gender). Multiple regression was the most appropriate technique for this study, given the study hypotheses, which were designed to compare relationships among these multiple variables and the interest in measuring and comparing the effects of access and use on achievement. Standard multiple regression analyses were conducted to determine the relationships of the access and use variables with minority, FARMS, and female enrollment. Four stepwise multiple regression analyses were conducted to compare access and use with achievement for each set of predictor and criterion variables: (a) access and mathematics, (b) access and reading, (c) use and mathematics, and (d) use and reading.

For example, for the access and mathematics analyses, the dependent variable (z-scored percentage of school mathematics achievement) was entered. Next, the control variables (dummy-coded minority, FARMS, and female enrollment) were entered. The six access variables (z-scored) were entered stepwise in an effort to find the most parsimonious set of access predictors that are the most effective in predicting mathematics achievement. Similarly, these steps were followed for the access and reading, use and mathematics, and use and reading analyses.

The objective was to determine which access and use variables would improve the accuracy in predicting mathematics and reading achievement. Regression models provided the regression coefficients and correlations, and proportion of variance was necessary to evaluate the access and use variables (predictors) and their significance in predicting the mathematics and reading achievement scores (criterions). The data compiled for this study were analyzed using the Statistical Package for the Social Sciences (SPSS) version 14.0 for Windows.

Chapter 4: Research Findings

This section describes the results of the descriptive and inferential techniques used to test the hypotheses of this study. The first section shows the results of the hypothesis testing for technology access variables using minority, FARMS, and gender enrollment variables. The second section discusses the results for testing the hypotheses for technology use. The third section addresses hypothesis testing for determining the relationships of access and use in the prediction of achievement. This study focused on examining access and use variables to provide insight into potential policy-relevant relationships. The main effects analyzed were the distribution and relationships of technology access and use based on school demographics, characterized by minority, SES, and gender student enrollment, as well as the relationship between access and use and student achievement.

The research findings will be reported in five sections. First, descriptive findings will be presented. This analysis compared technology access for schools categorized by levels of minority (race), FARMS (SES), and female enrollment (gender). The next section provides findings addressing technology use for schools by levels of minority, FARMS, and female enrollment. Afterward, the third section describes findings addressing technology access and use in schools categorized by levels of mathematics and reading achievement. The fourth section presents the results of the analysis of technology use in schools categorized by levels of mathematics and reading achievement. The last section provides a summary of the research findings.

Descriptive Analyses for Technology Access

Descriptive statistics for technology access are presented in the following sections. Correlation, central tendency, and variability statistics were calculated.

The correlation between the minority and FARMS enrollment variables was $r = .682$, $p < .001$. The coefficient is moderate, positive, and statistically significant. The correlation of determination ($R^2 = .47$) indicates that close to half (47%) of the variance in minority enrollment is predictable from FARMS enrollment or vice versa. (With any bivariate correlation, predictions can be viewed for either variable: e.g., minority enrollment predicts FARMS enrollment or FARMS predicts minority enrollment.). Table 3 shows the correlations for the technology access variables.

The correlations for technology access variables show statistically significant positive relationships between teacher classroom computer and classroom Internet and student-to-computer ratio and student-to-classroom computer ratio. Classrooms with five or more computers and teacher classroom computer also showed a positive relationship. Student-to-computer ratio and classrooms with five or more computers showed a statistically negative relationship.

The strongest statistically significant positive relationship was found between teacher classroom computer and classroom Internet, $r = .75$, $p \geq .000$. As the number of teacher classroom computers increases, classroom Internet access also increases. The coefficient of determination ($R^2 = .56$) indicates that 56% of variance for teacher classroom computer is associated with the variance in classroom Internet access. The second highest correlation was found between student-to-computer ratio and student-to-classroom computer ratio, $r = .58$, $p \leq .001$, and was considered moderate. The

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correlations imply that as the student-to-computer ratio improves (decreases), the student-to-classroom computer ratio also improves. The R² value of .34 indicates that 34% of the variance in the student-to-computer ratio is explained by the variance in the student-to-classroom computer ratio.

Table 3

Correlations of Technology Access Variables

Access	Student-computer ratio	Student-classroom computer ratio	Teacher classroom computer	Classroom Internet	Classroom with 5+ computers	Teacher technology expertise
Student-computer ratio	1.000					
Student-classroom computer ratio	.581**	1.000				
Teacher classroom computer	−.123	.064	1.000			
Classroom Internet	−.013	.110	.746**	1.000		
Classroom with 5+ computers	−.193**	−.071	.157*	.101	1.000	
Teacher technology efficacy	−.013	−.043	.067	−.029	.093	1.000

Note. *p ≤ .05. **p ≤ .001.

Differences in access and minority enrollment (race). The first hypothesis tested access among schools with minority enrollment. This study's null hypothesis is that students in high-minority schools will have the same level of technology access as students in low-minority schools. Table 4 provides descriptive measures of central tendencies and variability for each of the six technology access variables, comparing

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levels (low, medium, high) of minority population in the 229 schools included in the

study.

Table 4

Mean and Standard Deviation for Access and Minority Enrollment

	Low (0–30%) ($n = 75$)		Medium (30%–65.7%) ($n = 76$)		High (65.8%–100%) ($n = 78$)	
Access variable	*M*	*SD*	*M*	*SD*	*M*	*SD*
Student-computer ratio	4.30	2.39	4.30	2.76	4.76	3.82
Student-classroom computer ratio	7.94	4.56	13.64	33.58	22.32	67.28
Number of teacher classroom computers	43.93	15.20	48.96	10.63	43.35	16.10
Number of classrooms with 5+ computers	4.47	7.68	2.91	3.69	5.37	8.92
Number of classrooms with Internet	45.21	14.42	48.34	11.86	46.71	11.21
Teacher technology efficacy (%)	61.10	6.15	60.33	6.31	58.12	7.19

Note. N = 299

The results indicate different levels of access associated with minority enrollment.

Schools with lower minority enrollment have slightly lower student-to-computer ratios

and substantially lower student-to-classroom computer ratios compared to high-minority

schools. Schools with higher minority enrollment have more classrooms with five or

more computers and more classrooms with Internet access compared to schools with

lower minority enrollment. The numbers of teachers with classroom computers were

similar among the groups. Teachers in low-minority schools had higher levels of

technology efficacy compared to teachers in high-minority schools.

Differences in access and FARMS enrollment (SES). Hypothesis 2 was

concerned with SES and technology access. The null hypothesis stated that low-SES

(high-FARMS) middle school students would have the same levels of technology access as high-SES (low-FARMS) middle school students. Table 5 presents the means and standard deviations for the six access variables by FARMS enrollment.

Table 5

Means and Standard Deviations for Access and FARMS Enrollment

	Low (*n* = 75)		Middle (*n* = 76)		High (*n* = 78)	
Access variable	*M*	*SD*	*M*	*SD*	*M*	*SD*
Student-computer ratio	4.43	2.04	4.22	2.33	4.71	4.27
Student-classroom computer ratio	8.77	4.53	9.21	12.28	25.85	73.43
Number of teacher classroom computers	47.81	13.07	47.49	12.67	41.05	16.15
Number of classrooms with 5+ computers	48.93	11.66	47.17	13.89	44.27	11.74
Number of classrooms with Internet	4.15	7.72	4.13	5.63	4.49	7.18
Teacher technology efficacy (%)	60.31	54.22	59.84	75.46	59.37	74.40

Note. N = 299.

The results indicate different levels of access associated with FARMS enrollment. Schools with lower FARMS enrollment have lower student-to-computer ratios and lower student-to-classroom computer ratios compared to high-FARMS schools. Schools with higher FARMS enrollment have more classrooms with five or more computers and but fewer classrooms with Internet access compared to schools with lower FARMS enrollment. High-FARMS schools have fewer teachers with classroom computers. Teachers in low-FARMS schools had slightly higher levels of technology efficacy compared to teachers in high-FARMS schools.

Differences in access and female enrollment (gender). Table 6 presents the

means and standard deviations for the six access variables by female enrollment.

Table 6

Means and Standard Deviations for Access and Female Enrollment

	Low (*n* = 76)		Middle (*n* = 76)		High (*n* = 77)	
Access variable	*M*	*SD*	*M*	*SD*	*M*	*SD*
Student-computer ratio	4.42	3.48	4.50	2.78	4.44	2.91
Student-classroom computer ratio	22.25	68.98	9.42	6.38	12.56	31.61
Number of teacher classroom computers	45.72	13.46	46.91	10.63	46.13	13.51
Number of classrooms with Internet	47.25	11.66	47.17	13.89	44.27	11.74
Number of classrooms with 5+ computers	4.26	7.42	4.54	6.42	3.97	7.70
Teacher technology efficacy (%)	59.13	63.93	59.50	74.49	60.85	66.79

Note. N = 299.

The results indicate different levels of access by gender. Schools have similar

student-to-computer ratios, but schools with higher female enrollment have lower

student-to-classroom computer ratios compared to schools with lower female enrollment.

Schools with lower female enrollment have more classrooms with five or more

computers and more classrooms with Internet access compared to schools with higher

female enrollment. Schools enrolling more females also have more teachers with

classroom computers and more teachers with higher levels of technology efficacy

compared to schools with lower female enrollment.

Multivariate Analyses for Access and Use by School Demographics

Table 7 presents the regression results that describe the overall relationship of

technology access and minority enrollment.

Table 7

Regression Analysis for Technology Access and Minority Enrollment

Variable	*B*	*SE B*	B	*t*	Sig.
Student-to-computer ratio	−0.016	0.049	−0.033	−0.333	0.739
Student-to-classroom computer ratio	0.080	0.048	0.160	1.670	0.096
Number of classrooms with Internet	0.088	0.050	0.176	1.763	0.079
Number of teacher classroom computers	−0.056	0.051	−0.113	1.114	0.266
Number of classrooms with 5+ computers	0.025	0.034	0.050	0 .738	0.461
Teacher technology efficacy (%)	−0.049	0.033	−0.097	−1.460	0.146

Note. R^2 = .049. Adjusted R^2 = .024. $F(6, 222)$ = 1.924, $p \leq .078$.

The multiple regression analyzed minority enrollment using the six access variables as predictors. The regression was a rather poor fit (adjusted R^2 = .024), and the overall relationship was not significant, $F(6, 222)$ = 1.924, $p \leq .078$. The variables student-to-classroom computer ratio, number of classrooms with Internet, and number of classrooms with five or computers were positively related to minority enrollment. The variables student-to-computer ratio, number of teachers with classroom computers, and teacher technology efficacy were negatively related to minority enrollment. None of the access variables were significant.

Table 8 displays the regression results that describe the overall relationship between technology access and FARMS enrollment.

Table 8

Regression Analysis for Access and FARMS Enrollment

Variable	B	SE B	β	t	Sig.
Student-to-computer ratio	−.087	.047	−.179	−1.848	.066
Student-to-classroom computer ratio	.140	.046	.288	3.048	.003
Number of classrooms with Internet	.038	.048	.079	.801	.424
Number of teacher classroom computers	−.109	.049	−.226	−2.254	.025
Number of classrooms with 5+ computers	.023	.033	.047	.705	.481
Teacher technology efficacy (%)	−.014	.032	−.028	−.431	.667

Note. R² = .071. Adjusted R² = .046. F(6, 222) = 2.831, p ≤ .011.

The multiple regression model indicates a significant relationship between access and FARMS enrollment. The multiple regression analyzed FARMS enrollment using the six access variables as predictors. The model accounted for 7.1% of the variance in FARMS enrollment. The regression was a rather poor fit (adjusted R^2 = .046), and the overall relationship was significant, F(6, 222) = 2.831, $p \leq$ .011. The variables student-to-classroom computer ratio (.140) and the number of teachers with classroom computers (−.109) were statistically significant.

The access variable student-to-classroom computer ratio has a *t* statistic t(222) = 3.048, p ≤ .003, and has a greater impact on the model compared to the teacher classroom computer variable. The slope associated with student-to-classroom computer ratio is not equal to zero ($b \neq 0$) and indicates a weak but statistically significant relationship with FARMS enrollment.

Teacher classroom computer has a probability of the *t* statistic (−2.254) for the *b*

coefficient (−.109) of p ≤ .025, which is less than the level of significance of .05. The

slope associated with teacher classroom computer is not equal to zero (*b* ≠ 0) and

indicates a weak, negative, but statistically significant relationship with FARMS

enrollment. The direction of the relationship shows that as the level of teacher classroom

computers increases, the level of FARMS enrollment decreases.

Surprisingly, in comparison of the access models for minority and FARMS

enrollment and the high correlation between them, the results were very different. These

results will be discussed further in chapter 5.

Table 9 presents the regression results that describe the overall relationship

between technology access and female enrollment.

Table 9

Regression Analysis for Access and Female Enrollment

Variable	*B*	*SE B*	β	*t*	Sig.
Student-to-computer ratio	.104	.049	.208	2.111	.036
Student-to-classroom computer ratio	−.114	.048	−.228	−2.375	.018
Number of classrooms with Internet	−.014	.050	−.029	−.288	.774
Number of teacher classroom computers	.016	.051	.031	.307	.759
Number of classrooms with 5+ computers	−.015	.034	−.031	−.453	.651
Teacher technology efficacy (%)	.039	.033	.078	1.167	.244

Note. R² = .037. Adjusted R² = .011. F(6, 222) = 1.408, p ≤ .212.

The multiple regression model indicates no significant relationship between

access and female enrollment. The multiple regression analyzed female enrollment using

the six access variables as predictors. The model accounted for 3.7% of the variance in

female enrollment. The regression was a rather poor fit (adjusted $R^2 = .011$), and the overall relationship was not significant, $F(6, 222) = 1.409$, $p \leq .212$. The variables student-to-computer ratio, number of teachers with classroom computers, and teacher technology efficacy were positively related to female enrollment. The variables student-to-classroom computer ratio, number of classrooms with Internet, and number of classrooms with five or computers were negatively related to female enrollment. Two variables were significant: student-to-computer ratio (.104) and student-to-classroom computer ratio ($-.114$). Overall, the multiple regression model indicates that there is no significant relationship between access and female enrollment.

Descriptive Analyses for Technology Use

Descriptive statistics for technology use are presented in the following sections. Correlation, central tendency, and variability statistics were calculated. Table 10 shows the results of the correlation of the technology use variables.

Table 10

Correlations of Technology Use Variables

	GI	ORG	PM	MD	COM	DD	CG	PC	UCM	IL	RBS	PT	CLW	TCIM
Gather information	1.000													
Organize information	.368**	1.000												
Perform measurement	.311**	.413**	1.000											
Manipulate data	.329**	.455**	.546**	1.000										
Communicate information	.457**	.392**	.423**	.520**	1.000									
Display data	.349**	.457**	.444**	.624**	.536**	1.000								
Create graphics	.461**	.378**	.455**	.474**	.542**	.538**	1.000							
Perform calculations	.343**	.265**	.427**	.436**	.365**	.440**	.418*	1.000						
Understand complex material	.241**	.193**	356**	.396**	.394**	.439**	382**	.430**	1.000					
Individualize learning	.299**	.231**	.328**	.362**	.314**	.361**	327**	.386**	.395**	1.000				
Remediate basic skills	276**	.196**	320**	.340**	.356**	.390**	338**	.334**	.315**	.546**	1.000			
Publish text	.449**	.397**	.319**	.359**	.485**	.398**	476**	.395**	.312**	.296**	.175**	1.000		
Connect language to words	.186**	.214**	.317**	.358**	.313**	.329**	244**	.341**	.391**	.429**	.381**	.349**	1.000	
Teacher creates instructional material	.080	.059	054	.112	.233**	.220**	.230**	.186**	.210**	.260**	.186**	.177**	.203**	1.000

Note. N = 299. Variables were standardized: M = 0, SD = 1.

**p ≤ .01.

The results of the correlation analysis indicate small to moderate and positive correlations for the majority of the technology use variables. The strongest relationship appears between manipulate data and display data, $r = .62$, $p \geq .000$. This implies that students who manipulate data more also tend to display data more frequently. R^2 was .38, implying that 38% of variance for manipulating data is associated with displaying data. The second highest correlations were between individualize learning and remediate basic skills, $r = .55$, $p \geq .000$, and manipulating data and performing measurements, $r = .55$, $p \geq .000$. This result suggests that the more students use technology for individualized learning, the more they use it for remediating basic skills.

The second result suggests that the more students use technology to manipulate data, the more they use it to perform measurements. In this case, R^2 was .30, implying that 30% of variance for individualized learning is associated with remediating basic skills and that 30% of variance for manipulate data is associated with perform measurements. For the teacher use variable, a rather small relationship was found between teacher-creates-instructional-material and individualized learning, $r = .26$, $p \geq .000$. This implies that the more teachers use technology to create instructional material, the more students use technology for individualized learning. R^2 was .07, implying that only 7% of variance for teachers creating instructional material is associated with students individualized learning.

Differences in technology use for minority enrollment (race). Null hypothesis

4 states that there are no differences between minority and nonminority enrollment and

technology use. Table 11 presents the means and standard deviations for technology use

and minority enrollment.

Table 11

Means and Standard Deviations for Use and Minority Enrollment

	Low-minority schools (*n* = 75)		Medium-minority schools (*n* = 76)		High-minority schools (*n* = 78)	
Use	*M*	*SD*	*M*	*SD*	*M*	*SD*
Gather information	2.63	0.632	2.59	0.593	2.53	0.639
Organize information	1.80	0.717	1.78	0.793	1.83	0.692
Perform measurement	1.55	0.759	1.38	0.783	1.41	0.889
Manipulate data	1.56	0.663	1.62	0.673	1.50	0.769
Communicate information	2.17	0.760	2.11	0.741	1.99	0.830
Display data	1.81	0.711	1.91	0.751	1.82	0.752
Create graphics	1.96	0.706	1.93	0.736	2.03	0.789
Perform calculations	1.75	0.981	2.22	0.805	2.32	0.852
Understand complex material	1.44	0.826	1.46	0.599	1.24	0.871
Individualized learning	1.79	1.031	1.97	0.832	1.63	0.968
Remediate basic skills	2.12	0.885	2.07	0.929	1.99	0.987
Publish text	2.37	0.673	2.46	0.642	2.23	0.788
Connect language to words	1.76	1.038	1.74	0.929	1.29	1.06
Teacher creates instructional material	2.76	0.541	2.79	0.471	2.62	0.608

The results indicate differing levels of use for minority enrollment. Generally, schools with lower minority enrollment tend to use technology more often compared to high-minority schools, particularly for gathering information, publishing text, communicating with others, connecting language to words, and remediating basic skills. More teachers in low-minority schools are more likely to use technology to create instructional materials, as compared to teachers in high-minority schools. Teachers in high-minority schools use technology more to organize information and perform calculations, as compared to low-minority schools.

Differences in technology use and FARMS enrollment (SES). Null hypothesis 5 was formulated to test technology use among schools based on FARMS enrollment. The null hypothesis stated that students in high-SES (low-FARMS) schools would have the same level of technology use as students in low-SES (high-FARMS) schools. Table 12 presents the means and standard deviations for technology use by FARMS enrollment.

Descriptive statistics for technology use show differences in technology use among schools based on FARMS enrollment. Low-FARMS schools tend to use technology more for gathering information, publishing text, performing calculations, communicating with others, creating graphics, and remediating basic skills compared to high-FARMS schools. High-FARMS schools use technology more to organize information and perform measurements when compared to low-FARMS schools. Teachers in low-FARMS schools use technology more to create instructional materials compared to teachers in high-FARMS schools.

Table 12

Means and Standard Deviations for Use and FARMS Enrollment

Use	Low-FARMS schools (*n* = 75)		Medium-FARMS schools (*n* = 76)		High-FARMS schools (*n* = 78)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Gather information	2.65	0.626	2.58	0.572	2.51	0.659
Organize information	1.73	0.777	1.82	0.647	1.86	0.768
Perform measurement	1.43	0.808	1.46	0.738	1.45	0.892
Manipulate data	1.55	0.703	1.61	0.613	1.53	0.785
Communicate information	2.19	0.748	2.14	0.778	1.94	0.795
Display data	1.87	0.723	1.86	0.725	1.82	0.769
Create graphics	2.03	0.735	2.03	0.730	1.87	0.762
Perform calculations	2.25	0.871	2.16	0.801	1.88	1.019
Understand complex material	1.52	0.777	1.38	0.692	1.24	0.840
Individualized learning	1.81	1.036	1.87	0.854	1.71	0.968
Remediate basic skills	2.12	0.915	2.09	0.882	1.96	0.999
Publish text	2.47	0.664	2.50	0.600	2.10	0.783
Connect language to words	1.85	0.954	1.63	1.03	1.31	1.036
Teacher creates instructional material	2.81	0.425	2.80	0.490	2.55	0.658

Differences in use and female enrollment (gender). Table 13 presents the

means and standard deviations for technology use by female student enrollment.

Table 13

Means and Standard Deviations for Use and Female Enrollment

Use	Low-female enrollment schools (*n* = 76)		Medium-female enrollment schools (*n* = 76)		High-female enrollment schools (*n* = 77)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Gather information	2.49	0.702	2.61	0.591	2.65	0.556
Organize information	1.78	0.723	1.87	0.737	1.77	0.742
Perform measurement	1.32	0.820	1.57	0.869	1.45	0.735
Manipulate data	1.43	0.680	1.64	0.778	1.60	0.634
Communicate information	1.88	0.816	2.16	0.767	2.22	0.719
Display data	1.70	0.654	1.89	0.842	1.95	0.686
Create graphics	1.79	0.718	2.17	0.773	1.96	0.697
Perform calculations	1.97	0.979	2.16	0.925	2.16	0.828
Understand complex material	1.39	0.767	1.39	0.818	1.35	0.757
Individualized learning	1.78	0.918	1.80	0.994	1.81	0.960
Remediate basic skills	1.93	1.024	2.16	0.910	2.08	0.855
Publish text	2.22	0.723	2.42	0.753	2.42	0.636
Connect language to words	1.59	1.009	1.54	1.064	1.65	1.023
Teacher creates instructional material	2.64	0.582	2.74	0.500	2.78	0.553

Descriptive statistics for technology use indicate differences in technology use among schools, categorized by their level of female enrollment. Schools with high female enrollment tend to use technology more for gathering information, publishing text, communicating with others, connecting language with words, remediating basic skills, and performing calculations compared to schools with low female enrollment. Teachers in schools with high female enrollment use technology more for creating instructional materials compared to teachers in schools with lower female enrollment.

To further investigate the relationship of technology access and use compared to school demographics of minority, FARMS, and female enrollment, a series of regression analyses were conducted. These results are presented in the next section.

Table 14 presents the regression results that describe the overall relationship between technology use and minority enrollment.

Table 14

Regression Analysis of Technology Use and Minority Enrollment

Variable	B	SE B	β	t	Sig.
Gather information	−0.051	0.041	−0.103	−1.255	0.211
Organize information	0.043	0.041	0.086	1.058	0.291
Perform measurement	−0.052	0.043	−0.103	−1.200	0.231
Manipulate data	0.028	0.048	0.056	0.580	0.562
Communicate information	−0.021	0.046	−0.041	−0.447	0.655
Display data	0.047	0.048	0.095	0.981	0.328
Create graphics	0.061	0.046	0.122	1.333	0.184
Perform calculations	−0.019	0.042	−0.038	−0.462	0.644
Understand complex material	−0.037	0.041	−0.074	−0.911	0.363
Individualized learning	0.016	0.043	0.033	0.376	0.707
Remediate basic skills	0.008	0.042	0.016	0.187	0.852
Publish text	0.016	0.043	0.032	0.373	0.710
Connect language to words	−0.097	0.040	−0.194	−2.413	0.017
Teacher creates instructional material	−0.011	0.036	−0.023	−0.317	0.752

Note. $R^2 = .071$. Adjusted $R^2 = .010$. $F(14, 214) = 1.171$, $p \leq .299$.

The multiple regression model indicated no significant relationship between technology use and minority enrollment. The adjusted R^2 value of .010 shows that the independent use variables explain very little of the variance in minority enrollment. However, the results show a significant negative relationship between the variable connect-language-to-words (–.097) and minority enrollment. The probability of the *t* statistic (–2.413) for the *b* coefficient (–.097) was $p \leq .017$, which is less than the level of significance of .05. The slope associated with connect- language-to-words is not equal to zero ($b \neq 0$) and indicates a weak, negative, but statistically significant relationship with minority enrollment. The connecting- language-to-words variable is coded so that higher values are associated with more frequent use. In this inverse relationship, higher values for students who use technology for connecting words to language are associated with lower levels of minority enrollment.

Table 15 shows the regressions that describe the overall relationship between technology use and FARMS enrollment. The multiple regression model indicated a significant relationship between technology use and FARMS enrollment, $F(14, 214) =$ 3.006, $p \leq .001$. The R^2 value (.164) indicates that the use variables explain 16.4% of the variance in FARMS enrollment. The model shows four use variables that were significantly related to FARMS: organize information (.092), publish text (–.108), connect-language-to- words (–.084), and teacher-creates-instructional-materials (–.070). The *t* statistics were less than the level of significance of .05. The slopes associated with the seven use variables were not equal to zero ($b \neq 0$). The *b* coefficient associated with organize information is positive, indicating that more frequent use of technology for organizing information is associated with higher FARMS enrollment.

Table 15

Regression Analysis of Technology Use and FARMS Enrollment

Variable	B	SE B	β	t	Sig.
Gather information	−0.038	0.038	−0.077	−0.999	0.319
Organize information	0.092	0.037	0.190	2.465	0.014
Perform measurement	0.034	0.040	0.071	0.868	0.386
Manipulate data	0.003	0.044	0.006	0.070	0.944
Communicate information	−0.036	0.042	−0.074	−0.842	0.401
Display data	0.049	0.045	0.102	1.110	0.268
Create graphics	−0.009	0.042	−0.018	−0.206	0.837
Perform calculations	−0.029	0.038	−0.061	−0.769	0.443
Understand complex material	−0.021	0.038	−0.043	−0.553	0.581
Individualized learning	0.066	0.040	0.135	1.647	0.101
Remediate basic skills	−0.011	0.039	−0.023	−0.288	0.774
Publish text	−0.108	0.040	−0.222	−2.718	0.007
Connect language to words	−0.084	0.037	−0.174	−2.282	0.023
Teacher creates instructional material	−0.070	0.033	−0.145	−2.139	0.034

Note. $R^2 = .164$. Adjusted $R^2 = .110$. $F(14, 214) = 3.006$, $p \leq .001$.

These results indicate rather limited technology use for high-level instructional activities among low SES students. This is an indication that low SES students tend to use technology more for low-level, drill and practice applications.

The *b* coefficients for publish text, connect-language-to-words, and teacher-creates-instructional-materials were negative, indicating an inverse relationship in which more frequent use is associated with lower FARMS enrollment. This is an important finding given that these variables are associated with key instructional goals for the middle school curriculum and teachers who may be integrating technology into their practice.

Table 16 presents the regression results describing the overall relationship between technology use and female enrollment.

Table 16

Regression Analysis of Technology Use and Female Enrollment

Variable	*B*	*SE B*	β	*t*	Sig.
Gather information	0.006	0.040	0.013	0.155	0.877
Organize information	−0.072	0.040	−0.144	−1.791	0.075
Perform measurement	0.027	0.043	0.054	0.639	0.524
Manipulate data	−0.016	0.047	−0.033	−0.343	0.732
Communicate information	0.115	0.046	0.231	2.528	0.012
Display data	0.059	0.048	0.118	1.232	0.219
Create graphics	−0.014	0.045	−0.027	−0.301	0.763
Perform calculations	0.007	0.041	0.015	0.178	0.859
Understand complex material	−0.071	0.040	−0.142	−1.749	0.082
Individualized learning	−0.018	0.043	−0.036	−0.413	0.680
Remediate basic skills	−0.012	0.042	−0.023	−0.280	0.780
Publish text	0.051	0.043	0.103	1.204	0.230
Connect language to words	−0.036	0.040	−0.072	−0.909	0.364
Teacher creates instructional material	0.025	0.035	0.051	0.722	0.471

Note. $R^2 = .086$. Adjusted $R^2 = .026$. $F(14, 214) = 1.439$, $p \le .137$.

The multiple regression model indicated no significant relationship between technology use and female enrollment, $F(14, 214) = 1.439$, $p \le .137$. The model shows that the use variables explained only 8.6% of the variance in female enrollment. However, the model shows a significant relationship between the variable communicate with others (.115) and female enrollment. The *b* coefficient is positive, indicating that higher values for using technology to communicate with others are associated with higher female enrollment.

Table 17 summarizes the relationship of technology access and use compared by minority, FARMS, and female enrollment reported in effect sizes.

Table 17

Size of Relationships for Technology Access and Uses: Digital Divide

	Effect size		
	Minority	FARMS	Female
Access			
Student-to-computer ratio	–	–	.104
Student-to-classroom computer ratio	–	.140	–.114
Number of teacher classroom computers	–	–.109	–
Use			
Connect language to words	–.097	–.084	–
Publish text	–	–.108	–
Organize information	–	–.092	–
Communicate information	–	–	.115
Teacher creates instructional material	–	–.070	–

Descriptives for Technology Access and Mathematics Achievement

Descriptive statistics for technology access and achievement are presented in the following sections. Correlation, central tendency, and variability statistics were calculated.

Correlations calculated for mathematics and reading were strong; $r = .93$, implying that 87% of the variance in mathematics achievement is associated with variance in reading achievement.

Table 18 presents the means, medians, and standard deviations for technology access by mathematics achievement. Descriptive statistics for technology access and mathematics achievement revealed differences in group means for each of the access variables. The low-achieving mathematics schools tended to have higher student-to-computer ratios, higher student-to-classroom computer ratios, fewer teachers with classroom computers, and fewer classrooms with Internet access compared to higher

achieving mathematics schools. High mathematics achieving schools tended to have more teachers with higher levels of technology efficacy.

Table 18

Means and Standard Deviations for Access and Mathematics Achievement (Percentage of Advanced + Proficient Scores)

	Low-mathematics achievement schools ($n = 76$)		Medium-mathematics achievement schools ($n = 77$)		High-mathematics achievement schools ($n = 76$)	
Access	*M*	*SD*	*M*	*SD*	*M*	*SD*
Student-computer ratio	4.81	4.30	4.18	2.40	4.38	1.96
Student-classroom computer ratio	36.90	112.34	23.11	132.19	9.03	4.42
Teacher classroom computer	41.74	14.91	46.78	14.03	47.67	13.56
Classroom Internet	44.80	12.86	46.77	12.46	48.71	12.22
Teacher technology expertise	58.36	7.76	59.74	6.62	61.92	5.83

Descriptive Analyses for Technology Access and Reading Achievement

The results in Table 19 present the means and standard deviations for technology access by reading achievement. Descriptive statistics for technology access and reading achievement group means indicated similar patterns of differences in comparison to those found for mathematics achievement. The low-achieving reading schools tended to have higher student-to-computer ratios, higher student-to-classroom computer ratios, fewer teachers with classroom computers, and fewer classrooms with Internet access compared

to higher achieving reading schools. High reading achieving schools tended to have more

teachers with higher levels to technology efficacy. Overall, low-achieving reading

schools tend to have less access compared to high-achieving reading schools.

Table 19

Means and Standard Deviations for Access and Reading Achievement (Percentage of Advanced + Proficient Scores)

Access	Low-reading achievement schools ($n = 76$)		Medium-reading achievement schools ($n = 77$)		High-reading achievement schools ($n = 76$)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Student-computer ratio	4.80	4.43	4.09	2.10	4.48	2.01
Student-classroom computer ratio	35.17	112.17	24.84	132.49	9.01	4.60
Number of teacher classroom computers	40.46	15.87	48.10	13.81	47.61	12.02
Number of classrooms with Internet	43.34	14.23	48.22	12.16	48.70	10.46
Teacher technology efficacy (%)	58.73	75.59	600.96	62.52	60.66	66.69

Multivariate Analyses of Access/Use and Mathematics/Reading Achievement

Null hypotheses 7 and 8 were concerned with the relationship of technology

access and use when compared to mathematics and reading achievement. The null

hypotheses stated that no relationship existed between schools' levels of access and use and their academic achievement scores. Data on access and use were analyzed to determine if differences in access and use existed in schools based on levels of mathematics and reading achievement. These results are also reported as part of the analysis to further investigate the relationships of technology and achievement.

Multivariate analyses of technology access and mathematics achievement. The regression analysis tested further the null hypothesis H_07 that no relationship exists between access and mathematics achievement. The five access variables represent the predictor variables, while mathematics achievement is the criterion variable. The objective was to use the access variables to predict mathematics achievement. The variables FARMS, minority, and female enrollment serve as control variables for the analysis. A stepwise multiple regression was conducted to test the hypothesis.

Table 20 presents the results of the regression analysis of access variables predicting mathematics achievement. Multiple regression analysis was used to investigate whether technology access significantly predicted student mathematics achievement, while controlling for minority, FARMS, and female enrollment. The results of the regression indicated that the model was significant, $F(6, 222) = 56.262$, $p \leq .001$. The model explains over 60% of variance in mathematics achievement. The predictor, teacher classroom computers (.162) was significantly related to mathematics achievement. The relationship was positive, suggesting that higher levels of teacher access to computers in their classrooms are associated with higher mathematics achievement.

Table 20

Regression Analysis of Technology Access Variables Predicting Mathematics Achievement

Variable	B	SE B	B	t	Sig.
Constant	0.691	0.081		8.513	0.000
FARMS	−0.932	0.100	−0.452	−9.316	0.000
Minority	−0.787	0.095	−0.394	−8.300	0.000
Female	0.142	0.086	0.071	1.653	0.100
Student-classroom computer ratio	−0.093	0.063	−0.093	−1.465	0.144
Teacher classroom computer	0.162	0.043	0.162	3.714	0.000
Student-computer ratio	0.030	0.063	0.030	0.483	0.629

Note. $R^2 = .603$. Adjusted $R^2 = .593$. $F(6, 222) = 56.262$, $p \leq .001$.

The magnitudes of the associated standard errors and *t*-tests show that teacher classroom computer, $t(222) = 3.714$, $p \leq .001$, had a greater impact on the model than student-to-computer ratio, $t(222) = -1.465$, $p = .144$. Hence, the null hypothesis $H_0 7$, that there are no relationships between students' levels of access to school technology and their academic achievement scores on the MSA for eighth-grade reading and mathematics, was not supported.

Multivariate analyses of technology access and reading achievement. The regression analysis investigated the null hypothesis $H_0 7$ that no relationship exists between access and reading achievement. The five access variables represent the predictor variables, while reading achievement is the criterion variable. The objective was to use the access variables to predict mathematics achievement. The variables minority, FARMS, and female enrollment served as control variables for the analysis. A stepwise multiple regression was conducted to test the hypothesis.

Table 21 presents the results of the regression analysis of access variables predicting reading achievement.

Table 21

Regression Analysis of Access Variables Predicting Reading Achievement

Variable	B	SE B	β	t	Sig.
Constant	0.681	0.078		8.486	0.000
FARMS	−1.071	0.096	−0.520	−11.124	0.000
Minority	−0.643	0.091	−0.321	−7.040	0.000
Female	0.116	0.083	0.058	1.402	0.162
Student-to-classroom computer ratio	−0.102	0.061	−0.102	−1.674	0.095
Teacher classroom computer	0.212	0.042	0.212	5.064	0.000
Student- computer ratio	0.061	0.061	0.061	1.002	0.317

Note. R^2 = .632. Adjusted R^2 = .622. $F(6, 222)$ = 63.656, p ≤ .001.

Multiple regression analysis was used to test if technology access significantly predicted reading achievement, while controlling for minority, FARMS, and female enrollment. The results of the regression indicate that the model is significant, $F(6, 222)$ = 63.656, $p ≤ .001$. The results of the regression analysis show that after controlling for minority, FARMS, and female enrollment, the teacher classroom computer variable was statistically significant.

Almost two-thirds of the variation (63.2%) in reading achievement was accounted for by the final model. This variation is slightly lower compared to variation in the mathematics model, a difference of 3.9%. Minority, FARMS, and female enrollment control variables accounted for 58.1%. The addition of the predictors accounted for 5.2% of the variance.

The *t* statistic for the access variables student-to-classroom computer ratio was −102, $p = .095$. The null hypothesis that the slope associated with access is equal to 0 ($b = 0$) is rejected. The results conclude that there is a statistically significant relationship between access and teacher classroom computer.

The coefficients for teacher classroom computer (.212) was positive, indicating a direct relationship in which higher numeric values for the number of teacher classroom computers is associated with higher reading achievement.

Table 21 shows the parameters of the model for predicting reading achievement using the access predictors. There is a negative relationship between reading achievement and the control variables FARMS (−1.071) and minority enrollment (−.643). For female enrollment, the relationship is positive (.116). Similarly, the standardized beta values suggest a slightly stronger impact for classroom computer access (.235) compared to teacher technology efficacy (.115) and student-to-classroom computer ratio (−.103). Based on the results of the regression analyses, the rejection of null hypothesis $H_0 7$ is supported. These results conclude that a significant relationship exists between access and mathematics and reading achievement.

The size of the relationships between technology access and achievement. The beta values from the estimates represent the effect sizes for technology access and achievement. The comparisons of effect sizes for mathematics and reading are shown in Table 22.

Table 22

Size of Relationships for Technology Access and Mathematics and Reading Achievement

Technology access	Effect size of dependent variable	
	Mathematics achievement	Reading achievement
Teacher classroom computer	.162	.212

The effect sizes for technology access and mathematics and reading achievement are similar. For access, the effect size for the number of teacher classroom computers (.162) associated with mathematics achievement was positive. The effect size for the number of teacher classroom computers associated with reading (.212) was slightly higher, a difference of .050. These positive effects suggest that the more teachers with computers in their classrooms are associated with higher achievement levels in mathematics and reading. These results may be explained by the high correlation between mathematics and reading and that usage may be associated with meaningful instruction.

Technology Use and Achievement

Hypothesis H_08 was formulated to test the relationship of technology use among schools based on mathematics and reading achievement. It was hypothesized that no relationships exist between students' level of use and their academic achievement levels.

Descriptives for technology use and mathematics achievement. Table 23 presents the means and standard deviations for technology use by levels of mathematics achievement.

Table 23

Means and Standard Deviations for Use and Mathematics Achievement

Use	Low-mathematics achievement schools (*n* = 76)		Medium-mathematics achievement schools (*n* = 77)		High-mathematics achievement schools (*n* = 76)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Gather information	2.39	0.675	2.68	0.572	2.67	0.575
Organize information	1.76	0.709	1.84	0.670	1.80	0.817
Perform measurement	1.32	0.898	1.57	0.751	1.45	0.773
Manipulate data	1.45	0.737	1.62	0.670	1.61	0.694
Communicate information	1.79	0.822	2.25	0.710	2.22	0.723
Display data	1.76	0.746	1.86	0.702	1.92	0.762
Create graphics	1.82	0.761	2.00	0.778	2.11	0.665
Perform calculations	1.75	0.981	2.22	0.805	2.32	0.852
Understand complex material	1.21	0.838	1.39	0.728	1.54	0.738
Individualized learning	1.63	0.921	1.94	0.894	1.82	1.029
Remediate basic skills	1.86	0.989	2.18	0.869	2.13	0.914
Publish text	2.07	0.772	2.49	0.620	2.50	0.643
Connect language to words	1.29	1.030	1.61	1.015	1.88	0.966
Teacher creates instructional material	2.62	0.610	2.75	0.542	2.79	0.471

Descriptive statistics for technology use and mathematics reveal differences in use among the groups. High-achieving mathematics schools tend to use technology more for each activity compared to low-achieving mathematics schools. High-achieving mathematics schools use technology more for gathering information, publishing text,

performing calculations, remediating basic skills, connecting language to words, and communicating with others compared to low-achieving mathematics schools. Teachers in high-achieving mathematics schools use technology more to create instructional materials compared to teachers in low-achieving mathematics schools.

Multivariate analyses for technology use and mathematics achievement. The regression analysis further tested the null hypothesis $H_0 8$ that no relationship exists between use and mathematics achievement. The five use variables represent the digital divide predictor variables, while mathematics achievement serves as the criterion variable. The objective was to determine if the use variables could predict mathematics achievement. The variables minority, FARMS, and female enrollment represent the control variables for the analysis. A multiple regression was conducted to test the hypothesis.

The results of the regression analysis of use variables predicting mathematics achievement are shown in Table 24. Multiple regression analysis was used to test if technology use significantly predicted mathematics achievement, while controlling for minority, FARMS, and female enrollment. The results of the regression indicate that the model is significant, $F(8, 220) = 43.073$, $p \leq .001$. More than half of the variation (61%) in mathematics achievement was accounted for by the use variables. Minority, FARMS, and female enrollment accounted for 57.3% of the variance. Publishing text (.144) and connecting language to words (-.097) were significant predictors.

The use predictors accounted for 6.4% of the variance. The ANOVA results indicate that the overall model significantly improves the prediction of mathematics achievement, $F(8, 220) = 43.073$, $p \leq .001$.

Table 24

Regression Analysis for Use Variables Predicting Mathematics Achievement

Variable	B	SE B	β	t	Sig.
Constant	0.752	0.082		9.142	0.000
FARMS	−0.921	0.104	−0.447	−8.893	0.000
Minority	−0.836	0.095	−0.418	−8.761	0.000
Female	0.072	0.087	0.036	0.819	0.414
Communicate information	0.088	0.052	0.088	1.696	0.091
Publish text	0.144	0.053	0.144	2.726	0.007
Connect language to words	−0.097	0.047	−0.097	−2.049	0.042
Organize information	0.012	0.049	0.012	0.250	0.803
Teachers create instructional materials	0.042	0.044	0.042	0.936	0.350

Note. R^2 = .610. Adjusted R^2 = .596. F(8, 220) = 43.073, p ≤ .001.

Table 24 presents the parameters of the model for predicting mathematics

achievement using the access predictors. There is a negative relationship between

mathematics achievement and FARMS (−.921) and minority enrollment (−.836), and

there is no significant relationship with female enrollment (.072). Publishing text,

communicating with others, and organizing information had positive relationships with

mathematics achievement, indicating that higher levels of use for these activities result in

higher levels of achievement. Connect language to words was negative, suggesting an

inverse relationship in which decreases in its numeric value tend to increase the values

for mathematics achievement.

The stronger effects were in publishing text (.144). The magnitudes of the

associated standard errors and *t*-tests show that publish text, $t(222) = 2.726$, p ≥ .007, had

a slightly greater impact on the model compared to communicate information, $t(222) =$

1.696, $p ≥ .091$. The results of the regression analysis indicate significant relationships

between technology use and mathematics achievement.

Descriptives for technology use and reading achievement. Table 25 presents

the means and standard deviations of the technology use variables and reading

achievement. Descriptive statistics for technology use among schools grouped by reading

achievement also indicated differences in technology use. Students in high-achieving

reading schools consistently use technology more to gather information, publish text,

perform calculations, communicate with others, create graphics, and remediate basic

skills compared to students in low-achieving reading schools. Students in high-achieving

reading schools also use technology more to understand complex material when

compared to students in lower-achieving reading schools. Teachers in high-achieving

reading schools use technology more to create instructional materials compared to

teachers in low-achieving reading schools. Overall, the differences were small.

Table 25

Means and Standard Deviations for Use and Reading Achievement

Use	Low-reading achievement schools (*n* = 76)		Medium-reading achievement schools (*n* = 77)		High-reading achievement schools (*n* = 77)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Gather information	2.36	0.706	2.66	0.576	2.72	0.506
Organize information	1.71	0.708	1.83	0.733	1.87	0.754
Perform measurement	1.36	0.905	1.47	0.754	1.51	0.774
Manipulate data	1.37	0.709	1.68	0.677	1.63	0.690
Communicate with others	1.78	0.826	2.21	0.695	2.28	0.723
Display data	1.72	0.741	1.87	0.714	1.95	0.746
Create graphics	1.83	0.755	1.97	0.743	2.12	0.711
Perform calculations	1.78	1.015	2.17	0.768	2.34	0.857
Understand complex material	1.17	0.870	1.43	0.658	1.54	0.756
Individualized learning	1.61	0.910	1.96	0.850	1.82	1.067

	Low-reading achievement schools ($n = 76$)		Medium-reading achievement schools ($n = 77$)		High-reading achievement schools ($n = 77$)	
Remediate basic skills	1.87	0.957	2.16	0.904	2.14	0.919
Publish text	2.03	0.782	2.42	0.636	2.62	0.565
Connect language to words	1.26	1.012	1.62	0.960	1.89	1.027
Teacher creates instructional material	2.61	0.613	2.78	0.503	2.78	0.506

Multivariate analyses of technology use and reading achievement. The

regression analysis tested hypothesis $H_0 8$ that no relationship exists between use and

reading achievement. The five technology use variables represent the digital divide

predictor variables, while reading achievement serves as the criterion variable. The

objective was to determine if the use variables could predict reading achievement. The

variables minority, FARMS, and female enrollment were the control variables for the

analysis. A multiple regression was conducted to test the hypothesis.

Table 26 presents the results of the regression analysis of use variables predicting

reading achievement. Multiple regression analysis was used to determine if technology

use significantly predicted reading achievement, while controlling for minority, FARMS,

and female enrollment. The results of the regression indicate that the model was

significant, $F(8, 220) = 47.862$, $p \leq .001$. The results of the regression analysis show that

publishing text is a significant predictor of reading achievement. Over half of the

variation (65.4%) in reading achievement was accounted for by the predictors. Minority

and FARMS accounted for 58.6%. Publishing text added 4% to the value, increasing the

variance explained to 62.6%. Next, communicating information increased the value by

0.7% to 63.3%. Teachers creating instructional materials added 0.9% to increase the

value to 64.2%. Finally, connecting language to words added 1.2%, increasing the value

to 65.4%.

Table 26

Regression Analysis of Use Variables Predicting Reading Achievement

Variable	B	SE B	β	t	Sig.
Constant	0 .735	0.080	–	9.232	0.000
FARMS	−1.072	0.100	−0.520	−10.702	0.000
Minority	−0.676	0.092	−0.338	−7.321	0.000
Female	0.051	0.085	0.025	0.603	0.547
Communicate information	0.077	0.050	0.077	1.536	0.126
Publish text	0.174	0.051	0.174	3.394	0.001
Connect language with words	−0.066	0.046	−0.066	−1.438	0.152
Organize information	0.044	0.047	0.044	0.924	0.356
Teacher creates instructional material	0.017	0.043	0.017	0.388	0.699

Note. $R^2 = .635$. Adjusted $R^2 = .622$. F (8, 220) = 47.862, p ≤ .001.

Table 26 presents the parameters of the model for predicting reading achievement

with the use predictors. There is a negative relationship between reading achievement

and the control variables FARMS (−1.072) and minority

(−.676). The control for female enrollment (.051) was positive but not significant.

Connecting language to words was the only negative use coefficient, suggesting that

decreases in this use of technology tend to increase mathematics achievement. The

magnitudes of the associated standard errors and *t*-tests show that publishing text, *t*(221)

= 3.394, p ≥ 000, has a slightly greater impact on the model than communicating

information, *t*(221) = 1.536, p ≥ .126. Similarly, the standardized beta values are slightly

stronger for publishing text (.174) compared to communicating information (.077),

organizing information (.044), and teachers creating instructional materials (.017).

Based on the results of the regression analyses, the null hypothesis H_08 was rejected. The alternative, that there is a relationship between technology use and mathematics and reading achievement, was supported.

The size of the relationships for technology use and achievement. The beta values from the estimates represent the effect sizes for technology use and achievement. The comparisons of effect sizes for mathematics and reading are shown in Table 27. The estimates suggest small effect sizes for technology use and mathematics and reading achievement. The variable publishing text had significant, positive effects for both mathematics and reading. The effects for reading were slightly higher, compared to mathematics, a difference of .030. Using technology to connect language to words had a negative effect on mathematics achievement.

Table 27

Size of Relationships for Technology Use and Mathematics and Reading

| | Effect size of dependent variables | |
Technology use	Mathematics achievement	Reading achievement
Publish text	.144	.174
Connect language to words	−.097	--

Summary of Findings

After performing the descriptive and multivariate analyses to test the hypotheses for this study, the results indicate the following. First, correlations between minority and FARMS enrollment show a moderate, positive, and statistically significant relationship. The correlation of determination ($r^2 = .47$) indicates that close to half (47%) of the variance in minority is predictable from FARMS.

The correlations for technology access variables indicate statistically significant positive relationships between teacher classroom computer and classroom Internet and student-to-computer ratio and student-to-classroom computer ratio. Classrooms with five or more computers and teacher classroom computer also have a positive relationship. Student-to-computer ratio and classrooms with five or more computers have a statistically significant negative relationship.

1. There were statistically significant differences between minority students and nonminority students in terms of access to school technology for middle schools in Maryland. The mean differences between the student-to-classroom computer ratios and minority enrollment were large, while the student-to-computer ratios, number of classrooms with Internet, number of classrooms with five or more computers, teacher classroom computers, and teacher technology efficacy were small. The regression results did not detect statistically significant relationships between the access variables and minority enrollment, so a racial digital divide was not present.

2. There were statistically significant differences in low-SES students compared to high-SES students in terms of access to school technology for middle schools in Maryland. Mean differences for access and FARMS enrollment showed that schools with low FARMS enrollment have lower student-to-computer ratios and lower student-to-classroom computer ratios compared to high-FARMS schools. Schools with higher FARMS enrollment have more classrooms with five or more computers but fewer classrooms with Internet access compared to schools with lower FARMS enrollment. High-FARMS

schools have fewer teachers with classroom computers. Teachers in low-FARMS schools have slightly higher levels of technology efficacy compared to teachers in high-FARMS schools. The regression analysis indicates a statistically significant relationship between access and FARMS enrollment.

Based on the results of both the descriptive and multivariate analyses, an SES digital divide was detected.

3. There were statistically significant differences between female students and male students in terms of access to school technology for middle schools in Maryland. A comparison of means for access variables for female enrollment shows that schools with higher female enrollment have lower student-to-classroom computer ratios than low-female schools. Schools with lower female enrollment have more classrooms with five or more computers and more classrooms with Internet access compared to schools with higher female enrollment. Schools with high female enrollment also have more teachers with classroom computers and more teachers with higher levels of technology efficacy compared to schools with low female enrollment.

The regression analysis revealed no statistically significant relationship between access and female enrollment for the overall model. However, the model revealed statistically significant relationships for two variables: student-to-computer ratio (.104) and student-to-classroom computer ratio (−.114).

Based on the results of the mean differences and regression analysis, a gender digital divide was determined.

The results of the correlation analysis of the 14 use variables indicate small to moderate and positive correlations for the majority of the technology use variables. The correlations range from .175 (publish text and remediate basic skills) to .624 (display data and manipulate data).

4. There were statistically significant differences between minority and nonminority students in terms of their use of school technology in middle schools in Maryland. The descriptive results show difference levels of use for minority enrollment. Generally, schools with lower minority enrollment tend to use technology more often compared to high-minority schools, particularly for publishing text, communicating with others, connecting language to words, and remediating basic skills. More teachers in low-minority schools use technology to create instructional materials compared to teachers in high-minority schools. Teachers in high-minority schools used technology more to organize information and perform calculations compared to teachers in low-minority schools.

The regression analysis indicated a significant negative relationship between the variable connect language to words (−.097) and minority enrollment. The probability of the t statistic (−2.413) for the b coefficient (−.097) was $p \leq .017$, which is less than the level of significance of .05.

5. There were statistically significant differences between low-SES students and high-SES students in their use of school technology in middle schools in Maryland. Descriptives for technology use show differences in technology use among schools based on FARMS enrollment. Low-FARMS schools tend

to use technology more for gathering information, publishing text, performing calculations, communicating information, creating graphics, and remediating basic skills compared to high-FARMS schools. High-FARMS schools use technology more to organize information and perform measurement when compared to low-FARMS schools. Teachers in low-FARMS schools use technology more to create instructional materials compared to teachers in high-FARMS schools.

The multiple regression model indicated a significant relationship between technology use and FARMS enrollment. The adjusted R^2 value indicates that the use variables explain 11% of the variance in FARMS enrollment. The model shows five use variables that are significantly related to FARMS: organize information (−.190), publish text (−.222), connect language with words (−.174), communicate information (−.157) and teacher creates instructional materials (−.145). The levels of significance were below .05. The slopes associated with the seven use variables were not equal to zero ($b \neq 0$). The negative b coefficients associated with organizing information, publishing text, connecting language with words, communicating information, and teachers creating instructional material, indicating that less frequent use of technology for these tasks is associated with higher FARMS enrollment.

6. There were statistically significant differences between female and male students in terms of their use of school technology in middle schools in Maryland. Descriptives for technology use and female enrollment show that schools with high female enrollment tend to use technology more for gathering information, publishing text, communicating information,

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connecting language with words, remediating basic skills, and performing

calculations compared to schools with low female enrollment. Teachers in

schools with high female enrollment use technology more for creating

instructional materials compared to teachers in schools with low female

enrollment.

The multiple regression model indicated a significant relationship between

technology use and female enrollment. The model indicated significant, positive

relationships between female enrollment and communicating information (.231) and

publishing text (.134). The positive coefficients indicate that higher values for using

technology to communicate information and publishing text are associated with higher

female enrollment.

Correlations between mathematics and reading achievement are strong ($R^2 =$

.870), which implies that the variance in mathematics achievement is associated with

variance in reading achievement.

There was a statistically significant relationship between students' level of access

to school technology and their academic achievement scores on the MSA for eighth-

grade reading and mathematics. Descriptive statistics for technology access and

mathematics achievement revealed differences in group means for student-to-computer

ratios, student-to-classroom computer ratios, and teachers with classroom computers.

Low-achieving mathematics schools tended to have higher student-to-computer ratios,

higher student-to-classroom computer ratios, and fewer teachers with classroom

computers compared to higher achieving mathematics schools. High mathematics

achieving schools tended to have more Internet access in classrooms and more teachers with higher levels of technology efficacy.

The multiple regression model for technology access predicting mathematics achievement explained over 60% of variance in mathematics achievement by the access variables. Coefficients for the control variables were FARMS enrollment (−.932), minority enrollment (−.787), and female enrollment (.142). After controlling for minority, FARMS, and female enrollment, the predictor for mathematics achievement was teacher classroom computers (.162). No effects were found for student access related to mathematics achievement.

The magnitudes of the associated standard errors and t-tests for teacher classroom computer were $t(222) = 3.714$, $p \leq .001$. Hence, the null hypothesis H_07, that there is no relationship between students' level of access to school technology and their academic achievement scores on the MSA for eighth-grade reading and mathematics, was supported.

Group means for technology access and reading achievement show similar patterns when compared to mathematics achievement. On average, low-achieving reading schools tend to have higher student-to-computer ratios, higher student-to-classroom computer ratios, fewer teachers with classroom computers, and fewer classrooms with Internet access compared to high-achieving reading schools. High-achieving reading schools tend to have more teachers with higher levels of technology efficacy. Overall, low-achieving reading schools tend to have less access compared to high-achieving reading schools.

The results of the regression analysis of technology access for reading
achievement indicated that almost two-thirds of the variation (63.2%) was accounted for
by the final model. This variation is slightly lower compared to the mathematics model,
a difference of 3.9%. Minority, FARMS, and female control variables accounted for
58.1%. After controlling for minority, FARMS, and female enrollment, the predictors
accounted for 5.2% of the variance. The coefficient for teacher classroom computer
(.212) was positive, indicating a direct relationship. Higher numeric values for teachers'
access to classroom computers are associated with higher reading achievement. There
were no effects for student access and reading achievement.

Based on the results of the regression analyses, the null hypothesis $H_0 7$ was
supported. These results conclude that no significant relationship exists between student
access and mathematics and reading achievement.

8. There was a statistically significant relationship between students' level of use
of school technology and their academic achievement scores on the MSA for
eighth-grade mathematics and reading. Group means for technology use and
mathematics indicated differences in use among the groups. High-achieving
mathematics schools tended to use technology more for each activity as
compared to low-achieving mathematics schools. High-achieving
mathematics schools used technology more for gathering information,
publishing text, performing calculations, remediating basic skills, connecting
language to words, and communicating information compared to low-
achieving mathematics schools. Teachers in high-achieving mathematics

schools used technology more to create instructional materials as compared to teachers in low-achieving mathematics schools.

Multivariate analyses for technology use and mathematics achievement indicated that more than half of the variation (61%) in mathematics achievement was accounted for by the use variables. Minority, FARMS, and female enrollment accounted for 57.3%. The use predictors accounted for 6.4% of the variance. The ANOVA results indicate that the overall model significantly improves the prediction of mathematics achievement, $F(8, 220) = 43.073, p \leq .001$).

After controlling minority, FARMS, and female enrollment, the variable publishing text (.144) and connecting language with words (−.097) were statistically significant predictors. Publishing text had positive relationship with mathematics achievement, indicating that higher levels of use result in higher levels of mathematics achievement. Connecting language to words was negative, suggesting an inverse relationship in which decreases in its use tend to increase the values for mathematics achievement.

The magnitude of the associated standard errors and t-tests for publishing text were $t(222) = 2.726, p \geq .007$. The results of the regression analysis indicate significant relationships between technology use and mathematics achievement.

Group means for technology use among schools grouped by reading achievement also indicated variations in technology use. Students in high-achieving reading schools consistently use technology more to gather information, publish text, perform calculations, communicate information, create graphics, and remediate basic skills compared to students in low-achieving reading schools. Teachers in high-achieving

reading schools use technology more to create instructional materials as compared to teachers in low-achieving reading schools.

The results of the regression analysis found that the model explained over half of the variation (63.5%) in reading achievement. Minority, FARMS, and female enrollment accounted for 58.6%. The use predictors accounted for 6.8% of the variance. The results indicate that the model significantly improves the prediction of reading achievement, $F(8, 220) = 74.862$, $p \leq .001$. The variable, publishing text (.174) was a significant predictor of reading achievement.

The magnitude of the associated standard errors and t-tests for publishing text were $t(221) = 3.394$, $p \geq 001$. The results of the regression analysis indicate significant relationships between technology use and reading achievement.

The research findings reported in this chapter are further analyzed and discussed in more detail in the following chapter. Conclusions and recommendations based on the study results are also provided.

Chapter 5: Discussion, Conclusions, and Recommendations

The final chapter of this dissertation provides a brief overview of the study, including a statement of the problem and overview of the methods used. The majority of the chapter is, however, devoted to a summary and discussion of the study hypotheses and to a discussion of the results of determining the impact of the digital divide on student achievement. The chapter also includes a discussion of the limitations of this study and recommendations for further study.

Summary of the Study Problem and Methodology

The purpose of this study was twofold. The first purpose was to determine if differences in access and use of technology, a digital divide, exists in Maryland public middle schools based on student demographics of race, class, and gender, and if so, the secondary purpose was to discover how this digital divide affected student achievement as measured by state assessments in mathematics and reading. Using 2007 state technology survey data and statewide assessment data to compare middle schools in Maryland, the quantitative analyses uncovered key findings about the digital divide in schools and the relationship between technology and student achievement. As education policies continue to promote technology as a resource for school improvement, this study contributes to the existing body of educational technology research that focuses on strategies for implementing technology as an intervention for improving academic achievement.

The research findings provided in Chapter 4 clearly indicate that differences in both access to and use of technology exist in schools based on their levels of minority and FARMS enrollment, indicating a digital divide. Further analysis reveals that several

access and use variables have a significant impact on mathematics and reading achievement.

Access Divide and Race

The first hypothesis addressed the access divide and race. The results of this study indicate that there are no digital divide effects for access in schools based on levels of minority student enrollment. The mean differences for the ratio of students to classroom computers were sizable; however, the multivariate analysis did not indicate any significant effects for access and minority enrollment. This result provides encouraging evidence that the racial digital divide in access is narrowing (Warschauer & Matuchniak, 2010).

Access Divide and Socioeconomic Status

Hypothesis 2 contended that there were no differences in access among schools based on SES. However, the results of the study indicate the contrary. There is an SES access divide, where students in schools with greater access to computers in the classroom are more economically advantaged than students in schools with less access. The size of the student-to-classroom computer effect was the largest in the model. In addition, schools with higher FARMS enrollment had fewer computers for teacher use in their classrooms. These effects raise concerns given the evidence of learning improvements associated with student access in the classroom (Mann et al., 1999). However, the study did not find a significant relationship between the student-to-computer ratio and classroom Internet variables, providing further evidence that policies directed at narrowing the access divide are making progress. The federal E-Rate and

Title I programs have made an impact on the level of computer and Internet access in the less wealthy schools.

Access Divide and Gender

Hypothesis 3 was concerned with differences in access among male and female school populations. The study analyses indicate significant effects for the student-to-computer and student-to-classroom computer ratios. The positive effect for the student-to-computer ratio indicates that higher ratios (fewer computers) are associated with higher female enrollment. For the student-to-classroom computer ratio, the relationship was significant and negative. The inverse relationship indicates that a higher ratio (fewer computers in the classroom) is associated with lower female enrollment. This is not to suggest that the distribution of computers in schools is determined by gender or that these variations can be explained by differences in the levels of male and female student enrollment; rather, these results point to a gender divide in access, which disputes prior research findings that indicate that the gender gap has closed (Debell & Chapman, 2003; Wenglinsky, 2005).

Use Divide and Race

The study addressed whether different uses of technology were associated with race in Hypothesis 4. The analyses indicate a racial divide in use. The use of technology among minority students to connect language to words showed negative effects. Schools with higher minority enrollment use technology less for connecting language to words (reading activity) compared to schools with lower minority student enrollment. This is puzzling given the heavy concentration of foreign students enrolled in English as a second language (ESL) programs that would utilize this type of instruction for vocabulary

development, word recognition, and reading skill development. There is evidence that language barriers influence technology use among minority students (Fairlie, 2004; Reid, 2001).

Use Divide and Socioeconomic Status

Hypothesis 5 looked at whether differences in the use of technology varied by SES. The analyses showed an SES divide in use, with significant negative effects for economically disadvantaged students in their use of technology to organize information, communicate information, publish text, connect- language-to-words and for teachers in those schools who use technology to create instructional materials. These effects are troubling because they are associated with more sophisticated uses of technology.

Organizing information involves processing information, such as, creating databases to catalog research information. These tasks tend to develop analytical or problem-solving skill (Burns, 2006).

Communicating information involves reporting results of investigations by using word processing, e-mail, and multimedia presentations, which are relatively high-level skills and related to reading goals for language and comprehension.

The negative relationship of FARMS enrollment and use for publishing text suggests that low-SES students are less likely to use technology to plan, edit, and analyze essays and written assignments when compared to high-SES students. Publish text is identified as a high-level use for writing and composition. More recently, the Common Core Curriculum standards have included the use of technology, including the Internet, to produce and publish writing (MSDE, 2011).

As indicated in the racial divide discussion, the variations in use for connecting language to words imply that language barriers could be a factor in low-SES schools. Connecting language to words is an instructional activity for reading and comprehension. These findings support prior research that low-SES schools making the transition from drill and practice applications to more constructivist uses limit instructional goals to developing computer skills as opposed to using technology to develop deeper understanding, analysis, and critical inquiry. In addition, low SES schools may be using low-level, drill and practice applications as a result of pressures to increase student performance on State assessments (Warschauer, Knobel, & Stone, 2004; Warschauer & Matuchniak, 2010).

The study results found a negative relationship in the use of technology by teachers to create instructional materials. This inverse relationship indicates that teachers in schools with lower FARMS enrollment are creating instructional materials. This may be an indication that teachers in low-SES schools tend to use the available software, which is generally drill and practice oriented, as opposed to developing their own instructional materials that may be more challenging for their students.

This finding supports evidence cited in Maryland's technology policy plan that high-poverty schools lag behind other schools in student use of technology (MSDE, 2007). In addition, this finding has implications for Title I schools in Maryland that are currently increasing their efforts to incorporate technology into their programs.

Use Divide and Gender

This hypothesis was designed to test whether technology use differed among schools based on female enrollment. Schools with higher female enrollment tend to use

technology more for communicating information and publishing text than schools with lower female enrollment. The use of technology for communication and word processing is an essential skill in conducting research, writing, and making presentations (Warschauer & Matuchniak, 2010; Wenglinsky, 2005). This is an interesting finding and suggests that girls are using technology for higher level instructional uses compared to boys. This also has implications for schools that provide access to e-mail, online discussions, and wikis for students.

This finding is consistent with prior research on the gender divide that finds that girls use technology in different ways when compared to boys. Girls are referred to as the "preeminent communicators and networkers" (Kennedy, Wellman, & Klement, 2003, p. 166). Girls use e-mail at school more often than boys. Girls also tend to more creative and expressive, while boys are more technical and competitive (Volman et al., 2005). The study results show that the gender divide in use is shifting from previous patterns in which boys used technology far more frequently than girls (Debell & Chapman, 2003).

Effects of Access on Achievement

Hypothesis 7 explored the effects of access on student achievement in mathematics and reading. This study makes it clear that mere access to technology in and of itself does not influence student achievement. However, access is required for student and teacher interactions with technology that result in an impact on achievement. This study investigated how patterns of access are associated with levels of achievement. This approach was not found in the research literature and may be of interest for those who question how variations in access are related to achievement.

For access, controlling for race, SES, gender, FARMS, and female enrollment, the identical effect sizes for technology access and mathematics and reading achievement can be explained by their high correlation. The results indicate that there are no effects of student access on mathematics and reading achievement. The data reflect only computers that are installed in the classroom and does not account for laptop computers on carts that are brought into classrooms as needed, which is a growing practice in middle and high schools.

The positive effects of teachers with classroom computers may suggest that teachers with dedicated access have more opportunity to integrate technology into their instruction or that they are more efficient at using computers for administrative duties, which allows more time for instruction, or that teachers may be assigned computers are an incentive for productivity.

Effects of Use on Achievement

The final hypothesis of the study concerned the relationship of technology use and student achievement. This is perhaps the most important area of the study because it relates to consensus among researchers that technology can influence achievement, depending on how it is used. A goal of this study was to explore the intersection of technology use and achievement to inform instructional practice at the middle school level on strategies for using technology to close gaps in achievement.

The use of technology to plan, draft, edit, and publish text had the largest positive effects for both mathematics and reading, with higher effects for reading. These findings are consistent with results reported for studies of technology use and achievement using data from NAEP for eighth-grade mathematics, reading, and science (Wenglinsky, 2005).

Positive results are associated with the use of applications. Publishing text (word processing) is considered a high-level use of technology that is used in all subject areas and correlates to Maryland's learning goals for writing and composition as outlined in the new Common Core Curriculum for English language arts.

Proponents of constructivist approaches to technology use support the evidence that active learning and student-centered activities that encourage communication improve achievement (Means, 2010; Wenglinsky, 1998, 2005).

Using technology to connect language to words had a negative effect on mathematics achievement. Connecting language to words is a fundamental reading skill that students usually master in elementary school. In middle school, this would represent use for remediation or reading interventions for ESOL students and not generally associated with mathematics instruction. This variable also shows negative effects on the digital use divide for minority and socioeconomic enrollment.

Implications

One implication of this study for policy makers and practitioners is the awareness of the multiple digital divides that go beyond a focus on unequal numbers of physical devices (computers and Internet). Technology interventions for school improvement should also consider the social context of its students and their communities. The potential of technology to provide rewarding learning opportunities for a diverse student population requires access and meaning use to achieve the desired outcomes.

This study identifies that some variables of access and use of technology are associated with improving mathematics and reading achievement, while other variables are not. The use of technology for word processing, and information processing are

important skills for students and there are recommendations for using these skills across the curriculum (MSDE, 2003). This study did not find strong evidence of technology uses that were associated with the goals for middle school mathematics instruction. There were no associations found for performing measurements and calculations or displaying and manipulating data. These results may indicate computers and the Internet are not heavily used for mathematics instruction. Many schools use graphing calculators as tools for students in their mathematics computations.

Technology is a flexible resource and can be suited to many learning situations. These finding do not suggest that other uses of technology could be effective in improving achievement and further research may uncover additional information on many other effective uses.

Consideration of these finding may assist in technology implementation planning, school improvement planning, and professional development programs. The information provided in this study may help educators make informed decisions regarding the placement of technology to provide the most effective access for students. The findings of this study suggest that classroom access is important.

The study design may be helpful in establishing some benchmarks for evaluating technology implementation in schools that incorporate student learning outcomes, rather than an inventory of hardware and generic indicators of use. There is very little information is available on school-level technology designs and whether the designs for technology implementation produce tangible results.

At the middle school level, literacy skills are emphasized for reading, writing, and quantitative literacy across content areas, and for the integration of STEM (science,

technology, engineering, and mathematics) programs. The Maryland Middle School Committee recommends technology use in all subject areas (MSDE, 2008). Results from this study may be helpful for educators who are working on plans to integrate technology into various subjects.

The literature suggests that professional development programs for technology should support technology integration into teaching and learning through clear goals and strategies for evaluation. This study found that many teachers have the technology skills to integrate technology into the curriculum. The comparative data for technology use and achievement presented in this study may be useful in developing professional development programs and instructional planning.

Limitations of the Study

This study looked at technology in Maryland schools at one point in time, the 2007 school year. The study did not consider prior student achievement or variations in access and use over time. This approach makes it difficult to determine causality not knowing whether the technology influenced the achievement or if achievement levels influence technology use. Taking into account student achievement in prior years and comparing students' technology experiences from the first year of middle school would enhance this study's findings.

Although the study includes some information about teacher technology expertise, the study did not address teacher practice as it relates to instruction with technology. Knowledge of teacher practice in the use of technology would provide a more complete picture of technology utilization.

Typical threats to internal validity in survey research include mortality, location, instrumentation, and instrument decay (Frankel & Wallen, 2000). Mortality was not a concern because this study considered point in time as opposed to longitudinal analysis. Location did not pose a threat since the surveys were completed in schools. Instrument decay was addressed in efforts to allow adequate time to survey completion and posting. These threats, although important considerations, posed no problems for this study.

The data drawn from the MTI inventory consists of self-reported responses completed at each school by staff and not by individual teachers or students. Multiple methods of collecting data, such as observations, interviews of teachers and students, information on software use, lesson plans, and professional development programs would enhance the accuracy of the data and provide a more realistic picture of technology access and use in schools.

Conclusions

The results of this study suggest that the digital divide is complex, multi-faceted, and dynamic. Using multiple measures of access helps to visualize that access means more than just counting computers. Effective technology implementation in schools requires access to an infrastructure that can support and maintain technology for daily operation, a funding process to keep the technology current, replacing out-dated equipment. More importantly, teachers who have the content knowledge, technological skills, and motivation to use technology in the most effective ways for their students can improve learning and increase achievement. There are variations in the digital divides in schools that reflect race, socioeconomic status, and gender. This study found the access divide based on race appears to be closed, while access divides for socioeconomic status

and gender are prevalent. The digital divides in use is a concern for the less wealthy schools and the 55,732 students who attend these schools.

A lesson learned from this study is that the critical factor for realizing technology's potential for school improvement is effective use. The design of this study took a different approach for exploring effective use by exploring its relationship to learning goals and student achievement. Using the digital divide measures of student uses of technology, as opposed to categorizing use by the software application, added a new perspective on how students use technology and for what purposes. The comparisons of the State's curriculum goals to specific student technology uses helped to establish which uses are considered important. High level uses were publishing text, organizing and communicating information, while low level reading skill use for connecting language to words were considered low level uses. The study also uncovered differences in how teachers use technology to create instructional materials. These finding may represent a basis for further inquiry.

The final component of the study was to compare the impact of these digital divides on student achievement. The access divides for students do not appear to be associated with mathematics and reading achievement. The use divides for low SES schools are important areas that require attention. Teachers in these schools may not have the knowledge and skills to use technology in effective ways or may be using other strategies to improve student achievement. These SES and gender use divides reveal similar patterns to variations in student achievement when comparing low and high SES students and male and female students.

Schools are in a unique position to provide learning opportunities with technology for children who otherwise may not have those opportunities. Teachers are vitally important in shaping technological experiences for their students. This study suggests that most middle school teachers have good technology skills for integrating technology into the curriculum. Teachers should not allow the barriers of the digital divide prevent them from having high expectations for student learning through the use of technology.

Efforts to address the digital divide are ongoing. From a policy perspective, the access divide is much easier to solve than closing gaps in use divide. Closing the use divide requires different resources and strategies. It is not clear whether technology learning standards will have a significant impact on technology use. Maryland, along with other states, is in the process of evaluating student technology proficiency. These evaluations will hopefully provide additional information on how technology is used in schools and its impact on students.

For the digital divides to close, continued support is needed. Older, out-dated computers will need replacement and technical support is an integral part of any successful school technology program. If students and teachers are to rely on technology as a learning resource, they need assurance that the technology is operational and technical staff is available to remedy technical problems. Reductions in technology funding at the federal level may place greater financial responsibility on state and local districts to provide technology infrastructure support.

Given the dynamic culture of the technology industry, there will undoubtedly be new developments in the technology industry that will influence education in new and hopefully beneficial ways. As technology evolves in society, schools may find new

learning opportunities that will ensure students have the skills necessary to be productive in a digital world.

Recommendations for Further Study

Several recommendations for further study are suggested. First, an extension of this research to include elementary and high schools would provide an overall assessment of technology and its impact on learning across Maryland's public schools. A comprehensive assessment across school levels would inform decision making for technology implementation that may foster greater collaboration and long-term planning.

Second, more research is needed on technology implementation that incorporates different methodologies and more sophisticated statistical techniques. Qualitative research approaches may provide greater insight into the social context of the digital divides in schools and offer different perspectives for how students use technology. Multilevel analyses of school effects of technology. This approach may uncover more information about technology use in schools by investigating within-school effects of technology on achievement. Path analyses could visualize the digital divide relationships and help uncover direct and indirect relationships of access, use, and achievement.

Evaluation studies of technology implementation models would help both policy makers and teachers who seek guidance in determining which strategies are effective and whether new ideas hold promise for improving student learning. These models could also inform professional development programs by helping to extend programs beyond fundamental training programs to more advanced levels of technology integration and constructivist approaches that utilize technology to create higher-order learning environments in the classroom.

Finally, research is needed to document the constructivist learning approaches that incorporate technology. The research evidence indicates this approach offers the most potential for using technology to increase achievement. As mentioned, very little is known about how middle schools are employing higher-order thinking skills and problem-solving instruction with technology. This information may prescribe effective uses of technology that are tailored to student needs, learning styles, cultural background, and interests.

APPENDICES

Appendix A: Maryland Technology Inventory

Maryland Online Technology Inventory

User Profile

School Profile

Please provide, verify and/or amend the following general information about your school in each text box.

School Name:

Street:

City:

State:

Zip:

Phone:

Fax:

Principal's Name

Principal's Email

School Web Site

Person Completing Survey:

Name:

Position:

Email:

Section 1:   School Profile

1.1 School Profile

1.   Please type in the total number within your school for the following.

Students*:

Teachers:

Classrooms**:

Offices:

Library Media Center:

Stationary Computer Labs***:

Mobile Computer Labs***:

Definitions

Students* - Please use your September 30 enrollment count. If you have no official enrollment count, you may enter zero.

Classrooms** - Any room where instruction takes place on a regular basis (this could include the gym, reading resource room, auditorium, etc.)

Stationary Computer Labs*** - Fixed locations containing multiple computers for sign-up use by classes or groups of individuals (not a lab where classes are assigned to meet every day – count this as a classroom.

Mobile Computer Labs**** - Portable carts containing multiple laptop computers that can be transported to a variety of locations.

Section 2:   Equipment Information

2.1 Equipment Count

Please answer every question in this section. If the answer is zero please enter a zero.

Definitions

PC: Personal desktop computer having a Pentium II processor or higher (or a Macintosh G3 or higher), 64 MB of RAM or higher

Laptops: A portable battery or AC-powered personal computer with an attached screen, having a Pentium II processor or higher and that can be used in a variety of temporary locations)

Portable Computing Devices: Small computerized devices that are designed for mobile computing (e.g. PDAs, portable word processors, and other handheld devices), running the Palm, Microsoft CE or Microsoft Pocket PC operating systems. Do not include graphing calculators.

Projection Devices: Devices that connect to a computer and display an enlarged image on a screen (e.g. computer/video projectors, large television monitors used to display computer screens [27” or larger], LCD panels)

Telephones: Phone jacks with telephone units attached, phones connected through data lines (IP telephony), and school-issued cell phones. Cell phones assigned to teachers should be included in the classroom count and those assigned to administrators in the office count

Stationary Computer Labs: Fixed locations containing multiple computers for sign-up use by classes or groups of individuals (not a lab where classes are assigned to meet every day – count this as a classroom)

Mobile Computer Labs: Portable carts containing multiple laptop computers that can be transported to a variety of locations

1.   Indicate the number of PCs in each location.

Offices Classrooms Library Media Center Stationary Computer Lab Mobile Computer Lab

2.   Indicate the number of Laptops in each location.

Offices Classrooms Library Media Center Stationary Computer Lab Mobile Computer Lab

3.   Indicate the number of Portable Computing Devices in each location.

Offices Classrooms Library Media Center Stationary Computer Lab Mobile Computer Lab

4.   Indicate the number of Projection Devices in each location.

Offices Classrooms Library Media Center Stationary Computer Lab Mobile Computer Lab

5.   Indicate the number of Telephones in each location.

Offices Classrooms Library Media Center Stationary Computer Lab Mobile Computer Lab

2.2 Computer Access in Classrooms

1.   How many classrooms have at least one computer or laptop for teacher use on a permanent basis? (The computer/laptop may be for teacher use only or shared with students) A "Computer" is a personal desktop computer having a Pentium II processor or higher (or a Macintosh G3 or higher), 64 MB of RAM or higher. A laptop is a portable battery or AC-powered personal computer with an attached screen, having a Pentium II processor or higher (or a Macintosh G3 or higher), 64 MB of RAM or higher and that can be used in a variety of temporary locations.

2.   How many classrooms have at least one computer or laptop for student use on a permanent basis? (The computer/laptop may be for student use only or shared with teacher. Be sure to include in this count any classrooms counted in the above question that have computers shared by teachers and students.) A "Computer" is a personal desktop computer having a Pentium II processor or higher (or a Macintosh G3 or higher), 64 MB of RAM or higher. A laptop is a portable battery or AC-powered personal computer with an attached screen, having a Pentium II processor or higher (or a Macintosh G3 or higher), 64 MB of RAM or higher and that can be used in a variety of temporary locations.

3. How many classrooms have at least 5 computers or laptops for student use on a permanent basis? (Be sure to include those counted in question above) A "Computer" is a personal desktop computer having a Pentium II processor or higher (or a Macintosh G3 or higher), 64 MB of RAM or higher. A laptop is a portable battery or AC-powered personal computer with an attached screen, having a Pentium II processor or higher (or a Macintosh G3 or higher), 64 MB of RAM or higher and that can be used in a variety of temporary locations.

2.3 Equivalent Access Standards

1.   Has your staff received information on the requirement that the equivalent access standards (Subpart B Technical Standards, Section 508 of the Rehabilitation Act of 1973, as amended) must be included in the evaluation and selection of technology-based instructional products?

Yes

No

Done Centrally

2.   Is your school monitoring the result of the evaluation and selection of technology-based instructional products, including a description of the accessible and non-accessible features and possible applicable alternative methods of instruction correlated with the non-accessible features?

Yes

No

Done centrally

Section 3: Network Access and Capabilities

1.   Check all locations where the listed capability exists.

Internet Access

TV/Video Reception

Wireless LAN Coverage

Wired for voice access (either through phone jack or IP telephony)

Location: Offices   Library Media Center

2.   Enter the total number of classrooms, stationary computer labs and mobile computer labs that have the following.

Please answer every question. If the answer is zero please enter a zero.

Internet Access

TV/Video Reception

Wireless LAN coverage

Wired for voice access (either through phone jack or IP telephony)

3.   Choose the category of WAN (Wide Area Network) connection that connects each of the listed locations in your school to the Internet

Offices   Classrooms (majority of classrooms)   Library/Media Center   Stationary Computer Labs   Mobile Computer Labs

Low Capacity: (Dial-up modem),   ISDN,   56K Frame Relay – less than 1.5 mbs)

Medium Capacity: (T-1,DSL,   Wireless – 1.5 mbs – 11 mbs)

High Capacity: (Multiple T-1,   T-3,   Cable Modem, Wireless – greater than 11 mbs but less than 45 mbs)

Very High Capacity: (ATM [Asynchronous Transfer Mode],   fiber optic – 45 mbs or greater)

4.   Our school's TV/Video reception is through (check all that apply)

Cable TV

Closed Circuit/Media Retrieval System

Satellite Dish

Distance Learning Network

Antenna

5.   The following types of Home/School communication systems are in place in our school (Check all that apply)

Voice Broadcast Bulletins (s system that dials a list of phone numbers and plays a recorded voice message)

Voice Mail

School Web Site (current within 3 months)

E-Mail

Other   (Specify)

6. Check any of the technology resources that are available for student or community use after school hours. (check all that apply)

Computer Lab

Library/Media Center

Classrooms

Other   (Specify)

Section 4: Assistive Technologies

4.1 Assistive Technologies

1.   Is assistive technology (e.g. portable word processors and braillers, electronic communication aids for speech, or computers with adaptive devices) used by teachers in your school for student with disabilities or students with learning difficulties? (Select the answer that best reflects the situation in your school)

Yes, for both students with disabilities who have an Individualized Education Plan or a 504 Plan and for students who experience difficulties learning but do not receive special education services or support thorough a 504 Plan

Yes, primarily for students with disabilities who have an Individualized Education Plan or a 504 Plan.

No, most teachers are not aware of these options.

No, most teachers are aware of these options but have not been trained on how to use with students.

No, there is not a clear process in place in our school for obtaining assistive technology

Section 5: **Support, Maintenance and Professional Development**

5.1 Support

1.   Which school-based employees provide the PRIMARY technical support (e.g. network administration, troubleshooting, and maintenance) for the equipment and network in your school? (choose one answer)

A staff member or technology coordinator as a full time job

A staff member or technology coordinator as a part-time assignment

School Library Media Specialist as part of additional job responsibilities

One or more staff members on a voluntary or ad hoc basis

School-based support is not available

2.   Which non school-based employees provide the PRIMARY technical support (e.g. network administration, troubleshooting, and maintenance) for the equipment and network in your school? (choose one answer)

Central Office

Vendor Contract

Students

Parents or Volunteers

Other support not available

3.   Which school-based employees provide the PRIMARY instructional support (e.g. professional development and lesson planning) for the use of technology to teachers in your school? (Choose one answer)

A staff member or technology coordinator as a full time job

A staff member or technology coordinator as a part-time assignment

School Library Media Specialist as part of additional job responsibilities

One or more staff members on a voluntary or ad hoc basis

School-based support is not available

4.   Which non school based employees provide the PRIMARY instructional support (e.g. Professional development and lesson planning) for the use of technology to teachers in your school? (Choose one answer)

Central Office staff members

Vendor Contract

Students

Parents or volunteers

Other support is not available

Section 6: Expertise of Teachers

For the following questions, please collect information on (or estimate) the percentage of teachers with the following levels of expertise. The percentages must add up to 100%.

To collect more accurate data, you may wish to take a "straw-poll" (show of hands) at a faculty meeting. If you have a school-wide email system, you may wish to email the following definitions to your teachers, asking them to reply indicating the categories that apply to them.

6.1 Personal Computer Use

1.   Novice Users – Can start a computer and work with desktop icons, use computers for administrative tasks such as e-mail and word processing.

%

2.   Intermediate Users – Understands file organization. Uses computer utilities to browse file structure. Knows how to backup files.

%

3.   Advanced Users – Able to attach printer or scanner. Able to upload digital files. Able to distinguish between or software error conditions.

%

6.2 Internet Use

1.   Novice Users – Use the web browser to go to specific Web site, able to search web and locate resources.

%

2.   Intermediate Users – Able to design classroom or homework activities for students, which require the students to use the Internet as a reference resource.

%

3.   Advanced Users – able to publish to the web; able to design an activity which requires students to publish to the web; able to develop an Internet activity such as WebQuest, or use a course management platform such as Blackboard, Centricity, ecollege.

%

6.3 Integration of Technology into the Curriculum and Instruction

1.   Novice Users – Uses software and/or networked resources with students in a supported lab or Library Media Center setting.

%

2.   Intermediate Users – Uses productivity tools, such as word processing and spreadsheets, to develop lesson plans. Able to help students use instructional software and access Web sites.

%

3.   Advanced users – Able to develop and deliver technology-infused lesson plans. Comfortable using instructional software with students.

%

Section 7: Student use of technology for learning activities

7.1 Technology use by students.

To collect more accurate data, you may wish to take a "straw poll" (a show of hands) at a faculty meeting.

Is technology used by students in your school to (choose one answer)

1.   Gather information /data from a variety of sources (e.g. via Internet, world Wide Web, Online services, CD-ROM-based reference software)

Every day or almost every day

A few times per month

A few times per year

Never

2.   Organize and store information (e.g. creating databases or spreadsheet files)

Every day or almost every day

A few times per month

A few times per year

Never

3.   Perform measurements and collect data in investigations or lab experiments (e.g. using probes and sensors)

Every day or almost every day

A few times per month

A few times per year

Never

4.   Manipulate/analyze/interpret information or data to discover relationships, generate questions, and/or reach conclusions (e.g. sorting databases or spreadsheet files, using electronic graphic organizers)

Every day or almost every day

A few times per month

A few times per year

Never

5.   Communicate/report information, conclusions, or results of investigations (e.g. in word processing documents, e-mail, online discussion areas, multimedia presentations, or on a web site)

Every day or almost every day

A few times per month

A few times per year

Never

6.   Display data/information (e.g. using charts, graphs, maps)

Every day or almost every day

A few times per month

A few times per year

Never

7.   Communicate/interact with others in the classroom/school/outside of school (e.g. using e-mail, bulletin boards, discussion areas)

Every day or almost every day

A few times per month

A few times per year

Never

8.   Plan, draft, proofread, revise and publish text

Every day or almost every day

A few times per month

A few times per year

Never

9.   Create graphics or visuals (e.g. diagrams, pictures, figures)
Every day or almost every day

A few times per month

A few times per year

Never

10.   Plan, refine, produce multimedia presentations

Every day or almost every day

A few times per month

A few times per year

Never

11.   Generate original pieces of visual art and/or musical composition

Every day or almost every day

A few times per month

A few times per year

Never

12.   Perform calculations (e.g. graphing calculators or spreadsheets)

Every day or almost every day

A few times per month

A few times per year

Never

13.   Develop a more complete understanding of complex materials or abstract concepts (e.g. through visual models, animations, simulations)

Every day or almost every day

A few times per month

A few times per year

Never

14.   Connect auditory language to the written word and/or graphic representations (for the emerging reader)
Every day or almost every day

A few times per month

A few times per year

Never

15.   Design and produce a product (Computer-aided manufacturing)

Every day or almost every day

A few times per month

A few times per year

Never

16.   Control other devices (robotics)

Every day or almost every day

A few times per month

A few times per year

Never

17.   Support individualized learning or tutoring (e.g. using computer or Web-based modules or courses)

Every day or almost every day

A few times per month

A few times per year

Never

18.   Remediate for basic skills (e.g. using drill and practice or tutorial software) Irregular basic tool use and drill and practice, integrated learning labs

Every day or almost every day

A few times per month

A few times per year

Never

19.   Accommodate for a disability or limitation (e.g. using assistive technology devices or software)

Every day or almost every day

A few times per month

A few times per year

Never

Section 8: Administrative and Productivity use of technology by school administrators

8.1 Administrative and productivity use of technology by school administrators

To collect more accurate data, you may wish to take a "straw poll" (a show of hands) at a faculty meeting.

How often do administrators in your school use technology for the following purposes?

1.   Communicating with staff members and other colleagues (e.g. via e-mail or discussion areas)

Every day or almost every day

A few times per month

A few times per year

Never

2.   Communicating with parents/guardians of students (e.g. via e-mail, telephone homework hotline).

Every day or almost every day

A few times per month

A few times per year

Never

3.   Posting/viewing/accessing school/district announcements or information (e.g. via Web site or electronic bulletin boards)

Every day or almost every day

A few times per month

A few times per year

Never

4.   Participating in on-line discussion groups or collaborative projects

Every day or almost every day

A few times per month

A few times per year

Never

5.   Diagnosing and placing students (e.g. via a student information system or computer-based test)

Every day or almost every day

A few times per month

A few times per year

Never

6.   Analyzing attendance and/or grades

Every day or almost every day

A few times per month

A few times per year

Never

7.   Analyzing tests

Every day or almost every day

A few times per month

A few times per year

Never

8.   Analyzing grades and progress reports

Every day or almost every day

A few times per month

A few times per year

Never

9.   Maintaining data on students (e.g. in a student information system, or database/spreadsheet files)

Every day or almost every day

A few times per month

A few times per year

Never

10.   Analyzing and/or reporting student/school improvement data (e.g. using the mdk12.org Web site)

Every day or almost every day

A few times per month

A few times per year

Never

11.   Creating instructional materials/visuals/presentations

Every day or almost every day

A few times per month

A few times per year

Never

12. Accessing curriculum/school improvement material from the Internet or school system Intranet

Every day or almost every day

A few times per month

A few times per year

Never

13. Researching educational topics on interest (e.g. via the Web, listservs, or e-mail)

Every day or almost every day

A few times per month

A few times per year

Never

14. Handling inventory, lockers, field trips or bus schedules

Every day or almost every day

A few times per month

A few times per year

Never

Section 9: Administrative and Productivity use of technology by Teachers

9.1 Administrative and productivity use of technology by teachers.

To collect more accurate data, you may wish to take a "straw poll" (a show of hands) at a faculty meeting.

How often do teachers in your school use technology for the following purposes?

1.   Communicating with staff members and other colleagues (e.g. via e-mail or discussion areas)

Every day or almost every day

A few times per month

A few times per year

Never

2.   Communicating with parents/guardians of students (e.g. via e-mail, telephone homework hotline).

Every day or almost every day

A few times per month

A few times per year

Never

3.   Posting/viewing/accessing school/district announcements or information (e.g. via Web site or electronic bulletin boards)

Every day or almost every day

A few times per month

A few times per year

Never

4.   Participating in on-line discussion groups or collaborative projects

Every day or almost every day

A few times per month

A few times per year

Never

5.   Diagnosing and placing students (e.g. via a student information system, a curriculum management system, or a computer-based test)

Every day or almost every day

A few times per month

A few times per year

Never

6.   Maintaining attendance and/or grades

Every day or almost every day

A few times per month

A few times per year

Never

7.   Generating and administering tests

Every day or almost every day

A few times per month

A few times per year

Never

8.   Calculating grades and generating progress reports

Every day or almost every day

A few times per month

A few times per year

Never

9.   Maintaining data on students (e.g. via a student information system, computer-based test or instructional or curriculum management system)

Every day or almost every day

A few times per month

A few times per year

Never

10.	Analyzing and or reporting student/school improvement data (e.g. using instructional and curriculum management systems)

Every day or almost every day

A few times per month

A few times per year

Never

11.	Creating instructional materials/visuals/presentations
Every day or almost every day

A few times per month

A few times per year

Never

12.	Accessing curriculum/school improvement material from the internet or school system Intranet

Every day or almost every day

A few times per month

A few times per year

Never

13.	Researching educational topics of interest (e.g. via the Web, listservs, or e-mail)

Every day or almost every day

A few times per month

A few times per year

Never

14.	Handling inventory, field trips

Every day or almost every day

A few times per month

A few times per year

Never

15.   Use a course management system (such as Blackboard, ecollege, WebCT) or collaboration tool (such as FirstClass) to support the delivery of instruction and facilitate communication with students

Every day or almost every day

A few times per month

A few times per year

Never

Section 10: Home Access

10.1 Home Access to the Internet

1.   What percent of the students in your school have access to the Internet in their homes?

2.   How did you arrive at this percent? (choose one answer)

Estimation

Survey of Students

Survey of Parents

Other (Specify)

Appendix B: Descriptives from the Maryland Technology Inventory for Middle Schools in the Digital Divide Study

Variables	N	M	SD
Schools	229 (15.9%)		
Students	178143 (20.9%)	778.00	249.88
Gender:			
Female	86551 (49%)	377.95	124.92
Male	91592 (51%)	399.97	127.73
Total	178143		
Race:			
American Indian	713 (0.4%)	3.58	2.77
Asian Pacific	9902 (6.0%)	44.81	56.74
African American	62670 (35.0%)	273.67	256.16
Hispanic	14139 (8.0%)	63.12	84.37
	87424		
White	90726 (51.0%)	396.18	296.86
	178150		
Socio-economic Status: FARMS enrollment	55732 (31.3%)	243.37	165.99
Teachers	12617 (21.1%)	55.34	16.10
Classrooms	11041	48.43	12.21
Computer labs	1217	5.34	51.97
Mobile labs	372	1.63	3.75
	1589		
PCs			
in classroom	23085	101.25	63.07
in library	4457	19.46	10.88
in computer lab	11252	49.14	33.68
in mobile lab	438	1.91	9.83
	39232		
Laptops:			
in classroom	2593	11.32	18.64
in library	340	1.48	3.71
in computer lab	32	0.14	0.49
in mobile lab	5108	22.31	29.90
	8073		
Total computers	47305	207.46	84.70
Total classroom computers	25678		
Classroom computers:			
%Teacher pc	10397	45.40	14.36
%At least 1 student pc	8330	36.38	19.47
%At least 5 student pcs	975	4.26	7.18
Internet:			
in classrooms	10708 (97%)	46.76	12.56
in labs	391	1.71	1.02
in mobile lab	293	1.28	1.75
% home internet	16853.93	73.60	20.63
Teacher Tech Expertise:			
%PC novice	5028	21.96	18.38
%PC intermediate	11643	50.84	18.47
%PC advanced	6229	27.20	15.54

Variables	N	M	SD
%Internet novice	6001	26.21	19.18
%Internet intermediate	12871	56.21	18.07
%Internet advanced	4022	17.56	11.40
%Integration novice	5640	24.63	16.59
%Integration intermediate	11175	48.80	17.05
%Integration advanced			
	6070	26.51	15.23

Appendix C: Contingency Tables for Technology Use and Minority School Enrollment - Frequencies and Percentages – N=229

Use	Low – Minority Schools (N = 75)	Middle - Minority Schools (N = 76)	High - Minority Schools (N = 78)	Total (N = 229)
Treatment	%	%	%	%
Gather information				
Never	0	0	.4	.4
Few times/ year	2.6	1.7	1.3	5.7
Few times/ month	7.0	10.0	12.2	29.3
Every day	23.1	21.4	20.1	64.6
Total	32.8	33.2	34.1	100.0
Organize information				
Never	.4	0	.4	.9
Few times/ year	10.9	14.8	10.0	35.8
Few times/ month	16.2	10.9	18.3	45.4
Every day	5.2	7.4	5.2	17.9
Total	32.8	32.2	34.1	100.0
Perform measurement				
Never	2.6	3.9	5.7	12.2
Few times/ year	12.2	14.8	12.2	39.3
Few times/ month	15.3	12.2	12.7	40.2
Every day	2.6	2.2	3.5	8.3
Total	32.8	32.2	34.1	100.0
Manipulate data				
Never	.4	.4	2.2	3.1
Few times/ year	16.2	14.8	16.2	47.2
Few times/ month	13.5	14.8	12.2	40.6
Every day	2.6	3.1	3.5	9.2
Total	32.8	33.2	34.1	100.0
Communicate with others	.0	.4	1.7	2.2
Never	7.0	6.1	6.6	19.7
Few times/ year	13.1	16.2	16.2	45.4
Few times/ month	12.7	10.5	9.6	32.8
Every day	32.8	33.2	34.1	100.0
Total				
Display data				
Never	.4	.0	.9	1.3
Few times/ year	10.5	10.9	10.5	31.9
Few times/ month	16.6	14.4	16.6	47.6
Every day	5.2	7.9	6.1	19.2
Total	32.8	33.2	34.1	100.0

Use	Low – Minority Schools (N = 75)	Middle - Minority Schools (N = 76)	High - Minority Schools (N = 78)	Total (N = 229)
Create graphics				
Never	.0	.0	.4	.4
Few times/ year	8.7	10.0	8.7	27.5
Few times/ month	16.6	15.3	14.4	46.3
Every day	7.4	7.9	10.5	25.8
Total	32.8	33.2	34.1	100.0
Perform calculations				
Never				
Few times/ year	1.7	0	3.5	5.2
Few times/ month	4.8	7.9	8.7	21.4
Every day	11.4	9.6	10.9	31.9
Total	14.8	15.7	10.9	41.5
	32.8	33.2	34.1	100.0
Understand complex material				
Never	3.9	.9	7.4	12.2
Few times/ year	13.5	17.0	13.1	43.7
Few times/ month	12.2	14.4	11.4	38.0
Every day	3.1	.9	2.2	6.1
Total	32.8	33.2	34.1	100.0
Individualized learning				
Never				
Few times/ year	3.9	.9	4.4	9.2
Few times/ month	9.6	9.2	11.4	30.1
Every day	8.7	13.1	10.9	32.8
Total	10.5	10.0	7.4	27.9
	32.8	33.2	34.1	100.0
Remediate basic skills				
Never				
Few times/ year	1.3	2.2	3.1	6.6
Few times/ month	7.0	6.6	7.4	21.0
Every day	10.9	11.4	10.5	32.8
Total	13.5	13.1	13.1	39.7
	32.8	33.2	34.1	100.0
Publish text				
Never	.0	.0	1.3	1.3
Few times/ year	3.5	2.6	3.5	9.6
Few times/ month	13.5	12.7	15.3	41.5
Every day	15.7	17.9	14.0	47.6
Total	32.8	33.2	34.1	100.0
Connect language to words				
Never	4.4	2.6	9.2	16.2
Few times/ year	9.2	11.8	11.8	32.8
Few times/ month	9.2	10.5	7.0	26.6
Every day	10.0	8.3	6.1	24.5
Total	32.8	33.2	34.1	100.0
Teacher creates instructional material				

Use	Low – Minority Schools (N = 75)	Middle - Minority Schools (N = 76)	High - Minority Schools (N = 78)	Total (N = 229)
Never				
Few times/ year	.0	.0	0	.0
Few times/ month	1.7	.9	2.2	4.8
Every day	4.4	5.2	8.7	18.3
Total	26.6	27.1	23.1	76.9
	32.8	33.2	34.1	100.0

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