EXAMINING THE DIGITAL DIVIDE: THE IMPACT OF SCHOOL DISTRICT TECHNOLOGY RESOURCES ON HIGH SCHOOL STUDENT, ONLINE, 2010-2011 END-OF-COURSE EXAM PERFORMANCE IN MISSOURI

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By

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DECEMBER, 2015
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EXAMINING THE DIGITAL DIVIDE: THE IMPACT OF SCHOOL DISTRICT
TECHNOLOGY RESOURCES ON HIGH SCHOOL STUDENT, ONLINE, 2010-2011
END-OF-COURSE EXAM PERFORMANCE IN MISSOURI

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Kevin R. Whaley
Dr. Timothy J. Wall, Dissertation Supervisor

ABSTRACT

The purpose of this study was to examine the digital divide by determining the main effects and interaction effects between Missouri school district technology variables and student End-of-Course exam performance. A secondary purpose was to attempt to construct a predictive model for Missouri End-of-Course exam performance at or above the state average based on school district technology variables. The measurements used in the study included school district responses to the Missouri Census of Technology and district level Missouri Algebra I and Communications Arts I End-of-Course exam assessment data. A research methodology employing statistical analysis, correlation analysis, and Multivariate Analysis of Covariance (MANCOVA) was used to investigate the impact of Missouri school district technology variables on End-of-Course exam performance.
CHAPTER 1

Introduction to the Study

This study investigated the digital divide by examining the relationship between Missouri public school district technology variables and performance on End-of-Course exams by public high school students from selected districts across the state of Missouri. School district technology variables investigated in this study included: (a) dollars per student spent on technology, (b) student to instructional computer ratios, (c) the existence of district-adopted technology standards, (d) technology proficiency levels of administrative and teaching staff, (e) average age of instructional computers, and (f) Internet bandwidth speed. This chapter provides background information, examines the conceptual underpinning that guides the study, identifies the problem statement and research questions, addresses the purpose of the study, lists the research hypotheses and limitations of the study, and defines key terms to be utilized in the study.

These variables were measured by school district responses to the Missouri Department of Elementary and Secondary Education Census of Technology portion of the Missouri Core Data Collection system. The Missouri Core Data system is a data collection tool used to update information about school districts. The Census of Technology portion of the Core Data system is designed to assess Missouri’s investment in school technology and provide important data to help advance public policy, increase public awareness, and support of technology. It also aids school districts in identifying local needs, developing strategies to facilitate school improvement processes, and comparing district progress with statewide data.
Background

In 1983, the National Commission on Excellence in Education published a report titled *A Nation at Risk: The Imperative for Educational Reform*. This report was credited with fostering the belief that America’s schools were failing, reform was needed, and accountability on the part of schools was the answer. This belief was reinforced in 2001 when the United States Congress passed the No Child Left Behind Act (Cong., 2001), which required states to create assessments, test students’ knowledge of basic skills, and ensure students’ mastery of those basic skills in order to receive federal funding. The passing of the Act perpetuated an assessment frenzy as states endeavored to find ways to assess a greater number of students than ever. To help accomplish this, many states utilized technology, which resulted in an increasingly large number of standardized assessments being delivered online.

One example of a state increasing its online standardized test administration is Missouri. The Missouri Department of Elementary and Secondary Education (MoDESE) began to move its Missouri Assessment Program (MAP) assessments online at the high school level in the spring of 2009. Some districts chose to administer the End-of-Course (EOC) assessments online in the initial year. Full online test administration by all districts took place (except by students in those districts who have alternative test form requirements indicated in their academic records) the following year. By the spring of 2015, four required EOC assessments in English, math, science, and social studies were administered online, and some grade level tests at the elementary level were also administered in an online format. These assessments, were taken by students in grades 3-12, were more rigorous when compared to the previous generation MAP tests, and
required a higher degree of technical knowledge and skill in the area of computer use (Smarter Balanced Assessment Consortium, 2012).

Administering standardized assessments online in Missouri creates several challenges for districts that are not found with paper-pencil testing. These challenges include addressing the basic logistics for giving assessments online for a very large number of students in an environment of finite technology resources. Further, the assessments not only evaluate students’ content knowledge, but also their technical computing ability (Smarter Balanced Assessment Consortium, 2012). Also, the quantities of technology infrastructure and personnel resources vary among school districts and schools. Therefore, there are many questions surrounding the impact these challenges may have on student online exam performance. This study evaluated the existence, or non-existence, of inequities in technology across Missouri school districts (and the relationships these inequities have with student assessment scores) by examining Missouri school district technology variables and comparing student performance on online EOC exams among Missouri school districts.

**Conceptual Underpinning**

The conceptual underpinning of this study utilized research pertaining to the digital divide, or the unequal distribution of technology in a society. Attewell (2001) and Clark and Gorski (2001) further defined this concept by describing the digital divide as the unequal distribution of technology in a society resulting from inequalities in access to computers and the Internet between groups of people based on one or more social or cultural identifiers. However, the unequal distribution of technology not only exists between demographic groups in a society, but also between schools and school districts.
For the purposes of this study, the term digital divide refers to the unequal distribution of technology among public school districts. More specifically, this study was guided by research pertaining to the first level digital divide identified in Hohlfeld, Ritzhaupt, Barron, and Kemker’s (2008) research, which focused on the equitable access to hardware, software, the Internet, and technology support within schools. Under their model, Hohlfeld et al. (2008) asserted that the empowerment of students and high student achievement cannot be reached unless equitable access exists. The concepts within their model were reinforced by several studies regarding the importance of eliminating the digital divide in order to increase overall student achievement (Brown, 2000; Huang & Russell, 2006; Morse, 2004; Ritzhaupt et al., 2013).

**Rationale for the Study**

The results of prior studies regarding the digital divide and the use of technology to increase student achievement are mixed and contradictory, as evidenced by research (Attewell, 2001; Newhouse, 2011; Ricketts & Wilks, 2002). For this reason, the continued study of the relationship between technology and student achievement continues to be of value in order to seek more clarity of this issue (Shapley, Sheehan, Maloney, & Caranikas-Walker, 2011). Further, there is a lack of information regarding the relationship between the digital divide, school district provided resources, and student performance on online assessments in Missouri. More research on this relationship may enable state departments of education and school districts who administer online assessments to determine how various technology components impact test performance.

Figure 1 provides a visual overview of the components of this study.
Figure 1. Graphical Representation Depicting Major Components of this Study
Statement of the Problem

The MoDESE uses the Missouri School Improvement Program (MSIP) to review and accredit its school districts. The MSIP entered its fifth version in 2013 and bases approximately 67% of a school district’s accreditation score on standardized assessment data (Missouri Department of Elementary and Secondary Education, 2014b). In short, if a school district fails to perform well on standardized assessments, it will affect their accreditation status. Not only does accreditation status affect certain types of school funding, but it also affects the perception of the school district, staff, and community as a whole.

Due to the role student assessment performance plays in achieving accreditation in Missouri, it is imperative students perform at high levels on state standardized assessments. Because the majority of standardized assessments in Missouri will soon be administered solely online, it is important to determine whether district technology variables play a role in student performance on those assessments. While early uses of technology for assessment focused on efficiency and cost reductions, computer-based assessments in the future will measure complex forms of learning as well as content knowledge (Pellegrino & Quellmalz, 2010). In order for students to be able to demonstrate mastery of these complex forms of learning, there must be a pedagogical shift in how students are taught (Newhouse, 2011). However, this pedagogical shift is difficult to achieve if teachers do not have the technology resources needed to do so.

Although a large quantity of research exists regarding technology in schools, the digital divide, and accountability, there is a lack of information about the relationship between school district technology variables and student assessment performance
Shapley, Sheehan, Maloney, and Caranikas-Walker (2011) indicated that the study of the relationship between technology and student achievement continues to be of value in order to seek more clarity of this issue. Also, while research exists that indicates there is a connection between the digital divide, technology in schools, and student achievement (Brown, 2000; Huang & Russell, 2006; Morse, 2004; Protheroe, 2005; Ritzhaupt, Feng Liu, Dawson, & Barron, 2013), Ritzhaupt et al. (2013) indicated a need for future study of all possible variables relating to the issue of the digital divide in schools in order to learn more about its impact on student achievement.

To fill the gap in the research, this study investigated the relationship between Missouri school district technology variables and student performance on online EOC exams within the context of the digital divide. To determine if district technology variables were related to student assessment performance, the researcher determined the main effects and interaction effects between Missouri school district technology variables, as measured by district responses to the Census of Technology, and student EOC exam performance data. Further, the researcher attempted to construct a predictive model for Missouri EOC exam performance at or above the state average based on school district technology variables in order to establish a better understanding of which, and to what extent, district technology variables impact student achievement. This research was necessary because the relationships between school district technology variables and student assessment performance was unclear. This study provided additional knowledge regarding these relationships. Ultimately, this study aimed to synthesize past and future research in order to provide additional information regarding the existence of a digital divide in Missouri’s schools and the impact it has on student achievement.
Standardized Examinations and Covariates Utilized in this Study

There are four MAP standardized assessments that were utilized in this study, two of which were used as covariates. A third covariate was also used as well.

The MAP Overview

The MAP measures how well students acquire essential knowledge and skills described in Missouri’s Learning Standards (Missouri Department of Elementary and Secondary Education, 2014a). The MAP also provides information to districts and the state regarding the overall quality of education being provided. Standardized assessments under this program are given in grades 3-12 via a variety of K-8 grade level tests and 9-12 subject area tests. For all assessments, student performance is reported in terms of four performance (or achievement) levels with Advanced and Proficient being the highest two levels and Basic and Below Basic being the lowest two. These performance levels are used to calculate approximately 67% of a school district’s accreditation score on standardized assessment data (Missouri Department of Elementary and Secondary Education, 2014a).

English I and Algebra I End-of-Course Exams

For this study the researcher used overall district achievement data from two EOC assessments taken during the 2010-2011: Algebra I and English I. These two assessments are generally taken upon completion of 9th grade level Communication Arts and Algebra courses. Data from these exams is publically available on the MoDESE website. Data from 2010-2011 was chosen due to the fact that this was the first year that all EOC exams were required to be administered in an online format by all Missouri school districts (Missouri Department of Elementary and Secondary Education, 2014a).
**Grade 8 Communication Arts and Grade 8 Math MAP Assessments**

For this study, the researcher used overall district achievement data from two MAP assessments taken during the 2009-2010 school year: Grade 8 Communication Arts and Grade 8 Mathematics. These two assessments are generally taken at the end of a student’s 8th grade year. Data from these exams is publically available on the MoDESE website. This study utilized district level achievement data from these two assessments as covariates to account for differences in independent variables and uncontrollable student variables by accounting for prior test performance by one cohort of students. The covariance analysis helped control for these differences (Pasternack & Charen, 1969; Wildt & Ahtola, 1978).

**Socio-Economic Status**

There is a large amount of research that affirms a strong relationship between socio-economic status and student achievement (Caro, McDonald, & Willms, 2009; Ewumi, 2012; Perry, 2012). This study utilized district level free and reduced lunch percentages from 2010-2011 as a covariate to account for differences in independent variables and uncontrollable student variables by accounting for socio-economic status. The covariance analysis helped control for these differences (Pasternack & Charen, 1969; Wildt & Ahtola, 1978). Data regarding school district free and reduced lunch rate was publically available on the MoDESE website.

**Purpose of the Study**

The purpose of the study was to examine the digital divide by determining the main effects and interaction effects between Missouri school district technology variables and student EOC exam performance. A secondary purpose was to attempt to construct a
predictive model for Missouri EOC exam performance at or above the state average based on school district technology variables.

**Research Questions and Hypotheses**

The following questions were developed in order to guide the study:

Research Question 1: What are the descriptive statistics for all variables under study within Missouri public school districts?

Research Question 2: Is there a relationship between Missouri school district technology variables and Missouri EOC scores at or above the state average, and, if there is a relationship, what variables are more closely related to the EOC scores at or above the state average?

$H_02$: There is no relationship between Missouri school district technology variables and Missouri EOC scores at or above the state average.

Research Question 3: Using socioeconomic status as a covariate, is there a difference in the main effects and interaction effects between the student achievement on EOC exams when considering district technology variables?

$H_03$: There is no difference in the main effects and interaction effects between the student achievement on EOC exams when considering district technology variables.

Research Question 4: Using past standardized assessment achievement data (8th Grade MAP assessment) as a covariate, is there a difference in the main effects and interaction effects between the student achievement on EOC exams when considering district technology variables?

$H_04$: There is no difference in the main effects and interaction effects between the student achievement on EOC exams when considering district technology variables.
Research Question 5: Can a predictive model be constructed for EOC scores at or above the state average based on Missouri technology variables?

H05: A predictive model cannot be constructed for EOC scores at or above the state average based on Missouri district technology variables.

Table 1 provides an overview of the research questions and analyses used in the study.
Table 1.
Overview of Research Questions, Variables, and Analyses

Examining the Digital Divide: The Impact of School District Technology Resources on High School Student, Online, 2010-2011, End-of-Course Exam Performance

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<th>Statistical Analysis</th>
<th>Analysis Rationalization</th>
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<tr>
<td>What are the summary statistics for all variables in the study?</td>
<td>Descriptive Statistics</td>
<td>Summary of data using means and standard deviations for each variable.</td>
</tr>
<tr>
<td>Is there a relationship between Missouri school district technology variables and Missouri EOC scores at or above the state average and if there is a relationship, what variables are more closely related to the EOC scores at or above the state average?</td>
<td>Pearson Correlation Coefficient</td>
<td>This analysis will help determine if a relationship exists between independent variables and dependent variables. If will also help determine which, if any, are significant (p &lt; [value TBA])</td>
</tr>
<tr>
<td>Using poverty/past assessment performance (8th grade MAP) as a covariate(s), is there a difference in main effects and interaction effects between EOC exam performance when considering school district responses to the Census of Technology?</td>
<td>Multivariate Analysis of Covariance (MANCOVA)</td>
<td>This analysis will account for the differences in independent variables as well as the uncontrolled student variables not measured in the study.</td>
</tr>
<tr>
<td>Can a predictive model be constructed for EOC scores at or above the state average based on Missouri responses to the COT?</td>
<td>Multiple Regression/Stepwise Linear Regression</td>
<td>The regression analysis will help predict an outcome variable from a predictor. The multiple regression, specifically the stepwise linear regression (where mathematical criterion used to determine which predictors are entered into model) will be used to predict an outcome variable from several predictors.</td>
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Public School District Variables

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<tr>
<td>Dollars per student districts allocate for technology (Ratio)</td>
<td>District English I EOC scores at or above the state average</td>
</tr>
<tr>
<td>Ratio of student instructional computers to students (Ratio)</td>
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<tr>
<td>Formal adoption of technology standards</td>
<td>District Algebra I EOC scores at or above the state average</td>
</tr>
<tr>
<td>Internet bandwidth speed (Nominal)</td>
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<td>Percentage of Administrators Technology Skill Level-Beginner (Ratio)</td>
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<tr>
<td>Percentage of Administrators Technology Skill Level-Intermediate (Ratio)</td>
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<tr>
<td>Percentage of Administrators Technology Skill Level-Advanced (Ratio)</td>
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<td>Percentage of Teachers Technology Skill Level-Beginner (Ratio)</td>
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<tr>
<td>Percentage of Teachers Technology Skill Level-Intermediate (Ratio)</td>
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<tr>
<td>Percentage of Teachers Technology Skill Level-Advanced (Ratio)</td>
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**Covariates**

8th Grade English and Math MAP scores
Free and Reduced Lunch Percentages
Limitations of the Study

This study had four limitations associated with it. First, school districts are complex organizations. This study did not take into account the factors such as course offerings, teaching pedagogy, experience level of teacher, and many others that influence student achievement on standardized tests. Second, this study did not attempt to explore the students’ opinions of computer-based standardized assessments and their perceived relationship to achievement. While it might be assumed that today’s students would be comfortable with using technology for testing in this study, it was not subject to measurement. Third, because of the self-reporting nature of the Missouri Census of Technology, results were limited by the extent to which all participants completing the Census answered the questions honestly and accurately. Finally, the researcher also worked in the field of educational technology within the geographic area of the study for several years and therefore may have had certain tacit knowledge not articulated in this study.

Definition of Key Terms

The study required the use of a specific vocabulary. The following definitions of key terms will assist the reader in understanding this study:

Achievement level descriptors. These descriptors include the following classifications: Advanced, Proficient, Basic, and Below Basic (defined below). They are determined by scale scores. The achievement level descriptor scale score ranges vary by subject and year and are set by MoDESE after the tests are taken (Missouri Department of Elementary and Secondary Education, 2012). These descriptors are defined as:

Advanced. Students scoring at this achievement level have an advanced
understanding of the skills and subject matter (Missouri Department of Elementary and Secondary Education, 2012).

**Proficient.** Students scoring at this achievement level understand the skills and subject matter at a greater level than at the basic and below basic levels (Missouri Department of Elementary and Secondary Education, 2012).

**Basic.** Students scoring at this achievement level understand concepts and skills present at the below basic level and also demonstrate some understanding of the skills and subject matter. (Missouri Department of Elementary and Secondary Education, 2012).

**Below Basic.** Students scoring at this achievement level have a limited understanding of the subject matter being tested (Missouri Department of Elementary and Secondary Education, 2012).

*Census of Technology.* The Census of Technology (COT) is designed to assess Missouri’s continuing investment in K-12 education technologies. It provides important data for the Missouri Department of Elementary and Secondary Education to share with state and national decision-makers to help advance public policy and increase public awareness and support for education technology. It also provides local school districts with data to help identify local needs, develop strategies to facilitate school improvement processes, and compare district progress with statewide data. The Census is a primary data source for measuring progress toward meeting state goals and objectives (Missouri Department of Elementary and Secondary Education, 2011).

*Digital Divide.* The unequal distribution of technology in a society resulting from inequalities in access to computers and the Internet between groups of people based on
one or more social or cultural identifiers (Attewell, 2001; Clark & Gorski (2001). For this study, the term digital divide as it pertains to schools, will refer to the unequal distribution of technology in public school districts (Bennett, Maton, & Kervin, 2008).

*Digital Natives.* Students who were born late enough in time that they do not know life without technology (Bennett et al., 2008).

*End-of-Course (EOC) assessments.* Part of the MAP, these assessments were administered in lieu of high school grade level assessments during the 2008-2009 school year in Algebra I, English II, and Biology and some districts were allowed to administer the tests online. The following year, English I, Algebra II, Geometry, American History, and U.S Government were added. Beginning with the 2014-2015 accountability year, districts must ensure that students complete EOC assessments in Algebra I, English II, Biology, and Government prior to high school graduation (Missouri Department of Elementary and Secondary Education, 2015).

*Missouri Assessment Program (MAP).* The MAP measures how well students acquire essential knowledge and skills described in Missouri’s Learning Standards. The MAP also provides information to districts and the state regarding the overall quality of education being provided. Standardized assessments under this program are given in grades 3-12 via a variety of K-8 grade level tests and 9-12 subject area EOC exams. For all assessments, student performance is reported in terms of four performance (or achievement) levels with *Advanced* and *Proficient* being the highest two levels and *Basic* and *Below Basic* being the lowest two. These performance levels are used to calculate approximately 67% of a school district’s accreditation score on standardized assessment data (Missouri Department of Elementary and Secondary Education, 2014a).
Technology Skill Levels: A Missouri COT question set asks public school districts to quantify the skill levels of their employees in a percentage. The skill levels are defined as:

Beginner. Basic technical skills including applications such as word-processing, some stand-alone software, and some Internet usage (email).

Intermediate. Regular use of applications, software, and Internet resources for increased productivity. Uses of applications include word-processor for student writing, research on the Internet, computer-generated presentations.

Advanced. Complete integration and mastery of the technology; using it effortlessly as a tool to accomplish a variety of learning, instructional and/or management tools.

Summary

This chapter discussed a non-experimental, quantitative research study. This chapter also introduced the rationale, or compelling need, to evaluate the relationship of school district technology resources to student standardized assessment achievement in Missouri. Additionally, this chapter defined the conceptual underpinnings for the study including, increasing school accountability and the digital divide. Chapter 1 also discussed prior research findings, the study’s purpose, and the limitations of the study. Finally, this chapter listed the research questions, hypotheses, and definitions of key terms that will be used in the study. The next chapter elaborates on the conceptual underpinnings for the study and review relevant literature that informed the study.
CHAPTER 2

Review of Related Literature

The quantity and availability of technology resources available to students in Missouri’s public schools varies greatly among school districts. Recent Census of Technology data from the MoDESE summary report (2011) revealed the following: (a) 93% of school buildings have a high speed connection to the Internet; (b) the current average student per instructional computer ratio is 2.34, however in some school buildings the ratio is 1; (c) 75% of teachers fully integrate technology into the curriculum; approximately 96% of districts report that technology is integrated into at least one core curriculum; and (d) a large discrepancy exists in the amount of funding school districts allocate to technology.

While these statistics may not seem initially concerning, closer examination reveals a problem: the majority of Missouri’s standardized assessments from the 3rd to 12th grade will be administered online beginning in the spring of 2015, yet not all students have equal access to technology resources in Missouri school districts. Little is known about the existence of the digital divide in Missouri and the relationship between school district technology variables and student achievement on online assessments. Therefore, this study focused on the measurable technology variables of Missouri school districts and their relationship to student performance on online EOC exams.

This chapter examines the research relating to the digital divide along with an overview of technology provided to students by public schools, both in the past and present. This review also presents research relating to education system accountability at the national level as well as accountability in Missouri, as well as research relating to
online standardized assessments. This chapter concludes by examining research pertaining to standardized assessments and the MAP.

**The Digital Divide**

The use of computer technology is becoming increasingly commonplace in every facet of society (Morse, 2004). However, despite the fact that technology is more commonplace, it is not distributed equally throughout society. For instance, research indicates that minority and poor families are less likely to have access to a computer or the Internet at home than are white or more affluent students (Attewell, 2001). The unequal distribution of technology not only exists between demographic groups in society, but also between schools and school districts (Cullen, 2001; Brown, 2000; Huang and Russell, 2006; Morse, 2004). This phenomenon began to attract the attention of researchers in the mid-1990s and, though the origin remains unknown, the term *digital divide* was coined (Gunkel, 2003).

**Defining the Term Digital Divide**

The term *digital divide* most commonly refers to the unequal distribution of technology resources in a society (Attewell, 2001; Clark & Gorski, 2001), or more specifically, the inequalities in access to computers and the Internet between groups of people based on one or more social or cultural identifiers (Clark & Gorski, 2001). However, the definition of *digital divide* is not homogeneous or univocal (Gunkel, 2003). In his critique of the digital divide, Gunkel (2003) provided several references to the widely varied ways in which the term has been used publically by various people since the mid-1990s including:
• use of the term by Moore (as cited in Gunkel, 2003) and Harmon (1996) to differentiate between advocates and detractors in debates about the value of information technology;

• use of the term to by members of the Clinton-Gore Presidential administration as well as Wolinsky (as cited in Gunkel, 2003) and Poole (1996) to reference the unequal distribution of resources in American schools;

• use of the term by Steward (1997) to describe the equipment incompatibilities that exist between cellphone networks; and

• use of the term in an official publication of the United States Department of Commerce’s National Telecommunications and Information Administration to reference the disparity in technology ownership among different demographic groups in the United States (NTIA, 1999).

To add even more ambiguity to the definition, some researchers within the last 10 years have identified a split in the definition of the digital divide into three parts: (a) the first digital divide, which aligns with Attewell’s (2001) and Clark & Gorski’s (2001) definition of unequal distribution of technology in society; (b) the second digital divide, which references the social differences in the ways computers are used at school and at home (Attewell, 2001; Hohlfeld, Ritzhaupt, Barron, & Kemker, 2008); and (c) the third digital divide, which references how technology can be used to empower the user to better their life by using information technology (Kim and Kim, 2001). In order to better illustrate this three-way definition of the digital divide as it relates to schools, Hohlfeld, Ritzhaupt, Barron, and Kemker (2008) developed the following framework:
In Figure 2, Hohlfeld et al. (2008) applied the three levels of the digital divide to a school setting. At the bottom level of the pyramid, 1st Level-School Infrastructure aligns with the first digital divide. Its focus is on equitable access to hardware, software, the Internet, and technology support within schools. In the middle level of the pyramid, 2nd Level-Classroom aligns with the second digital divide. Its focus is on how frequently teachers and students use technology in the classroom and for what purposes the technology is being used. The top level of the pyramid, 3rd Level-Individual Student aligns with the third digital divide. Its focus is on the development of student technology skills and the ability of students to select and use appropriate information technology for accomplishing objectives efficiently. Hohlfeld et al. (2008) noted that the levels are hierarchical—that is, student empowerment cannot occur unless use is occurring; therefore, use and empowerment cannot occur without equal technology access.

Hohlfeld et al. (2008) provided a framework that is directly supported by Ritzhaupt, Liu, Dawson, and Barron (2013) who state: “Schools are often perceived as
the mechanisms to narrow the digital divide within the United States by providing access to ICT [information and communication technology] and educating populations on how to use ICT to improve their livelihood” (p. 303). Huang and Russell (2006), Morse (2004), Cullen (2001), and Brown (2000) each supported Ritzhaupt et al.’s (2013) claim by positing that access to technology in schools should be equal.

**The Digital Divide and Student Achievement**

In schools across the country today, students are asked to use technology to learn and perform educational tasks with little thought to how a lack of experience using technology may impact some students. This is due to the belief that many students are digital natives, that is, they have grown up using technology and are comfortable with its use in many settings, therefore they are not negatively impacted when asked to perform tasks using technology (Bennett et al., 2008; Spires, Lee, Turner, & Johnson, 2008). While there are students who have more access to technology at home and/or school and may be more comfortable with its use than a person who does not have the same level of access (Brown, 2000), not all students have grown up immersed in technology. This is due to many factors such as socioeconomic status and the level of access provided to them at home by their caregivers (Brown, 2000). Also the availability of technology resources within and among school districts is inconsistent resulting in unequal access to technology resources by students at school resulting in a *First Digital Divide*, which prevents technology use by students and teachers as well as student empowerment (Hohlfeld et al., 2008). It is therefore plausible that the digital divide that exists for many students at home and school may impact student achievement at school in cases where technology use by students is required to complete day-to-day tasks as well as online
standardized assessments.

Technology’s impact on student achievement is difficult to measure due to the fact that the nature of the relationship between technology and student achievement is complex (Protheroe, 2005). Glennan and Melmed (1996) supported Protheroe (2005) by adding that research regarding instructional technology often times does yield assessments of the impact of technology, which are actually assessments of the instruction supported by the technology (as cited in Protheroe, 2005). The impact is also difficult to measure as many prior studies regarding the use of technology to increase student achievement are mixed and varied (Attewell, 2001; Newhouse, 2011; Ricketts & Wilks, 2002).

A majority of studies regarding the importance of eliminating the digital divide in order to increase student achievement focuses on doing so in order to increase the overall academic achievement and preparedness of students (Brown, 2000; Huang & Russell, 2006; Morse, 2004; Ritzhaupt et al., 2013). Overall academic achievement and preparedness of students are often tied to the importance of teacher-focused technology training (Brown, 2000; Huang & Russell, 2006; and Morse, 2004) and student-focused technology training to improve technology skill level (Cullen, 2001; Hess & Leal, 2001). Attewell (2001) identified these two factors as important technology-related variables that would lead to increased academic success and an increase in student attitudes toward learning. Other studies added that eliminating the digital divide is not as important to overall achievement as what types of activities the students use technology for, such as drill and skill activities resulting in little improvement or critical thinking and collaborative activities leading to high improvement (Attewell, 2001; Hohlfeld et al.,
In other words, improving overall student achievement is not about simply eliminating the digital divide, but also training teachers and students to use the technology and change how technology is used.

The Digital Divide and Student Performance on Standardized Assessments

There is a limited amount of research regarding the digital divide and its impact on student performance on standardized assessments. One reason for this might be Glennan and Melmed’s (1996) assertion that standardized tests, which are the current tools for measuring student achievement in the United States, do not measure the wide range of outcomes sought by the utilization of technology, such as problem solving skills, deeper understanding, or higher motivation, which all may be affected by technology integration (as cited in Protheroe, 2005). Another reason is that online standardized assessments that would require computer access for a greater number of students have only become available for many students across the United States within the last 10 years, making such research uncommon. For instance, online standardized assessments in Missouri began in 2009, and consisted primarily of multiple choice and constructed response questions. By the spring of 2015, four required EOC assessments in English, math, science, and social studies were administered online, and some grade level tests at the elementary level were also administered in an online format. These assessments, were taken by students in grades 3-12, were more rigorous when compared to the previous generation MAP tests, and required a higher degree of technical knowledge and skill in the area of computer use (Smarter Balanced Assessment Consortium, 2012). The research regarding the digital divide and its impact on standardized assessments that does exist is mixed and varied. For example, Huang and Russell (2006) suggested an increase
in assessment scores as access to technology increased. Vigdor, Ladd, and Martinez (2014) indicated an increase in technology access, in some instances, actually lowers math and reading scores because students end up spending less time working on academics when a computer is introduced. However, Claro et al. (2012) indicated a low, inexistent, or negative relationship between technology use and student performance on assessments. In other words, there is not a significant body of research that explicitly states that technology, let alone equal access to technology, is the cure-all for increasing student achievement.

Regardless of the variations in findings and conclusions among existing studies, researchers are consistent in advocating for schools to provide equal access to technology in order to narrow the digital divide. Unequal access does yield academic achievement issues in some populations of students. Further, it can be hypothesized that the existence of a digital divide prevents exposure to familiarity with technology, which in turn may impact online assessment performance due to lack of computer familiarity (Bennett, Braswell et al., 2008; Horkay et al., 2006; Ricketts & Wilks, 2002; Russell, 1999). This is especially important to consider as states continue to use technology to assess students on a more frequent basis even though the technology resources are not equally distributed among their schools and students.

School District Technology Resources

Research regarding school technology resources in the United States typically focuses on the growth of technology integration in schools, increased access to technology for students, and how teachers and students use technology. The following is a summary of the growth, types of access, and how technology was utilized in the 1980s
and 1990s as well as how it has and will be used since the turn of 21st century.

School District Technology Resources in the 1980s

Beginning in the 1980s, the United States experienced a large growth in the use of technology for instruction (Bialo & Sivin-Kachala, 1996). More specifically, the number of schools with one or more computers grew from 18 percent in 1981 to 95% in 1987 (U.S. Congress, 1988). Also, the ratio of students to computers from 1983 to 1987 improved from 112.4 to 36.8 (U.S. Congress, 1988). The earliest technology used in school by this researcher was the Apple IIe computer in early 1980s. This technology was one of the earliest instances in the United States to be funded by an Apple Computer Corporation grant. Available in a limited quantity in the school computer lab, the Apple IIe had a limited color display, was not able to be networked, and ran software programs from large 5.25” floppy discs that had to be flipped over during some educational games. These early software programs were used for drill, practice, and limited simulation in math, keyboarding, and social studies. Further, computer access by students was limited by the availability of the all-school computer lab as well as the comfort level of the students’ teachers in using the new technology with their students.

School Technology Resources in the 1990s

By the mid-1990s, the ability to network computers and access to the Internet became available in many schools. By 1996, 65% of public schools in the United States had Internet access (Scheffler & Logan, 1999). The tremendous investment in technology for schools indicated an expectation that educators integrate technology into education (Marcinkiewicz, 1993; Johnson, 1997). This was evidenced by Hays’ (1997) estimate that a total $4.1 billion investment was spent on educational technology during
the 1996-1997 school year (as cited in Scheffler & Logan, 1999). Also during this time, the student-to-instructional computer ratio dropped to approximately 10:1 (Scheffler & Logan, 1999). Though computers were still used for drill and skill activities, students were now able to create and engage in multimedia activities, as well as communicate, collaborate, and research with their local peers as well as those from around the world. However, despite the increased availability of computers in schools, the technology was largely underutilized (Marcinkiewicz, 1993). This was due, in part, to many factors such as lack of teacher training, experience using computers, and lack of consistent availability of computers in schools (Mueller, Wood, Willoughby, Ross & Specht, 2008; Penuel, 2006).

**School District Technology Resources Today**

Today, many schools pursue ways to provide increased access to technology in schools for students. A 2009 report from the U.S. Department of Education found that the digital divide in some schools still exists as indicated by the student-to-instructional computer ratio of 5.3:1 (Gray, Thomas, & Lewis, 2009). However, some school districts attempt to bridge this gap through 1:1 student computing initiatives in which every student is given a laptop or mobile device to allow a student to have full time access to a computer at home and school (Penuel, 2006, Stanhope & Corn, 2014). Other school districts defray the cost of providing a device to each of their students by allowing them to *Bring Your Own Device*, or BYOD (Stanhope & Corn, 2014). Under this type of program, students are allowed to bring a personal computer or mobile device of their choosing to school and access the school’s network for the purpose of accessing educational resources. The overall intent of a 1:1 or BYOD initiative is to allow students
to have Internet access at any given time, without having to be dependent on computer lab availability in the school or lack of access at home.

Despite 1:1 initiatives and BYOD programs being on the rise throughout schools in the Unites States, there is still a disparity in technology access for some students including those in rural or low-socioeconomic areas, among school districts in states, and even among schools within districts (Sundeen & Sundeen, 2013; Gray, Thomas, & Lewis, 2010). Further, despite increased technology access afforded to students by these initiatives and programs, use by teachers and students continues to vary for similar reasons seen in the 1990s, including lack of technology training and access to devices, especially in schools where there is not a 1:1 student-computer ratio (Penuel, 2006; Stanhope & Corn, 2014). Overall, while there seems to be some benefit in providing a 1:1 student-instructional computer environment, such as increased student engagement, enhanced writing, and improved technology skills (Penuel, 2006; Stanhope & Corn, 2014), there is limited information regarding the impact that 1:1 and/or increasing computer access for students has on standardized test performance in all content areas and should be an area of future study (Dunleavy & Heinecke, 2007).

**Education System Accountability**

In order for schools to remain an effective part of society as a whole, they must be proven to be effective at sustaining and improving society. As a result, school accountability has become a significant point of discussion among politicians, school personnel, and school system stakeholders. School districts that do not meet the prescribed accountability standards risk a loss of funding, imposition of sanctions, and a potential loss of legitimacy by their constituents.
For thousands of years, accountability in societal systems can be traced through various periods in time (Normore, 2004); however, the majority of the scholarly literature focusing on the subject of societal accountability has been developed over the course of the last 100 years (Normore, 2004; Shaffritz, Ott, & Jang, 2011) within the work of Weber (1922), McGregor (1957), Merton (1957), Selznick (1948), and Simon (1946). Accountability in each of these scholarly writings is not explicitly discussed, rather the concept of organizational structure and bureaucracy is deeply investigated. Therefore, it can be implied that the natural consequence of organizational structure and bureaucracy is accountability, that is the combination of specified goals and expectations in conjunction with each member of the organization’s responsibility to produce outcomes in alignment with those expectations. Though the specific perspective of each of these scholars varied, the emerging theme from their work was that accountability, which is a direct result of societal structures and bureaucracy, is an integral part of societal systems.

Relating specifically to education policy, accountability has been a long standing issue in the decades since the National Commission on Excellence in Education published a report titled *A Nation at Risk: The Imperative for Educational Reform*. The report (National Commission on Excellence in Education, 1983) is credited with fostering the belief that America’s students were performing at lower levels than students in other countries (Derthick & Dunn, 2009), identifying achievement gaps (Lemke, Hoerandner, & McMahon, 2006), and calling for reform of America’s education system. As a result of the report, the standards movement was formed (Normore, 2004). This movement called for the development of goals for all learners, development of standards for what should be learned, and the development of assessments that would measure student
learning of the standards.

Although the Commission’s (National Commission on Excellence in Education, 1983) report called for substantial change to the education system, one of the most significant catalysts for increasing accountability occurred in 2001 when the United States Congress passed the No Child Left Behind (NCLB) Act (ESEA, 2001). The NCLB Act established an assessment-driven accountability model aimed at ensuring 100% of students would be proficient in reading and math by 2014, while also ensuring the closing of achievement gaps between subgroups of students (Goertz & Duffy, 2003; Lee & Reeves, 2012). The main effect of the NCLB Act is that districts that achieve the prescribed proficiency levels receive a reward in the form of increased federal funding, while those that do not receive tiered sanctions in the form of reputation-damaging labeling, restructuring, loss in funding, or eventually complete take over by their home state.

Within the last three years, as the deadline of 100% proficiency in reading and math by 2014 drew near, many states were not going to be able to meet the 100% standard prescribed by the NCLB. In 2011, the United States Department of Education began allowing states to apply for waivers from the stipulations of the NCLB in exchange for rigorous and comprehensive State-developed plans designed to improve educational outcomes for all students, close achievement gaps, increase equity, and improve the quality of instruction (U.S. Department of Education, 2014). As of August 2014, 43 states, the District of Columbia, and Puerto Rico were approved for waivers. Even though many of these states have incorporated non-test measures and measures of student growth as a part of their accountability plan (Polikoff, McEachin, Wrabel, & Duque,
high-stakes assessment is still at the forefront of accountability policy.

**Standardized Assessment**

Standardized assessment as an accountability measure has become a point of focus in the field of education. This focus is due largely in part to the standards reform movement resulting from *A Nation at Risk: The Imperative for Educational Reform* (1983) and, of most influence, the NCLB Act (2001). There were several identified purposes of standardized testing in the United States, including monitoring student performance, measuring teacher effectiveness, and ensuring accountability (Goertz & Duffy, 2003; Lane, 2004; Siegel, 2004; Supovitz, 2009). However, one purpose stood out within the literature—motivation (Froese-Germain, 2001; Goertz & Duffy, 2003; Noddings, 2004; Supovitz, 2009). Motivation in the sense of accountability means that extrinsic rewards and sanctions associated with standardized tests can be used to motivate school performance. As outlined in the NCLB Act (ESEA, 2001), rewards for schools that met the prescribed proficiency standards received increased funding, while those that did not were labeled, risked restructuring, lost funding, and were eligible for takeover by their state.

While the use of standardized testing as an accountability measure is a widely accepted manner in which education systems are held accountable (Supovitz, 2009), critics of school accountability posit that test scores are a poor measure of progress for several reasons including test bias and construct validity. Test bias is the notion that standardized tests are discriminatory to certain demographic groups (Froese-Germain, 2001; Grodsky et al., 2008; Shepard, 2002; Siegel, 2004). This is evidenced by the fact that these groups consistently fail some standardized tests at higher rates than others.
More specifically related to bias is construct validity, also known as test item bias. In cases where construct validity is an issue, test items are often, if not routinely, biased against certain minority groups, women, and or test takers who are of low socioeconomic status (Grodsky et al., 2008). Medina and Neill (1990) identified characteristics of standardized tests that can bias the results of minority students and students from low-income backgrounds and include (as cited in Froese-Germain, 2001) questions that are written in formal English rather than common vernacular of certain groups; test questions that seek responses that ignore cultural experiences, perspectives, and knowledge of children of certain races or backgrounds; and questions that do not take into account students who have unique ways of knowing and problem solving.

It is clear that standardized assessments are an integral part of school accreditation in the immediate future and beyond (Goertz & Duffy, 2003). Despite the criticisms, there are certain beneficial effects that have surfaced as a result of the test-based accountability system. Supovitz (2009) noted that some of the benefits are the alignment of curriculum standards, easy administration of assessments on a large scale, as well as the ability of the test-based system to meet its desired goal to demonstrate public accountability of school systems.

**Online Standardized Assessment**

Increased accountability in the wake of the NCLB Act (2001) perpetuated an assessment frenzy as states endeavored to find ways to assess a greater number of students than ever, while also finding a cost effective means to do so. As with so many things in life today, the answer has been to utilize technology to accomplish this task. As a result, assessments are increasingly administered electronically online.
There are several advantages to moving to an online assessment delivery mode. These advantages include increased test security, cost reduction, ease of standardizing testing conditions, ability to control test sequencing, ability to diagnose student deficiencies in a timely manner, and increased speed of scoring and providing feedback (Bodmann & Robinson, 2004; Maguire, Smith, Brallier, & Palm, 2010; Pellegrino & Quellmalz, 2010; Smith & Caputi, 2007). However, the significance of each of these advantages did not seem to be the focus of the majority of the literature, rather within the literature laid a recurring theme of study—comparing student performance on paper-and-pencil against an online assessment.

Bodman and Robinson (2004) found that in a comparison of speed and performance differences among the two test modes between university students that there was not a difference in completion time. Ricketts and Wilks (2002) noted that while students prefer online assessment, the preference as well as the performance on the exam is linked to how the test is presented in terms of factors such as question type or the need to scroll on the screen. Hewson (2012) asserted that student performance results among test modes did not differ depending on whether or not students were required to use their preferred or non-preferred method of testing. Bennett, Braswell, et al. (2008) and Escudier, Newton, Cox, Reynolds, and Odell (2011) found that there was not a significant difference in test performance between the two test delivery modes. Overall, there is sufficient evidence across many studies to conclude that online assessment test modes do not significantly help or hinder student performance.

Even though test form does not seem to impact student achievement, there is other research that indicates there might be factors outside of the online assessments
themselves that do. Bennett et al. (2008) indicated that computer familiarity was a significant factor in online assessment performance leading to the possibility that some students may have scored better due to their familiarity with computers. This supported the conclusions of earlier studies by Horkay, Bennett, Allen, Kaplan, and Yan (2006), Ricketts and Wilks (2002), and Russell (1999) in which they identified several technology factors that may impact assessment performance. There exists a possibility that students are not only being assessed on the subject matter content, but are also inadvertently being assessed on their ability to use a computer when they are asked to complete a standardized test electronically (Ricketts & Wilks, 2002). Some factors related to this include slow keyboarding speed as a negative effect on open-ended responses and an underestimate of achievement on math exams due to the inability to show work without paper (Russell, 1999). Also, students who had more hands on computer skills as well as those who took the online assessment on a school computer they were familiar with versus an unfamiliar laptop scored higher on writing tests as well (Horkay et al., 2006). It is critical to note the limitations of those studies included the variance in results based on item types, reliability of the technology, and the fact that the studies are old in terms of technology as opposed to today where technology has become more reliable and computers are easier to use (Bennett, Braswell, et. al 2008). The next section examines and synthesizes literature relating to education system accountability, which is the catalyst for the increase in online assessments.

**Missouri School District Accountability**

The MSIP is the state of Missouri’s school accountability system. The MSIP began in 1990 and entered its fifth version in 2013. The MSIP’s four policy goals
(Missouri Department of Elementary and Secondary Education, 2014c) are: (a) to articulate the state's expectations for student achievement with the ultimate goal of all students graduating ready for success in college and careers; (b) distinguish performance of schools and districts in valid, accurate and meaningful ways so that districts in need of improvement can receive appropriate support and interventions, and high-performing districts can be recognized as models of excellence; (c) empower all stakeholders through regular communication and transparent reporting results; and (d) promote continuous improvement and innovation within each district.

To help monitor these policy goals and hold school districts accountable, the State Board of Education maintains a set of standards for all Missouri schools. They also create Annual Performance Reports (APR) for each public school district and charter school. The APR shows how well each district meets the standards, in the following areas (Missouri Department of Elementary and Secondary Education, 2014c):

- MAP tests
- ACT, SAT, Compass and ASVAB (military test) scores
- Successful completion of advanced courses
- Career education placement
- College placement
- Graduation rates
- Attendance rates
- Subgroup achievement

It is important to note that approximately 67% of a school district’s accreditation score is based on standardized assessment data (Missouri Department of Elementary and Secondary Education, 2014c).
Secondary Education, 2014b). Should a school district fail to perform well on the MAP assessments, it could adversely affect its accreditation status. The following section examines the history and current practices of standardized assessment in Missouri.

**Standardized Assessment in Missouri**

In 1985, Missouri’s General Assembly enacted the Excellence in Education Act. The Act included provisions for pupil testing, discipline codes, incentive grants for schools which developed innovative programs, and scholarships for potential education undergraduate students (Ruhl & Graham, 1991). The Act also included provisions for minimum teacher salaries, a beginning teacher assistance program, teacher preparation standards, and assessment of candidates for administrator licensure (Ruhl & Graham, 1991). However, the most significant provisions within the Act were in regard to school accountability. Core competencies in reading, mathematics, science, and social studies were established and districts were required to assess students based on the competencies (Stenger, 2006). As a result, the Missouri Mastery and Achievement Test (MMAT) was created to test students in grades 3, 6, 8, and 10 in the areas of reading, mathematics, science, and social studies (Ruhl & Graham, 1991; Stenger, 2006).

The MMAT was utilized until 1993 when Missouri Judge Byron Kinder issued the ruling that stated the “state’s system of funding education was so unfair and unequal that it was unconstitutional” (A Primer, 1993, p. 7). The ruling also set the requirement that a new system be established. That system would be formed under a new law—the Outstanding Schools Act (OSA). The new law increased education funding and established the following goals (A Primer, 1993): (a) strengthening basic education in core content areas and ensuing students know information and can use their knowledge.
and critical thinking skills in their lives, (b) adopting challenging performance standards to ensure national and international competiveness, (c) developing curriculum frameworks to serve as guides, not mandates, (d) implementing a new statewide assessment system to ensure that schools and school districts have to deliver, (e) ensuring teamwork and demanding full accountability for results, and (f) increasing equity for school children.

As a result of OSA, a new state assessment, the MAP, was created (Stenger, 2006). Originally, the MAP was designed to be a grade span test that measured the Missouri Show-Me Standards in the following grades and subjects:

- Grades 3, 7, and 11 in Communication Arts
- Grades 4, 8, and 10 in Mathematics
- Grades 3, 7, and 10 in Science

The MAP assessment was utilized in its initial form until NCLB was passed in 2001. Under the provisions of NCLB, Missouri developed grade level tests in reading and mathematics in grades 3-8 and once in high school (Missouri Department of Elementary and Secondary Education 2014a). By 2007-2008, science assessments would be included in grades 3-5, once in grades 6-9, and once in grades 10-12 (Missouri Department of Elementary and Secondary Education 2014a).

The MoDESE began to replace the high school grade level assessments with EOC assessments in the spring of 2008. Algebra I, English II, and Biology were the first EOCs to be administered. In 2009, Government, American History, English I, Algebra II, and Geometry were implemented. Rather than taking a MAP assessment upon completion of a grade level, high school students would take an EOC when they
completed the respective course.

During the first few years of EOC implementation, tests were offered to districts in a paper-pencil or online format. Full online test implementation occurred (except by students who have alternative test form requirements indicated in their academic records) in 2010. In the spring of 2015, nine required EOC assessments in the subjects of communication arts, math, science, and social studies were administered online and some tests at the elementary level were also administered in an online format. By the spring of 2015, four required EOC assessments in English, math, science, and social studies were administered online, and some grade level tests at the elementary level were also administered in an online format. These assessments, were taken by students in grades 3-12, were more rigorous when compared to the previous generation MAP tests, and required a higher degree of technical knowledge and skill in the area of computer use (Smarter Balanced Assessment Consortium, 2012).

Moving to an online assessment system creates several challenges for districts, including addressing the logistics for giving assessments online for a very large number of students in an environment of finite technology resources. Further, the assessments not only assess a student’s content knowledge, but also their technical computing ability (Smarter Balanced Assessment Consortium, 2012). Chapter 3 provides an overview of the theoretical lens through which this study was conducted.

**Summary**

The need for research concerning the digital divide in schools and its impact on student achievement is clear. The digital divide manifests itself in school systems through the unequal distribution of technology resources. Several researchers advocated
for the elimination of the digital divide by school systems in order to impact student achievement (Brown, 2000; Cullen, 2001; Huang & Russell, 2006; Morse, 2004; Ritzhaupt et al., 2013). The elimination of the divide in schools can be realized by states and school districts working to provide students equal access to technology resources.

Most recently, Ritzhaupt et al. (2013) indicated a need for future study. Their research regarding the digital divide focused exclusively on gender, ethnicity, and socioeconomic status, as well as several other demographics related to the digital divide, such as the geographic region of a school or residence and the education level of a student’s parents. Ritzhaupt et al. (2013) stated “All possible variables should be examined in our discourse about the digital divide” (p. 303). This study examined some of those variables specific to Missouri school districts as there was a lack of information regarding the digital divide, manifested by the unequal distribution of district technology resources and the impact on student assessment performance in Missouri.

This chapter synthesized literature regarding detailed the impact of the digital divide on student achievement. This chapter also examined research regarding technology in schools in the past and present. Further, online standardized assessments, school system accountability, and accountability in Missouri were examined. Because student achievement is the pinnacle of education system accountability and school districts are being held accountable for the performance of their students on online assessments, it is important that districts know how unequally distributed technology resources, or digital divide, impact student achievement. Chapter three identifies this study’s methodology, describes the variables examined, and provides the research design and data analysis techniques utilized in the study.
CHAPTER 3

Research Design and Methodology

This chapter is divided into subsections. First, the background and study rationale are discussed. Second, the problem statement is offered. Third, the purpose statement is described. Fourth, the research questions and hypotheses are provided. Fifth, the population and sample is presented along with a discussion of the research design, instrumentation, data collection, and analysis. Finally, a chapter summary is provided.

Background and Study Rationale

In recent years, there has been a movement towards the use of computer-based testing for standardized assessment in order to increase the efficiency and cost effectiveness. Starting in the spring of 2015, a majority of standardized assessments in Missouri public schools in grades 3-12 were administered online. However, the availability of technology resources as well as the funding for technology in schools varies among Missouri school districts (Missouri Department of Elementary and Secondary Education, 2011) creating a Level 1 digital divide (Hohlfeld, Ritzhaupt, Barron, & Kemker, 2008).

As Missouri school districts seek to increase the student achievement levels on standardized tests, it must be determined if there is a relationship between school district technology variables and student performance on online EOC exams. The results of prior studies regarding the use of technology to increase student achievement are mixed and contradictory, as evidenced by research (Attewell, 2001; Newhouse, 2011; Ricketts & Wilks, 2002). For this reason, the study of the relationship between technology, the digital divide, and student achievement continues to be of value in order to seek more
clarity of this issue (Ritzhaupt et al., 2013; Shapley et al., 2011). Even less is known about the relationship between school district-provided technology resources and student performance in online assessments. More research on this relationship would enable state departments of education and school districts who administer online assessments to determine how various technology components impact test performance while also providing information regarding the existence of a digital divide in schools and its impact on student achievement.

**Statement of the Problem**

The MoDESE uses the MSIP to review and accredit its school districts. The MSIP entered its fifth version in 2013 and bases approximately 67% of a school district’s accreditation score on standardized assessment data (Missouri Department of Elementary and Secondary Education, 2014b). In short, when a school district fails to perform well on standardized assessments, it affects their accreditation status. Not only does accreditation status affect certain types of school funding, but it also affects the perception of the school district, staff, and community as a whole.

Due to the role student assessment performance plays in achieving accreditation in Missouri, it is imperative students perform at high levels on state standardized assessments. Because all standardized assessments in Missouri are administered solely online, it is important to determine if district technology variables play a role in student performance on those assessments. Early uses of technology for assessment focused on efficiency and cost reductions; however, newer computer-based assessments push towards measuring complex forms of learning in addition to content knowledge (Pellegrino & Quellmalz, 2010). But, in order for students to be able to demonstrate mastery of these
complex forms of learning, there must be a pedagogical shift in how students are taught (Newhouse, 2011), which is difficult to achieve if teachers do not have the resources needed to do so. Also, some research does exist that indicates there is a connection between the digital divide, technology in schools, and student achievement (Brown, 2000; Huang & Russell, 2006; Morse, 2004; Protheroe, 2005; Ritzhaupt, Feng Liu, Dawson, & Barron, 2013). Ritzhaupt et al. (2013), in their study of digital divide and its impact on student achievement, indicated a need for future study of all possible variables relating to this issue in schools in order to learn more about this issue.

Although a large quantity of research exists regarding technology in schools, the digital divide, and accountability, there is a lack of information about the relationship between school district technology variables and student assessment performance (Ritzhaupt et al., 2013). Shapley et al. (2011) indicated that the study of the relationship between technology and student achievement continues to be of value in order to seek more clarity of this issue. To help fill the gap in the research, this study investigated if there is a relationship between Missouri school district technology variables and student performance on online EOC exams. To determine if district technology variables are related to student assessment performance, the researcher determined the main effects and interaction effects between Missouri school district technology variables, as measured by district responses to the Census of Technology and student EOC exam performance data. Further, the researcher attempted to construct a predictive model for Missouri EOC exam performance at or above the state average based on school district technology variables in order to establish a better understanding of which, and to what extent, district technology variables impact student achievement. This research was
necessary because there is a lack of information regarding the relationship between Missouri public school district technology variables and online student assessment performance. This study provided additional knowledge regarding this relationship, and, ultimately, synthesized past and future research in order to provide additional information regarding the existence of a digital divide in Missouri’s schools and the impact it has on student achievement.

**Purpose of the Study**

The purpose of the study was to examine the digital divide by determining the main effects and interaction effects between Missouri school district technology variables and student EOC exam performance. A secondary purpose was to construct a predictive model for Missouri EOC exam performance at or above the state average based on school district technology variables.

**Research Questions and Hypotheses**

The following questions were developed in order to guide the study:

*Research Question 1:* What are the descriptive statistics for all variables under study?

*Research Question 2:* Is there a relationship between Missouri school district technology variables and Missouri EOC scores at or above the state average and if there is a relationship, what variables are more closely related to the EOC scores at or above the state average?

*H₀₂:* There is no relationship between Missouri school district technology variables and Missouri EOC scores at or above the state average.

*Research Question 3:* Using socioeconomic status as a covariate, is there a
difference in the main effects and interaction effects between the student achievement on EOC exams when considering district technology variables?

$H_03$: There is no difference in the main effects and interaction effects between the student achievement on EOC exams when considering district technology variables.

Research Question 4: Using past standardized assessment achievement data (8th Grade MAP assessment) as a covariate, is there a difference in the main effects and interaction effects between the student achievement on EOC exams when considering district technology variables?

$H_04$: There is no difference in the main effects and interaction effects between the student achievement on EOC exams when considering district technology variables.

Research Question 5: Can a predictive model be constructed for EOC scores at or above the state average based on Missouri technology variables?

$H_05$: A predictive model cannot be constructed for EOC scores at or above the state average based on Missouri district technology variables.

Methodology

To facilitate this study, the following research design, population, measurements, data collection strategies, and data analysis techniques were utilized to carry out the research and answer the research questions.

Research Design

The research design utilized a quantitative, non-experimental correlational methodology. Quantitative studies allow researchers to statistically analyze numerical data for reliability, significance, and correlation using descriptive statistics (Creswell, 2009; Thompson, 2006). A non-experimental correlational study was chosen
because the independent variables will not be manipulated at any point in the study (Creswell, 2009). Because this study did not attempt to establish a causal relationship, correlational methods were used to establish the degree to which the independent and dependent variables are related (Creswell, 2009; Thompson, 2006). This study provided a descriptive statistical analysis of the data. Also, this study used the Pearson’s-r correlation coefficient to determine if a relationship exists between independent variables and dependent variables. The Pearson’s-r correlation coefficient also helped determine which, if any, of the relationships were significant (Field, 2009).

Also, this study utilized a two-way Multivariate Analysis of Covariance (MANCOVA) to evaluate differences in means of the independent and dependent variables while holding constant for two covariates: prior test performance and socio-economic status. To accomplish this, the study accounted for differences in independent variables and uncontrollable student variables by accounting for prior test performance by one cohort of students across two years of assessment. The study also accounted for differences in independent variables and uncontrollable student variables by accounting for socioeconomic status, which was determined by each district’s free and reduced lunch percentage. The covariance analysis controlled for these differences (Pasternack & Charen, 1969; Wildt & Ahtola, 1978).

Finally, an attempt to establish a predictive model occurred by utilizing regression analysis. The regression analysis helped predict an outcome variable from a predictor. The multiple regression, specifically the stepwise linear regression where mathematical criterion is used to determine which predictors are entered into model, were used to predict an outcome variable from several predictor variables (Field, 2009).
Measurements in the Study and Data Collection

The study was limited to two archival data sets, which were acquired from the MoDESE. Permission to utilize the data was obtained from the Institutional Review Board (IRB) at the University of Missouri-Columbia. The first data set utilized was the school district responses to the 2010-2011 MoDESE COT. The COT, completed during the MSIP April cycle, is designed to assess Missouri’s continuing investment in K-12 education technologies and provides important data for MoDESE to share with state and national decision-makers to help advance public policy and increase public awareness and support for education technology. It also provides local school districts with data to help identify local needs, develop strategies to facilitate school improvement processes, and compare district progress with statewide data. The COT is a primary data source for measuring progress toward meeting state goals and objectives (Missouri Department of Elementary and Secondary Education, 2011). For this study, school district responses to the COT provided information regarding the availability and variance of technology resources across Missouri school districts. The COT data was available upon written request through the MoDESE Office of System Management.

The second data set utilized in this study was the EOC exam assessment data acquired as a part of the MAP, which as was publically available MoDESE Comprehensive Data system. Data from two EOC tests taken during 2010-2011 was utilized—Algebra I and English I. These two assessments are generally taken upon completion of 9th grade level Communication Arts I and Algebra I courses. Data from 2010-2011 was selected due to the fact that this was the first year that all EOC exams were required by MoDESE to be administered in an online format by all Missouri school
districts (Missouri Department of Elementary and Secondary Education, 2014a).

Data from two additional MAP assessments taken during the 2009-2010 school year was utilized—Grade 8 Communication Arts and Grade 8 Mathematics. These two assessments are generally taken at the end of a student’s 8th grade year. Data from these exams was publically available on the MoDESE website. This study utilized district level achievement data from these two assessments as covariates to account for differences in independent variables and uncontrollable student variables by accounting for prior test performance by one cohort of students taking assessments across two school years, 2009-2010 and 2010-2011. This covariance analysis helped control for these differences (Pasternack & Charen, 1969; Wildt & Ahtola, 1978).

Finally, there was a large quantity of research that affirmed a strong relationship between socio-economic status and student achievement (Caro et al., 2009; Ewumi, 2012; Perry, 2012). This study utilized district level free and reduced lunch percentages from 2010-2011 as a covariate to account for differences in independent variables and uncontrollable student variables by accounting for socio-economic status. This data was publically available on the MoDESE website. The covariance analysis helped control for these differences (Pasternack & Charen, 1969; Wildt & Ahtola, 1978).

Variables

**Independent variables.** The eleven independent variables that were examined in this study were:

- Dollars per student districts allocate for technology;
- Ratio of student instructional computers to students;
- Whether or not a district has formally adopted a set of technology
standards;

- Percentage of administrators with a beginner technology skill level;
- Percentage of administrators with an intermediate technology skill level;
- Percentage of administrators with an advanced technology skill level;
- Percentage of teachers with a beginner technology skill level;
- Percentage of teachers with an intermediate technology skill level;
- Percentage of teachers with an advanced technology skill level;
- Internet bandwidth speed; and
- Percentage of teachers fully integrating technology into curriculum and instruction.

**Dependent variables.** The two dependent variables that were examined in this study were (a) the total percentage of advanced and proficient students at or above the state level on the Algebra I EOC exam, and (b) the total percentage of advanced and proficient students at or above the state level on the English I EOC exam. Table 2 lists the dependent and independent variables in the study.

| Table 2. **Independent and Dependent Variables Explored in the Study by Data Type** |
|-----------------------------------------------|----------------|
| **Variables**                                 | **Data Type** |
| **Independent Variables**                    |                |
| 1. Dollars per student districts allocate for technology | Ratio         |
| 2. The ratio of student instructional computers to students | Ratio         |
| 3. Formal adoption of technology standards    | Nominal       |
| 4. Percentage of teachers fully integrating technology into curriculum and instruction | Ratio         |
| 5. Internet bandwidth speed                   | Nominal       |
| **Percentage of a School District’s Administrators with:** |            |
| 6. Beginner technology skill level            | Ratio         |
| 7. Intermediate technology skill level        | Ratio         |
8. Advanced technology skill level

9. Beginner technology skill level

10. Intermediate technology skill level

11. Advanced technology skill level

Dependent Variables

12. Total percentage of advanced and proficient students at or above the state average on the Algebra I EOC exam

13. Total percentage of advanced and proficient students at or above the state average on the English I EOC exam.

Population

The Missouri school districts included in this study were limited to those that responded to the 2011 Census of Technology and whose students completed each of the following four Missouri Assessment Plan assessments: 2009-2010 school year 8th grade Mathematics and Communication Arts and 2010-2011 school year Algebra I and English I EOC exams. In 2011, all Missouri school districts were required to complete the COT. Further, during the 2009-2010 school year, all districts were required to administer the two identified 8th grade assessments. However, of the two assessments from the 2010-2011 school year that were used, only the Algebra I EOC exam was required to be administered by all Missouri school districts. The English I EOC exam was optional and administered by districts wishing to receive bonus points in their district accreditation calculations. As a result, the population did not include all Missouri school districts, but instead included a total of 360 Missouri school districts that met the aforementioned criteria. This population was identified by utilizing publically available data from MoDESE.

Data Analysis Procedures

Once the data was received from MoDESE, data not relevant to this study was
eliminated to avoid any potential analysis challenges (Fayyad et al., 1996; Norton, 1999.)

Data was placed into an electronic spreadsheet format that was capable of being imported
into the most current available version of Statistical Package for the Social Sciences
(SPSS®), a statistical software program. The SPSS® software contains numerous options
and algorithms that aid in automating the statistical analysis process. The intent of the
analysis was to answer the five research questions outlined earlier in this chapter. In
descriptive statistics, the Pearson correlation coefficient, 2-Way MANCOVA and
multiple regression are statistical analyses that were used. Table 2 indicates the analysis
strategies that were utilized to answer the research questions.

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Data Type</th>
<th>Analysis Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Descriptive Statistics</td>
<td>Ratio, Interval, Nominal</td>
<td>Mean, Median, Mode, Standard Deviation</td>
</tr>
<tr>
<td>2. Relationship between Variables</td>
<td>Ratio, Interval, Nominal</td>
<td>Pearson’s Correlation Coefficient, p-Value (if significant, then post-hoc analysis)</td>
</tr>
<tr>
<td>3. Difference, Interaction, SES as Covariate</td>
<td>Ratio, Interval, Nominal</td>
<td>2-WAY MANCOVA, Main Effect, Interaction Effect</td>
</tr>
<tr>
<td>4. Difference, Interaction, Prior Test Performance as Covariate</td>
<td>Ratio, Interval, Nominal</td>
<td>2-WAY MANCOVA, Main Effect, Interaction Effect</td>
</tr>
<tr>
<td>5. Predictive Model</td>
<td>Ratio, Interval, Nominal</td>
<td>Multiple Regression, Stepwise Linear</td>
</tr>
</tbody>
</table>

**Summary**

This chapter was divided into subsections. First, the background and study rationale was discussed. Second, the problem statement was offered. Next, the purpose statement was described. Fourth, the research questions and hypotheses were provided. Fifth, the population and sample was presented along with a discussion of the research design, instrumentation, data collection, and analysis.
CHAPTER 4

Presentation and Analysis of Data

Research has shown that there is a connection between the digital divide, technology in schools, and student achievement (Brown, 2000; Huang & Russell, 2006; Morse, 2004; Protheroe, 2005; Ritzhaupt, Feng Liu, Dawson, & Barron, 2013). However, research regarding the digital divide and the use of technology to increase student achievement is often mixed and contradictory (Attewell, 2001; Newhouse, 2011; Ricketts & Wilks, 2002). Shapley, Sheehan, Maloney, and Caranikas-Walker (2011) indicated that the study of the relationship between technology and student achievement continues to be of value in order to seek more clarity of this issue. Also, Ritzhaupt et al. (2013) indicated a need for future study of all possible variables relating to the issue of the digital divide in schools in order to learn more about its impact on student achievement. Further, literature review found that there is a lack of information regarding the relationship between the digital divide, school district provided resources, and student performance on online assessments in Missouri. To help fill the gap in the research, this study investigated the relationship between Missouri school district technology variables and student performance on online EOC exams within the context of the digital divide. The results of this study may enable state departments of education and school districts to determine how the digital divide may impact student achievement in their respective organizations.

This chapter provides the presentation and analyses of those data collected to test the research hypotheses outlined in the study. First, the research design is described. Next, the population and sample for this study are detailed. Statistical analyses, including
descriptive analysis, correlation, MANCOVA and regression are detailed for the related research question(s). Finally, a summary of the chapter is presented.

**Review of Research Design**

This study utilized a quantitative, non-experimental, correlational methodology. Quantitative studies allow researchers to statistically analyze numerical data for reliability, significance, and correlation by using descriptive statistics (Creswell, 2009; Thompson, 2006). A non-experimental correlational study was chosen because the independent variables will not be manipulated at any point in the study (Creswell, 2009). Because this study did not attempt to establish a causal relationship, correlational methods were used to establish the degree to which the independent and dependent variables are related (Creswell, 2009; Thompson, 2006).

The data for the study were collected from publically available archival data sets available on the Internet via the MoDESE Comprehensive data system and through a data request submitted to MoDESE in order to answer the following research questions:

*Research Question 1:* What are the descriptive statistics for all variables under study?

*Research Question 2:* Is there a relationship between Missouri school district technology variables and Missouri EOC scores at or above the state average and if there is a relationship, what variables are more closely related to the EOC scores at or above the state average?

*Research Question 3:* Using socioeconomic status as a covariate, is there a difference in the main effects and interaction effects between the student achievement on EOC exams when considering district technology variables?
Research Question 4: Using past standardized assessment achievement data (8th Grade MAP assessment) as a covariate, is there a difference in the main effects and interaction effects between the student achievement on EOC exams when considering district technology variables?

Research Question 5: Can a predictive model be constructed for EOC scores at or above the state average based on Missouri technology variables?

Independent and Dependent Variables

Table 4 lists the independent and dependent variables explored in the study.

Table 4. Independent and Dependent Variables Explored in the Study

<table>
<thead>
<tr>
<th>Variables</th>
<th>Independent Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Dollars per student districts allocate for technology</td>
</tr>
<tr>
<td></td>
<td>2. The ratio of student instructional computers to students</td>
</tr>
<tr>
<td></td>
<td>3. Formal adoption of technology standards</td>
</tr>
<tr>
<td></td>
<td>4. Percentage of teachers fully integrating technology into curriculum and instruction</td>
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<tr>
<td></td>
<td>5. Internet bandwidth speed</td>
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<tr>
<td></td>
<td>Percentage of a School District’s Administrators with:</td>
</tr>
<tr>
<td></td>
<td>6. Beginner technology skill level</td>
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<td></td>
<td>7. Intermediate technology skill level</td>
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<td></td>
<td>8. Advanced technology skill level</td>
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<tr>
<td></td>
<td>Percentage of School District’s Teachers with:</td>
</tr>
<tr>
<td></td>
<td>9. Beginner technology skill level</td>
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<tr>
<td></td>
<td>10. Intermediate technology skill level</td>
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<tr>
<td></td>
<td>11. Advanced technology skill level</td>
</tr>
<tr>
<td></td>
<td>Dependent Variables</td>
</tr>
<tr>
<td></td>
<td>12. Total percentage of advanced and proficient students at or above the state average on the Algebra I EOC exam</td>
</tr>
<tr>
<td></td>
<td>13. Total percentage of advanced and proficient students at or above the state average on the English I EOC exam.</td>
</tr>
</tbody>
</table>

Population

Missouri school districts selected for this study were limited to those that
responded to the 2011 Census of Technology and whose students completed each of the following four Missouri Assessment Plan assessments: 2009-2010 school year 8th grade Mathematics and Communication Arts and 2010-2011 school year Algebra I and English I EOC exams. In 2011, participation in the Missouri Census of Technology was optional for school districts. Further, during the 2009-2010 school year, all districts were required to administer the two identified 8th grade assessments. However, of the two assessments from the 2010-2011 school year that were used, only the Algebra I EOC exam was required to be administered by all Missouri school districts. The English I EOC exam was optional and administered by districts wishing to receive bonus points in their district accreditation calculations. As a result, the population did not include all Missouri school districts, but instead included a total of 360 Missouri school districts that met the aforementioned criteria.

**Statistical Analyses**

The data collected were analyzed using four methods. First, this study provided a descriptive statistical analysis of the data. Second, this study used the Pearson’s-$r$ correlation coefficient to help determine if a relationship exists between independent variables and dependent variables. The Pearson’s-$r$ correlation coefficient also helped determine which, if any, of the relationships were significant (Field, 2009). Third, this study utilized a two-way MANCOVA to evaluate differences in means of the independent and dependent variables while holding constant for two covariates: prior test performance and socio-economic status. To accomplish this, the study accounted for differences in independent variables and uncontrollable student variables by accounting for prior test performance by one cohort of students across two years of assessment. The
study also accounted for differences in independent variables and uncontrollable student variables by accounting for socioeconomic status, determined by each district’s free and reduced lunch percentage. The covariance analysis helped control for these differences (Pasternack & Charen, 1969; Wildt & Ahtola, 1978). Fourth, an attempt to establish a predictive model occurred by utilizing regression analysis. The regression analysis helped predict an outcome variable from a predictor. The multiple regression, specifically the stepwise linear regression where mathematical criterion were used to determine which predictors were entered into model, was used to predict an outcome variable from several predictor variables (Field, 2009).

**P-Value**

This study established a $p$-value at 0.05 and rejected the null hypothesis if the $p$-value was smaller than or equal to 0.05. If the $p$-value was rejected, then post-hoc tests for main effect and interaction effects were performed by the research at the results were analyzed (Field, 2009). The analysis utilized Pearson’s $r$ correlation coefficient, measures of centrality, standard deviations, figures, charts, and graphs to represent the findings and facilitate analysis of the results.

**Null Hypotheses**

In order to investigate the problem, address the purpose, and to answer the research questions in this study, the following null hypotheses were tested:

$H_01$: There is no difference in the descriptive statistics of all variables under study among Missouri public school districts.

$H_02$: There is no relationship between Missouri school district technology variables and Missouri EOC scores at or above the state average.
$H_{03}$: There is no difference in the main effects and interaction effects between the student achievement on EOC exams when considering district technology variables.

$H_{04}$: There is no difference in the main effects and interaction effects between the student achievement on EOC exams when considering district technology variables.

$H_{05}$: A predictive model cannot be constructed for EOC scores at or above the state average based on Missouri district technology variables.

**Research Question One**

In this study, Research Question 1 sought to determine the descriptive statistics for the Missouri public school districts included in the identified population. Three hundred and sixty districts were included in the study. The eleven independent variables that were examined in this study are illustrated as follows.

*Independent Variable 1.* Dollars per student districts allocate for technology. Dollars per student ranged from $0$ to $1027.20$. The average dollars per student was $128.36$ ($SD = 104.07$). See Figure 3.

*Figure 3.* Histogram of Dollars Spent Per Student on Technology
Independent Variable 2. Ratio of student instructional computers to students.

Ratios of student computers to students ranged from .1 to 1.3. The average ratio was .49 ($SD = .18$). See Figure 4.

Figure 4. Histogram of Ratio of Computer to Students
Independent Variable 3. Whether or not a district has formally adopted a set of technology standards. Ten districts had no formally adopted a set of technology standards, the remaining 350 schools had. See Figure 5.

*Figure 5. Histogram of Adoption of Technology Standards*
Independent Variable 4. Percentage of administrators with a beginner technology skill level. Of all the districts, 283 had 0% of administrators with a beginner technology skill level and the percentage of administrators with a beginner technology skill level ranged from 0-67% in each district (M = 4.69%, SD = 12.52%). See Figure 6.

Figure 6. Histogram of % of Administrators at Beginner Technology Skill Level
Independent Variable 5. Percentage of administrators with an intermediate technology skill level. Forty-two districts had 0% of administrators with an intermediate technology skill level and the percentage of administrators with an intermediate technology skill level ranged from 0-100% in each district (M = 58.16%, SD = 33.16%). 76 districts had 100% of administrators at the intermediate level. See Figure 7.

Figure 7. Histogram of % of Administrators at Intermediate Technology Skill Level
Independent Variable 6. Percentage of administrators with an advanced technology skill level. Of the districts, 110 had 0% of administrators with an advanced technology skill level and the percentage of administrators with an advanced technology skill level ranged from 0-100% in each district (M = 30.85%, SD = 31.36%). Thirty districts had 100% of administrators at the advanced level. See Figure 8.

Figure 8. Histogram of % of Administrators at Advanced Technology Skill Level
Independent Variable 7. Percentage of teachers with a beginner technology skill level. Of the districts, 117 had 0% of teachers with a beginner technology skill level and the percentage of teachers with a beginner technology skill level ranged from 0-66% in each district ($M = 9.96\%$, $SD = 12.13\%$). See Figure 9.

![Histogram of % of Teachers at Beginner Level](image)

**Figure 9.** Histogram of % of Teachers at Beginner Technology Level
Independent Variable 8. Percentage of teachers with an intermediate technology skill level. Five districts had 0% of teachers with an intermediate technology skill level and the percentage of teachers with an intermediate technology skill level ranged from 0-100% in each district (M = 55.74%, SD = 21.49%). Six districts had 100% of the teachers at an intermediate technology skill level. See Figure 10.

Figure 10. Histogram of % of Teachers at Intermediate Technology Level
Independent Variable 9. Percentage of teachers with an advanced technology skill level. Nineteen districts had 0% of teachers with an advanced technology skill level and the percentage of teachers with an advanced technology skill level ranged from 0-100% in each district (M = 27.90%, SD = 22.17%). Two districts had 100% of the teachers at an advanced technology skill level. See Figure 11.

Figure 11. Histogram of % of Teachers at Advanced Technology Level
Independent Variable 10. Internet bandwidth speed. Three districts did not report bandwidth. The majority of districts had 1.5 - 9.9 MB (58.22%, n = 209) or 10MB - 45 MB (30.64%, n = 110). 11 districts had over 100 MB of bandwidth. Eight districts had had 385KB - 1.4MB and 19 districts had 45MB - 100MB. See Figure 12.

Figure 12. Histogram of Internet Bandwidth Speed
Independent Variable 11. Percentage of teachers fully integrating technology into curriculum and instruction. The percentage of teachers fully integrating technology into curriculum and instruction ranged from 0-100% with an average of 68.14% of teachers in districts fully integrating technology ($SD = 26.80\%$). Nine districts reported 0% of teachers fully integrating technology, whereas 42 districts reported 100% of teachers fully integrating technology into curriculum. See Figure 13.

*Figure 13. Histogram of % of Teachers Integrating Technology in the Classroom*
There were three covariate variables:

*Covariate Variable 1. Percent of Free and Reduced Lunches.* The average percent of students with free or reduced lunches across all districts was 53.58% (14.35). The percentage ranged from 14.6% to 53.58%. See Figure 14.

*Figure 14.* Histogram of Percent of Students on Free and Reduced Lunches
Covariate Variable 2. Total percentage of advanced and proficient students at or above the state average on the 8th grade Math exam. Average percentage of students at or above state average on the Math exam was 50.36% (SD = 13.25%), with the percentage across districts ranging from 9% to 100%. Of the districts, 196 had 50% or more of their students at or above state average. See Figure 15.

Figure 15. Histogram of 8th Grade Math Scores
**Covariate Variable 3.** Total percentage of advanced and proficient students at or above the state average on the 8th grade Communication Arts exam. The average percentage of students at or above state average on the Communication Arts exam was 50.88% (SD = 1178%), with percentage from districts ranging from 9% to 100%. 205 districts had 50% or more of their students at or above state average. See Figure 16.

![Figure 16. Histogram of 8th Grade Communication Arts Scores](image)

*Dependent Variable 1.* Total percentage of advanced and proficient students at or above the state average on the Algebra I EOC exam. The average percentage of students at or above state average on the Algebra I EOC exam was 56.16% (SD = 13.42%), with the percentage across districts ranging from 9% to 100%. Of 360 districts, 256 (out of 360, 71.11%) had 50% or more of their students at or above state average. See Figure 17.
Dependent Variable 2. Total percentage of advanced and proficient students at or above the state average on the English I EOC exam. The average percentage of students at or above state average on the English I EOC exam was 58.78% (SD = 16.47%), with percentage across districts ranging from 5.4% to 94.4%. Out of 360 districts, 265 (out of 360, 73.61%) had 50% or more of their students at or above state average. See Figure 18.
Research Question Number Two

The second research question asked if there was a relationship between Missouri school district technology variables and Missouri EOC scores at or above the state average. Using the bivariate (dichotomous) variables for Missouri EOC scores (e.g., dependent variables) and the covariates, correlations were conducted between the technology variables, covariates, and the Missouri EOC scores. Table 5 presents these correlations.

Table 5. Correlations Between Independent Variable and Dependent Variables

<table>
<thead>
<tr>
<th></th>
<th>English I EOC Scores</th>
<th>Algebra I EOC Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dollars per student</td>
<td>.07</td>
<td>.01</td>
</tr>
<tr>
<td>Ratio of computer:student</td>
<td>.01</td>
<td>-.02</td>
</tr>
<tr>
<td>Adoption of technology standards</td>
<td>.12*</td>
<td>.11*</td>
</tr>
<tr>
<td>% of Administrators at Beginner technology skill level</td>
<td>.06</td>
<td>-.06</td>
</tr>
<tr>
<td>% of Administrators at Intermediate technology</td>
<td>.009</td>
<td>-.01</td>
</tr>
<tr>
<td>skill level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>% of Administrators at Advanced technology skill level</td>
<td>-.02</td>
<td>.01</td>
</tr>
<tr>
<td>% of Teachers at Beginner technology skill level</td>
<td>-.03</td>
<td>-.03</td>
</tr>
<tr>
<td>% of Teachers at Intermediate technology skill level</td>
<td>.08</td>
<td>.04</td>
</tr>
<tr>
<td>% of Teachers at Advanced technology skill level</td>
<td>-.03</td>
<td>-.07</td>
</tr>
<tr>
<td>Internet bandwidth speed</td>
<td>.06</td>
<td>.11*</td>
</tr>
<tr>
<td>% of teachers integrating technology</td>
<td>.05</td>
<td>.01</td>
</tr>
<tr>
<td>% of free and reduced lunches</td>
<td>-.26**</td>
<td>-.30**</td>
</tr>
<tr>
<td>8th grade Math scores</td>
<td>.40**</td>
<td>.38**</td>
</tr>
<tr>
<td>8th grade Communication Arts scores</td>
<td>.48**</td>
<td>.27**</td>
</tr>
</tbody>
</table>

*Note.* *p < .05, **p < .01

Having 50% or more students at or above state average for the Algebra I EOC exam was associated with two of the independent variables: internet bandwidth ($r = .11, p = .04$) and adoption of technology standards ($r = .11, p = .04$). Having 50% or more students at or above state average for the Algebra I EOC exam was positively associated with having higher bandwidth speeds and having a formal technology adoption. The covariate variables of free and reduced lunch ($r = -.26, p < .01$), 8th grade Math scores ($r = .40, p < .01$) and 8th grade Communication Arts scores ($r = .48, p < .01$) were all correlated with Algebra EOC scores.

For having 50% or more students at or above state average for the English I EOC exam, was associated with one variable—the adoption of technology standards ($r = .12, p = .02$). Having a formal adoption of technology standards was associated with having 50% or more of a school’s students at or above state average for the English I EOC. Again, the covariate variables of free and reduced lunch ($r = -.30, p < .01$), 8th grade Math scores ($r = .38, p < .01$) and 8th grade Communication Arts scores ($r = .27, p < .01$) were all correlated with English I EOC.
Thus, hypothesis two was somewhat supported: there were three significant relationships. Having faster bandwidth was associated with those schools having 50% or more of their students at or above state average for the Algebra I EOC exam. Having a formal technology adoption was associated with those schools having 50% or more of their students at or above state average for the English I EOC exam and the Algebra I EOC exam.

**Research Question Number Three**

The third research question asked if, using socioeconomic status as a covariate, there was a difference in the main effects and interaction effects between the student achievement on EOC exams when considering district technology variables. A multivariate analysis of covariance was conducted with EOC exam scores as the two dependent variables, and socioeconomic status (free lunches) as the covariate. For independent variables, the variables that significantly correlated with exam scores were added to the model. These were Internet bandwidth speed and whether or not schools had a formal adoption of technology standards.

The results of the MANCOVA appear in Table 6. The only significant predictor was socioeconomic status, the covariate (p < .01). Neither Internet speeds nor adoption of technology standards significantly predicted either dependent variable. The interaction of adoption standards and Internet speeds also was not predictive of EOC scores.

### Table 6. Results of Technology Variables Predicting EOC Scores, Controlling for SES

<table>
<thead>
<tr>
<th></th>
<th>SS</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English I</td>
<td>7486.16</td>
<td>1</td>
<td>7486.16</td>
<td>47.81</td>
<td>.01</td>
</tr>
<tr>
<td>Algebra I</td>
<td>9869.01</td>
<td>1</td>
<td>9869.01</td>
<td>40.80</td>
<td>.01</td>
</tr>
<tr>
<td>Internet Speed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Thus there is no support, after controlling for SES, that district technology variables influence student achievements on EOC exams.

**Research Question Number Four**

The fourth research question asked if, using past standardized assessment achievement data (8th Grade MAP assessment) as a covariate, there was a difference between the main effects and interaction effects between the student achievement on EOC exams when considering district technology variables. A multivariate analysis of variance was conducted with EOC exam scores as the two dependent variables, and past standardized assessment achievement data (8th Grade MAP assessment) as the covariate. For independent variables, the variables that significantly correlated with exam scores were added to the model. These were Internet bandwidth speed and whether or not schools had a formal adoption of technology standards.

The results of the MANCOVA appear in Table 7. The only significant predictor was the covariates of past exam scores. Neither Internet speeds nor adoption of technology standards significantly predicted either dependent variable. The interaction of adoption standards and Internet speeds also was not predictive of EOC scores.

### Table 7. Results of Technology Variables Predicting EOC Scores, Controlling for Past Scores

<table>
<thead>
<tr>
<th></th>
<th>SS</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Past Math scores</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Research Question Number Five

The fifth research question asked if a predictive model be constructed for EOC scores at or above the state average based on Missouri technology variables. To examine this question, two separate linear regressions were conducted. The outcome variable was all the scores that scored above average. In the first regression it was the English I EOC scores. In the second regression it was the Algebra I EOC scores. The independent variables in both regressions were each of the technology variables entered into a stepwise linear regression. A stepwise linear regression enters in all the independent variables but then removes all non-significant variables, leaving only the significant variables in the final model (Field, 2009).

For the regression model predicting English I EOC scores, the significant predictor was percent of teachers at advanced technology skill level ($B = .07, SE = .02, t = 2.95, p = .004$). The other significant predictor was the ratio of student to computers ($B = 6.89, SE = 2.98, t = 2.34, p = .02$). All other predictors were non-significant and removed from the model. This left with an R-squared of .088, meaning that these two variables predict roughly 9% of the variance associated with English I EOC scores, $F(2,
For the regression predicting Algebra I EOC scores, none of the variables were significant predictors, and thus the model failed to run.

**Overall Findings**

There were three correlational findings. First, faster bandwidth was associated with those schools having 50% or more of their students at or above state average for the Algebra I EOC exam. Having a formal technology adoption was associated with those schools having 50% or more of their students at or above state average for the English I EOC exam and the Algebra I EOC exam. However, after controlling for SES, these two district technology variables failed to influence student achievements on EOC exams. Second, after controlling for past exam scores, the two district technology variables that were entered in the MANOVA (adoption of technology standards and internet bandwidth) were not predictive of EOC scores. And third, to see which technology variables were most predictive of Algebra I EOC exam scores and English I EOC exam scores, linear stepwise regression were conducted. Ratio of students to computer was a significant predictor of English I EOC scores as well as the percentage of teachers at advanced technology skill level. However, none of the technology variables were significant predictors of Algebra I EOC scores. Thus, it seems, over and above SES and past scores, technology variables have little influence on EOC scores.

Chapter 5 provides suggestions for future research. This future research would contribute to the general body of knowledge while potentially allowing the districts studied to more completely understand how technology variables impact certain EOC exam scores. Chapter 5 also lists the findings, conclusions, and limitations of the study.
CHAPTER 5

Findings, Conclusions, and Recommendations

In Missouri, 67% of a school district’s accreditation score is based on student standardized assessment performance data. Having a high accreditation score effects school funding as well as the perception of the school district, staff, and community as a whole. However, standardized assessments in Missouri are largely administered in an online format. This could be troublesome due to the unequal distribution of technology resources, or digital divide, which exists in and among Missouri school districts. This study examined the digital divide by investigating the impact of district technology variables on student performance on high school student, online, standardized assessments in Missouri. This chapter provides an overview of the problem and purpose of this study, population, and statistical methods, as well as a discussion of the findings, conclusions, recommendations, and limitations of the study.

Problem of the Study

Although a large quantity of research exists regarding technology in schools, the digital divide, and accountability, there is a lack of information about the relationship between school district technology variables and student assessment performance (Ritzhaupt et al., 2013). Also, Shapley et al. (2011) indicated that the study of the relationship between technology and student achievement continues to be of value in order to seek more clarity of this issue. This study investigated if there is a relationship between Missouri school district technology variables and student performance on online EOC exams. This research was necessary because there is a lack of information regarding the relationship between Missouri public school district technology variables and online
student assessment performance. This study gave full consideration to prior research in order to provide additional information regarding the existence of a digital divide in Missouri’s schools and the impact it has on student achievement.

**Purpose of the Study**

This study was conducted for two main purposes. The first purpose of this study was to examine the digital divide by determining the main effects and interaction effects between Missouri school district technology variables and student End-of-Course exam performance. The second purpose of this study was to attempt to construct a predictive model for Missouri EOC exam performance at or above the state average based on school district technology variables. In order to accomplish these two purposes, data from the 2010-2011 Missouri Census of Technology, along with MAP data from 2009-2011 was acquired. The data was then statistically analyzed to determine if relationships between school district technology variables and EOC exam performance existed. The data was further analyzed in order to see if a predictive model for EOC exam performance could be created.

**Limitations of the Study**

This study had four limitations. First, school districts are complex organizations. This study did not take into account the factors such as course offerings, teaching pedagogy, experience level of teacher, and many others that influence student achievement on standardized tests. Second, this study did not attempt to explore the students’ opinions of computer-based standardized assessments and their perceived relationship to achievement. While it might be assumed that today’s students would be comfortable with using technology for testing in this study, it was not subject to
measurement. Third, because of the self-reporting nature of the Missouri Census of Technology, results may have been limited by the extent to which all participants completing the Census answered the questions honestly and accurately. Finally, the researcher has also worked in the field of educational technology within the geographic area of the study for several years and therefore may have had certain tacit knowledge not articulated in this study.

Population

The Missouri school districts that were included in this study were limited to those that responded to the 2011 COT and whose students completed each of the following four MAP assessments: 2009-2010 school year 8th grade Mathematics and Communication Arts and 2010-2011 school year Algebra I and English I EOC exams. In 2011, all Missouri school districts were required to complete the COT. Further, during the 2009-2010 school year, all districts were required to administer the two identified 8th grade assessments. However, of the two assessments from the 2010-2011 school year that were used, only the Algebra I EOC exam was required to be administered by all Missouri school districts. The English I EOC exam was optional and administered by districts wishing to receive bonus points in their district accreditation calculations. As a result, the population did not include all Missouri school districts, but instead included a total of 360 Missouri school districts that met the aforementioned criteria.

Statistical Methods

Descriptive statistics, including mean and standard deviation, for each independent variable, dependent variable, and covariate were calculated. Also, Pearson’s-$r$ correlation coefficient was calculated to help determine if a relationship
exists between independent variables and dependent variables. The Pearson’s-\(r\) correlation coefficient also helped determine which, if any, of the relationships were significant (Field, 2009). Additionally, this study utilized a two-way MANCOVA to evaluate differences in means of the independent and dependent variables while holding constant for two covariates: prior test performance and socio-economic status (Pasternack & Charen, 1969; Wildt & Ahtola, 1978). Finally, a multiple regression, specifically the stepwise linear regression where mathematical criterions are used to determine the predictors to be entered into model, was used to predict an outcome variable from several predictor variables (Field, 2009).

**Independent Variables**

Eleven independent variables were examined in this study:

- Dollars per student districts allocate for technology;
- Ratio of student instructional computers to students;
- Whether or not a district has formally adopted a set of technology standards;
- Percentage of administrators with a beginner technology skill level;
- Percentage of administrators with an intermediate technology skill level;
- Percentage of administrators with an advanced technology skill level;
- Percentage of teachers with a beginner technology skill level;
- Percentage of teachers with an intermediate technology skill level;
- Percentage of teachers with an advanced technology skill level;
- Internet bandwidth speed; and
Percentage of teachers fully integrating technology into curriculum and instruction.

**Dependent Variables**

The two dependent variables that were examined in this study were (a) the total percentage of advanced and proficient students at or above the state level on the Algebra I EOC exam, and (b) the total percentage of advanced and proficient students at or above the state level on the English I EOC exam. The MANCOVA was completed to test for significant differences between independent variables. Using MANCOVA, independent variables which were determined to have a significant relationship by Pearson’s-\(r\) correlation coefficient were examined against both dependent variables while holding constant for two covariates: a) free and reduced lunch percentages in order to control for socioeconomic status (Caro et al., 2009; Ewumi, 2012; Perry, 2012), and b) 2009-2010 Grade 8 Communication Arts and Grade 8 Mathematics data in order to control for test-taking ability. Use of a covariate was recommended by Pasternack & Charen (1969) and Wildt & Ahtola (1978) in order to account for differences in independent variables and uncontrollable student variables.

**Discussion of Study Findings**

The discussion of findings is organized by research question. Careful examination of the data collected in order to answer the problem and research questions in this study let to the following findings:

*Research Question 1*: What are the descriptive statistics for all variables under study?

Descriptive statistics calculated for the independent variables revealed: (a)
districts allocated between $0 and $1027.20 per student for technology with an average allocation of $128.36; (b) the ratio of student computers to students ranged from .1 to 1.3 with the average being .49 only 10 districts did not have formally adopted technology standards; (c) administrator technology skill level varied within districts, but overall 76 out of 360 districts had administrators at the beginner skill level, 318 out of 360 districts had administrators at the intermediate skill level, and 250 out of 360 districts had administrators at the advanced skill level; (d) teacher technology skill level varied within districts, but overall 243 out of 360 districts had teachers at the beginner skill level, 355 out of 360 districts had teachers at the intermediate skill level, and 341 out of 360 districts had teachers at the advanced skill level; (e) Internet bandwidth speed varied among districts with the majority of districts having a 1.5-9.9MB connection (58.22% n=209) or 10MB-45MB connection (30.64%, n=110); and (f) an average of 68.14% of teachers fully integrate technology into instruction. Table 8 summarizes the descriptive statistics.

Table 8. Descriptive Statistics of Study Variables

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>M(SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dollars per student</td>
<td>$128.26 (104.06)</td>
</tr>
<tr>
<td>Ratio of computer: student</td>
<td>.50 (.18)</td>
</tr>
<tr>
<td>Adoption of technology standards</td>
<td>.97 (.16)</td>
</tr>
<tr>
<td>% of Administrators at Beginner technology skill level</td>
<td>4.69% (12.52)</td>
</tr>
<tr>
<td>% of Administrators at Intermediate technology skill level</td>
<td>58.16% (33.17)</td>
</tr>
<tr>
<td>% of Administrators at Advanced technology skill level</td>
<td>30.85% (31.36)</td>
</tr>
<tr>
<td>% of Teachers at Beginner technology skill level</td>
<td>9.96% (12.13)</td>
</tr>
<tr>
<td>% of Teachers at Intermediate technology skill level</td>
<td>55.74% (21.49)</td>
</tr>
<tr>
<td>% of Teachers at Advanced technology skill level</td>
<td>27.90% (22.17)</td>
</tr>
<tr>
<td>% of teachers integrating technology</td>
<td>68.14% (26.80)</td>
</tr>
<tr>
<td>% of Free and Reduced Lunches</td>
<td>53.58% (14.35)</td>
</tr>
<tr>
<td>8th grade Math Scores</td>
<td>50.36% (13.25)</td>
</tr>
<tr>
<td>8th grade English Scores</td>
<td>50.88% (11.78)</td>
</tr>
</tbody>
</table>
Descriptive statistics calculated for the covariates revealed: the free and reduced lunch percentage varied among districts with an overall average being 53.58%; the average percentage of students at or above state average on the 8th Grade Math assessment was 50.36% with 196 districts having 50% or more of their students at or above state average; and the average percentage of students at or above state average on the 8th Grade Communication Arts assessment was 50.88% with 205 districts having 50% or more of their students at or above state average.

Descriptive statistics calculated for the dependent variables revealed: the average percentage of students at or above state average on the Algebra I EOC exam was 56.16% with 256 districts having 50% or more of their students at or above state average; and the average percentage of students at or above state average on the English I EOC exam was 58.78% with 265 districts having 50% or more of their students at or above state average.

As expected, independent variable data, covariate variable data, and dependent variable data varied widely among districts in the study. It was apparent that technology hardware, Internet access, funding, skill levels, and implementation varied greatly in the Missouri school districts that were studied. Therefore, a digital divide, or unequal distribution of technology resources (Attewell, 2001; Clark & Gorski, 2001), exists among districts in Missouri. More specifically, it can be confirmed that a 1st and 2nd level digital divide is indeed present.

At the 1st level, hardware, software, Internet access, and support for technology are unequally distributed, while at the 2nd level use of technology by teachers is widely varies. Figure 19 helps to illustrate this conclusion. Hohlfeld et al. (2008) point out that the levels of the divide are hierarchical. Therefore the model supports the findings from
this study in that by having a 2nd level divide, the districts studied must also have a 1st level divide. However, this study was unable to determine whether or not the existence of a 3rd level divide existed in the districts under study.

**Figure 19.** Levels of the Digital Divide in Schools (Hohlfeld et al., 2008)

*Research Question 2:* Is there a relationship between Missouri school district technology variables and Missouri EOC scores at or above the state average and if there is a relationship, what variables are more closely related to the EOC scores at or above the state average?

*Ho2:* There is no relationship between Missouri school district technology variables and Missouri EOC scores at or above the state average.

Calculation of Pearson’s- *r* correlation coefficient was recommended by Creswell, (2009), Field (2009), and Thompson (2006) in order to determine the degree to which the independent and dependent variables were related, while also determining which of the relationships were significant. It was found that having 50% or more of their students at or above state average for the Algebra I EOC exam was positively associated with having higher bandwidth speeds (*r* = .11, *p* = .04) and having a formal adoption of a set of
technology standards \((r = .11, p = .04)\). The covariate variables of free and reduced lunch \((r = -.26, p < .01)\), 8th grade Math scores \((r = .40, p < .01)\) and 8th grade Communication Arts scores \((r = .48, p < .01)\) were all correlated with Algebra EOC scores.

Also, having 50% or more of their students at or above state average for the English I EOC exam was positively associated to only one variable—adoption of technology standards \((r = .12, p = .02)\). Again, the covariate variables of free and reduced lunch \((r = -.30, p < .01)\), 8th grade Math scores \((r = .38, p < .01)\) and 8th Grade Communication Arts scores \((r = .27, p < .01)\) were all correlated with the English I EOC. Because there were three significant relationships between district technology variables and Missouri EOC exam scores, the null hypothesis is rejected.

It is apparent that faster Internet speed was associated Algebra I EOC exam performance. It was also apparent that having a formal set of technology standards was associated English I and Algebra I EOC performance. The variance in Internet speed (a variable often mentioned when discussing the existence of a digital divide) having an influence on students is supported by Brown (2000) and Hohlfeld et al. (2008). Further, formal adoption of technology standards indicates districts are aware of how technology is used by teachers and teachers are asked to align their use of technology to those standards. This study supports Brown (2000), Huang and Russell (2006), and Morse (2004) in that academic achievement and preparedness of students are often tied to the importance of teacher-focused technology training and use.

Further, this study supports Attewell (2001), Hohlfeld et al. (2008), and Ritzhaupt et al. (2013) in that it is not necessarily the type and quantity of technology that is being used, rather it is the types of activities the students use technology for, such as drill and
skill activities resulting in little improvement or critical thinking, which would be guided by adopted standards.

*Research Question 3:* Using socioeconomic status as a covariate, is there a difference in the main effects and interaction effects between the student achievement on EOC exams when considering district technology variables?

*H₀₃:* There is no difference in the main effects and interaction effects between the student achievement on EOC exams when considering district technology variables.

After determining which independent variables were positively associated to the dependent variables, a MANCOVA was performed using socioeconomic status as a covariate. The MANCOVA analysis was recommended by Pasternack and Charen (1969) and Wildt and Ahtola (1978) in order to help account for differences in independent variables and uncontrollable student variables. Use of socioeconomic status as a covariate has been supported in research by Caro, McDonald, and Wilms (2009), Ewumi (2012), and Perry (2012). Though socioeconomic status was a significant predictor \( p < .01 \), it was found that there is no support, after controlling for SES, that district technology variables influence student achievements on EOC exams. Therefore the null hypothesis is accepted.

This finding in the study supports research that indicates how technology’s impact on student achievement is difficult to measure due to the fact that the nature of the relationship between technology and student achievement is complex (Protheroe, 2005; Glennan & Melmed, 1996). The impact is also difficult to measure as many prior studies regarding the use of technology to increase student achievement are mixed and varied (Attewell, 2001; Newhouse, 2011; Ricketts & Wilks, 2002). Still, when accounting for
socioeconomic status this study indicates that district technology variables do not impact these two particular EOC exams.

**Research Question 4:** Using past standardized assessment achievement data (8th Grade MAP assessment) as a covariate, is there a difference in the main effects and interaction effects between the student achievement on EOC exams when considering district technology variables?

**H04:** There is no difference in the main effects and interaction effects between the student achievement on EOC exams when considering district technology variables.

After determining which independent variables were positively associated to the dependent variables, a MANCOVA, was performed using prior test performance as a covariate. As in research question 3, the MANCOVA analysis was recommended by Pasternack and Charen (1969) and Wildt and Ahtola (1978) in order to help account for differences in independent variables and uncontrollable student variables. Though prior test performance was a significant predictor \( p < .01 \), it was found that there is no support, after controlling for prior test performance, that district technology variables influence student achievements on EOC exams. Therefore, the null hypothesis is accepted. This finding is supported by the research outlined in research question 3. It is equally apparent, when accounting for prior test performance, this study indicates that district technology variables do not impact these two particular EOC exams.

**Research Question 5:** Can a predictive model be constructed for EOC scores at or above the state average based on Missouri technology variables?

**H04:** A predictive model cannot be constructed for EOC scores at or above the state average based on Missouri district technology variables?
The final statistical analysis employed was a regression analysis. The multiple regression, specifically the stepwise linear regression where mathematical criterion are used to determine which predictors are entered into model, was recommended by Field (2009). Two separate linear regressions were conducted, one for English I scores and the other for Algebra I EOC scores. The outcome variable was all the scores that scored above the state average. The independent variables in both regressions were all the technology variables, entered into a stepwise linear regression. A stepwise linear regression enters in all the independent variables but then removes all non-significant variables, leaving only the significant variables in the final model.

For the regression model predicting English I EOC scores, the significant predictors were percent of Teachers at Advanced technology skill level ($B = .07, SE = .02, t = 2.95, p = .004$). The other significant predictor was the ratio of student to computers ($B = 6.89, SE = 2.98, t = 2.34, p = .02$). All other predictors were non-significant and removed from the model. This left with an R-squared of .088, meaning that these two variables predict roughly 9% of the variance associated with English I EOC scores, $F(2, 162) = 7.80, p < .01$. For the regression predicting Algebra I EOC scores, none of the variables were significant predictors, and thus the model failed to run. Therefore, because a predicative model could be constructed for English I scores, the null hypothesis was rejected.

With teacher advanced skill level and student to computer ratio only accounting for 9% of the variance associated with English I scores, and a failure to establish a model for Algebra I EOC scores, the difficulty in measuring the impact of the digital divide on student achievement is highlighted (Attewell, 2001; Glennan and Melmed, 1996;
Newhouse, 2011; Protheroe, 2005; Ricketts & Wilks, 2002). Also, while this finding may seem contrary to much of the literature review in Chapter 2, this study does support the notion that the digital divide’s impact is difficult to measure as many prior studies regarding the use of technology to increase student achievement are mixed and varied (Attewell, 2001; Newhouse, 2011; Ricketts & Wilks, 2002).

Conclusions

This study was provided evidence that a first and second level digital divide (Hohlfeld et al., 2008) exists among the studied Missouri school districts and includes an unequal distribution of technology hardware, Internet access, funding, skill levels, and implementation. Of each of these variables, Internet speed and the adoption of formal technology standards were correlated with higher test scores. However, when accounting for socioeconomic status, the existence of the digital divide in the studied Missouri school districts did not have an impact on English I or Algebra I EOC exams. Similarly, when accounting for prior test performance, the existence of the digital divide in the studied Missouri school districts did not have an impact on English I or Algebra I EOC exams.

This study reaffirms the strong relationship between socio-economic status and student achievement (Caro, McDonald, & Willms, 2009; Ewumi, 2012; Perry, 2012). Attempting to address the existence of the digital divide in school districts by increasing Internet bandwidth or adopting a set of technology standards would not directly impact English I or Algebra I EOC scores and, therefore, would not be a prudent use of district funds. This study supports Attewell’s (2001), Hohlfeld et al.’s (2008) and Ritzhaupt et al.’s (2013) research that improving student achievement is not about simply eliminating
the digital divide, but also training teachers and students to use the technology and change how technology is used. This study also supports Claro et al.’s (2012) research which indicated a low, inexistent, or negative relationship between technology use and student performance on assessments.

Additionally, the student to computer ratio as well as the percentage of teachers at the advanced technology skill level were predictors of English I EOC performance in a linear regression, however, none of the technology variables were significant predictors of Algebra I EOC scores. School districts might consider reducing the student to computer ratio in Communication Arts classrooms while also providing professional development that would increase the technology skills of teachers to advanced levels. This could lead to an impact on English I EOC scores, however, the impact would not be realized when accounting for prior test performance or socioeconomic status. This conclusion is supportive of Attewell’s (2001), Brown’s (2000), Huang & Russell’s (2006), and Morse’s (2004) research which posits overall academic achievement and preparedness of students are often tied to the importance of teacher-focused technology training.

Overall, it would seem district technology variables have little influence on Missouri English I or Algebra I EOC exam scores. Therefore, it can be determined that, when considering all variables in this study, the existence of a digital divide among Missouri school districts does not appear to have an impact on these two tested areas. Allocating additional funding to increase technology, or decrease the existence of the digital divide, should not be done so in an effort to impact student performance in Communication Arts or Algebra.
Recommendations

Several recommendations for practitioners and future research are based on the conclusions. Leaders of school districts in Missouri should continue to evaluate and consider how socioeconomics factors play a role in student achievement. This study found some technology variables that had a significant impact on test scores, however the significance was nullified when accounting for free and reduced lunch rates. The importance of socioeconomics cannot be ignored when addressing issues in education (Caro, McDonald, & Willms, 2009; Ewumi, 2012; Perry, 2012).

Also, school leaders, as well as teachers, should worry less about technology’s impact on student performance on standardized tests while giving more concern to how technology might be positively affecting students in other ways. More specifically, school leaders and teachers should find ways to develop their technology skills, as well as their students’ technology skills, which is supported by Caro, McDonald, & Willms (2009), Ewumi (2012), and Perry (2012), in order to impact overall student achievement.

Further, leaders of school districts in Missouri should consider finding ways to lower student to computer ratios in English classrooms while also providing opportunities to increase English teacher technology skills that are statistically proven to impact test performance in English. This could not only increase student achievement, but also increase student engagement, enhanced writing, and improved technology skills (Penuel, 2006; Stanhope & Corn, 2014).

When considering further research on this topic, researchers who examine the impact of the digital divide on student achievement should use socioeconomic status and/or prior test performance to control for variances in students, districts, and variables.
(Caro, McDonald, & Willms, 2009; Ewumi, 2012; Perry, 2012). Controlling for these variables ensures that the complex nature of the relationship between technology and student achievement is addressed (Protheroe, 2005). Most importantly, accounting for socioeconomic status ensures that the importance of socioeconomics in educational studies is not ignored (Caro, McDonald, & Willms, 2009; Ewumi, 2012; Perry, 2012).

Also, researchers should consider using a construct valid survey instrument to more accurately survey Missouri district technology (Field, 2009). The Missouri COT asks for information, such as technology skill levels of administrators and teachers in school districts, which is subjective to the opinion of the person filling out the survey form. Also, the COT does not ask information regarding the technology skill level of students. Using a construct valid survey instrument would allow for the collection of more accurate and detailed information regarding many district technology variables which, in turn, could enhance the types of data available for study.

Additionally, researchers should examine this topic of the digital divide and its impact on student achievement to a deeper and more focused degree. This study should be replicated for other Missouri EOC tested subjects in order to determine if the results of this study are subject-specific. Also, online assessments in Missouri at the time of this study were only administered in grades 9-12. The state assessments are now also being administered in an online format in grades 3-8. Further study of the impact of the digital divide on student performance on online assessments at different grade levels is needed. Finally, further studies regarding how technology use in schools impacts overall student achievement, not just achievement on standardized assessments, are needed.
Summary

In research conducted prior to this study, Protheroe (2005) noted that technology’s impact on student achievement is difficult to measure due to the fact that the nature of the relationship between technology and student achievement is complex. It is even more complex when accounting for the digital divide, prior test performance, or perhaps most importantly, the socioeconomic status of students. This study sought to add to the research base regarding the impact of district technology resources divide on high school student, online, EOC exam performance in Missouri. Through this study, it was established that, the existence of a digital divide had little impact on student English I or Algebra I End-of-Course exam performance. Continued research is needed regarding technology’s impact on student achievement in Missouri in order to better understand how to ensure student success in an increasing digital world. The results of this study can be used to inform researchers and leaders who seek to understand the impact of the digital divide on student online assessment performance. The benefit will come from an increased understanding of how technology may or may not have an impact on student achievement.
References


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Appendix A

IRB Approval Letter

Institutional Review Board
University of Missouri-Columbia

February 20, 2015
Principal Investigator: Kevin R Whaley
Department:

Your Exempt Application to project entitled EXAMINING THE DIGITAL DIVIDE: THE IMPACT OF SCHOOL DISTRICT TECHNOLOGY RESOURCES ON HIGH SCHOOL STUDENT, ONLINE, END-OF-COURSE EXAM PERFORMANCE IN MISSOURI was reviewed and approved by the MU Institutional Review Board according to terms and conditions described below:

IRB Project Number 2001555
IRB Review Number 201678
Approval Date of this Review February 20, 2015
IRB Expiration Date February 20, 2016
Level of Review Exempt
Project Status Active - Open to Enrollment
Exempt Categories 45 CFR 46.101b(4)
Risk Level Minimal Risk

The principal investigator (PI) is responsible for all aspects and conduct of this study. The PI must comply with the following conditions of the approval:

1. No subjects may be involved in any study procedure prior to the IRB approval date or after the expiration date.
2. All unanticipated problems, adverse events, and deviations must be reported to the IRB within 5 days.
3. All changes must be IRB approved prior to implementation unless they are intended to reduce immediate risk.
4. All recruitment materials and methods must be approved by the IRB prior to being used.
5. The Annual Exempt Form must be submitted to the IRB for review and approval at least 30 days prior to the project expiration date. If the study is complete, the Completion/Withdrawal Form may be submitted in lieu of the Annual Exempt Form.
6. Maintain all research records for a period of seven years from the project completion date.
7. Utilize all approved research documents located within the attached files section of eCompliance. These documents are highlighted green.

If you have any questions, please contact the IRB at 573-882-3181 or irb@missouri.edu.

Thank you,
Vita

Kevin Robert Whaley was born in Kansas City, Missouri to Wes and Zoe Whaley on March 6, 1977. Following graduation from Oak Park High School in Kansas City, Missouri in 1995, he received the following degrees: B.A. in History from Park University (2000); M.Ed. in Information Science and Learning Technologies from University of Missouri-Columbia (2003); Ed.S. in Educational Leadership from University of Missouri-Kansas City; Ed.D. in Educational Leadership and Policy Analysis from the University of Missouri-Columbia (2015). He is married to the former Katherine Louise Hughes of Kansas City, Missouri.