ACHIEVEMENT OF CATHOLIC HIGH SCHOOL STUDENTS INVOLVED IN A ONE-TO-ONE LAPTOP INITIATIVE PROGRAM

by

Matthew J. Buckley

Liberty University

A Dissertation Presented in Partial Fulfillment
Of the Requirements for the Degree
Doctor of Education

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ABSTRACT

There has been limited research regarding the achievement levels of high school students after the implementation of a one-to-one laptop initiative program within the Catholic high school environment. A one-to-one laptop initiative is a program wherein each student is provided a laptop to complete coursework, take assessments, collaborate with peers, and access resources. Upon review of the conceptual framework of the history of Catholic education, 21st century teaching and learning, and the integration of technology within the classroom, this study used archival data to determine if student achievement was impacted by a one-to-one laptop initiative. A one-way, between-subjects MANOVA was used to analyze the data from students representing two schools in this non-experimental, causal-comparative, posttest-only study. To further explore the source of the significant multivariate difference between the two schools were compared on each of the seven subscales of the Iowa Tests of Educational Development (ITED) using a series of seven univariate ANOVAs. After analysis, it was determined that students from the school without the laptop program scored higher than students from the school with the laptop program on six of seven ITED subscales as well as on ITED Composite scores. The samples did not differ significantly on the four of the ITED subscales, nor on the ITED Composite scores. Implications, limitations, and recommendations for future research were also presented following an in-depth discussion of the results.

Keywords: Catholic education, educational technology, one-to-one laptop initiative
Dedication

This dissertation is dedicated to my wife, Amber, and my children, Easton, Adalyn, and Rowan. Know that you all are the most important part of my life, and each of you makes me a better person.

To my children, I encourage and expect you to give your very best and to always leave everything better than you found it. Always be intentional in your interactions with others and always know that you have God by your side.
Acknowledgements

I want to thank God and my Savior, Jesus Christ, for giving me the strength and dedication in both my education and my career. Each day, I strive to fulfill my calling within my vocation and to make a positive difference in the lives of those in which I have the privilege of serving and leading. I am blessed to have been surrounded by excellent mentors who I admire dearly, and I know that the placement of those people within my life were purposeful.

Thank you to my wife, Amber, for supporting me much more than I deserve. Your love, support, and encouragement mean the world to me. To our children, Easton, Adalyn, and Rowan, being your father is my greatest honor. I will never forget the late nights of holding and rocking each of you to sleep while studying texts and writing papers for my doctorate degree – those times are memories that I will forever cherish. Your mother and I expect great things from each of you.

I thank my parents and grandparents for always believing in me and for instilling in me the understanding of work ethic and perseverance. I would not be the person I am without each of your influence and devotion to me.

Thank you to my dissertation chair, Dr. Pearson. Without your knowledge, experience, and guidance, I would not have been able to complete this dissertation. I sincerely appreciate your mentorship and encouragement.

To Dr. Michael, I thank you for all you have taught me about statistics and technical writing. You challenged me to keep working until I understood, and you taught me to view quantitative statistics in a whole new way. Thank you for all of your help.
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CHAPTER ONE: INTRODUCTION

Overview

Only a few studies have examined the effects of a one-to-one laptop initiative within a Catholic high school setting (Kulow, 2014; Goodwin, 2012). This study used a quantitative methodology and a non-experimental, causal-comparative, posttest-only research design to evaluate the impact of one such initiative. The purpose of the study was to determine if a difference exists between the achievement scores of Catholic high school students who were involved in a one-to-one laptop initiative and the achievement scores of Catholic high school students who were not involved in a one-to-one laptop initiative. Chapter One provides a background and overview of the study. The chapter begins with a description of the unique setting that defines the Catholic high school experience. Part of that experience is the expectation for high academic success that results from greater student investment in coursework, more time spent on homework, better attendance, and more focused concentration and attention during classes. The chapter also introduces one-to-one laptop initiatives and describes the potential value of these initiatives within the context of Catholic education. Previous research on the efficacy of laptop initiatives will be summarized, along with the recommendations of previous researchers for additional research on laptop initiatives. That review leads to the problem statement for the present study. The purpose of the study will be explained, as well as the study’s significance for Catholic education. Finally, the study’s research question will be introduced, and definitions of terms that are pertinent to this study will be given.

Background

Catholic schools consistently outperform public schools, charter schools, and nonreligious private schools in academic achievement measured by a variety of national
standardized assessments (MacGregor, 2013). Despite this demonstrated superiority, the nation’s best secondary educational system faces an existential crisis as Catholic school enrollment continues to decline nationwide (Cassandra, 2017). MacGregor (2013) cited the following reasons for the national decline in enrollment: fewer priests and nuns, rising cost of tuition for families, and a faltering commitment to Catholic religion.

As a result of this national crisis, MacGregor (2013) discussed the several efforts that Catholic school leaders are employing in an effort to sustain Catholic schools: making Catholic schools affordable, enhancing the educational process in order to be more competitive with and superior to alternative forms of education, and propelling Catholic schools forward by upholding the highest standards in student achievement and engagement. Catholic schools must be responsive and relevant to changing societal demands and educational advancements. To accomplish this, administrators are examining a variety of ways to ensure that Catholic high school students will experience success in their post-secondary education and be fully prepared for the challenges that lay beyond high school. School leaders must continue to convince parents and stakeholders that a Catholic education is a worthy investment in the child’s future (Weitzel-O’Neill & Torres, 2012).

In order to best market a Catholic education, school leaders must ensure that the academic experience that the school provides is highly competitive within the educational marketplace and prepares students for success in post-secondary education. Integrating technology into the Catholic high school curriculum allows schools to enhance their competitiveness, better meet learning objectives of all their students, and supplement instructional and assessment practices for more timely feedback regarding students’ progress (Dachos, 2017). One of the ways in which Catholic school administrators can integrate
technology into the curriculum is through the implementation of a one-to-one laptop initiative program wherein students are provided with a laptop computer to complete their coursework, access instructional resources, take assessments electronically, and collaborate closely with peers (Keengwe, Schnellert, & Mills, 2012). Holland and Holland (2014) noted that technology in the classroom provides an opportunity for educators to more easily create a personalized academic plan for their students.

It is important for researchers to study the effectiveness of one-to-one laptop initiatives with regard to student achievement and student engagement, specifically within the Catholic school environment. The successful implementation of one-to-one laptop initiatives will not only prepare students for post-secondary education and 21st century careers (MacGregor, 2013), but will also enhance the competitiveness of Catholic secondary education and give administrators a means of setting the Catholic educational experience apart from the alternatives in their marketing efforts (MacGregor, 2013).

Twentieth century teaching emphasized time-based memorization and retelling of facts. Students were viewed as passive recipients of content knowledge who demonstrated learning through routine summative assessments. This teaching and learning paradigm supported 20th century educational goals by providing students with the knowledge base and skill sets that were needed for jobs that required procedural cognitive work and labor (Dede, 2010; Pacific Policy Research Center, 2012). However, Dede (2010) suggested that the 21st century “has seen a dramatic shift in the economic model for industrialized countries” (p. 2), and because of this, successful workers need new, different skills that support creativity, innovation, flexibility, and fluency in information and communication technologies.
One way in which schools have responded to the changing demands of the 21st century job market is by integrating technology into the instructional curriculum. One of the ways of integrating technology into the curriculum is the implementation of one-to-one laptop initiative programs. One-to-one laptop initiative programs are relatively new and take on various formats. Typically, students are assigned a laptop or tablet computer that they use both within the classroom and at home (Dede, 2010). These laptop devices are used to complete coursework and assignments, collaborate with peers, access additional resources, and take classroom assessments (Sauers & Mcleod, 2012). Providing all students with their own computers offers the benefits of equal access, standardization, easy upgrades, simple networking and the ability to monitor student progress and online behavior (Penuel, 2006).

To gain an understanding of the historical context of this study, it is also important to look at the history of Catholic education in the United States. Catholic education was built on the premise and tradition that Catholic schools are designed to be communities of faith, communities of learners, and communities serving parishes and wider communities. In a mostly Protestant 19th century America, there was some anti-Catholic sentiment related to heavy immigration from Catholic Ireland after the 1840s and a feeling that Catholic children should be educated in public schools in order to become American (Bryk, Lee, & Holland, 1993). The Irish and other Catholic ethnic groups looked to parochial schools not only to protect their religion, but to preserve their cultural heritages and languages (Greeley, McCready, & McCourt, 1976). By the mid-1960s, Catholic school enrollment reached an all-time high with nearly six million students. Beginning in the 1970s, however, most of the teaching nuns left their orders. This resulted in some Catholic school closures and, in those schools that remained open, required
the hiring of lay teachers. Those hirings were accompanied by substantial increases in costs and required that schools charge higher tuition (Caruso, 2012).

Nuzzi, Frabutt, and Holter (2012) recognized the importance of Catholic education by highlighting the strong reputation of academic scholarship, community contributions, and student growth in conscience and faith. Miller (2006) noted that a Catholic school must be inspired by a supernatural vision; Catholic education must be an “instrument for the acquisition of information that will improve the chances of worldly success” (p. 178) for high school students. The literature is full of examples of how educational environment and classroom climate can make a difference in whether or not students choose to engage in classroom instruction. That engagement, in turn, plays an important part in determining whether or not students will master the educational objectives and standards (Dupont, Galand, Nils, & Hospel, 2015).

Societal shifts, driven by technology, have had a profound impact on educational infrastructure, resources, stakeholder relationships, and learners (Sheninger, 2014). Parents and legislators alike look to the schools to keep up with the changing economy. Schools must be accountable to these expectations. Phillips and Wong (2012) argued that recent attention to school accountability has encouraged teachers’ creativity in the classroom, honoring the creative tension in teaching. The call for a paradigm shift in education is supported by research showing that traditional instructor-centered lectures are ineffective in reaching and engaging students. Conversely, creating classroom and school environments that encourage active participation, interactive learning, and collaboration have proved to be more effective in reaching today’s changing educational goals (Sauers & Mcleod, 2012).

Papert’s (1991) constructionism learning theory posits that learners construct mental models to understand the world around them (Papert & Harel, 1991). Constructionism advocates
student-centered discovery learning wherein students use information they already possess to acquire more knowledge (Papert & Harel, 1991). Students learn through participation in project-based learning where they make connections between different ideas and areas of knowledge, facilitated by the teacher through coaching rather than through lectures or by providing step-by-step guidance (Lei & Zhao, 2008).

Student engagement is necessary and indispensable for students’ academic success achievement. Engagement with learning is essential because engagement leads to sustained interaction and practice. Coaching, instruction, and feedback become critical to ensure that students develop good habits and increase their proficiency (Irvin, Meltzer, & Dukes, 2007). Meltzer and Hamann (2004) outlined the following practices that teachers can adopt to engage students: make content relevant to students’ lives, create safe and responsive classrooms, and have students interact with each other and with instructional objectives.

**Problem Statement**

Even as many Catholic educators and leaders are attempting to re-shape Catholic school learning for the 21st century (Kennedy, 2013; Frabutt et al., 2012), minimal research has been completed on the complexities of Catholic education in a digital age (Tellez, 2013; Zukowski, 2012). Several studies have been conducted to evaluate the influence of one-to-one laptop initiatives on student engagement, but the results of these assessments have been inconsistent (Cassandra, 2017). Some studies have found no differences in student engagement and achievement attributable to one-to-one laptop initiatives (Silvernail & Gritter, 2007; Shapley, Sheehan, & Maloney, 2009; Hu, 2007). However, other researchers have found that student achievement and engagement are enhanced in schools that have implemented one-to-one laptop initiatives (Marzano & Waters, 2009). The Catholic ninth grade population that was examined in
this study is unique as there is a dearth of literature regarding achievement and engagement among Catholic high school students who are involved in one-to-one laptop initiative programs (Kulow, 2014; Cassandra, 2017; Goodwin, 2012). More research into the effects of one-to-one laptop initiatives are needed in this environment (Rosen & Beck-Hill, 2012). This research is especially needed to investigate the efficacy of one-to-one laptop initiative programs among students in higher grade levels, using larger samples than have characterized some previous research, and while keeping other aspects of the curriculum constant (Goodwin, 2012; Kulow, 2014).

**Purpose Statement**

The purpose of this study was to determine if a difference exists between the achievement scores of Catholic high school students who were involved in a one-to-one laptop initiative and the achievement scores of Catholic high school students who were not involved in a one-to-one laptop initiative. Data for this study were collected from ninth grade students attending two Catholic high schools in the same diocese in southern Mississippi. One of the schools had adopted a one-to-one laptop initiative program (subsequently referred to as Catholic School A), while the other school (Catholic School B) utilized a traditional approach to classroom instruction and assignment and assessment facilitation.

The independent variable in this study was the one-to-one laptop initiative program, i.e., Catholic School A employed a one-to-one laptop initiative program while Catholic School B did not. The schools were otherwise very similar, both in demographic composition and in curriculum. The dependent variables in this study were student achievement levels measured by students’ subtest and composite scores on the Iowa Test of Educational Development (ITED) assessment. ITED scores of the ninth graders in Catholic Schools A and B were compared.
subsequent to Catholic School A’s implementation of a one-to-one laptop initiative. Since students were not randomly assigned to treatments and were compared only following implementation of the laptop initiative at Catholic School A, the research design used in the study is designated as a non-experimental, causal-comparative, posttest-only design (Gravetter & Forzano, 2016; Johnson & Christensen, 2016). Consequently, differences in the academic achievement between students in the two schools involved in the study cannot be unambiguously attributed to the presence or absence of a laptop initiative, but any differences that were observed might be attributable to the laptop initiative program.

Significance of the Study

Catholic high schools are among the highest academic achieving secondary educational institutions in the nation (Jeynes, 2013). With a rapidly declining national enrollment, however, Catholic high school administrators are pressed to find ways of generating enrollments by becoming more competitive in the larger educational marketplace. Toward that end, some Catholic dioceses have increasingly integrated technology into their curricula (MacGregor, 2013) in order to effectively prepare students for post-secondary education and ultimately top-level careers. It is important, therefore, to examine objectively the efficacy of those efforts within a Catholic high school population. Findings from this study have the potential to guide the Catholic school administrators who were most directly involved in the research as they search for ways of improving and marketing their schools. The findings from this study may also be generalized to other Catholic high schools that display similar demographics and curricula.

Research Questions

The research question for this study is the following:
**RQ1**: Is there a difference in ninth grade Catholic high school student achievement scores on the ITED assessment between students involved in a one-to-one laptop program versus students who were not involved in a one-to-one laptop initiative program?

**Definitions**

Listed below are terms and definitions pertinent and relevant to this research study:

1. *Achievement* – The attainment of an educational goal at a successful level as determined by an education standard within a particular context or domain (Ford & Nichols, 1991).

2. *Catholic education* – A school controlled and operated by an agency of the Catholic church. Its philosophy is developed from church teachings (Bryk, Lee, & Holland, 1993).


4. *Google Chromebook* – A Chromebook is a laptop running Chrome OS as its operating system. The devices are designed to be used primarily while connected to the Internet, with most applications and data residing “in the cloud” (Mann, 2014).

5. *One-to-one laptop initiative* – a program wherein each student has a laptop computer for both school and home ubiquitous use and access. One-to-one laptop computer programs may be either school district provided, individual student provided, or a combination (Collins & Halverson, 2010).

6. *PowerSchool Learning* – PowerSchool Learning is a learning management and classroom collaboration solution that empowers teachers with real-time student interaction inside and outside the classroom, bringing in more social and collaborative learning.
7. *Student Engagement* – Engagement is conceptualized as a psychological process, specifically, the attention, interest, investment, and effort that students expend in the work of learning (Marks, 2000).

8. *Technology Integration* – Technology integration is a process in which computers and other technologies are used as tools to support the task of learning (Keengwe, Pearson, & Smart, 2009, p. 334). This process involves “establishing the best ways to incorporate education technology into the curriculum as teaching tools” (Keengwe et al., 2009, p. 334).
CHAPTER TWO: LITERATURE REVIEW

Dear brothers and sisters, Catholic schools and universities make a great contribution to the mission of the Church when they serve growth in humanity, dialogue and hope.

—Pope Francis, Catholic schools in the service of humanity, 2017

Overview

This chapter discusses the relevant literature on Catholic schools and one-to-one laptop programs. This chapter has been divided into six parts ranging from Mayer’s Cognitive Theory of Multimedia Learning to Catholic education to technology and one-to-one laptop programs. In the first and second sections, the history of Catholic education will be reviewed before discussing some of the current issues with Catholic schools. In the third section, teaching and learning in the 21st-century classroom context will be discussed followed by a general discussion of technology in the classroom. In the last two sections, the historical perspective on one-to-one laptop programs with be presented followed by a discussion of the empirical research on the academic effects of one-to-one laptop programs. This literature review chapter will conclude with a brief summary.

Conceptual Framework

Mayer (2009) developed the Cognitive Theory of Multimedia Learning which hypothesizes that people learn best from images and words rather than just words alone. As such, Mayer (2009) suggests that multimedia instructional messages designed with an understanding of how the human mind works are more likely to lead to meaningful learning than those which are not.

In the broader scope, Mayer’s theory focuses on the intellectual activity that takes place during the occurrence that we call learning, and they are based on claims about how information
is processed and how the brain develops and uses graphics and images to consolidate the acquisition and production of knowledge (Mergel, 1998). Mayer (2009) drew on the work of the generative theorists, Wittrock (1992) and Sternberg (1985), and the dual coding theory of Paivio (1986) when he proposed a generative theory of multimedia learning. According to the generative theory (Wittrock, 1992) meaningful learning occurs when the learner creates relationships between his or her prior knowledge and the new concepts being presented. It is important to note that this theory focuses on the initiation of relationships and not on the storage of information.

Basically, Mayer’s theory specifies that students are only able to process a certain amount of new information at one time; therefore, in order to maximize students’ learning ability, teachers must create meaningful relationships between the learner and content being presented (Mayer, 2009). The Cognitive Theory of Multimedia Learning is based on three assumptions: (1) that there are separate networks for processing visual and auditory experiences in a person’s memory, (2) each information network is limited in the amount of information that can be processed at any given time, and (3) processing information is an active process designed to erect coherent mental representations which will create meaningful relationship with the content as an effort of storing to memory (Mayer, 2009). See figure 1 for Cognitive Theory of Multimedia Learning diagram.
According to the Cognitive Theory of Multimedia Learning model, the learner must engage in five cognitive processes in order for meaningful learning to occur within a multimedia environment. First, the learner selects the relevant words for processing in verbal working memory. At the same time, the learner selects relevant images for processing in visual working memory. After that, the learner organizes selected words into a verbal mental model and selected images into a visual mental model. Finally, the learner integrates word-based and image-based representations with prior knowledge (Mayer, 2009).

Thus, the integration of multimedia into course content increases the potential for learners to not only remember what they have learned, but also to be able to apply what they have learned to new situations. More access to educational technology, with specific regard to a one-to-one laptop initiative, provides a highly accessible opportunity for students to engage with course content and commit what is learned to memory (Milligan, Littlejohn, & Margaryan, 2013).

**History of Catholic Education**
To gain a contextual understanding of Catholic education, it is important to understand the historical background of Catholic schooling in the United States. Catholic education has a long and interesting history in the United States and was built on the premise and tradition that Catholic schools are designed to be communities of faith, communities of learners, and communities serving parishes and wider communities (Bryk, Lee, & Holland, 1993; Ristau, 1992; Walch, 1996). As early as the 17th century, Catholic schools were in operation in the United States, primarily found in Maryland, Louisiana, and Florida (Bryk et al., 1993). By the mid-1800s, public “common” schools were more commonplace, with Massachusetts becoming the first state to have compulsory education. Although public schools were considered to espouse nonsectarian Christian curriculum for character development, they promoted Protestant materials (e.g., studying the King James version of the Bible) and Protestant values (Bryk et al., 1993; Buetow, 1970; Greeley, McCready, & McCourt, 1976).

By the end of the 19th-century, immigrants, half being Catholics from Ireland, were arriving at the United States in record numbers, leading to anti-immigrant sentiment and a rise in nativism (Coleman & Hoffer, 1987; McCluskey, 1959; Ristau, 1992). Catholic immigrants who attended public schools at this time most likely experienced persecution and pressure to assimilate into the dominant American culture (Bryk et al., 1993). The Church wanted to ensure Catholic youth maintained their religious practices and worried that public schools would lead to abandonment of faith, so a system of Catholic (parochial) schools was soon created to ameliorate the issue (Walch, 2004). Aside from wanting to maintain their Catholic faith, the Irish and other Catholic ethnic groups saw parochial schools as a means of cultural enhancement (Coleman & Hoffer, 1987; Greeley et al., 1976; McCluskey, 1959; Ristau, 1992).
As anti-immigrant, anti-Catholic sentiments rose, several states passed the Blaine Amendments by the 1880s, which stated that taxes could not be used to fund parochial schools (Bryk et al., 1993; Buetow, 1970; Greeley et al., 1976). Nevertheless, parochial schools continued to be built, and nuns were used as low wage teachers to help alleviate the need for funding (Buetow, 1970; Greeley et al., 1976; Walch, 1996, 2004). Eventually, around 1910, Catholic education became more formalized and professionalized through educator training and the founding of the Catholic Educational Association (now National Catholic Educational Association). Even so, the conditions and the teaching staff of Catholic schools were considered inferior to that of public schools until well after World War II (Bryk et al., 1993; Buetow, 1970).

Enrollment in Catholic schools continued to grow, and enrollment peaked to around 5.2 million by the early 1960s, which accounted for 12% of all school-aged children (National Catholic Educational Association, 2017). A significant decline in both student enrollment and number of schools occurred in the 70s and 80s, and as enrollment declined, many Catholic schools closed (National Catholic Educational Association, 2017). The number of nuns joining the Church also declined and many nuns serving in schools were pulled from their posts. Better-educated teachers were hired to replace nuns (National Catholic Educational Association, 2017). Although a seemingly positive development in educator professionalism, this meant higher wages and, in turn, higher tuition rates that many students and families could not afford (National Catholic Educational Association, 2017).

Research suggests that Catholic schools consistently outperform public schools, charter schools, and non-religious private schools in academic achievement measured by a variety of national standardized assessments (MacGregor, 2013). Yet, the Catholic education system is facing critical challenges as Catholic school enrollment continues to decline nationwide creating
a potential organizational crisis for Catholic educational institutions (McDonald, 2004; National Catholic Educational Association, 2017). MacGregor (2013) suggests that along with rising tuition, a faltering commitment to Catholicism, and fewer priests and nuns as contributing factors to the current enrollment crisis.

**21st Century Classroom: Teaching and Learning**

Over time, there has been a shift in teaching and learning in the classroom from the 20th century to the 21st century. The design of 20th century teaching emphasized time-based memorization and retelling of facts. Students were passive learners of content knowledge and demonstrated understanding through routine summative assessment. This construct of teaching and learning supported 20th century educational goals through student preparation in the use of routine skills (Pacific Policy Research Center, 2012) for jobs that consisted of procedural cognitive work and labor (Dede, 2010). Dede (2010) suggested that the 21st-century “has seen a dramatic shift in the economic model for industrialized countries” (p. 2), and the successful worker, therefore, needs skills that support creativity, innovation, flexibility, and fluency in information and communication technologies to contribute to economic growth.

Globalization has become the central feature of the 21st-century. It takes moments to connect to anyone globally, and today’s citizens must be prepared to communicate on a global scale. Benade (2014) defined 21st century learning as teaching and learning that prepares young people for engaging in complex socio-economic and political contexts that are deeply influenced by globalization and the revolution in digital technology” (p. 338). Students may already come into the classroom with a foundational knowledge of digital technology but few understand how to use this technology on a global scale.
The Partnership for 21st Century Skills (2016) proposed three areas of skills that are needed in the 21st century. The skill areas included a) learning and innovation, b) information, media, and technology, and c) life and career (see Figure 2). According to the Partnership for 21st Century Learning (2015), “this framework describes the skills, knowledge and expertise students must master to succeed in work and life; it is a blend of content knowledge, specific skills, expertise and literacies” (p. 1). Although the Partnership for 21st Century Skills “represents each element distinctly for descriptive purposes, the Partnership views all the components as fully interconnected in the process of 21st-century teaching and learning” (p. 1).

Such skills form a framework that can be used for evaluating the effectiveness of schools and instructional programs (e.g., one-to-one laptop programs) in preparing 21st-century students. However, these three domains of skills should also be supported by the systems of schooling. This support includes “standards, assessments, curriculum, instruction, professional development and learning environments [that] must be aligned to produce a support system that produces 21st century outcomes for today’s students” (Partnership for 21st Century Learning, 2015, p. 7). Therefore, not only should schools seek the development of 21st-century skills, but they should also situate the learning and acquisition of these skills in a systems framework. That is, 21st-century skills should not be viewed in isolation, but rather, these skills should be understood as supporting new systems of schooling and, in turn, these skills be supported by school systems (i.e., standards, assessments, curriculum, instruction, professional development and learning environments; Partnership for 21st Century Skills, 2016).
The Partnership for 21st Century Learning (2015) defines each of the distinct, yet interconnected parts of the framework in the following ways. Learning and innovation skills are “increasingly being recognized as those that separate students who are prepared for a more and more complex life and work environments in the 21st century, and those who are not” (Partnership for 21st Century Learning, 2015, p. 3). For example, “creativity, critical thinking, communication and collaboration is essential” to prepare students for the future (p. 3). In regard to information, media, and technology, students live in a technological and “media-driven environment, marked by various characteristics, including 1) access to an abundance of information, 2) rapid changes in technology tools, and 3) the ability to collaborate and make individual contributions on an unprecedented scale” (p. 5). For example, to function in this environment it is believed that students should possess critical thinking skills for the influx and
consumption of information via media. The last domain of the framework including life and
career alludes to the need for critical thinking skills and content knowledge necessary for
functioning in today’s “complex life and work environments” (p. 6).

Kay and Honey (2006) stated, “Today’s students need critical reasoning, creative,
technical, and interpersonal skills to solve complex problems; design new product prototypes;
and collaborate across teams and borders using technology as one of their fundamental tools,
canvases, or means of communications” (p. 63). However, the academic needs of students in the
21st century differ greatly from the past century, which often focused on low-level skills like rote
memorization. For instance, Benade (2014) argued that “[s]chooling is critiqued for upholding an
industrial-age approach to education, replete with its age-cohorts, periodization of the day, static
notions of linear knowledge as that to be learnt for some future purpose and pedagogy that
focuses on teachers who teach and students who learn facts by rote” (p. 342).

Research suggests this factory-style approach to pedagogy is no longer appropriate for
the needs and technological advances of the 21st-century. For example, Kay and Honey (2006)
argued for the importance of meeting the learning needs of students in the 21st century,
suggesting that “Back to basics or accountability limited to mastery of traditional core subjects
will not provide young Americans with the adequate base from which to fend off or excel in the
new global competition” (p. 66). To better understand the changes in learning brought about by
the turn of the century, Table 1 illustrates the shift in the necessary skills of students from 20th-

Table 1.

*Shifting from 20th Century Learning to 21st-Century Deeper Learning*
<table>
<thead>
<tr>
<th>20th-Century Learning</th>
<th>21st-Century Deeper Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facts and procedures</td>
<td>Understanding concepts</td>
</tr>
<tr>
<td>Formative fact quizzes/tests</td>
<td>Apply learn-to-learn skills</td>
</tr>
<tr>
<td>Lecture</td>
<td>Student inquiry</td>
</tr>
<tr>
<td>Direct instruction</td>
<td>Project- and problem-based learning</td>
</tr>
<tr>
<td>Competition</td>
<td>Collaboration</td>
</tr>
<tr>
<td>Note taking via outlining</td>
<td>Setting goals and making plans</td>
</tr>
<tr>
<td>Memory skills</td>
<td>The 4Cs plus technology skills (i.e.,</td>
</tr>
<tr>
<td>Bell curve</td>
<td>Individual progress</td>
</tr>
<tr>
<td>Grades for content</td>
<td>Individualized feedback for content and</td>
</tr>
<tr>
<td>Bubble tests</td>
<td>Performance rubrics</td>
</tr>
<tr>
<td>Teacher centered</td>
<td>Self-directed, student-centered agency</td>
</tr>
<tr>
<td>Class rank</td>
<td>Transfer of learning</td>
</tr>
<tr>
<td>Sequenced curriculum</td>
<td>Need to know progress</td>
</tr>
<tr>
<td>Measure only content and basic skills</td>
<td>Assess 4Cs as path to understanding</td>
</tr>
<tr>
<td>Teacher as information giver, expert, and</td>
<td>Teacher as process facilitator and higher</td>
</tr>
<tr>
<td>The given curriculum based in textbooks</td>
<td>Authentic investigations using multiple</td>
</tr>
<tr>
<td>Student as information absorber</td>
<td>Student as active researcher on- and offline</td>
</tr>
<tr>
<td>Student as re-callner</td>
<td>Student as maker and communicator of own</td>
</tr>
<tr>
<td>Teacher as grader</td>
<td>Student as self-assessor</td>
</tr>
<tr>
<td>Students learn from listening</td>
<td>Learn from doing</td>
</tr>
<tr>
<td>Print literacy</td>
<td>Digital literacy</td>
</tr>
</tbody>
</table>

Bellanca (2017) provides insight into the shift from 20th century learning to 21st century deeper learning. The shift to 21st-century deeper learning skills is important for Catholic schools. Indeed, Catholic school educators and leaders should work to not only understand but also support the unique needs of 21st century students as well as the skills necessary to be a productive citizen who can help better society. For example, by integrating 21st-century skills into primary and secondary education, Catholic schools can remain relevant to the educational marketplace while also preparing students to enter the marketplace (Youniss & Convey, 2000).

In particular, Catholic school leaders and teachers can help make Catholic education relevant for the marketplace and an engaging educational experience for the 21st-century student. Some of the recent efforts made by Catholic school leaders to help their schools remain relevant include making Catholic schools more affordable, offering services that make them more competitive with public and charter schools and upholding the highest expectations for student engagement and achievement (MacGregor, 2013). School leaders often make the argument to parents and stakeholders that a Catholic education is an investment in a child’s future that will prepare them for success in postsecondary education in order to enter the job market as a skilled professional and laborer (Weitzel-O’Neill & Torres, 2011).

Another important way that Catholic schools can remain relevant to their customers in the educational marketplace is by integrating technology into the school and classroom curriculum (Dachos, 2017). This technological integration is important and has become more common with the globalization of society. As Marx and Engels (1848/2010) argued in the 19th century, “The need of a constantly expanding market for its products chases the bourgeoisie over the entire surface of the globe. It must nestle everywhere, settle everywhere, establish
connexions everywhere” (p. 6). Hence, what Marx and Engels predicted hundreds of years ago, technology is helping bring to fruition. Indeed, Dachos (2017) suggests that integrating technology may help schools enhance competitiveness, better meet learning objectives of all students, and supplement instructional and assessment practices for more timely feedback regarding students’ progress.

**The Role of the Educator.** The role of the educator is continuously changing as student needs and technology evolve. Along with changes in the job, businesses that supply educational materials and technologies have been quick to push new products with educators being expected to adapt to the next new product that promotes 21st-century skills.

While change can be difficult, educators generally understand that a one-size-fits-all instructional approach does not ensure that all children will grasp the necessary skills needed in order to succeed in his or her individual goals (Benade, 2014). The adoption of Google education apps and use of Google Chromebooks is an example of educators’ willingness to embrace change and new technologies, with more than half of all primary and secondary students in the United States using Google education products. It should also be noted that Google attributes this success not to the adoption by school districts but by working directly with educators in the classroom (Singer, 2017).

With the adoption of technology in the classroom comes the need for digital citizenship education. Digital citizenship pertains to being responsible online, including protecting the privacy of ourselves and others, copyright laws, being kind to one another online, etc. An adolescent brain does not have a fully developed prefrontal cortex, where logical thinking occurs, yet does have an active reward center, where impulsive, risk-seeking behavior earns a feel-good rush of dopamine. Taking this into account, one can quickly understand the importance
of explicitly teaching digital citizenship to children and their parents. The 21st-century educator understands the necessity of digital citizenship and weaves it into his/her lessons regularly (International Society for Technology in Education, 2010).

**Learning vs. Teaching.** Christensen, Horn, and Johnson (2011) suggested that “the way we learn doesn’t always match up with the way we are taught. If we hope to stay competitive—academically, economically, and technologically—we need to reevaluate our educational system, rethink our approach to learning, and reinvigorate our commitment to learning. In other words, we need disruptive innovation” (p. 14). Christensen et al. (2011) referred to teaching as the techniques by which educators convey knowledge and content through their own instructional styles. Learning, then again, is very different. Learning certainly contains and involves the attainment of knowledge, skills, and content; nevertheless, it is much more than just the transmission of knowledge. Learning includes understanding, synthesis, evaluation, and application of those skills and concepts. While learning can occur by listening to a teacher communicate knowledge, it is more effectively achieved through problem-solving, reflection, active learning, and practice. To put it simply, learning is about mastery of a wide variety of content and skills (Mintz, 2015).

Mintz (2015) states that learning is holistic—meaning that learning is about recognizing the value of three areas: cognitive, affective, and psycho-motor. Mintz (2015) mentions Benjamin Bloom’s categories in this argument on the holistic approach of learning. The student-centered classroom provides an environment that is conducive to students’ abilities to apply, analyze, synthesize, generalize, and evaluate while also creating a capacity to monitor and organize one’s emotional responses as well. Unfortunately, a classroom focused on just teaching
does not value that same holistic approach, although the purpose is the acquisition of knowledge, learning cannot be ultimately assured without a focus on the learner.

Bell Laboratories mathematician, Henry Pollak, argued that “[w]ith technology, some mathematics becomes more important, some mathematics becomes less important, and some mathematics becomes possible” (as cited in Dingman and Madison, 2011, p. 15). Indeed, technology has changed not only education but also society. With this technological change, certain aspects of education have become more important. This aspect has been captured by the notion of 21st-century learning (Partnership for 21st Century Learning, 2015). With 21st century learning, student-centered learning takes precedence over the traditional teacher-centered, lecture-style instruction. However, although the rise of the technological and information age has made student learning more important among other things, it has also made other parts of education less important. For instance, rote memory skills and other 20th century skills have become less important (see Table X). Some of the other ways that technology has made certain aspects of education possible included things like online learning programs and hybrid learning environments (Gray, Thomas, Lewis, & Tice, 2010). Student-centered learning provides opportunities for interactive collaboration with others.

**Technology in the Classroom**

In education, technology represents a concept that has been used to describe tools or an instrument to augment or deliver instruction like computers and laptops (Sullivan, 2009). In the classroom, technology takes the forms of many things, including but not limited to chalk and mechanical pencils to overhead projectors, televisions, and computers among many other things (Dunleavy, Dextert, & Heinecket, 2007). From a historical perspective, there have been dramatic changes in classroom technology. For instance, these changes include overhead projectors and
TVs, among many other forms of technology. Over the last couple of decades, one of the most important things happening in the classroom is the integration of technology and computers for teaching and learning (Dunleavy et al., 2007; Sullivan, 2009).

The integration of computer technology into the 21st-century classroom includes many benefits and drawbacks. The next wave of technology in the classroom continues to progress, leading to the integration and implementation of technology into the instructional curriculum. One of the ways that Catholic schools can integrate technology into the classroom at different grade levels is through the school curriculum. One form of technology that can be integrated into the classroom curriculum is through a one-to-one laptop initiative program.

Definition(s) of One-to-One Laptop Programs

What are one-to-one laptop programs? Different scholars have provided different definitions of one-to-one laptop programs. Zhenge, Warschauer, Lin, and Change (2016) defined one-to-one laptop programs as consisting of technological programs where “all the students in a class, grade level, school, or district are provided computers for use throughout the school day and, in some cases, at home” (p. 1053). Penuel, Kim, Michalchik, Lewis, Means, and Murphy (2001) defined one-to-one laptop programs as including three characteristics:

(1) providing students with use of portable laptop computers loaded with contemporary productivity software (e.g., word processing tools, spreadsheet tools, etc.), (2) enabling students to access the Internet through schools’ wireless networks, and (3) a focus on using laptops to help complete academic tasks such as homework assignments, tests, and presentations. (p. 331)

What can be concluded by these definitions is that both students and teachers can benefit from the implementation of one-to-one laptop programs. That is, one-to-one laptop programs are
“not about the laptops. It’s about what the 1:1 laptops enable in terms of new ways of teaching and learning” (Dunlevy, Dextert, & Heinecket, 2007, p. 451). In this sense, students are provided laptops to do many academic and social things, such as completing their coursework, accessing instructional resources, taking assessments electronically, and collaborating with peers (Dede, 2010; Keengwe, Schnellert, & Mills, 2012; Sauers & Mcleod, 2012). While teachers use technology in the classroom to create personalized academic plans for their students, individualize learning, and monitor students’ academic progress and online behavior (Holland & Holland, 2014; Penuel, 2006; Penuel et al., 2001).

**History of One-to-One Laptop Programs**

There has been the widespread usage of laptops over the past decade. This widespread adoption of laptops for one-to-one laptop programs has increased for several reasons, including the decreased costs of computers and the growing interest and need for technology both within the classroom and within society (Cavanaugh, Dawson, & Ritzhaupt, 2011; Cuban, 2003). One of the first one-to-one laptop programs originated in Melbourne, Australia for girls in the fifth-grade during the early 1990s (Cavanaugh et al., 2011; Cuban, 2003). Other one-to-one laptop programs included the 1997 “Anytime Anywhere Learning” program launched by Microsoft and a statewide one-to-one laptop program in 2002 in Maine. Another approach to encourage one-to-one laptop use in schools includes “bring-your-own-device” policies at the school and district levels to encourage the connection between the school and the home. However, one-to-one laptop programs have been launched in other countries throughout the world besides Australia and the United States, especially with the use of inexpensive laptops like Google’s Chromebook. For example, Peru and Uruguay received 1.5 million small XO laptops for being part of the One Laptop per Child program (Tate & Warschauer, 2017).
Technological adoption is a topic that has concerned many scholars. Cuban (2003) argued that, although digital technological adoption in schools is often initially strong, the subsequent implementation of digital technologies in schools has been haphazard. This haphazard implementation often occurs when there are insufficient curricular ties between technology and curriculum and/or when teacher support is lacking. Indeed, Cuban argued that the cycle of technology adoption often runs its course. Although this technology was often believed to be the crux to help transform teaching and learning in schools, technology has often failed to impact the teaching and learning in the long-term. Similarly, Ames (2016) suggested that the One Laptop per Child that had been distributed to over a million children in developing countries throughout the world had problems with implementation and the allocation of funding since substantial effort is required to develop the necessary infrastructure to effectively implement a program like One Laptop per Child. For instance, often students who attend schools in developing countries would benefit more from a prioritized focus on spending money for building schools, training teachers, developing curricula, providing books and other materials, and subsidizing student attendance. Ames argued that these types of things should be addressed before technological programs can be leveraged for education change. In the context of Catholic education in the United States, empirical research points to the many benefits and drawbacks of one-to-one laptop programs to improve schooling processes and outcomes.

**Related Literature**

Research has examined one-to-one laptop programs in schools and classrooms. To obtain a systematic understanding of one-to-one laptop programs and their impact on the classroom learning, a total of five research synthesis reviews have been conducted (Bebell & O’Dwyer, 2010; New South Wales Department of Education and Training, 2009; Penuel, 2006; Penuel,
Kim, Michalchik, Lewis, Means, & Murphy, 2001; Zheng, Warschauer, Lin, & Chang, 2016). After briefly touching on these research reviews, the focus will be placed on the most recent meta-analysis and research synthesis on learning in one-to-one laptop classrooms.

**Empirical Research on One-to-One Laptop Programs**

Penuel, Kim, Michalchik, Lewis, Means, and Murphy (2001) provided the first systematic review of the literature on one-to-one laptop programs, which opened the door for future research into this area. Penuel (2006) conducted the next literature review on one-to-one laptop programs. Penuel identified a two-wave typology of studies that had examined one-to-one laptop learning. The first type of studies examined the implementation of one-to-one laptop programs. The second type of studies examined the outcomes that resulted from the implementation of one-to-one laptop programs. These two different types of studies and research approaches inform how one-to-one laptop programs get examined empirically.

The New South Wales Department of Education and Training (2009) conducted another literature review on one-to-one laptop programs that focused on Penuel’s implementation studies. The New South Wales Department of Education and Training suggested that one of the most important factors with the potential to impact the success of a one-to-one laptop program was pedagogy, including how these programs have been implemented. This implementation is what affects the academic achievement. This implementation includes things like the attitudes and beliefs of teachers and school leaders, classroom management, teachers’ professional development, and technical support to ensure laptops and software remain functioning.

Bebell and O’Dwyer (2010) found that support for many benefits of one-to-one laptop learning, such as “increased student and teacher technology use, increased student engagement
and interest level, and modest increases in student achievement” (p. 4). They recommended that technology like computers and laptops should be used to support the learning processes.

Zheng, Warschauer, Lin, and Chang (2016) conducted the most recent meta-analysis and research synthesis by examining 10 studies that examined one-to-one laptop programs in subject areas including English, reading, writing, mathematics, and science (see Table 2). Zheng et al. found that one-to-one laptop programs have had a positive impact on the academic achievement of students across these different academic subject areas. However, in some cases, the positive effect of one-to-one laptop programs has not been empirically supported. Below, I draw on Zheng et al.’s review results while delving into the particulars of the studies they examined as well as extending the scope by considering other studies that were excluded.

Table 2.

<table>
<thead>
<tr>
<th>Academic Subject</th>
<th>N</th>
<th>Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>English/Language Arts</td>
<td>6</td>
<td>Grimes &amp; Warschauer, 2008; Gulek &amp; Demirtas, 2005; Hansen et al., 2012;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hur &amp; Oh, 2012; Lowther, Inan, Ross, &amp; Strahl, 2012; Rosen &amp; Manny-Ikan,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2011</td>
</tr>
<tr>
<td>Reading</td>
<td>4</td>
<td>Bryan, 2011; Lowther et al., 2012; Rosen &amp; Beck-Hill, 2012; Rosen &amp; Manny-Ikan, 2011</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gulek &amp; Demirtas, 2005; Lowther et al., 2012; Beck-Hill, 2012; Rosen &amp;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Manny-Ikan, 2011</td>
</tr>
</tbody>
</table>
Regarding the English/language arts subject area, previous research suggests that one-to-one laptop programs tended to positively influence student’s academic achievement (Grimes & Warschauer, 2008; Gulek & Demirtas, 2005; Hansen et al., 2012; Hur & Oh, 2012; Lowther, Inan, Ross, & Strahl, 2012; Rosen & Manny-Ikan, 2011). That is, one-to-one laptop programs can help improve students’ English language arts learning. However, it can take over two years to realize the positive effects of one-to-one laptop programs on English language arts achievement (Grimes & Warschauer, 2008), which is likely the case because both teachers and students must take time to adjust their practices (Suhr, Hernandez, Warschauer, & Grimes, 2010).

Previous research suggests that students’ reading achievement in one-to-one laptop programs, however, was not statistically different than their counterparts who did not participate in such a program (Bryan, 2011; Lowther et al., 2012; Rosen & Beck-Hill, 2012; Rosen & Manny-Ikan, 2011). Moreover, some studies indicated that there was a lack of reading growth for students in one-to-one laptop programs while compared to non-participating peer
counterparts (Bernard, Bethel, Abrami, & Wade, 2007; Shapley, Sheehan, Maloney, & Caranikas-Walker, 2011). Shapley, Sheehan, Maloney, and Caranikas-Walker (2010b) and Bebell and Kay (2010), however, found that one-to-one laptop programs tended to have positively increased reading scores when this technology was used at home along with being used at school.

Previous research suggests that one-to-one laptop programs had a tendency to have a positive effect on science achievement (Dunleavy & Heinecke, 2008; Hur & Oh, 2012) and mathematics achievement (Grimes & Warschauer, 2008; Gulek & Demirtas, 2005; Lowther, Strahl, Inan, & Bates, 2007; Rosen & Manny-Ikan, 2011). However, some studies suggested either no effect or a negative effect on mathematics achievement (Bernard et al., 2007; Dunleavy & Heinecke, 2008; Hansen et al., 2012). Regarding mathematics achievement and one-to-one laptop programs, research suggests technology should be used consistently and on a daily basis if it is going to have a positive effect on mathematics achievement (Warschauer, 2011). Similarly, the more frequent use of technology during science also has been shown to have a positive effect on science scores based on standardized assessments (Bebell & Kay, 2010), but the effect of one-to-one laptop programs on science achievement is not always significant, especially for minority and at-risk student populations (Zheng, Warschauer, Hwang, & Collins, 2014).

Zheng et al. (2016) also reported the synthesized results of all 96 studies that they screened with 10 of the 96 studies being included in the synthesis of academic achievement in the one-to-one laptop programs in the five different subject areas. Zheng et al. synthesized the findings from these 96 studies into four areas, including teaching and learning processes, teacher and student perceptions, 21st-century skills, and the digital divide.
In terms of teaching and learning processes, four main areas were identified. These areas included a) increased frequency and breadth of student technology use, b) increased student-centered, individualized, and project-based learning, c) increased quantity and genres of writing, and d) improved teacher-student and home-school relationship. Of course, it is not unexpectedly, students generally used more technology when participating in one-to-one laptop programs (Bebell & Kay, 2010; Bernard et al., 2007; Russell, Bebell, & Higgins, 2004). However, this expectation should not always be assumed to be the case for positively influencing teaching and learning in the classroom (Morris, 2011; Padmanabhan & Wise, 2012).

Research also suggested an increase in student-centered, individualized, and project-based learning for students who participated in one-to-one laptop programs. For example, there tended to be a greater focus on student-centered or individualized learning (Annable, 2013; Cavanaugh et al., 2011; Clariana, 2009; Corn, Tagsold, & Patel, 2011; Danielsen, 2009; Dawson, Cavanaugh, & Ritzhaupt, 2006; Donovan, Hartley, & Strudler, 2007; Drayton, Falk, Stroud, Hobbs, & Hammerman, 2010; Dunleavy et al., 2007; Grant, Ross, Wang, & Potter, 2005; Grimes & Warschauer, 2008; Harris, 2010; Lowther et al., 2007; Mouza, 2008; Newhouse & Rennie, 2001; Niles, 2006; Russell et al., 2004; Sprenger, 2010; Storz & Hoffman, 2013; Warschauer, 2007; Zheng et al., 2014). One-to-one laptop programs also enhanced project-based learning through activities like online research (Annable, 2013; Cavanaugh et al., 2011; Corn et al., 2011; Grant et al., 2005; Jones, 2013; Mouza, 2008; Windschitl & Sahl, 2002).

Research has also suggested that one-to-one laptop programs enhance writing and have a generally positive effect on the classroom, school, and community relationships. Writing and its associated features like editing/revising and online research and information collection was the most common among students in one-to-one laptop programs, and these students often spent
more time writing that other students not participating in one-to-one laptop programs (Grimes & Warschauer, 2008; Hansen et al., 2012; Harris, 2010; Suhr et al., 2010; Trimmel & Bachmann, 2004; Wade, 2010; Zheng, Warschauer, & Farkas, 2013). Additionally, one-to-one laptop programs improve the relationship between not only teachers and students but also the school and students’ home. However, teachers often held negative preconceptions about these programs prior to their implementation in the classroom (Maninger & Holden, 2009).

**Major themes concerning one-to-one laptop program.** Zheng et al. (2016) identified student and teacher perceptions as a major theme that has been addressed by previous research (Bebell & Kay, 2010; Burgad, 2008; Cotten, Hale, Moroney, O’Neal, & Borch, 2011; Grant et al., 2005; Grimes & Warschauer, 2008; Lei & Zhao, 2008; Lowther et al., 2012; Mouza, 2008; Rosen & Beck-Hill, 2012). In terms of student perceptions, research suggests that students often held positive attitudes toward laptop programs (Lowther et al., 2003; Rosen & Beck-Hill, 2012; Suhr et al., 2010) and in one-to-one laptop environments, students tended to have higher student engagement, motivation, and persistence when compared to other students not in a one-to-one laptop environment (Khambari, Moses, & Luan, 2009; Mouza, 2008; Niles, 2006; Russell et al., 2004; Trimmel & Bachmann, 2004; Whiteside, 2013). However, the findings derived from previous research have not consistently been supported across the literature (Cotten et al., 2011; Donovan, Green, & Hartley, 2010; Hur & Oh, 2012; Zuber & Anderson, 2013).

In terms of teacher perceptions, the findings were not as optimistic or supportive as student perceptions. Teachers had many concerns and raised many issues with the use of technology and the use and implementation of one-to-one laptop programs (Carlson, 2007; Gunner, 2007; Khambari et al., 2009; Maninger & Holden, 2009; McGrail, 2006, 2007; Windschitl & Sahl, 2002; Zuber & Anderson, 2013). These teacher concerns were about the “use
of laptops for instruction, either due to limited technology skills, lack of sufficient technical support, uncertainty about ways in which the technology would affect them, or fear of losing control in the classroom” (Zheng et al., 2016, p. 1071).

One of the major needs was based on the idea of creating a technologically conducive environment “where learning drives the use of technology, instead of the other way around” (Maninger & Holden, 2009, p. 7), which often leaves teachers feeling frustrated (Dunleavy et al., 2007). Although technical support and professional development were often not sufficient for teachers (Corn et al., 2011; Lei, 2010), when teachers received professional training and development (Danielsen, 2009) and technological support they tended to become more confident in the use of technology (Burns & Polman, 2006; Howard et al., 2015; Inan & Lowther, 2010; Murphy, King, & Brown, 2007; Zuber & Anderson, 2013). Hence, when teachers have been prepared with the proper training, support, and professional development, they tend to be more likely to use technology in the classroom more frequently by integrating it into their daily instruction and curriculum (Chandrasekhar, 2009; Drayton et al., 2010; Grimes & Warschauer, 2008; Inan & Lowther, 2010; Lei, 2010; Lowther et al., 2012; Zuber & Anderson, 2013).

One-to-one laptop programs have the potential to prepare students with 21st-century skills. The Partnership for 21st Century Skills (2016) maintain that three areas of 21st-century skills are needed, including a) learning and innovation, b) information, media, and technology, and c) life and career. Previous research has used these three skill areas to evaluate the effectiveness of one-to-one laptop programs in preparing students for the 21st century (Zheng et al., 2016).

Zheng et al. (2016), however, suggests that based on their literature review, only two of these skill areas have been supported by previous studies, including learning and innovation.
(Cowley, 2013; Grimes & Warschauer, 2008; Lei & Zhao, 2008; Lowther et al., 2003; Maninger & Holden, 2009; Mouza, 2008; Oliver & Corn, 2008; Pogany, 2009; Rosen and Beck-Hill, 2012; Shapley et al., 2011) and information, media, and technology (Corn et al., 2011; Greenwood, 2007; Harris, 2010; Lei & Zhao, 2008; Mo et al., 2013; Wade, 2010; Warschauer, 2007, 2008). However, previous research supporting these two areas remains weak (Zheng et al., 2016).

In regard to the third area concerning the enhancement of life and career through the development of 21st-century skills, previous research has tended to focus on college and career readiness (Danielsen, 2009; Niles, 2006; Zheng et al., 2014). However, as Zheng et al. (2016) argued, “studies rarely attempted to operationalize and systematically measure the growth of 21st-century skills in laptop students compared with control students” (p. 1074).

Pittaluga and Rivoir (2012) argued that one-to-one laptop programs may help to reduce the digital divide by providing access to technology regardless of a student’s socioeconomic level background. In particular, the socioeconomic context was found to influence one-to-one laptop program implementation. McKeeman (2008) and Shapley et al. (2011) suggested that students from low-socioeconomic level backgrounds are likely to benefit more from one-to-one laptop programs than other students from higher-socioeconomic level backgrounds. McKeeman and Shapley et al. argued that this difference likely stems from the fact that students from low-socioeconomic level backgrounds have less access to technological resources than their higher-socioeconomic level counterparts. Therefore, further research regarding the achievement and benefits of a one-to-one laptop program over time for students from different socioeconomic backgrounds is still needed.

However, Warschauer (2007) argued that differences exist in both resources and critical thinking skills between students from low- and high-socioeconomic backgrounds. This finding
has also been supported by previous research (Bebell & Kay, 2010; Rousseau, 2007; Smith, 2012; Zuber & Anderson, 2013). Nonetheless, one-to-one laptop programs did tend to yield a positive impact (Cottone, 2013; Cowley, 2013; Bebell Kay, 2010; Rosen & Manny-Ikan, 2011; Weber, 2012; Zheng et al., 2013; Zheng et al., 2014). As Zheng et al. (2016) noted, the findings are mixed regarding whether or not one-to-one laptop program initiatives can reduce the digital divide for students from different socioeconomic backgrounds.

**Summary**

In conclusion, this literature review provided a historical background to and context of Catholic education in the United States. Catholic education has persisted for hundreds of years. During this time, it has adapted to many different challenges. One of the most recent is the integration of technology into the classroom. Nonetheless, Catholic schools have emerged as inclusive institutions open to people from different backgrounds and affiliations; they serve both religious Catholics and non-Catholics. Similar to the challenges faced by Catholic schools, the 21st-century has ushered in new ways of teaching and learning. Indeed, technological advances have changed how traditional teaching and learning has occurred in the classroom. One of the most recent approaches for addressing students’ needs for the 21st-century are one-to-one laptop programs. Indeed, these programs have been implemented for different grade levels, including primary and secondary education and in different subject areas. This dissertation aims to examine the relationship between student achievement in Catholic education at the secondary level and the implementation of and students’ participation in one-to-one laptop programs.
CHAPTER THREE: METHODS

Overview

The purpose of this study was to determine if a difference exists between the achievement scores of Catholic high school students who were involved in a one-to-one laptop initiative (enrolled in Catholic School A) and the achievement scores of Catholic high school students who were not involved in a one-to-one laptop initiative (enrolled in Catholic School B). This chapter will begin by addressing the choice of a quantitative methodology over the qualitative and mixed-methods alternatives. The research design that was necessitated by the circumstances of the research will be identified and the limitations of that design will be noted. The study’s single research question will be posed, along with its corresponding null hypothesis. The study’s target and accessible populations are identified next, and the sampling methodology is specified. The ITED instrument that was used to collect data on academic achievement is described next, followed by a discussion of procedures used to collect the data. The chapter concludes with a discussion of data analytic methods used to clean and screen the data and to address the study’s research question.

Design

This study will utilize a nonexperimental, causal-comparative quantitative research design. The non-experimental, causal-comparative research design is most appropriate because this study seeks to determine whether a difference exists between the two groups (with one-to-one laptop initiative and without one-to-one laptop initiative) regarding student achievement and student engagement scores (Gall et al., 2007). According to Gall et al. (2007), some researchers prefer to use a causal-comparative research design because using intact groups to examine the independent variable is more coherent with the approach in which educational practitioners view
and utilize research and data within their respective organizations. The independent variable for this study is the one-to-one laptop initiative program. A one-to-one laptop initiative program is defined as providing each student with a laptop computer for both school and home ubiquitous use and access. One-to-one laptop computer programs may be either school district provided, individual student provided, or a combination (Collins & Halverson, 2010). The dependent variables are the student achievement scores as measured by assessment results from the Iowa Test of Educational Development (ITED) and student engagement scores as measured by the Student Engagement Scale (Dornbusch & Steinberg, 1990). The Student Engagement Scale has three subscales consisting of students’ homework, attendance, classroom attention/concentration, and an overall composite engagement score. Engagement is defined as and conceptualized as a psychological process, specifically, the attention, interest, investment, and effort that students expend in the work of learning (Marks, 2000).

**Research Question**

The research questions for this study is the following:

**RQ1:** Is there a difference in ninth grade Catholic high school student achievement scores on the ITED assessment between students involved in a one-to-one laptop program versus students who were not involved in a one-to-one laptop initiative program?

**Null Hypothesis**

The null hypothesis for this study is the following:

**H₀:** There is no statistically significant difference in ninth grade Catholic high school student achievement scores (determined by ITEP scores on Reading, Written Expression, Vocabulary, Mathematics, Computation, Social Studies, Science, and overall Composite scores).
between students involved in a one-to-one laptop program versus students who were not involved in a one-to-one laptop initiative program.

**Participants and Setting**

**Population**

The target population for this study, i.e., “the entire set of individuals who have the characteristics required by the researcher” (Gravetter & Forzano, 2016, p. 136) consisted of ninth grade students enrolled in Catholic high schools within the regional Catholic diocese in south Mississippi. There were five Catholic high schools within the diocese that enroll 254 ninth grade students. The gender breakdown of the population was as follows: 48.1% males, 51.9% females. The ethnic breakdown of the population was as follows: 8.7% African American, 0.1% American Indian, 2.7% Asian, 3.6% Hispanic, 81.4% Caucasian, 3.5% Multiracial. Students in the diocese resided in the middle-income suburban region along the Mississippi Gulf Coast.

**Sample**

The study sample, i.e., “the individuals who are selected to participate in the research study” (Gravetter & Forzano, 2016, p. 135) consisted of ninth grade students enrolled at Catholic School A (laptop group) and Catholic School B (no laptop group) during the 2017-2018 school year. Those participants formed a convenience sample, i.e., “individuals [selected for a study] on the basis of their availability and willingness to respond” (Gravetter & Forzano, 2016).

Spring 2018 ITED data for Schools A and B were provided by Iowa Assessments in the form of Building Summary documents. These documents included students’ ITED scores and gender information for 81 students enrolled at School A (52.5% female and 47.5% male) and 57 students enrolled at School B (61.4% female and 38.6% male). Power analyses performed using G*Power software (Faul, Erdfelder, Lang, & Buichner, 2007) determined that these samples
provided about 77% statistical power for a multivariate (MANOVA) comparison of the groups on all seven ITED subscales, and about 82% statistical power for separate univariate (ANOVA) group comparisons on the individual ITED subscales and ITED composite scores. Although the sensitivity of the statistical tests to between-group differences would have been greater with larger samples, the available samples provided reasonably good power to detect population effects of medium strength (Dattalo, 2008).

The two Catholic high schools involved in this study were very similar. Both were interparochial high schools governed by the Catholic diocese, diocesan department of education, school advisory council, and school principal. Although demographic information specific to the students whose ITED scores were analyzed in this study was limited to gender only, Table X provides demographic and academic information about ninth graders at School A (laptop group) and School B (no laptop group) compiled from school records. This table shows that students at the two schools were demographically very similar, and it is reasonable to assume that the students whose data were analyzed were also similar. Students in both schools were enrolled in the following courses during the 2017-2018 school year, wherein course objectives and lesson plans were derived from the same curriculum: religious studies, English language arts, biology, health, physical education, Mississippi history, world geography, and geometry.
### Table 3

**Comparison Table of Catholic School A and Catholic School B Student Demographic and Academic Characteristics, Compiled from School Records**

<table>
<thead>
<tr>
<th>Category</th>
<th>Catholic School A (Laptop Group)</th>
<th>Catholic School B (No Laptop Group)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Enrollment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total School Enrollment</td>
<td>403 students</td>
<td>387 students</td>
</tr>
<tr>
<td>Ninth Grade Enrollment</td>
<td>81 students</td>
<td>57 students</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>52.5%</td>
<td>61.4%</td>
</tr>
<tr>
<td>Female</td>
<td>47.5%</td>
<td>38.6%</td>
</tr>
<tr>
<td><strong>Ethnicity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td>3.5%</td>
<td>7.1%</td>
</tr>
<tr>
<td>American Indian</td>
<td>0.0%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Asian</td>
<td>2.5%</td>
<td>2.9%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>4.0%</td>
<td>4.9%</td>
</tr>
<tr>
<td>White</td>
<td>87.3%</td>
<td>81.7%</td>
</tr>
<tr>
<td>Multiracial</td>
<td>2.7%</td>
<td>3.1%</td>
</tr>
<tr>
<td><strong>Tuition</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catholic family</td>
<td>$6,000 per year</td>
<td>$5,350 per year</td>
</tr>
<tr>
<td>Non-Catholic family</td>
<td>$7,000 per year</td>
<td>$6,000 per year</td>
</tr>
<tr>
<td><strong>Courses in which Ninth Grade Students are Enrolled</strong></td>
<td>Religious Studies</td>
<td>Religious Studies</td>
</tr>
<tr>
<td>English</td>
<td>English</td>
<td>English</td>
</tr>
<tr>
<td>Biology I</td>
<td>Biology I</td>
<td>Biology I</td>
</tr>
<tr>
<td>Health</td>
<td>Health</td>
<td>Health</td>
</tr>
<tr>
<td>Physical Education</td>
<td>Physical Education</td>
<td>Physical Education</td>
</tr>
<tr>
<td>Mississippi Studies</td>
<td>Mississippi Studies</td>
<td>Mississippi Studies</td>
</tr>
<tr>
<td>World Geography</td>
<td>World Geography</td>
<td>World Geography</td>
</tr>
<tr>
<td>Geometry</td>
<td>Geometry</td>
<td>Geometry</td>
</tr>
<tr>
<td><strong>Accreditation</strong></td>
<td>Catholic School A is accredited by AdvancED SACS and the Mississippi Department of Education (MDE).</td>
<td>Catholic School B is accredited by AdvancED SACS and the Mississippi Department of Education (MDE).</td>
</tr>
<tr>
<td>Curriculum</td>
<td>Catholic Diocese and MDE</td>
<td>Catholic Diocese and MDE</td>
</tr>
<tr>
<td>------------</td>
<td>-------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Graduation Rate</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Average ACT Composite Score</td>
<td>23.4</td>
<td>24.5</td>
</tr>
<tr>
<td>Extracurricular Participation Rate</td>
<td>96%</td>
<td>94%</td>
</tr>
<tr>
<td>Geographic Location</td>
<td>Southeastern US region in suburban community</td>
<td>Southeastern US region in suburban community</td>
</tr>
<tr>
<td>Average Median Income</td>
<td>$46,434 per year</td>
<td>$46,765 per year</td>
</tr>
<tr>
<td>School Governance and Leadership</td>
<td>Catholic School A is an interparochial high school governed by the Catholic diocese, diocesan department of education, school advisory council, and school principal.</td>
<td>Catholic School B is an interparochial high school governed by the Catholic diocese, diocesan department of education, school advisory council, and school principal.</td>
</tr>
<tr>
<td>Feeder Parishes</td>
<td>18 parishes</td>
<td>4 parishes</td>
</tr>
<tr>
<td>Feeder Elementary Schools</td>
<td>6 schools</td>
<td>1 school</td>
</tr>
<tr>
<td>Religion</td>
<td>Catholic</td>
<td>70.3%</td>
</tr>
<tr>
<td></td>
<td>Non-Catholic</td>
<td>29.7%</td>
</tr>
<tr>
<td>Number of Teachers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Number of Teachers</td>
<td>30 teachers</td>
<td>26 teachers</td>
</tr>
<tr>
<td>Ninth Grade Teachers</td>
<td>6 teachers</td>
<td>6 teachers</td>
</tr>
<tr>
<td>Student Teacher Ratio</td>
<td>13:1</td>
<td>15:1</td>
</tr>
</tbody>
</table>

**Instrumentation**

The instrument used in this study to measure academic achievement was the Iowa Test of Educational Development (ITED; Forsyth, Ansley, Feldt, & Alnot, 2000). This instrument is a nationally standardized, norm-referenced test administered during the spring semester of students’ ninth grade year. The data analyzed in this study were collected near the end of the
2017-2018 school year. The ITED measures student achievement in the following seven subject areas: Reading, Written Expression, Vocabulary, Mathematics, Computation, Social Studies, and Science. In addition to these subscale scores, an overall Composite score is provided. The ITED also provides scores for English Language Arts (averaged from the Reading, Written Expression, and Vocabulary subscales), and Math Total (averaged from the Mathematics and Computation subscales), but those measures were redundant to the subscales and were not analyzed. Also provided in the Building Report documents, but not analyzed in this study, were ACT Composite and SAT Reading and Math scores predicted from students’ ITED performance.

The time required to administer the ITED is 3 hours and 31 minutes. Each subject area is scored separately and is designed to show what the student knows compared to what the student should know at the specified grade level. ITED produces developmental standard scores (i.e. scaled scores) for each subject. A student’s total composite score is calculated by averaging the subject scores. The composite average score on the ITED ranges from 1 to 99 points. A score of 1 point is the lowest possible score meaning that the student seldom or rarely: understands stated information and ideas, infers implied meaning, draws conclusions, interprets nonliteral language, makes generalizations from or about a text, identifies the author’s purpose or viewpoint within a text, evaluates aspects of writing style or structure, applies math concepts and procedures, makes inferences with quantitative information, solves quantitative reasoning problems, makes inferences or predictions from data, judges the relevance and adequacy of information, or recognizes the rationale for and limitations of scientific procedures. A score of 99 points is the highest possible score meaning that the student: understands stated information and ideas, infers implied meaning, draws conclusions, interprets nonliteral language, makes generalizations from or about a text, identifies the author’s purpose or viewpoint within a text, evaluates aspects of its
style or structure, makes inferences with quantitative information and solves a variety of quantitative reasoning problems, usually applies math concepts and procedures, makes inferences and predictions from data, recognizes the rationale for and limitations of scientific procedures, and usually judges the relevance and adequacy of information.

The ITED test is made up of a paper booklet and separate answer folder. The booklet contains the questions and the answers are written or marked in the answer folder. Upon students’ completion of the assessment, answer documents are sent to a scoring center where they are scored, and data reports are made available to the school administration. Permission to use the data from this instrument was secured by the Superintendent of Education. See Appendix A for permission letter from Superintendent of Education.

Internal consistency reliability for the ITED was reported using the Kuder-Richardson Formula 20 (K-R 20) as .920 for Reading, .923 for Writing, .925 for Math, and .969 for Complete Composite scores (Dunbar & Welch, 2015). Furthermore, the ITED has demonstrated validity within many schools.

**Procedures**

The researcher began by identifying two Catholic secondary educational institutions within the same Catholic diocese with similar demographics that met the established criteria, i.e., one school that had implemented a one-to-one laptop initiative (Catholic School A) and one school that utilized a traditional instructional setting without a one-to-one laptop initiative (Catholic School B). Next, the researcher contacted the Superintendent of Education for the department of education within the specified Catholic diocese to obtain permission to conduct research in both schools. The researcher received a letter from the Superintendent of Education offering permission and support to conduct the study. The Superintendent of Education provided
permission and access to obtain student demographic data and ITED assessment data. The researcher next sought, and subsequently received, Institutional Review Board (IRB) approval to conduct the study. The IRB application included the following documents: permission request letters, parental consent forms, survey questionnaire, and assessment descriptions. (See Appendix B for IRB approval.)

Teachers at Catholic School A (laptop group) and Catholic School B (no laptop group) have all attended diocesan professional development sessions. Teachers at both schools have also attended professional development sessions on the diocesan curriculum, lesson scope and sequencing, lesson planning, and assessment writing to ensure that all are clear on the objectives and standards that students are expected to master in each course. Administrators at Catholic School A and Catholic School B were provided with a lesson plan checklist and assessment checklist to ensure consistency and standardization in curriculum delivery and instruction.

During the spring semester of the 2017-2018 academic year, students at both schools took the ITED assessment. This took place near the end of the school year as courses were nearing completion. Each school was provided a Directions for Administration manual which outlined instructions for the test administration as well as a script of instructions to be read aloud to students. The testing environment and instructions were the same for both schools. Both schools took the test on the same date and at the same time. The test was timed, and students at both schools were given the same amount of time to complete the assessment. In a few cases certain students received testing or other academic accommodations (e.g., additional time). Those students were excluded from this study. Students completed the assessment by marking answers in the machine-scorable booklet. Upon completion of the assessment, each school’s testing coordinator collected the assessment, secured the booklets and student response
documents, and shipped them to the testing publisher as described in the Directions for Administration manual.

The researcher received ITED assessment data from the database administrator of the diocesan department of education for both schools. Those data were sent via email and consisted of Building Summary Documents. Those documents provided scores on each of the seven ITED subscales and complete composite scores, as well as the student’s gender. These documents did not present the data in a format that could be electronically imported to SPSS. Consequently, the SPSS data file used in this study was created manually. That data file did not include the names of individual students nor could students’ names be determined from the data that were recorded. The researcher will maintain the data for five years following the publication of this study. At the end of that period of time, the researcher will destroy all data files used in this study by shredding printed documents and deleting electronic data. Students’ ITED data will be maintained indefinitely by their schools as part of their permanent school records.

Data Analysis

The data analysis for this study included both descriptive and inferential statistics. Descriptive statistics (frequency counts and percentages) were used to summarize sample data pertaining to gender, the sole demographic variable reported in the Building Report documents. Inferential statistics (a between-subjects one-way MANOVA and several between-subjects one-way ANOVAs) were used to address the study’s research question by comparing the ITED scores of students who were exposed to a laptop initiative (Catholic School A) against the ITED scores of students who were not exposed to that initiative (Catholic School B).

Prior to performing any of these analyses, however, the data were cleaned and screened in the manner recommended by Tabachnick and Fidell (2013). Tabular frequency distributions
were generated for all variables in the data file to identify and correct any data entry errors and to evaluate missing data. Multivariate outliers (i.e., cases whose scores on the individual variables were unremarkable, but whose patterns of scores across those variables were statistically aberrant) were evaluated using the Mahalanobis distance statistic, evaluated for significance against the chi-square distribution using the .001 level of significance (Meyers, Gamst, & Guarino, 2016). Screening for univariate outliers was accomplished by standardizing scores on all subscales and composite scores and searching for z-scores exceeding ±3.30 (p < .001 in a normal distribution). Outliers, both multivariate and univariate, exert a disproportionate effect on the MANOVA and ANOVAs that were used to address the study’s research question. Once identified, the outliers were deleted as described in Chapter 4.

Differences in the academic achievement of students in School A (laptop group) and School B (no laptop group) were evaluated using a MANOVA and a series of ANOVAs. The validity of both of those statistical procedures is conditional on the data showing certain characteristics, the so-called statistical assumptions of the procedures. Consequently, tests were performed to test those statistical assumptions prior to performing the MANOVA and ANOVAs. Those tests will be described here, with the results of the tests provided in Chapter 4. In addition to eliminating multivariate and univariate outliers, distributions of all dependent variables were evaluated for normality both visually, by examining frequency histograms, and statistically by calculating measures of skewness and kurtosis as well as the Kolmogorov-Smirnov test. Deviations from normality distort the exact significance levels reported for the MANOVA and ANOVA significance tests. Dependent variables that are found to be non-normal are typically normalized through the use of a data transformation such as the square root or log10 transformation (Tabachnick & Fidell, 2013). MANOVA also assumes the absence of
multicollinearity, i.e., that the dependent variables are not strongly correlated. When multicollinearity exists, the weights used in forming the linear combination of dependent variables are unstable and can change dramatically with the addition or removal of just a few cases. Multicollinearity was evaluated in this study by examining correlations among the dependent variables and by calculating the tolerance statistic for each dependent variable. The MANOVA also assumes that relationships between the dependent variables are not strongly nonlinear. Linearity of relationships among the dependent variables was evaluated by generating scatterplots and examining those graphs for signs of strong nonlinearity, i.e., a cigar-shaped scatterplot. The accuracy of the exact significance levels output from the MANOVA is distorted to the degree that the data violate the assumptions of homogeneity of the variance and covariance matrices. Those assumptions were tested using Box’s M test for equality of covariances and Levene’s test for homogeneity of variance.

With the tests of the statistical assumptions completed, the MANOVA and ANOVAs were performed to compare the academic achievement scores students at Catholic School A (with laptops provided by the school) and Catholic School B (without laptops provided). The first comparison utilized a one-way between-subjects MANOVA. The independent variable in that analysis was the laptop program, with two levels, represented by students enrolled in Catholic School A and Catholic School B. The MANOVA procedure compared the groups on a linear combination of all seven ITED subscales. That linear combination was developed specifically to maximize between-group separation and enhance the likelihood of identifying a statistically significant difference. The MANOVA is a very powerful procedure because it combines the between-group separation provided by each of several individual dependent variables into a single composite variable. It is possible for groups to show no significant
differences on the individual dependent variables, yet differ significantly on the linear combination of variables that is constructed in the MANOVA (Gall et al., 2007; Tabachnick & Fidell, 2007).

Students at the two schools were also compared on each of the ITED subscales considered separately. Those comparisons were performed using a series of seven between-subjects one-way ANOVAs (one for each of the seven ITED subscales) with Welch’s robust $F$ test substituted in place of the more common Fisher’s $F$ test. Welch’s test was used to compensate for violations of the homogeneity of variance assumption on some of the ITED subscales. Welch’s $F$ test is robust to violations of the homogeneity of variance assumption, especially when the dependent variable is normally distributed, as was true in this study. One final between-subjects one-way ANOVA, also utilizing Welch’s robust $F$ test, was used to compare students from the two schools on ITED Composite scores.

Chapter 4 provides detailed descriptions of all data processing used to prepare the data for analysis. Results of the tests of the statistical assumptions of the MANOVA and ANOVAs are provided, along with descriptions of how violations of those statistical assumptions were mitigated. The results of the MANOVA and ANOVAs described next in that chapter, and the implications of the statistical results to the study’s research question are discussed.
CHAPTER FOUR: FINDINGS

Overview

The purpose of this study was to determine if a difference exists between the achievement scores of Catholic high school students who were involved in a one-to-one laptop initiative and the achievement scores of Catholic high school students who were not involved in a one-to-one laptop initiative. The study utilized a quantitative methodology and a non-experimental, causal-comparative, posttest-only research design. The scores of two preexisting groups of Catholic ninth grade students were compared in the study. These students came from two demographically similar Catholic high schools in the Southeastern US, School A and School B. School A implemented a one-to-one laptop program prior to academic achievement testing at the end of the 2017-2018 school year; School B had no such initiative. Academic achievement was measured using the Iowa Test for Academic Development (ITED) and the study compared students simultaneously on seven ITED subscale scores (Reading, Written Expression, Vocabulary, Mathematics, Computation, Social Studies, and Sciences) using multivariate analysis of variance (MANOVA). The groups were also compared on the individual ITED subscales and ITED Composite scores using univariate analysis of variance (ANOVA). All data were provided by Iowa Assessments. This chapter describes how the data were cleaned and then screened to determine if the statistical assumptions of the MANOVA and ANOVAs were met. Where violations of the statistical assumptions were identified, there is a discussion of the measures that were taken to mitigate the negative effects of those violations. After data cleaning there remained 80 students to represent School A (where the one-to-one laptop initiative was conducted) and 57 students to represent School B (without a laptop initiative). Power analyses are reported in this chapter which estimate how much statistical power was provided by the
available sample sizes to support the study’s key analyses. The chapter describes the sample insofar as possible, but the only demographic information provided by Iowa Assessments was gender. The chapter turns next to the results of the MANOVA used to evaluate the multivariate difference between students representing School A and School B. That is followed by the results of univariate ANOVAs used to examine between-group differences on each of the ITED subscales considered singly as well as ITED composite scores. The chapter concludes with a summary.

**Research Question**

**RQ1:** Is there a difference in ninth grade Catholic high school student achievement scores on the ITED assessment between students involved in a one-to-one laptop program versus students who were not involved in a one-to-one laptop initiative program?

**Null Hypothesis**

**H₀₁:** There is no statistically significant difference in ninth grade Catholic high school student achievement scores (determined by ITED scores on Reading, Written Expression, Vocabulary, Mathematics, Computation, Social Studies, Science, and overall Composite scores) between students involved in a one-to-one laptop program versus students who were not involved in a one-to-one laptop initiative program.

**Preliminary Data Processing, Data Cleaning, and Tests of Assumptions**

**Preliminary Data Processing**

ITED data for Schools A and B were provided by Iowa Assessments in the form of Building Summary documents. These documents did not present the data in a format that could be electronically imported to SPSS. Consequently, the SPSS data file used in this study was created manually. Each record in the file included a case identification number, a code indicating
whether the individual was a student at School A or School B, a code representing the student’s
sex, scores on the ITED subscales Reading, Written Expression, Vocabulary, Mathematics,
Computation, Social Studies, and Science, and ITED Composite scores. All ITED scores were
recorded as developmental standard scores (SS). Data were provided by Iowa Assessments for
81 students representing School A and 57 cases representing School B.

Data Cleaning

Data cleaning was performed using the methods and sequencing recommended by
Tabachnick and Fidell (2013). Tabular frequency distributions were created for all variables to
check for missing data and out-of-range data entries. There were no out-of-range values. Two
students in School B were responsible for all missing data. The Reading, Written Expression,
Vocabulary, Computation, and Social Sciences subscales were each missing one value and there
were two missing values on the Composite variable.

Multivariate outliers within each of the schools were screened next. Multivariate outliers
can show unremarkable scores on each of several variables, yet show a pattern of scores across
the variables that is statistically aberrant. Multivariate outliers exert a disproportionate influence
on the results of multivariate analyses (including the MANOVA used in this study) and are not
representative of the rest of the sample. For these reasons, Tabachnick and Fidell (2013) and
Meyers, Gamst, and Guarino (2017) have recommended that multivariate outliers be deleted.

Multivariate outliers were screened in this study by calculating the Mahalanobis distance statistic
\( D \) for each participant using their scores on the seven subscales of the ITED. Values of \( D \) were
evaluated against the chi-square distribution using \( df = 7 \) (the number of variables used in
calculating \( D \)) and a stringent significance level \( (p < .001) \). One multivariate outlier from School
A (laptop group) was identified in this way and was deleted from the data file, leaving 80 cases
to represent School A. School B (no laptop group) data contained no multivariate outliers and continued to be represented by 57 cases.

Univariate outliers within each of the schools were screened next by standardizing all ITED variables and then searching for \( z \)-scores exceeding \( \pm 3.3 \) (\( p < .001 \) in a normal distribution). Univariate outliers exert a disproportionate effect on the outcome of analyses in which they appear, are statistically aberrant, and are unrepresentative of the rest of the sample in which they appear. There were no univariate outliers in School A. One student in School B produced a univariate outlier, an extremely low Social Studies score (SS score = 238, \( z = -3.3 \)). This extreme score was deleted, but all other data from the student were unremarkable and were retained for subsequent analyses.

A preliminary analysis using an independent-samples \( t \)-test indicated that male and female students differed significantly on Written Expression, with 77 females scoring significantly higher (\( M = 316.25, SD = 28.03 \)) than 59 males (\( M = 304.47, SD = 30.54 \)), \( t(134) = 2.34, p = .021 \) (two-tail). Having determined that females scored significantly higher than males on the Written Expression subscale, it was important to determine if females were represented differentially in the two schools. School A included 52.5% females and 47.5% males, while School B included 61.4% females and 38.6% males. While the representation of females in School B would be expected to inflate somewhat that school’s performance on the Written Expression subscale, relative to School A, the schools did not differ significantly in their gender distributions, \( \chi^2(N = 137, df = 1) = 1.07, p = .301 \). Based on this, it was determined that it was not necessary to treat gender as a covariate in subsequent analyses addressing the study’s research question.

**Tests of the Statistical Assumptions**
The results of the MANOVA and ANOVAs used in this study are valid only to the extent that the data analyzed show certain properties. Two of these statistical assumptions, i.e., the absence of multivariate and univariate outliers, were tested and found to be satisfied during preliminary data cleaning and screening.

**Normality.** The MANOVA also assumes multivariate normality, i.e., the linear combination of dependent variables (the “variate”) created in the analysis is normally distributed in each of the groups being compared. Related to this, ANOVA assumes that the dependent variable in that univariate analysis is normally distributed within each of the groups being compared. SPSS does not provide a test of multivariate normality, but Meyers et al. (2017) have noted that if all of the individual dependent variables are normally distributed, the assumption of multivariate normality is almost certainly satisfied as well. The assumption of normality of the individual ITED subscales and composite scores was evaluated both visually, by examining frequency histograms of the variables, and statistically, by calculating measures of skewness (asymmetry) and kurtosis (peakedness or flatness). As recommended by Hair, Black, Babin, and Anderson (2010), values of skewness and kurtosis exceeding ±1.0 were considered indicative of serious deviations from normality. The Kolmogorov-Smirnov (K-S) test was also used to determine if the distributions differed significantly from normal. Given this test’s sensitivity to trivial departures from normality (Meyers et al., 2017), values of the K-S statistic were evaluated using a stringent level of significance ($p < .001$). Figure 3 shows frequency histograms for all dependent variables for Schools A (laptop group) and B (no laptop group). Data from School A are graphed in the left column and data from School B are graphed in the right column. Table 4 provides measures of skewness and kurtosis for all distributions and summarizes the results of Kolmogorov-Smirnov tests of deviations from normality. A distribution was considered non-
normal if: (a) measures of skewness and/or kurtosis exceeded ±1.0, and (b) the K-S test was significant at \( p < .001 \). Only one distribution was found to be non-normal using these criteria: the School A distribution of scores on the Written Expression subscale, where skewness = -1.04, kurtosis = 1.39, and K-S = 0.14, with \( p < .001 \). Tabachnick and Fidell (2013) have noted that, when the data deviate from normality, “With almost every data set in which we have used transformations, the results of analysis have been substantially improved” (p. 87). Accordingly, both square root and log10 data transformations were examined to see if either would be effective in normalizing the distribution scores on the Written Expression subscale.
Figure 3. Frequency histograms for ITED Reading, Written Expression, Vocabulary, Mathematics, Computation, Social Studies, and Science subscales, and Composite scores for School A (left column) and School B (right column).
Table 4

Measures of Skewness and Kurtosis and Results of Kolmogorov-Smirnov (K-S) Tests of Normality for ITED Reading, Written Expression, Vocabulary, Mathematics, Computation, Social Studies, and Science Subscales, and Composite Scores for Schools A and B

<table>
<thead>
<tr>
<th>Variable</th>
<th>School A (Laptop Group)</th>
<th>School B (No Laptop Group)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Skewness</td>
<td>Kurtosis</td>
</tr>
<tr>
<td>Reading</td>
<td>-0.01</td>
<td>-0.36</td>
</tr>
<tr>
<td>Written Expression</td>
<td>-1.04</td>
<td>1.39</td>
</tr>
<tr>
<td>Vocabulary</td>
<td>-0.42</td>
<td>0.35</td>
</tr>
<tr>
<td>Mathematics</td>
<td>-0.71</td>
<td>-0.19</td>
</tr>
<tr>
<td>Computation</td>
<td>-0.24</td>
<td>-0.57</td>
</tr>
<tr>
<td>Social Studies</td>
<td>-0.75</td>
<td>0.15</td>
</tr>
<tr>
<td>Science</td>
<td>-0.81</td>
<td>0.04</td>
</tr>
<tr>
<td>Composite</td>
<td>-0.58</td>
<td>-0.15</td>
</tr>
</tbody>
</table>

Note. School A was represented by 80 students on all variables. There were scattered missing data for School B, resulting in sample sizes ranging from 55 (Composite) to 57 (Mathematics and Science).

The square root transformation was more effective than the log10 transformation.

However, the square root data transformation not only changes the shape of the distribution toward greater normality, it also alters and reflects the scores. That is, the lowest original score become the highest transformed score and the highest original score become the lowest transformed score. To avoid the confusion that can result from using reflected scores, Tabachnick and Fidell (2013) have recommended re-reflecting square root transformed scores so that higher scores again indicate higher amounts of the attribute being measured, and lower
scores indicate lower amounts of the attribute. The square root transformed Written Expression scores were re-reflected in the manner described by Tabachnick and Fidell (2013). These re-reflected square root transformed Written Expression scores will be referred to subsequently simply as Written Expression scores unless the context requires greater clarity. Figure 4 shows histograms for the transformed Written Expression scores for Schools A and B, and Table 5 provides measures of skewness and kurtosis for the distributions and the results of Kolmogorov-Smirnov (K-S) tests of deviations from normality. A comparison of Figures 3 and 4 shows a clear improvement in the shape of the distribution of Written Expression scores for School A (laptop group) following the data transformation (Figure 4). The distribution of scores for School B (no laptop group) was already reasonably normal prior to the transformation and remained so following the transformation. (The two high scores seen in the School B frequency histogram in Figure 4 were evaluated for outlier status by standardizing those transformed scores and comparing the resulting $z$-scores to the criterion value of $z = \pm 3.3$. The scores in question approached, but did not reach, the criterion and were therefore not considered to be outliers.) Measures of skewness and kurtosis were dramatically improved for the transformed Written Expression scores for School A, compared to the original scores. For School B, kurtosis was increased by the transformation, but the K-S test was not significant. It was concluded that the distributions of transformed Written Expression subscale scores were reasonably normal for both schools.
Figure 4. Frequency histograms for ITED transformed Written Expression subscale scores for School A (on the left) and School B (on the right).

Table 5

*Measures of Skewness and Kurtosis and Results of Kolmogorov-Smirnov (K-S) Tests of Normality for Transformed ITED Written Expression Subscale Scores for Schools A and B*

<table>
<thead>
<tr>
<th>Variable</th>
<th>School A (n = 80) (Laptop Group)</th>
<th>School B (n = 56) (No Laptop Group)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Skewness</td>
<td>Kurtosis</td>
</tr>
<tr>
<td>Transformed Written Expression</td>
<td>-0.40</td>
<td>-0.06</td>
</tr>
</tbody>
</table>

**Absence of multicollinearity.** Multicollinearity exists when the dependent variables in the MANOVA are strongly correlated with each other. This is problematic in the MANOVA because it causes the weights used in forming the linear combination of dependent variables (the variate) to become unstable. In other words, the weights can change dramatically with the addition or deletion of just a few cases. For example, if there are two dependent variables in a
MANOVA and they are highly correlated, it means that one is essentially redundant to the other in discriminating between the groups. There is no point in strongly weighting both variables since their strong correlation suggests that they measure the same construct. Consequently, the variable that provides slightly better group separation will be strongly weighted in forming the variate and the redundant second variable will be given a very small weight. With the addition or deletion of just a few cases, though, the variable that once provided better group separation might now be a slightly less effective discriminator, causing the pattern of weights to reverse. The variable that was once strongly weighted is now given only a weak weight and the variable that was once given a weak weight is now strongly weighted. This is problematic to the extent that the weights used in creating the variate give clues as to what it is that the variate is measuring and informs one’s interpretation of the nature of the difference between the groups.

Multicollinearity was evaluated in two ways in this study. First, Table 6 shows correlations among the ITED subscales. The presence of several correlations greater than .80 suggested that multicollinearity might be an issue in the study. A more conclusive test for multicollinearity, however, is provided by the tolerance statistic (Meyers et al., 2017). The tolerance statistic indicates the proportion of variance in each dependent variable that is not explained by the other dependent variables considered conjointly. Low tolerance values (.10 or less) are indicative of severe multicollinearity because those low values indicated that most of the variance in a dependent variable is explained by the other dependent variables. Tolerance statistics were calculated for each variable and were found to range from .43 (for Computation) to .22 (for Social Studies). It was concluded that, despite the presence of several strong correlations between the dependent variables, multicollinearity was not problematic in this study.
Table 6

*Correlations Among the Seven ITED Subscales*

<table>
<thead>
<tr>
<th>Variables</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Reading</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Transformed Written Expression</td>
<td>.77</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Vocabulary</td>
<td>.72</td>
<td>.69</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Mathematics</td>
<td>.66</td>
<td>.62</td>
<td>.62</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Computation</td>
<td>.61</td>
<td>.54</td>
<td>.49</td>
<td>.73</td>
<td>--</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Social Studies</td>
<td>.77</td>
<td>.68</td>
<td>.83</td>
<td>.62</td>
<td>.55</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>7 Science</td>
<td>.78</td>
<td>.68</td>
<td>.73</td>
<td>.70</td>
<td>.55</td>
<td>.79</td>
<td>--</td>
</tr>
</tbody>
</table>

*Note.* Due to scattered missing data, sample sizes ranged from 135 to 137. All correlations were significant at $p < .001$ (two-tail).

**Linearity.** MANOVA assumes that the dependent variables are linearly related, or more precisely, that the variables are not strongly *nonlinearly* related, within each of the groups in the analysis. The linearity assumption was evaluated in this study by generating scatterplots for all pairs of dependent variables for both groups, shown in Figure 5. These scatterplots were greatly enlarged compared to what is shown in Figure 5 and were examined to identify any scatterplots showing the strongly banana-shaped configuration that marks a strongly nonlinear relationship. No such configurations were apparent, and it was concluded that the linearity assumption was satisfied.
Figure 5. Scatterplots for relationships among ITED subscales for Reading, Written Expression, Vocabulary, Mathematics, Computation, Social Studies, and Science for School A (top) and School B (bottom).
**Homogeneity of variance-covariance matrices.** MANOVA assumes that the groups in the analysis show similar variances and covariances. This assumption was evaluated using a preliminary run of the MANOVA in order to take advantage of the diagnostic features included in the output, including Box’s M test of equality of covariance. Tabachick and Fidell (2013) have pointed out that Box’s M test is sensitive to even trivial violations of the assumption of homogeneous variance-covariance matrices and because of this Laerd Statistics (2015) has recommended using a stringent level of significance ($p < .001$) when evaluating the significance of Box’s M test. Using that criterion for significance, Box’s M test indicated no significant violation of the assumption, $\text{Box’s M} = 51.21, \text{F}(28, 47079.38) = 1.721, p = .010$.

**Homogeneity of variances.** MANOVA assumes that the groups in the analysis show approximately equal variances on each of the dependent variables. This assumption was also tested using a preliminary run of the MANOVA to use the diagnostic features included in the output, specifically, Levene’s test of equality of variances. Two dependent variables were identified which violated the homogeneity of variance assumption: Social Studies, $F(1, 133) = 7.84, p = .006$, and Science, $F(1, 133) = 4.24, p = .041$. Laerd Statistics (2015) has noted that there are no alternatives to MANOVA in SPSS that are robust with respect to violations of the homogeneity of variance assumption and they recommended that such violations be handled by adopting a more stringent level of significance ($p < .01$ instead of $p < .05$) when evaluating the multivariate between-group difference. In addition, univariate ANOVAs performed on the individual dependent variables to identify the source(s) of the multivariate difference should be performed using Welch’s robust $F$ test instead of Fisher’s $F$ test. Jan and Shieh (2013) also recommended Welch’s robust $F$ when group variances are heterogeneous and pointed out that
when the dependent variables are normally distributed, as was true in this study, Welch’s robust $F$ test provides nearly the same statistical power as Fisher’s $F$ test.

**Descriptive Statistics**

Although data were provided by Iowa Assessments for 81 students from School A (laptop group) and 57 students from School B (no laptop group), data cleaning described previously resulted in the loss of one case from School A. In addition, one extreme score was deleted from the data from School B and there were small additional amounts of missing data in the School B sample. There were 80 valid scores on all dependent variables for School A. For School B, scattered missing data caused sample sizes to vary slightly from one variable to the next. On the seven subscales of the ITED, sample sizes ranged from 55 to 57 and there were 55 valid Composite scores.

Of the 80 students representing School A, 42 (52.5%) were female and 38 (47.5%) were male. Of the 57 students representing School B, 35 (61.4%) were female and 22 (38.6%) were male. As noted previously, the distribution of genders did not differ significantly between the schools. Iowa Assessments did not provide any other demographic information about the students and so no other sample characteristics are available.

**Power Analyses**

Two power analyses were performed using G*Power software (Version 3.1.9.2; Faul, Erdfelder, Lang, & Buchner, 2007) to determine how much statistical power was provided by the available sample size to support the study’s MANOVA and ANOVAs. Statistical power is defined as the probability that an effect of a specified strength that actually exists in the population will be detected as statistically significant in a sample that is drawn from that population (Dattalo, 2008). The first power analysis estimated statistical power for the
MANOVA; the second estimated statistical power for the univariate ANOVAs used to identify the source(s) of the multivariate between-group difference.

**MANOVA power analysis.** Parameters input to the MANOVA power analysis were as follows. The population effect to be detected was assumed to be of moderate strength as measured by Cohen’s $f^2 = .15$ (Dattalo, 2008), $\alpha$ was set at .01 (to mitigate the violation of the homogeneity of variance assumption), number of groups was set at two, and number of dependent variables was set at seven. Finally, the total sample size was set at 135 (80 from School A and 55 from School B). This sample size setting requires some explanation. The MANOVA procedure uses listwise deletion of missing data, such that the only cases that are included in the analysis are those that have complete data, and complete data were available in this study for only 135 cases. Results of the power analysis are summarized in Figure 6. For a sample of $N = 135$, evenly divided between two groups, statistical power was estimated at 77.1%, very close to the standard 80% frequently adopted in the social sciences (Dattalo, 2008). Although some statistical power is lost if sample sizes are unequal, as was the case in this study, Pituch and Stevens (2016) have suggested that the definition of “equal” sample sizes should be relaxed somewhat to “similar” and noted that sample sizes can generally be considered to be similar if the ratio of the largest sample size to the smallest sample size is no more than 1.5:1. In this study, with 80 students representing School A and 55 representing School B, the ratio was 1.45:1. It is not likely, therefore, that the uneven sample sizes in this study had a dramatically negative effect on statistical power. Since statistical power $= 1 - \beta$, it follows that the probability of a Type II error (also known as a $\beta$ error) in the MANOVA (i.e., failing to detect a medium strength population effect as statistically significant in the analysis of sample data) was equal to $\beta = 22.9%$. 
The population effect to be detected was assumed to be of moderate strength as measured by Cohen’s $f = .25$ (Dattalo, 2008), $\alpha$ was set at .05, total sample size was set as 135 (the smallest total $N$, seen in analyses of Social Studies and Composite scores), and two groups were specified. Results of the power analysis are summarized in Figure 7. For a sample of $N = 135$, evenly divided between two groups, statistical power was estimated at about 82.2%. Since statistical power = 1 – $\beta$, it follows that the probability of a Type II error (i.e., a $\beta$ error) in each ANOVA was equal to $\beta = 17.8\%$. Although G*Power estimates statistical power for Fisher’s $F$ test in the one-way ANOVA, not
the Welch’s robust $F$ tests used in this study (to mitigate heterogeneous sample variances), Jan and Shieh (2015) have observed that when the dependent variables are normally distributed, as they were in this study, Welch’s test is only marginally less powerful than Fisher’s test.

*Figure 7.* Statistical power as a function of sample size for the one-way between-subjects ANOVAs.

**Results**

This section of the chapter presents the results of the study’s key analyses. A one-way between-subjects MANOVA was used to test the significance of the multivariate difference between students representing School A (laptop group) and School B (no laptop group). That analysis compared the two samples simultaneously on the seven subscales of the ITED. A series of one-way between-subjects ANOVAs were used to evaluate significant between-group differences on each of the ITED subscales considered singly, as well as ITED Composite scores.

**MANOVA**
A one-way, between-subjects MANOVA was used to analyze the data from students representing School A and School B in this non-experimental, causal-comparative, posttest-only study. Two preexisting groups of students were compared in the MANOVA and missing data were deleted in a listwise fashion. Students in School A (n = 80) were exposed to a one-to-one laptop initiative program prior to end-of-year academic achievement testing, while students in School B (n = 55) had no such exposure. The independent (or “grouping”) variable in the MANOVA was laptop initiative, with two levels: exposure and no exposure. The seven subscales of the ITED served as dependent variables in the analysis: Reading, Written Expression, Vocabulary, Mathematics, Computation, Social Studies, and Science.

The one-way MANOVA reduces the problem of comparing groups on multiple dependent variables to a univariate problem by creating a linear combination of the dependent variables, called a “variate,” on which the groups are compared (Goodstein, 1987). When dependent variables are expressed in z-score form and the number of dependent variables is equal to k, the variate takes the following form:

\[
\text{Variate} = (w_1 * DV_1) + (w_2 * DV_2) + \ldots + (w_k * DV_k)
\]

The numerical weights (w_1 - w_k) used to create the variate are chosen so as to maximize the separation (i.e., difference) between group means (called “centroids”) on the variate. More specifically, the variate that is created maximizes the ratio of between-group variance on the variate relative to within-group variance. This ratio of between-group variance to within-group variance defines the F ratio that is used in testing the significance of the difference between the groups, and the value of F is maximized by the weights chosen in creating the variate. This maximizes the likelihood that the between-group difference will be found significant. The weights selected in forming the variate do not only reflect the degree to which each dependent
variable contributes to the separation of the groups; the weights also reflect the degree to which each dependent variable provides unique separation of groups, i.e., separation that is not provided by the other dependent variables. The MANOVA provides a very powerful analytic tool because it is possible for groups to not differ significantly on any of the individual dependent variables in the analysis yet be found to differ significantly on the variate formed by weighting and combining those dependent variables.

Using listwise deletion of missing data, there were 80 cases in the analysis to represent School A and 55 cases to represent School B. School A showed a mean on the variate (i.e., centroid) of $M = -0.33$ ($SD = 1.03$). School B showed a centroid of $M = 0.48$ ($SD = 0.94$). Wilk’s lambda, $\Lambda = .864$, was used to evaluate the separation of groups provided by the variate, and the significance of group separation was found to be statistically significant using the $F$ ratio, $F(7, 127) = 2.857, p = .008$. The strength of the treatment effect (i.e., the effect of the independent variable on the dependent variables) was measured using eta-squared and was found to be strong, $\eta^2 = .136$, indicating that group membership (i.e., School A vs. School B) explained 13.6% of the variance in the variate (Murphy & Myors, 2004). It was concluded that the study’s null hypothesis, that there was no significant difference in the academic achievement of Catholic high school students as a function of exposure to a one-to-one laptop program, was rejected.

However, as will be described next, the difference was not in the hypothesized direction. Students in School B, without a one-to-one laptop initiative, generally outperformed students in School A, with the laptop initiative.

Having established that students differed significantly on an optimally weighted linear combination of ITED subscale scores (i.e., the variate), attention turned to interpreting that variate. This was facilitated by reanalyzing the same data using discriminant analysis.
Discriminant analysis is mathematically identical to the one-way between-subjects MANOVA, but provides somewhat richer output, including correlations between the dependent variables and the variate (called “loadings”) that are sometimes useful in better understanding what exactly was measured by the variate, and thus, in what way the groups differed. Those loadings are shown in Table 7. It is axiomatic in statistics that two variables (or a variable and a variate) measure the same construct to the degree that they are correlated. Based on that principle and using Cohen’s (1992) guidelines for the interpretation of correlation strengths, the variate upon which students in School A ($M = -0.33, SD = 1.03$) and School B ($M = 0.48, SD = 0.94$) differed significantly was seen to be strongly and positively related to Vocabulary, Social Studies, and Science, moderately and positively related to Written Expression and Reading, with only a weak relationship to Mathematics and Computation. Remembering that higher variate scores were seen in School B and lower variate scores were seen in School A, the pattern of loadings shown in Table 7 indicated that students representing School B tended to score higher than those from School A on all ITED subscales except mathematics. These univariate differences will be considered next.

Table 7

*Correlations (Loadings) Between the MANOVA Variate and ITED Subscale Scores*

<table>
<thead>
<tr>
<th>ITED Subscales</th>
<th>$r$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading</td>
<td>.38</td>
</tr>
<tr>
<td>Written Expression</td>
<td>.41</td>
</tr>
<tr>
<td>Vocabulary</td>
<td>.55</td>
</tr>
<tr>
<td>Mathematics</td>
<td>-.13</td>
</tr>
<tr>
<td>Computation</td>
<td>.10</td>
</tr>
</tbody>
</table>
Social Studies  .52
Science  .47

*Note. N = 135.*

**ANOVA**s

To further explore the source of the significant multivariate difference between School A (laptop group) and School B (no laptop group), the schools were compared on each of the seven subscales of the ITED using a series of seven univariate ANOVAs. Welch’s robust $F$ test was substituted in place of Fisher’s $F$ in these analyses due to violation of the homogeneity of variance assumption on the Social Studies and Science dependent variables. Missing data were deleted in listwise fashion, i.e., only cases were analyzed who provided data on all dependent variables, just as was true in the MANOVA. Group descriptive statistics and the results of Welch’s robust $F$ tests used to compare the groups are shown in Table 8. For the Written Expression subscale, Table 8 provides descriptive statistics calculated for transformed scores and for scores in their original form (in parentheses), but only transformed scores were used in the MANOVA and ANOVAs. Contrary to expectations, School B scored higher than School A on six out of seven ITED subscales, and significantly higher on three of those subscales—Vocabulary, Social Studies, and Science. School A scored very slightly ahead of School B on Mathematics, but that difference was not significant. The eta-squared ($\eta^2$) statistic was used to evaluate effect strengths. All of these values were in the range .01 to .06 suggested by Murphy and Myors (2004) as defining small statistical effects.
Table 8

*Group Means and Standard Deviations on the ITED Subscales and Results of Welch’s Robust F Test Between-Group Comparisons*

<table>
<thead>
<tr>
<th>ITED Subscale</th>
<th>School A (n = 80) (Laptop Group)</th>
<th>School B (n = 55) (No Laptop Group)</th>
<th>Welch’s F</th>
<th>df</th>
<th>p</th>
<th>(\eta^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading</td>
<td>293.65 31.44</td>
<td>302.62 25.90</td>
<td>3.28</td>
<td>1, 128.61</td>
<td>.073</td>
<td>.022</td>
</tr>
<tr>
<td>Written Expression</td>
<td>6.31 1.92 (307.23) (31.35)</td>
<td>6.97 2.07 (316.35) (26.29)</td>
<td>3.48</td>
<td>1, 110.61</td>
<td>.065</td>
<td>.026</td>
</tr>
<tr>
<td>Vocabulary</td>
<td>280.38 24.89</td>
<td>290.56 20.12</td>
<td>6.87</td>
<td>1, 129.47</td>
<td>.010</td>
<td>.046</td>
</tr>
<tr>
<td>Mathematics</td>
<td>292.39 26.66</td>
<td>289.49 29.22</td>
<td>0.34</td>
<td>1, 109.06</td>
<td>.559</td>
<td>.003</td>
</tr>
<tr>
<td>Computation</td>
<td>288.10 27.53</td>
<td>290.22 26.29</td>
<td>0.20</td>
<td>1, 119.63</td>
<td>.653</td>
<td>.002</td>
</tr>
<tr>
<td>Social Studies</td>
<td>301.45 31.21</td>
<td>312.76 20.28</td>
<td>6.51</td>
<td>1, 132.64</td>
<td>.012</td>
<td>.040</td>
</tr>
<tr>
<td>Science</td>
<td>295.88 37.73</td>
<td>308.84 27.94</td>
<td>5.25</td>
<td>1, 132.21</td>
<td>.024</td>
<td>.034</td>
</tr>
</tbody>
</table>

*Note.* Means and standard deviations for the Written Expression subscale are calculated both for transformed scores and original scores (in parentheses). The Welch’s F test comparison of School A and School B utilized transformed scores.

**Analysis of ITED composite scores.** A one-way between-subjects ANOVA using Fisher’s F statistic was used to compare ITED Composite scores from students from the two schools. All statistical assumptions for the ANOVA were satisfied: Composite scores were normally distributed in both groups, all outliers were deleted, and the groups showed approximately equal variances on the Composite score dependent variable. Although the students representing Schools A and B in this study were found in the MANOVA to differ significantly on an optimally weighted linear combination of the seven ITED subscales, the samples did not differ significantly on ITED Composite scores. Students from School A (n = 80, M = 295.98, SD
= 26.51) scored somewhat lower than students from School B ($n = 55, M = 302.62, SD = 24.81$), but the difference was not significant, $F(1, 133) = 2.36, p = .127$.

It is simple enough to explain why the samples differed significantly on a linear combination of ITED subscale scores in the MANOVA but did not differ on ITED Composite scores, which are simply averaged subscale scores. Averaging the seven subscale scores essentially weights each of the subscales with a weight equal to $1/7 = .143$ and then combines those weighted subscales by summing. In contrast, the combination of subscales created in the MANOVA involved differential, optimal weighting of the subscales prior to summing so as to create a variate that was crafted specifically to maximize the separation of the groups.

**Summary**

This quantitative study used a non-experimental, causal-comparative, posttest-only research design to determine if a difference exists between the academic achievement scores of Catholic school ninth graders who were involved in a one-to-one laptop initiative (School A) and a demographically similar group of Catholic school ninth graders who were not exposed to that laptop program (School B). Academic achievement was measured only once in both samples (i.e., posttest-only), at the end of the 2017-2018 school year, using the Iowa Test of Educational Development (ITED). That test comprises seven subscales and also an overall Composite score. After careful data cleaning and testing to ensure that all statistical assumptions were satisfied, students representing the two schools were compared using a one-way between-subjects MANOVA. That analysis evaluated the significance of the multivariate between-group difference using the seven ITED subscales simultaneously. A power analysis estimated that the available sample of 80 students from School A and 55 students from School B provided statistical power of about 77% for that MANOVA. The MANOVA found a statistically
significant multivariate difference between students representing School A and School B. The effect was quite strong, with group membership (i.e., School A or B) explaining 13.6% of the variance in the variate. Based on this result, the null hypothesis, that there was no significant difference in the academic performance of students exposed to the one-to-one laptop program and students without exposure to that program, was rejected. However, the difference in academic performance between the two samples was not in the expected direction. Students representing School B generally outperformed students representing School A. A series of one-way between-subjects ANOVAs was used to explore the source(s) of the significant multivariate effect. Those analyses showed that students from School B scored higher than students from School A on six of seven ITED subscales as well as on ITED Composite scores. These univariate differences favoring School B were weak, but statistically significant on three ITED subscales: Vocabulary, Social Studies, and Science. The samples did not differ significantly on the other ITED subscales, nor on ITED Composite scores.

Chapter 5 will focus on interpreting the findings that were reported in this chapter. Much of that discussion will consider interpretive challenges that resulted from research design limitations and delimitations. The use of a convenience sample, the choice of research designs, the selection of outcome measures, and the use of a quantitative methodology all had consequences for interpreting the study’s outcomes. Chapter 5 will discuss these and other limitations and delimitations of the study. That chapter will also summarize what was learned from this study and will offer suggestions for further research.
CHAPTER FIVE: CONCLUSIONS

Overview

The purpose of this quantitative, non-experimental, causal-comparative, posttest-only study was to address the research question: Is there a difference in ninth grade Catholic high school student achievement scores on the ITED assessment between students involved in a one-to-one laptop program versus students who were not involved in a one-to-one laptop initiative program? This chapter will summarize the results of the statistical analyses that were performed to address that research question, will offer several explanations for the results that were obtained, and will consider the implications of those results as they are related to previous research into the efficacy of laptop initiative programs. Study limitations will be examined and suggestions for future research will be recommended in light of these limitations.

Discussion

The independent variable in this study was the laptop initiative program and was represented by two samples of ninth grade Catholic students. Students attending School A participated in a one-to-one laptop program wherein each student received a laptop. The purpose of the laptops was to submit course assignments, take assessments, collaborate with peers, and access course materials and resources. In contrast, students attending School B were not provided with laptops. Students attending the two schools were demographically similar, but not identical. Academic achievement was the dependent variable, measuring using ITED test scores. The ITED includes seven subscales: Vocabulary, Reading Comprehension, Language, Spelling, Mathematics, and Computation. The ITED also offers an overall, Composite score. A between-subjects one-way MANOVA was used to compare the two samples on the seven ITED subscales. That analysis identified a significant between-group difference in academic
achievement. A series of seven between-subjects one-way ANOVAs, one for each of the seven ITED subscales, was then used to explore the source(s) of the multivariate effect and an additional ANOVA compared the groups on the ITED Composite. Those ANOVAs found that students attending the two schools differed significantly on three of the seven subscales: Vocabulary, Social Studies, and Science. However, differences between the groups were not in the expected directions. Students attending School B, without a laptop initiative program, outperformed students representing School A, with the laptop program. This finding was partially consistent with previous research that demonstrated no significant advantages resulting from distributing laptops to students (Bryan, 2011; Lowther et al., 2012; Rosen & Beck-Hill, 2012; Rosen & Manny-Ikan, 2011). However, findings from the present study were inconsistent with some other previous studies that showed that laptop initiatives were effective in promoting higher academic outcomes (Grimes & Warschauer, 2008; Gulek & Demirtas, 2005; Hansen et al., 2012; Hur & Oh, 2012; Lowther, Inan, Ross, & Strahl, 2012; Rosen & Manny-Ikan, 2011).

There are several possible explanations for the unexpected finding that students at School A who participated from a laptop initiative program performed at lower levels than students at School B who did not participate in that type of program. First, Suhr, Hernandez, Warschauer, and Grimes (2010) have noted that it can take more than two years to realize the positive effects of one-to-one laptop programs which is likely explained by the amount of time it takes teachers and students to adjust their practices. It is possible that the timeframe of the present study was of insufficient length to allow the effects of the laptop program to emerge in a measurable way.

Second, although School B was selected as a no-treatment comparison group due to the demographic similarity of students in the two schools, it was found that School B had more female students (61.4%) than school A (52.5%). This difference in the percentages of female
students attending the schools did not reach statistical significance due to the relatively small sample sizes, but the gender difference is still important because female high school students tend to score higher on achievement tests than male students of the same age (Voyer & Voyer, 2014). Indeed, that gender effect was observed in this study as well, with female students scoring significantly higher than male students on the Written Expression subscale of the ITED.

The research design used in this study offers a third explanation for the unexpected findings. Field research like this does not often offer the opportunity to utilize powerful experimental research designs. This study used a non-experimental, causal-comparative, posttest-only design, also sometimes called the static-group comparison by Campbell and Stanley (1963) in their seminal work on experimental and quasi-experimental research designs for educational research. Those authors pointed out weaknesses that are inherent in the causal-comparative posttest-only design that could have affected the results of this study. Because participants were not randomly assigned to the two levels of the independent variable (i.e., School A with laptops vs. School B without laptops), there is no guarantee that the students in those groups were equivalent prior to launching the laptop initiative program. In fact, there was evidence for nonequivalence of the groups in this study, with School B represented by more female students than School A. It is possible that School B was ahead of School A in academic performance even before the laptop program was launched and that this difference obscured any benefits resulting from the program. Not only were the students from School A and School B somewhat different, their school environments were undoubtedly different in many ways other than the presence or absence of a laptop initiative. The teachers in the two schools were different and it is possible that differences in curriculum and instruction between the schools had a greater effect on students’ achievement than differences in the availability of laptops.
The posttest-only nature of the research design also worked against demonstrating program efficacy because it offered no pretest assessment of academic performance prior to initiating the laptop program against which to compare posttest performance. The best possible comparison group for students at School A in this study would have been those same students, measured both before and after launching the laptop initiative program, and the design would have been further strengthened had students at School B been similarly evaluated in both pretest and posttest assessments (May, 2012). The inclusion of both pretests and posttests administered to students at both schools might have shown that students at School A improved significantly more from pretest to posttest than did students at School B, even though School B was still ahead at the posttest. Such a finding would have supported the efficacy of the laptop initiative program.

Related to research design deficiencies was a fourth potential explanation for the failure to observe the expected positive results of the laptop initiative program, i.e., the quantitative methodology used in this study. The use of quantitative educational outcome measures provides a multitude of advantages, but quantitative research does not provide the kind of rich data that might have identified the benefits of providing students with laptops (Yilmaz, 2013). Interviews with students, their parents, and their teachers might well have revealed the qualitative benefits of laptop availability.

A fifth explanation for the failure in this study to see evidence of the efficacy of the laptop initiative program might be found in the dependent variables that were used. Standardized academic achievement tests are rather far removed from the kinds of day-to-day benefits that one would expect laptops to provide. Having a laptop available for use as a student researches a report or science fair project would be expected to provide a clear advantage in completing those tasks, but that benefit might not extend very well to improving the student’s standardized
achievement test scores at the end of the school year. In other words, the dependent variables used in this study may not have been sensitive to the kinds of benefits that the laptop program provided.

With all of these explanations in mind for the failure of this study to demonstrate the efficacy of the laptop initiative program, that failure may also reflect the reality that the laptops did not make much of a difference in the lives of the students who received them. All of the students in this study attended private, Catholic high schools, and that is not an inexpensive proposition for their parents. It is reasonable to expect that many or most of the students in both schools came from homes in which there were already one or more computers available. Laptops might have benefited students while they were at school, but those benefits might not have extended into the students’ home environments. The advantages of a one-to-one laptop initiative might be seen more clearly if those laptops were the only computers to which students had access.

**Implications**

This research contributes to the knowledge base of the field of educational technology, specifically in regards to the academic achievement of students involved in a one-to-one laptop initiative. The uniqueness of this study is that it was conducted in a Catholic high school setting. Although this study did not generate any evidence for the efficacy of the laptop initiative, some previous research has demonstrated that efficacy. Perhaps there is something unique about the Catholic high school environment in this study that made laptop availability a less potent treatment than it would have been in some other environment. In other words, perhaps the effectiveness of laptop programs is moderated by some variable or variables associated with the environments in which those programs are applied. One possibility was suggested previously,
i.e., the relative wealth of the parents of most of the students in this study meant that they probably had access to computers at home already, and some students who attended School B might have carried personal laptops with them. Additional research is needed to explore the efficacy of laptop initiatives and the conditions that moderate that efficacy.

Limitations

Several study limitations were suggested in the previous discussion that might have contributed to the failure to observe the expected positive results from the one-to-one laptop initiative: (a) an insufficient period of time passed following initiation of the laptop program for the effects of the laptops to emerge, (b) the treatment group (School A) and comparison group (School B) were nonequivalent groups and the comparison group had the advantage of a higher percentage of female students, (c) the research design did not include pretesting that might have allowed the expected effect to be observed, (d) the use of a qualitative methodology precluded the collection of the rich data that might have demonstrated some of the more subtle benefits of the laptop program, (e) the ITED might not have been sensitive to the day-to-day benefits derived from laptop availability, and (f) treatment differences between the groups were probably diluted by virtue of the fact that home computers and personal laptops carried to school are ubiquitous, especially in families who have the financial means necessary to send their children to private schools.

There were additional study limitations that affected the external validity of the study, i.e., the extent to which the results can be generalized beyond the samples that were examined. The study: (a) examined students from only one grade, (b) who attended only two schools, (c) which were both located within the same Diocese. Thus, the results of this study may not be generalizable to all Catholic high school students or to students in other grades.
Recommendations for Future Research

Future research on the effectiveness of one-to-one laptop initiative programs should attempt to avoid as many of the limitations that affected the present study as possible. The purpose of this study was to extend findings from previous research on laptop initiatives into the Catholic high school environment, so future research should also focus on Catholic high schools. However, results would generalize more broadly if data collected in future studies were collected from a broader assortment of Catholic high schools within other Catholic Dioceses in a wider variety of geographical locations. The use of true experimental designs is unlikely in field research like this, and in the absence of random assignment of participants to groups, there are likely to be differences between those groups on a variety of student and school variables that confound the treatment effect. Because of this, great care should be taken in future research to collect data on the characteristics of both the students and their school environments so as to enable the statistical control of these confounding variables. Future work would also benefit from the use of pretest-posttest designs that offer substantially greater opportunity to observe treatment effects than did this posttest-only research. Future research might also benefit from the use of multiple posttests, potentially spread across two or more years following the launch of the laptop initiative. This would not only provide the time needed for the effects of laptop availability to emerge but would also give the opportunity to study the “staying power” of the laptop program. More variety in outcome measures would also be desirable in future research. In addition to standardized academic achievement test scores, researchers might include quantitative data on homework assignments, papers, and other school projects that might be more strongly impacted than standardized test scores by laptop availability. In addition to expanding the quantitative measures of program effectiveness, qualitative data from interviews
with students, teachers, and parents would be useful. Finally, as research in an area matures, it is often the case that treatment effects that are observed in one setting are not observed in other settings, suggesting the presence of one or more moderating variables (Baron & Kenny, 1986). Methods are available within both ANOVA style research and multiple regression research to explore potential moderator variables (Frazier, Tix, & Barron, 2004) and these methods also allow for the inclusion of covariates that would enable researchers to simultaneously control statistically for student and school variables that might otherwise confound the independent variable.

**Summary**

Chapter Five discussed the findings of this study of the efficacy of a one-to-one laptop initiative within a Catholic high school. Students who participated in the laptop program differed significantly on three standardized test score subscales from students who did not participate in such a program, but the difference was not in the expected direction. Students in the laptop program performed at a lower level than did students who were not exposed to a laptop program. Several explanations for those unexpected results were presented in this chapter, stemming primarily from methodological and research design limitations that accompany applied field research studies like this one. The chapter concluded with recommendations for future research to evaluate the efficacy of one-to-one laptop initiative programs within Catholic high schools.
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APPENDIX

Appendix A: Permission Letter from Superintendent of Education

April 17, 2018

Matthew J. Buckley
Doctorate Candidate
Liberty University

Dear Mr. Buckley:

I have carefully reviewed your research proposal entitled “Achievement and Engagement of Catholic High School Students Involved in a One-to-One Laptop Initiative Program.” I hereby grant you permission to conduct your study within schools of the Catholic Diocese of Biloxi. You will also be allowed access and utilization of student test data.

Check the following boxes, as applicable:

☐ Data will be provided to the researcher stripped of any identifying information.
☒ I am requesting a copy of the results upon study completion and/or publication.

Sincerely in the Lord,

Mike Ladner, Ph.D.
Appendix B: IRB Approval

Liberty University
Institutional Review Board

May 10, 2018

Matthew J. Buckley
IRB Application 3310: Achievement of Catholic High School Students Involved in a One-to-One Laptop Initiative

Dear Matthew J. Buckley,

The Liberty University Institutional Review Board has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds your study does not classify as human subjects research. This means you may begin your research with the data safeguarding methods mentioned in your IRB application.

Your study does not classify as human subjects research because it will not involve the collection of identifiable, private information.

Please note that this decision only applies to your current research application, and any changes to your protocol must be reported to the Liberty IRB for verification of continued non-human subjects research status. You may report these changes by submitting a new application to the IRB and referencing the above IRB Application number.

If you have any questions about this determination or need assistance in identifying whether possible changes to your protocol would change your application’s status, please email us at irb@liberty.edu.

Sincerely,

G. Michele Baker, MA, CIP
Administrative Chair of Institutional Research
The Graduate School

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