THE EFFECTS OF IPAD DEVICES ON ELEMENTARY SCHOOL STUDENTS’
MATHEMATICS ACHIEVEMENT AND ATTITUDES

A thesis presented
by
Jaclyn Singer

to
The School of Education
In partial fulfillment of the requirements for the degree of
Doctor of Education
in the field of
Education

College of Professional Studies
Northeastern University
Boston, Massachusetts
July 2015
Abstract

The integration of educational technology continues to increase as schools are endeavoring to challenge the traditional philosophy and practices of American schools. While there are many opportunities for the use of technology in classrooms and to design instruction employing the most recent technological tools, there is a need to better understand how to integrate iPad devices effectively in elementary math instruction. In response to these challenges, this exploratory case study that included quasi-experimental quantitative and qualitative data investigated the effect of iPad devices, as an individual learning tool on third grade students’ achievement and attitudes towards mathematics. The central research question that guided this study was: What is the process by which NPS School adopted iPads into a third grade mathematics classroom and what impact did it have on elementary school students’ mathematics achievement and attitudes? The succeeding sub-questions helped to provide a more complete and holistic view of the problem of practice. How does third grade students’ math achievement differ when integrating an iPad into instruction compared to the traditional-textbook based education for a unit of study? and How do students attitudes towards mathematics differ when using tablet devices compared to the traditional means of instruction? These research questions were answered using two sections of a third grade mathematics course, one that received teaching based on traditional instructional pedagogies while the other group received instruction with the integration of an iPad device. Course content, instructional design, assessments, inventories and the instructor remained consistent for both groups; the only difference was the intervention of iPads. Data on students’ learning achievement was collected through pre and post-tests and students’ attitudes were measured based on an Attitudes Towards Mathematics Inventory (ATMI). Interviews were conducted with the participating instructor and
coordinating administrator to provide more inclusive and holistic results. In addition, documents, in the form of teacher lessons plans were analyzed to provide further information about what teachers intended to do; specifically how the iPad device was used during the lesson. The results that emerged from this study exposed inconsistencies between the quantitative and qualitative data. Specifically, the results from the post-test and ATMI did not show a statistically significant difference while the interviews with the participating adults created a picture of a noticeable increase in student engagement, attitudes and productivity for students that used iPads for instruction compared to the students who did not use the devices.

*Keywords:* iPads, academic achievement, attitudes towards mathematics, math instruction, technology integration, elementary math classrooms, 21st century learning
Acknowledgements

Completing my doctoral degree has been one of my most challenging and rewarding academic achievements. This accomplishment was made possible with the support and guidance from many people.

I would like to thank my research advisor, Dr. Kelly Conn, who assisted me with her expertise and guidance throughout the dissertation process. I would also like to thank my second reader, Dr. Sara Ewell, and my third reader, Dr. Nancy Giordano, for providing valuable feedback on my research.

Thank you to the participants and my colleagues who made this study possible. I am appreciative of their willingness to find the time to help me. I acknowledge how busy everyone was and I cannot thank them enough for volunteering to be a part of my research.

There are not enough words to describe my sincere gratitude to my family. To my grandparents, who I know were encouraging me from above, I wish they were here to celebrate this accomplishment. I would like to thank my Grandma Lois for being my biggest cheerleader and never doubting my ability to complete the program. Thank you for constantly checking in on my progress even when I did not want to talk about it. Thank you to my sister Stacey, who continually supported me throughout this journey. And last but certainly not least, my parents, Sheila and Jeffrey, who constantly offered their support and encouragement. I am so thankful for their outpouring of love and reassurance when I needed it most.
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Chapter 1: Introduction

The United States educational system has the responsibility of providing a free and appropriate education to all students. Recent concern over the education system’s ability to educate students in order to remain globally competitive has led to an increased interest in school reform using instructional technologies (Schank & Jona, 1999).

The ultimate goal of education is to prepare students for productive and independent lives within our society (Collins & Halversont, 2010). Mathematics skills taught in the elementary grades help to provide the basic skills, knowledge and solid foundation that is necessary for children to advance in their education, making early achievement critical for future success (Claessens & Engel, 2013). Additionally, it is important to nurture and establish a positive disposition towards mathematics early on in a child’s education. Students who lack skills or possess negative attitudes towards mathematics are at risk for failure in middle school, high school and beyond. Intervening at a critical and premature stage in a child’s mathematical learning will help to lay the foundation of a successful mathematical future.

In order to meet the needs of 21st century learners, educational institutions across the United States are increasingly integrating technology into classrooms (Lage, Platt & Treglia, 2000). The U.S Department of Education encourages educational institutions to design instruction employing the most recent technological tools to optimally prepare students. Meeting students at their own ability level, building on what they already know, and implementing a language-rich curriculum are current recommended strategies for teaching math. Technology can enhance each of these pedagogical approaches to teaching mathematics.

If students build a strong mathematical foundation in the elementary grade levels, students will have more success in their future (Carr, 2012). According to the Common Core
State Standards (CCSS) that are taught in elementary schools, the ability to be able to know and do mathematics by solving a range of problems and engaging in key practices is strongly aligned with the knowledge needed for college and career readiness. Schoenfeld (2002) further states that mathematics literacy is “a core component of intelligent decision making in everyday life, in the workplace, and in our democratic society” (p. 2). As our society is ever evolving, those who are technologically literate will have access to jobs and economic empowerment, while those without such skills will not (Moses, 2001). Mathematical success in schools has usually provided further openings for students to develop technological literacy and advance into higher education and employment opportunities (Schoenfeld, 2002).

Another challenge the American education system is facing is developing and maintaining students’ positive attitudes towards learning mathematics. Research conducted in prior years has shown that positive attitudes towards mathematics has an impact on students’ tendency to pursue a career in math-related fields and enrolling in advanced mathematics courses (Maple and Stage, 1991, Trusty, 2002).

According to Furner and Berman (2003), students that hold negative attitudes and dispositions towards mathematics will have impeded academic success and learning will be limited. In contrast, when students are positive and engaged with mathematics, students are more motivated to learn, try more demanding tasks and accept new thoughts. Therefore, it is necessary to improve the relationship that students have with mathematics. Instruction must be reflective in using resources and strategies that stimulate students’ attitudes, motivation and interests (Beilock & Willingham, 2014, Deci & Ryan, 1985, Farooq & Shah, 2008).

Recent studies indicate that students are increasingly disengaged and feel negatively towards school and what they are learning in the classroom because of the lack of relevance to
the 21st century students are living in (Garet, Means, Mitchell, Murphy, Shkolnik, Song, & Uekawa, 2005). Often, the traditional structure and approach of schools do not incorporate the needs of the current shift from the information age to the technological age.

According to Preciado-Babb (2012), iPads and other tablet devices have helped students to develop new relationships with math content when they are able to practice and learn using these technologies. Students who have better attitudes towards math may be more motivated in mastering mathematical content and skills. Kulik (1994) communicates that students like their classes better and develop a more positive attitude when their classes incorporate technology based instruction. Moreover, Sivin-Kachala (1998) established that students’ attitudes toward learning and their own self-concept improved consistently when technology was integrated into instruction. Therefore, understanding ways to improve students’ attitudes towards math is essential.

Technology has become a significant tool for assisting students in mathematical problem solving, reasoning, and exploration (NCTM, 2000). The National Council of Teachers of Mathematics (NCTM) support the notion that technology tools are essential for learning mathematics in the 21st century. Technology can be used in the mathematics classroom as a method to show students a variety of ways to approach mathematical ideas and processes and to create connections to skills and activities that are of interest to them (Regan, 2014). Moreover, integration can help children see how technology devices can be used as a tool to help solve problems in a society built on information and technology. iPad tablets in particular have been shown to hold great promise (Herro, Kiger & Owens, 2013). If educational institutions were better able to understand how to use iPad devices effectively in elementary math instruction, then
the United Stands may be better able to help all students meet their learning and emotional goals in mathematics.

To help students stay academically competitive, exploring the impact of iPad devices in elementary classrooms is fundamental to identifying effective instructional practices.

**Purpose Statement**

The purpose of this study was to examine the process by which NPS School adopted iPads into a third grade mathematics classroom and what impact it had on elementary school students’ mathematics achievement and attitudes. This exploratory case study design that incorporated quasi-experimental quantitative and qualitative data helped to provide insights on the process and impact that iPad devices had on elementary school students’ mathematics achievement and attitudes.

**Significance**

There is a real concern for pupils, schools, communities and the American society that students are not achieving in mathematics. Students are graduating from the education system unprepared for college and the professional world, leaving them unable to academically compete for occupational opportunities (Smith & Turner, 2015). At a larger level, if students are deficient in mathematics, our nation will fall short compared to our international counterparts. It is necessary to reverse this trend in order to adequately prepare students for their future academics and potential careers. Mathematical preparedness is critical to provide the essential opportunities to remain globally competitive and to prepare students for the real world.

**Deficiencies in the evidence.** The current research regarding tablet devices in classrooms is relatively new due to the novelty of the devices. There is a need to study and identify if tablet devices will provide academic and attitude benefits for elementary school
students. In order for educators and schools to identify ways to accept the challenge of meeting high accountability measures and ways to prepare 21st century students, it is essential to recognize the impact of tablet devices.

Much of the research previously conducted incorporates the broad range of technologies (Banister 2010, Donovan, Green & Hartley 2010, Holcomb 2009, Ifenthaler & Schweinbenz 2013, Lowther, Ross & Morrison 2003). These studies include many devices such as computers, digital cameras, graphing calculators, the Internet, LCD projectors etc. Research that specifically focuses on tablet devices and iPads is necessary to narrow the scope of the effect this one tool may have on achievement and students’ attitudes.

**Research Questions**

The following was the central question that guided this study: What was the process by which NPS School adopted iPads into a third grade mathematics classroom, and what impact has it had on elementary school students’ mathematics achievement and attitudes? The succeeding sub-questions helped to provide a more complete and holistic view of the problem of practice.

Sub-Question 1: How does third grade students’ math achievement differ when using an iPad compared to the traditional-textbook based education for a unit of study?

This question was explored by evaluating students’ academic achievements that used an iPad for learning compared to students’ academic achievements that were taught by a traditional means of instruction. Traditional means of instruction is referred to as methods that are focused on paper and pencil practice. This method encompasses classrooms that are predominately using textbooks and worksheets to practice content that was transmitted from the teacher to the student. Data was collected before the treatment from both groups to obtain pretest measures. This data
was compiled to determine if the two groups differ significantly before the treatment. At the culmination of the study, post assessment data was collected and compared to see the relationship between the two groups.

In order to accumulate multiple perspectives, a more complete understanding, and an explanation of the quantitative results, the participating instructor and coordinating administrator were interviewed to inductively explore the teacher and administrative experience using iPads in the classroom as it relates to student achievement and attitudes. The instructor was guided to discuss exactly how the iPads were implemented and utilized in the classroom, moreover, how the students were engaged with the tool and the classroom management with the devices. The instructor was also asked to speak about the results that the quantitative data portrayed. For example, is what occurred in the classroom supportive or contrary of the quantitative data results? The administrator was steered to discuss the groundwork, preparation, maintenance, and experiences with the iPads in the district, and, to share challenges and successes from integrating the technology in the classroom. The inclusion of this qualitative data collection helped to deepen the level of understanding of this problem of practice while gaining a greater insight to the reasons behind the quantitative data results (Rubin and Babbie, 1997). Additionally, documents in the form of teacher lessons plans also provided further information about what teachers intended to do; specifically how the iPad device was used during lessons.

Further discussed in Chapter 2, the existing literature has revealed that tablet devices may have an impact on student achievements and student attitudes. Therefore, the first sub-research question in this study aimed to determine if the results also impacted elementary aged students.

Sub-Question 2: How do students’ attitudes towards mathematics differ when using iPad devices compared to the traditional means of instruction?
In this study, groups of students received a different level of technology integration. This question was explored by administering attitude surveys to the group of students learning with an iPad device and to the group of students that received the traditional means of instruction. Data regarding students’ attitudes was collected through an inventory that illustrated the various ways that students feel about mathematics and their own feelings concerning the subject. Through this research sub-question, data revealed how students’ attitudes were affected by the use of iPad devices in an elementary classroom.

The null hypothesis is as follows:

*There is no difference between the group of students utilizing iPads during instruction and the group of students not using the iPads in terms of student motivation on a Student Attitude Inventory.*

The directional hypothesis is as follows:

*Mathematics students in the third grade who receive instruction utilizing iPads will have better attitudes towards mathematics on the Attitudes Towards Mathematics Inventory compared to students who receive the traditional textbook based education.*

**Relating the Discussion to Audiences**

This study was designed to capture data that can be used as evidence to help advise school officials the impact of the iPads on student performance and attitudes towards mathematics to better support decisions on instructional needs. Now more than ever, due to the Common Core Learning Standards and the high accountability measures, schools and educators are in need of evidence of strategies and practices that are effective in helping students achieve high levels of learning.
This research is beneficial to an academic and scholarly audience to contribute to discussions on whether and how iPad initiatives can make a difference in the mathematics classroom. Scholars have raised concerns whether the educational value of tablet devices are worth the investments that schools make to purchase the technologies. This research provides evidence for educational uses that will either support or reject the need for iPads in the elementary classroom.

This research creates deliberations around supplemental ways in which our schools can become more connected to our students and better prepare them for the workforce. Likewise, this study adds to the literature ways to effectively integrate iPad devices to improve success and attitudes. As outlined in the constructivist learning theory, students are the most successful when student-centered instruction is utilized and students take an active role in the construction of their own knowledge (Lutz & Huitt, 2004). This theoretical framework helps districts, and teachers consider educational technology and 21st Century Skills as a means to improve student achievement and attitudes towards mathematics.

**Researcher Positionality**

The experiences and life history of a researcher may have an effect on the way in which a situation is understood and/or explored (Briscoe, 2005). Briscoe (2005, p. 26) states “it is questionable whether the researcher (from a privileged group), even with the best of intentions, can adequately interpret the world of those who experience oppression. Such lacks result in a perception, interaction, interpretation, and representation of the other that is at best incomplete and at worst subordinating.” As a researcher conducting a study in my place of employment, a conscious effort was made to reflect upon my own experiences and positionalities to construct appropriate interpretations of this study’s findings.
In my experience as a student who received an education that incorporated large amounts of technology, I hold a positive bias towards the integration of instructional technology. I believe that using technological devices within the classroom is a way to improve instruction, participation and attitudes of students. Especially with all of the advantages previously mentioned that the Apple iPad offers, all students have the chance to be an active participant in all aspects of the lesson rather than a passive observer. I predict that the use of the devices will have a positive effect on students’ academic achievements and attitudes towards mathematics.

Elementary aged students thrive on immediate feedback and results. I have confidence that the immediate feedback that the technological devices provide students will offer them a sense of accomplishment, improvement in attitudes, and pride in their work. Students will want to do well and get the correct answers on programs utilized on the iPad. The instant responses can help to boost their self-confidence that drives them to work harder and put in more of an effort. Moreover, the iPads will allow for individual, student centered approaches to teaching rather than teacher centered approaches.

**Researcher background.** For the past ten years I have been employed as an educator in a suburban community that is approximately twenty miles east of New York City. I serve as an elementary math academic intervention teacher for the fifth grade. The main focus of my position is to provide extra support for students who are at risk of not achieving a standard of proficiency. As the fifth grade math specialist, I also serve as a math coach to classroom teachers providing them with strategies, tools, skills and techniques to successfully teach and meet all of the students’ needs.

Working with students that typically struggle to do well in mathematics, I often come across children who elicit poor attitudes towards the subject area. My first goal as their teacher
is to help them believe that they can do well and can be a successful math student. Successful academic outcomes are largely grounded in meeting the emotional needs of students. If students are not emotionally allowing themselves to succeed in math, I have found that they will continue to struggle and be reluctant to complete practice work. Before working on students’ academic needs, I am certain it is important to make them believe in themselves and believe that they can do well and enjoy doing math. By first creating a positive attitude towards math, I have seen students put forth more of an effort.

It has been my experience that when technology of any sort is integrated into the classroom, students are more interested and enthused to work on mathematics. When students are given an opportunity to use technology in a lesson, even something as simple as a calculator, a shift in students’ attitudes are evident. For example, when practicing basic multiplication, students are more willing and motivated when they can use quick response codes (QR) and technology to check their own answers. For this reason I believe that using iPads with students will enhance math achievements and attitudes towards the subject.

From the time I was a child, I have always taken an interest in technology. Upon starting my professional career as an educator, I was curious in how technology could be used to support teaching and learning. My first master’s degree was awarded in a Math, Science and Technology (MST) program at Hofstra University located on Long Island, New York. This program was designed for educators who were seeking ways in which the learning of science and mathematics could be enhanced with the use of technology. During the course of the program, I became passionate about encouraging the use of technology in the classroom to promote connections between 21st century learning skills and the content that was being taught. Initially, the school in which I teach had a set of iPods that were available for use. After using the iPods
whenever possible, it was evident that I needed to change what I was using in the classroom with the ways that technology was evolving outside of the classroom. The next creative tool that rolled out from Apple was the iPad. In hopes of continuing to use revolutionary technology, myself and a colleague created a proposal for iPads in the classrooms. The proposal was accepted by the districts’ technology director and assistant superintendent of instruction. A pilot program was introduced into my school district for one classroom in the 2013-2014 school year. The feedback from the teachers, students and parents was overwhelmingly positive. It was decided by my district’s Board of Education to expand the iPad pilot program for the district’s entire third grade for the 2014-2015 school year. The results of this research study are highly anticipated to see the effect that the devices have on student achievements and attitudes towards mathematics.

According to data from the 2012-2013 New York State Assessment results, 21% of the students in the current district used for this research study scored proficient on the mathematics assessment (engageNY.org). It was evident that the student achievement rate at the elementary school in which I am employed falls below New York State’s average (engageNY.org). Additionally, proficiency levels of students’ in my district are far below that of neighboring school districts. Current teaching methods are not producing satisfactory results, so it is necessary to transition new approaches of teaching and educating our students.

My own perspective and experiences, which include researching and reading through the various literature associated with the impact of tablet devices on students achievement, have helped me believe that the devices will have a positive effect on student successes. Overall, gaining a deeper understanding in regards to the benefits and disadvantages to the integration of iPads into elementary classrooms is essential. It is necessary to recognize all of the positive
influences iPad devices can have on student learning but also the negative impact prior implementations have experienced. This will allow me to hold a deeper understanding on the influence iPad devices have on student achievement and attitudes towards math. Additionally, this will allow the most valid results of the study to develop which will help educators make informed decisions about using iPad technology in elementary classrooms.

In order to mitigate the bias held by the researcher, several strategies were employed. Primarily, multiple data sources were used to triangulate the data in an effort to provide the most accurate description of the iPad intervention. Creswell (2012) notes that triangulation is “the process of corroborating evidence from different individuals, types of data, or methods of data collection in descriptions and themes in qualitative research” (p. 259). This strategy helped to ensure that the information from the study is truthful and credible due to the use of multiple sources of information. Moreover, the researcher remained distant from the study by not having any contact with the students and participating adults. Implementing measures such as cross and counter checking of the data helped to deter any prior biases held. In addition, transparency of methods and interpretation when reporting the findings is of the utmost significance to avoid potential biases in the study.

**Theoretical Framework**

Two common theoretical threads are apparent in the literature regarding the effect of tablet devices on student achievement and attitudes in mathematics; the Constructivist Learning Theory and the Technological Pedagogical Content Knowledge (TPACK). Both of these theoretical frameworks provided conceptual underpinnings from the literature related to this study’s research questions. A closer look at each theory provides greater understanding of the subsequent literature.
Constructivist learning theory. Different educational philosophies have guided the way in which students are educated, the method in which teachers instruct, and the culture of schools and districts in the 21st century. The first theoretical framework that structured this research study is known as the Constructivist Learning Theory, which is largely based on the belief that learners create new knowledge for themselves. This theory supports the notion that each individual creates distinct meaning and experiences as they learn.

Liu and Chen (2010) define constructivism as:

Constructivism means that learning involves constructing, creating, inventing and developing one’s own knowledge and meaning. The role of the teacher is a facilitator who provides information and organizes activities for learners to discover their own learning. (p. 65)

History of constructivist learning theory. The constructivist learning theory has roots in the work of John Dewey, Lev Vygotsky and Jean Piaget. These three figures are eminent in regards to the development of the theory. They all share the same notion that classrooms must carry out constructivist ideas that reflects that there is a connection between the environment in which human beings live in and the psychological process of learning (Liu & Chen, 2004).

The constructivist learning theory is based on the belief that learning is advanced when children construct new knowledge themselves. According to constructivists, learning involves interaction, collaboration, and real world situations as part of the learning process. The origin of the constructivist learning theory is famously initiated in the work of Jean Piaget.

Zhang and Kou (2012) convey:
Piaget thought that human’s cognitive structure should construct from the interaction with the environment gradually and the human’s cognitive structure develop by the internal and external cause. (p. 2,294)

Constructivist ideas also stem from the work of John Dewey and his progressive model for teaching and learning. In his essay, “The Psychological Aspect of the School Curriculum” Dewey (1897) reasoned that a child’s interests and experiences is the most fundamental occurrences that will help a child learn.

Dewey (1897) stated:

Only when the individual has passed through a certain amount of experience, which he vitally realizes on his own account, is he prepared to take the objective and logical point of view, capable of standing off and analyzing the facts and principles involved. (p. 168-169)

The value of personal experiences that can influence a child’s education was a major emphasis in John Dewey’s work (Lutz & Huitt, 2004). His philosophy was that human beings construct knowledge through the interactions and connections one has with their surrounding environment. The constructivist theory had been developed on the concept that personal experiences help to provide the “foundation for the development of the necessary attributes for successful living” (Lutz & Huitt, 2004, p.2). As a leader in the reform of education to take on a more constructivist approach in the early 20th century, his work carved a path for later researchers to follow.

**Significance of the theory.** New strategies for instruction and assessment of student learning have developed out of the transformation in paradigm for teaching based on constructivism. Dewey’s philosophy influenced many areas of teaching and education around
the world (Kopelman & De Ville, 2001). Kopelman and De Ville (2001) conveyed that several teaching techniques advocated by Dewey and his constructivist theory such as becoming creative problem solvers, working in small, interactive groups, participating in open discussions and being able to adapt to new data and problems has been integrated into school curriculums. Many schools have implemented constructivist teaching theories by having teachers take on the role of the facilitator while students take an active role in constructing their own knowledge (Liu & Chen, 2010).

**Technological pedagogical content knowledge (TPACK) framework.** The second theoretical framework that structured this research study was the Technological Pedagogical Content Knowledge (TPACK) developed by Mishra and Koehler. The TPACK framework builds on the earlier work of Lee Shulman (1986) which argues that teachers must assimilate pedagogical and content knowledge and how they are related to good teaching practices. Mishra and Koehler (2009) argue that teaching with technology is a complex task that would benefit from a framework that integrates technology with the interactions between what a teacher knows and how that can be applied in the classroom.

Technology can no longer be viewed as a separate entity from content and pedagogical knowledge. Prior views of teaching methodologies view the relationship of the three components as the connection driving the pedagogy followed by the integration of technology. Mishra and Koehler (2009) altered Shulman’s (1986) work advising that a third component be built into a framework; TPACK, which focuses around content, pedagogy and technology, and the correlation between them (Mishra & Koehler, 2009). In the TPACK model, the technology factor motivates the judgments regarding content and pedagogy (Mishra & Koehler, 2009). Mishra and Koehler (2009) argue that each situation in a classroom may involve a unique
interaction of the three components which is why the TPACK framework is helpful to support the complexity in the knowledge of each component

Mishra and Koehler (2009) further:

Thus, teachers need to develop fluency and cognitive flexibility not just in each of the key domains (T, P, and C), but also in the manner in which these domains and contextual parameters interrelate, so that they can construct effective solutions. (p. 66)

For this reason, the TPACK model helps create the profound rationale and flexible construction around core pedagogical issues while establishing an equilibrium among all components.

In preparing students for the 21st century, teachers need to be equipped with the awareness of the association between the pedagogy and content knowledge with technological knowledge (Jang, 2010). Jang (2010) furthermore asserts that teachers must have the ability to apply technological strategies to promote student learning. The addition of a new technology device such as an iPad for educating students promotes an instructor to challenge the integration of the three basic components of knowledge (technology, pedagogy, and content). Mishra and Koehler (2006) argue that in addition to developing content appropriate instruction, teachers must also recognize how to efficiently and effectively integrate technology in connection with specific content and pedagogy. An educator’s TPACK can be used to decide how to appropriately integrate technology to best support teaching and learning. Apparent in figure 1, the Technological Pedagogical Content Knowledge transpires when the three knowledges overlap. Jang and Tsai (2012) validate that the development of TPACK can help to maximize teaching effectiveness and efficiency and help teachers achieve more positive and preferable teaching and learning outcomes.
The TPACK framework was an essential component in structuring the qualitative module of this research study. The development of the participating instructors TPACK was investigated through the execution of interviews revolving around how the iPad devices were implemented in the classroom and the analysis of lesson plan documents.

Figure 1: Reproduced by permission of the publisher, © 2012 by tpack.org
Chapter 2: Review of the Literature

As presented by Machi and McEvoy (2009), the purpose of the literature review is that it “summarizes and evaluates the existing knowledge on a particular topic” (p. 2). Additionally, it serves the purpose of laying out the arguments of discovery and advocacy for the research study. The purpose of this study was to understand the process by which NPS School adopted iPads into a third grade mathematics classroom and what impact the devices had on elementary school students’ mathematics achievement and attitudes. While a substantial amount of research exists on the integration of technology into classrooms (Banister, 2010; Donovan, Green & Hartley, 2010; Holcomb, 2009; Ifenthaler & Schweinbenz, 2013; Lowther, Ross & Morrison, 2003), additional research is needed to postulate how iPad devices weigh specifically on elementary aged students’ mathematic achievements and attitudes towards mathematics. This chapter creates a framework by including relevant literature that contextualizes prior research to help understand the topic of study.

This review is organized into multiple sections to create an outline to support the research purpose within this study. The review begins with the history of mathematics instruction. The analysis continues with pedagogical practices. The third section of this review will explore prior uses of technology in the classroom, more specifically computers, graphing calculators, iPods and iPads. The fourth section will consider research that supports the integration of technology into educational settings followed by a section addressing the research that does not support the integration of technology into classrooms. Finally, the sixth section will explore research regarding students’ attitudes towards mathematics.
History of Mathematics

The major reform effort in the areas of mathematics has been ongoing for many years because of the fear that the United States was not staying academically competitive with our international counterparts. Soviet Union’s launching of Sputnik in 1957 jump-started the United States to survey the quality of the nation’s mathematics instruction (Hersh, 2009). In response to the failed attempt of reform efforts in the early 1980’s, President Ronald Reagan proposed a report called “Nation at Risk,” scrutinizing the quality of education in the United States. This report highlighted that students were advancing through the schooling system with minimal efforts and without rigorous coursework. As a result, “Nation at Risk” fronted the much needed reforms that public education desired.

In the late 1980’s, the National Council of Teachers of Mathematics (NCTM) created an infrastructure to frame the groundwork in ways to teach children mathematics. These curriculum standards stressed the importance of problem solving, communication, and connections. More specifically, a main focal point of the standards included the significance of mathematical reasoning so that students could make sense of mathematics. The NCTM firmly believes that mathematical reasoning, sense making, problem solving and communication should be reinforced by technologies that support learning (NCTM, 2011).

According to the NCTM (2011), technological tools that are used strategically help to support students in exploring and identifying mathematical concepts and relationships. More generally, technology tools help to “increase students’ access to information, ideas, and interactions that can support and enhance sense making, which is central to the process of taking ownership of knowledge” (p. 1). The NCTM additionally reports that prior research has been conducted to maintain the notion that learning, mathematical procedures, skills and the
development of advanced mathematical proficiencies that include problem solving and reasoning are supported by the use of technology.

There are many research studies that support the link between effective instruction and student achievements (Konstanopoulos & Hedges, 2004). Guskey & Sparks (1996) convey that students’ mathematics deficiencies may stem from weak foundation knowledge and concepts that are necessary for a student’s success. Teaching children mathematics is more than using a good textbook, demonstrating with manipulatives or having students work in groups (Putnam, Heaton, Prawat & Remillard, 1992). More importantly, Putnam et al. (1992) convey that the mathematical instruction that students experience is shaped by the learning environment that affords children to actively engage in exploring ideas through problem solving. Vecellio (2013) expresses that there is a need to place an importance on mathematics instruction as a more robust way of exposing students to the content as opposed to the actual curriculum. The best way to reach students is in the way instruction is designed and delivered (Vecellio, 2013). With the intentions of improving student learning, a national shift of teaching around the Common Core State Standards is the most recent initiative the United States is adopting and implementing.

**International comparisons.** American students currently lag behind other countries in mathematics as identified by data provided by the Program for International Student Assessment (PISA), Trends in International Mathematics and Science Study (TIMMS) and National Center for Education Statistics (NCES). Gaps acknowledged by the NCES indicate that the performance of United States students in mathematics literacy in the most recent assessment fall below the average score. Moreover, the United States results rank thirty-sixth out of the sixty-five participating countries (PISA, 2012).
According to the National Science Board (2002), the performance of United States students continue to rank substantially below that of students that are internationally comparable. The achievement gap amplifies as the grade levels progress. The board furthers that “the percentage of students scoring in mathematics at a level considered proficient is only about a quarter at the 4th and 8th grades and one in six in 12th grade” (National Science Board, 2002).

Carnoy and Rothstein (2013) assert that policymakers and analysts are greatly uneasy regarding the performance of American students on international assessments. The most recent release of results of the Trends in International Mathematics and Science Study (TIMMSS) prompted the U.S. Secretary of Education, Arne Duncan, to release a statement describing the results as unacceptable and that there is a dire need to accelerate achievements in schools to close the large achievement gaps (Carnoy & Rothstein, 2013).

By the end of the eighth-grade, United States students are two years behind in math compared to their peers in other countries (OECD, 2010). “Achievement gaps occur when one group of students outperforms another group and the difference in average scores for the two groups is statistically significant (that is, larger than the margin of error)” (US Department of Education, 2011). Research conducted by Suter (2000) revealed that achievement discrepancies between the United States and international counterparts may be influenced by the presentation of the mathematics curriculum. For example, as supported by the constructivist learning theory, students are the most successful when student-centered instruction is utilized and students take an active role in the construction of their own knowledge (Lutz & Huitt, 2004). If the way in which mathematics instruction is delivered has an effect on how well students achieve, it is important for the United States to reform the way in which content area is presented in order to maintain a high quality, largely successful education system.
Based on research about how students think, new educational approaches, and the integration of technology into educational systems, the last few decades have seen changes in mathematics instruction in many countries (Suter, 2000). With the constant advances in technology that is available for instruction, educators must strive to ensure that students acquire extensive knowledge using iPad devices, enabling them to integrate into the world of work and meet the demands of the 21st century. It is crucial for pedagogical approaches for teaching mathematics to develop and advance alongside the progression of technology. Prior research supports the notion that the integration of technology, more specifically tablet devices, in the higher education classroom could help to support students’ learning, attitudes and overall achievement (Conn, 2012; Donovan, Green & Hartley, 2010; Holcomb, 2009). Given the significance of the issue, there appears to be few studies conducted that have examined the impact at the elementary level, more specifically, third grade.

**National comparisons.** In 2002, the No Child Left Behind (NCLB) Act was introduced to increase student accomplishments and to help close the achievement gap. Even with federal mandates, United States students’ assessment results have continued to fall below average in mathematics achievement (National Assessment of Educational Progress [NAEP], 2012).

Alongside the NCLB initiative, Race to the Top (RTTP) and the introduction of Common Core Learning Standards across the nation required all schools to be held accountable for student progress. NCLB has placed a much higher level of perceived accountability on public schools by labeling schools by their performance level and publicizing the reports to help the community understand how well the schools are doing. Additionally, high stake assessments are required by states to illustrate improvement in students’ academic performance. School districts across the nation are adapting curriculums and integrating new innovations to meet requirements set forth
by federal mandates. Research has shown that integrating technology in the classroom can be used to promote students’ learning, attitudes and overall achievement (Enriquez, 2010). In order to achieve higher student success that supports authentic learning, many schools are transitioning towards using tablet devices such as mobile tablets as a means of enhancing instruction (Hu, 2011; Murray & Olcese, 2011).

**Local comparisons.** According to engageNY.org, in 2012, 31% of New York State students met or exceeded the math proficiency standard. According to data from the 2012-2013 New York State Assessment results, 21% of the students in the district used for this research study scored proficient on the mathematics assessment. More precisely, the specific elementary school utilized in this study, 17.5% of the third graders, 37% of the fourth graders and 27% of the fifth grade students are classified as students who are above proficiency and students who are proficient. Therefore, in this district, 79% of the students are classified as not quite proficient, and students who are well below proficient at each grade level (engageNY.org).

The fact that schools are underperforming internationally, across the nation and throughout New York State, suggests that schools need to modify their current practices in order to assure the success of the students who are currently in the classroom. Utilizing 21st century teaching approaches that include technology can help students’ learn new knowledge (Prensky, 2001).

**Pedagogical Practices**

An approach of instruction that is prevalent in many school districts to address the Common Core Learning Standards is known as Cognitively Guided Instruction (CGI). CGI is an approach to teaching that focuses on students thinking. Moreover, mathematics instruction is directed by what students already know and comprehend, which provides a foundation for teachers to develop students’ mathematical understanding (Chambers & Lacampagne, 1994.) A
classroom that exhibits Cognitively Guided Instruction has students spending much of their time on problem solving activities and application of various math concepts. Students use their mathematical thinking and problem solving strategies to complete problems on their own instead of direct instruction from their teacher (Franke & Kazemi, 2001).

In addition to CGI, teacher questioning to elicit students thinking is an essential methodology that is necessary in elementary school classrooms. The level of questions asked affects the level of understanding a student achieves. The *Principles and Standards for School Mathematics* (NCTM, 2000) highlights the prominence of asking questions to challenge students thinking. Questioning students in ways to give them a chance to justify their thinking in multiple ways will help to give them a deeper mathematical understanding (Herbel-Eisenmann & Breyfogle, 2005).

Higher order thinking questioning is an essential component to the Common Core curriculum (engageNY.org). These thought provoking questions promote analysis, synthesis and evaluation as opposed to the basic recall of information (Wimer, Ridenour, Thomas & Place, 2001). In a study conducted by Wimer et al. (2001), it was found that higher level questioning leads to higher levels of learning. Moreover, the questioning approach to teaching mathematics promotes the development of mathematical skills. This study has concluded that through the use of this questioning technique, students are able to make sense, reason, and apply mathematics.

Pedagogy around the Common Core Curriculum should include learning experiences that are more realistic and engaging than a typical lecture and drill and practice (Vecellio, 2013). A component to this new program is to create citizens that are ready for a technological society. As new technological devices are continually introduced into society and integrated into the educational system, learning approaches in education are transforming. To maintain cutting edge
approaches to instruction and to keep up with the 21st century, tablet devices are making their way to becoming a teaching tool and a learning mechanism (Amin, 2010). The use of high-tech tools is imbedded into all aspects of today’s curriculum (engageNY.org). The integration of technology can help students in analyzing, evaluating and making sense of mathematics. Integrating technology will engage students and give them the power to gain deeper understanding of new learning (Sitkins, 2013). When individual students have access to tablet devices, they are connected to outside sources which will help lead to concrete knowledge.

**Technology Integration to Adapt to 21st Century Learners**

Technology integration and new innovations have created a trend in the American education system. “Technology can be defined as any tool that can be used to help promote human learning, including but not limited to calculators, tablets (such as iPads), Smart Boards, video cameras, digital cameras, MP3 players, Portable Digital Assistants (PDAs), and, of course, the computer” (Huneycutt, 2013 p. 1). Technology has been shown to improve attitudes and achievement in mathematics (Christmann & Badgett, 2003; Grinager, 2006; Li & Ma, 2010; Sanchez, Zimmerman & Ye, 2004). There are many kinds of technology that can be incorporated into a classroom.

**Use of Technology in the Classroom**

With the introduction of computers over 30 years ago, there is much research that supports the notion that technology can help to transform teaching and learning (Falloon, 2013). To consider the significance and impact that technology has in teaching and learning, a review of the historical connection between technological innovations and education are essential. Educational technology has been defined by Grinager (2006) as “the use of hardware, software
and other digital technologies to advance learning, teaching and administration in K-12 and post-secondary settings” (p.1).

Educational technology has significantly evolved over time, which has changed the world in which we live (Grinager, 2006). As new innovations prevail, legislators and school officials search for techniques to adapt and integrate new tools in support of teaching and learning, and to adequately prepare students. Throughout the years, technology integration has looked differently as our society progresses.

**Integration of computers.** The technological transformation in education began in the 1980s with the introduction of the personal computer (PC), developed by IBM. It was at this time that the benefits of using computers to support the classroom were recognized by educators. The integration of computers into the classroom was an attempt to help bridge the gap between the needs of individual students and different classroom environments (Donovan, Green & Hartley, 2010).

As technology rapidly developed, educators began to recognize the benefits of using computers in education. As time progressed, the presence of computers in the classrooms was steadily increased. For example, “…in 1995, 84% of 7,000 fourth grade students’ reported that they had computers in their classroom, and 79% had computer labs in their schools” (Lowther, Ross & Morrison, 2003, p.23). Taylor, Casto and Walls (2007) assert that there are more computers in schools today than ever before.

It is often the case that students are enthusiastic and eager to utilize technology in the classroom (Conn, 2010). In years past, desktop computers served as a method to engage students. Pilli and Aksu (2013) report on a study examining the effects of computer-assisted instruction on fourth grade students’ achievements, retention, attitudes towards mathematics, and
attitudes towards computer-assisted-instruction. In this study, an experimental group of students were taught using computers while a control group of students received lecture-based, traditional instruction. This study relates that students who were exposed to computer-assisted instruction significantly outperformed students who were exposed to traditional instruction on the achievement post-tests. Moreover, the findings also indicate that the results of a mathematics attitude scale test that students in the experimental group participated in, gained a more positive attitude towards computer-assisted mathematics learning.

In 2003, Christmann and Badgett conducted a study comparing the effects of computer based instruction on students’ academic achievement in grades kindergarten through sixth grade. This study revealed that students excelled more when receiving traditional instruction supplemented with computers compared to receiving only traditional instruction. In a more recent study, Li and Ma (2010) also support their findings of computer based instruction having a positive effect on academic achievements. Computer technology in mathematics education has a great potential to impact teaching and learning to help increase achievement (Li & Ma, 2010).

Computer technology helps to enhance students learning in a myriad of ways (Moss, 2004). Integrating computers into the curriculum provides students with a more learner-centered environment that helps to generate an atmosphere that interests learners (Serin, 2011). A study conducted by Donovan, Green & Hartley, (2010) revealed that the use of computers in the classroom helped to create a more student centered classroom which has helped to further engage students in higher order thinking skills. For example, Page (2002) found that classrooms that utilize teaching methodologies that incorporate computers allows students to take on a participatory role in their own education. This approach lets children learn more on their own and produced positive learning outcomes in mathematics achievement. “Technology-enriched
classrooms were prone to produce more student-centered and individualized interactions, and non-technological classrooms consisted of the traditional model of teacher centeredness” (Page, 2002, p. 403). Moreover, Swan and Mitrani (1993) conducted a study that supported these notions that computer-based classrooms are significantly more student centered than traditional classroom settings.

Swan and Mitrani (1993) conducted a study examining how the use of computers in the classroom can change the nature of teaching and learning and the level of interactions between students and teachers. This study entailed comparing interactions between high school students and teachers involved in computer based instruction and interactions between the same students and teachers during traditional classroom instruction. Outcomes indicate that teaching and learning in a computer based classroom is significantly more student centered and individualized than teaching and learning in traditional classroom settings. Furthermore, the instruction that utilized the computers was found to be more individualized than the style use in traditional classrooms. For example, students who received lectures had to move at a pace that was suited to the requirements of the group, which may inevitably leave some students behind. On the other hand, students using computers were able to learn and progress at their own pace, depending on their own individual needs. This study exposed that instructional technology is a way to improve education as it helped to provide differentiated instruction and address a myriad of student learning styles and needs. Alternatively, classrooms that are taught using a more traditional practice are geared to teacher-centered instruction, which did not result in a positive learning process.

**Integration of graphing calculators.** As a means to further support the use of technology, graphing calculators have been introduced into the classroom. Beginning in the
1970’s, the first handheld technology device was introduced into the mathematics classroom, now referred to as the scientific calculator (Drijvers & Weigand, 2010). In the 1980s, the graphing calculator became available for students, which created a major shift in pedagogies within classrooms. The graphing calculator was first introduced in 1985 by Casio, and was later advanced by Texas Instrument in 1995. With the use of calculators in the classroom, a new way of mathematics prevailed that included problem solving, numerical solving, and advanced graphing capabilities (Waits & Demana, 1998).

The integration of the graphing calculator brought great improvements to the way that mathematics had previously been taught (CUPM, 2004). Calculators promoted students learning and served as a way to develop more complex mathematical concepts. A common principal evident in prior literature supports the notion that graphing calculators have helped to increase time efficiency and to be able to work on more advanced mathematics (Bostic & Pape, 2010; Goos & Bennison, 2008). Although it is often believed that students should work out tasks by hand in order to gain a full conceptual understanding of a process, the technological age in which we live in requires exposure to technology that gives students an enhanced experience (Ozgun-Koca, Meagher & Edwards, 2011). In a study conducted by Merriweather and Tharp (1999), findings concluded that students were able to solve and understand more complex problems with the use of graphing calculators. This idea translated into students becoming more involved in their own learning. In conjunction, studies conducted by Bouck (2009) and Tan (2012) both explored the math performance of students using graphing calculators that indicated students perform better when using the calculators. Moreover, students were better able to problem solve while using the tools because they helped to eliminate the challenges that basic mental math may have on some students.
Graphing calculators are one of the most portable and most affordable technologies in mathematics education (Tan, 2012). Graham, Headlum, Sharp & Watson (2008) supported that the portability and inexpensive costs of the graphing calculator has helped to provide valuable resources within classrooms. Waits and Demana (1998) assert that graphing calculators can be a reasonable substitute for computers for all students due to their low cost, being user friendly, and their portability. Graphing calculators provide a good value of integrating technology into classrooms for much lower cost than using other devices or computers.

**Integration of iPods.** As digital technologies have shown to enhance K-12 teaching and learning, handheld devices started to become more prevalent in schools (Banister, 2010). The iPod has been described as a small and portable media player that can be loaded with audio or video files from a computer (French, 2006; Lacina, 2008). Banister (2010) has asserted that tablet devices, more specifically the iPod touch, has emerged as a pocket sized computer with unlimited possibilities that support the K-12 classroom. Moreover, the iPod touch has helped to provide engaging lessons using the multimedia capabilities for students and teachers.

Banister (2010) supports the notion that the quick and easy access to the internet with the iPod allows students to be able to take notes on material and to better consolidate myriads of information. More specifically related to the content area of mathematics, the iPod touch has provided several opportunities to practice computational problems. The use of the device allows teachers to customize to the learning needs of individual students to help them become more proficient in the math classroom.

According to Flumerfelt and Green (2013), schools must challenge instructional practices to increase student performance. Kiger, Herro & Prunty (2012) support the notion that by integrating the use of tablet devices for a short duration of two months as a means of
instructional technology, student growth will be evident. Their research discovered that when comparing two groups of students, one with iPod devices and one without, student achievement rates soared higher when using technology. This research study entailed four elementary classrooms that were learning multiplication. Two classrooms, labeled as the control groups, used Everyday math and flashcards to learn their multiplication facts. The two other classrooms, which were the experimental groups, integrated the use of iPod touch devices pre-loaded with multiplication applications to help support student learning. Prior to beginning the experiment, all students and teachers completed a survey to help identify and control pre-existing group differences. Moreover, test scores, report card data, and attendance were collected for all participants. A multiplication pre-test was administered to all participants prior to the intervention and a post-test was given to all students at the conclusion of the intervention. Findings from this study reveal that students in the experimental group outperformed students on a post multiplication test compared to the control group of students. These results convey that using mobile devices can be used as a lever to improve student achievement.

Another practice that came about with the growing use of the iPod has been the creation of audio and video products of lectures that can be revisited anytime and anywhere (French, 2006). French (2006) found that having lecture information at one’s fingertips will help students better absorb necessary information. In agreement, Lacina (2008) asserts that iPods allow students to view necessary academic material at their own convenience, truly making learning highly accessible. The use of iPods have permitted students to use their time more wisely by having the flexibility of deciding when and where they were able to complete their work (Richardson, Dellaportas, Perera & Richardson, 2013).
Banister (2010) has found that the biggest difference between the iPod touch and computers is the ability to customize specific classroom needs through the downloadable applications that are aligned with the classroom curriculums. Additionally, in a study conducted by Richardson, Dellaportas, Perera & Richardson (2013) in a college level course, a heightened level of student satisfaction was found due to the enjoyment and relationship that the iPods created. The “real-time” of the video, audio and applications made available by the iPods helped students to stay more engaged than other environments that mirror an online learning settings.

**Integration of iPads.** Teaching methods have given way to a great deal of changes over the past 100 years, which makes it necessary to consider new models of teaching and the way information is translated to students (Campo, Negro & Nunez, 2010). Currently, as a way for the United States educational system to provide students with new opportunities for success, tablet devices are becoming more prevalent in the classrooms (Carr, 2012; Conn, 2012; Donovan, Green & Hartley, 2010; Holcomb, 2009).

Tablet-like technology devices are unique in that they are highly portable, have a flat, touch screen interface, and offer application programs that can be downloaded directly to the device. One of the most commonly used devices is the Apple iPad. The iPad is a device with more than 375,000 applications that allows for endless possibilities both inside and outside of a classroom. The iPad is a 0.37-inch thin, 1.44-pound innovation that is on its way to revolutionizing learning (www.apple.com). The device contains advanced dual-bank Wi-Fi that permits high speed browsing, easy downloading and a source of enjoyment. The device was crafted to be portable and capable for unlimited opportunities (www.apple.com).

As described by Apple (2013),
The iPad inspires creativity and hands-on learning with features you won’t find in any other educational tool — on a device that students really enjoy using. Powerful apps from the App Store like iTunes U and iBooks let students engage with content in interactive ways, find information in an instant, and access an entire library wherever they go. (www.apple.com)

iPads in particular are useful with respect to having a dual-core processor, a front and rear facing camera that supports Apple’s face time video chat software and offers thousands of applications that are exclusively available for Apple devices. Moreover, the iPad has an excellent display due to a higher pixel resolution and retina display because of a large screen size compared to most other tablets. Therefore, this study focuses in on the iPad as an intervention.

The iPads can transform traditional classrooms into a place that utilizes 21st century, efficient technology resources (Herro, Kiger & Owens, 2013). The constant access to important educational resources transforms the learning experience for students (Falloon, 2013). Falloon (2013) furthers that this prevailing and versatile tool provides many ways to enhance education. The iPads can help to revolutionize the way learning is conducted in the classroom. Prior literature (Enriquez, 2010) supports the notion that iPads significantly transformed higher education and created more opportunities for academic development. Therefore, it is necessary to determine if the devices have a similar effect in an elementary classroom, more specifically in third grade math.

The iPad is more than digital textbooks for students to refer back to, but also serves as an interactive, engaging device to enhance students’ learning experiences. Students are able to receive personalized instruction based on their own learning needs that can be detected by many of the applications and e-books on the iPad (Takahashi, 2011). For example, students in this
research study will be operating an application called LearnZillion. This application is an online learning platform that is comprised of video lessons, assignments and activities that can be personalized for each student’s level of learning. Students will be able to work on skills that are specific to them. Students are able to work at their own pace and constantly refer back to appealing video tutorials always readily available at their fingertips. Takahashi (2011) states that for students who have been absent, missed a lesson or need a reteach, the iPad allows for an anytime, anywhere education. Utmost, the iPad is a sleek, user-friendly device that can help to motivate all types of learners to succeed (Li & Pow, 2011).

The iPad allows for many different lessons to materialize within one classroom at all times (Amin, 2010). The device is able to provide remediation, independent work, group activities and enrichment. For example, students that may need another explanation of certain concepts can individually navigate themselves to a tutorial video that may be found on the web or on an application. Other students may practice skills on different applications while others can be researching to delve further into topics to broaden their knowledge. Students learning with a tablet are able to take control of their learning, push themselves to all extremes, and create new opportunities for success.

Schools are continually looking for ways to help students achieve. Groundbreaking products such as the iPad are becoming highly sought after for use in the classroom and are user-friendly for students of all ages (Price, 2011). It has been found that “the use of mobile technology has become almost second nature to many students” (Carr, 2012, p. 272). With so many students being able to navigate the devices, and use them outside of the classroom, it is suggested to adapt instruction by integrating tablets for students to be in control of their own
learning. Schools that have established a place for mobile technology in the school building have seen surprising and exciting results (Hill, 2011).

Schools across the nation have spearheaded the movement of integrating the iPads into the classrooms. Bauleke and Herrmann (2010) convey that as students are growing up in an era of technology, it is often difficult for teachers to create memorable learning experiences for them. For this reason, it has been argued that it is necessary to incorporate the use of the iPad as an enhancement to the curriculum to reach millennium-aged students. “Students are ‘goin’ mobile across the United States, and educators are adjusting instructional and operational practices to reap learning benefits” (Kiger, Herro & Prunty, 2012, p. 76).

As technology is continuously evolving, the next major shift to incorporate 21st century technology into the classroom has been tablet devices such as the Apple iPad (Prensky, 2012). Haydon, Hawkins, Denune, Kimener and McCoy (2012) described a study comparing the effects of a worksheet condition and an iPad condition on academic engagement in a high school setting. Results from this study reveal that more academic work was completed correctly in less time and higher levels of active engagement were demonstrated in the iPad condition as compared to the worksheet condition. This investigation reinforced the notion that students completed more correct work in the same amount of time using technology than students who did not use technology. Moreover, this study concludes that technology provides positive effects and promotes active student learning.

As students in our classes are growing up in a highly technological driven society, it is necessary for schools to help students acquire the skills necessary to be a competitive citizen (Bauleke & Herrmann, 2010). The use of mobile technology in the classroom can help to deepen and enhance the learning process. A study conducted by Enriquez (2010), utilized tablet devices
in a higher education setting. Results from this research showed a significant positive impact on student performance and an overwhelmingly positive student perception of their learning experience when using the technology. The tablet devices provided students with a more interactive and collaborative learning experience. Moreover, the results of the attitudinal survey used in the study conveyed that students showed a significantly greater positive attitude towards their course compared to other students who did not use the devices. Highlights from the study include students’ abilities to better focus on the lectures, real-time assessments and feedback, and an ease of communication with other classmates and the instructor.

Using technology devices as a means of educational practice provides students with new opportunities to learn and succeed (Lage, Platt & Treglia, 2000). Lage, Platt & Treglia’s (2000) study conducted at a public university reveals that using learning technologies affords openings for students to learn in different ways that are otherwise not possible. For example, the tablet devices were used as a way to invert or flip the classroom for students to be able to listen to lectures outside of the classroom. The majority of the students favored this format of teaching and learning. In addition to enjoying the design and structure of the class using technologies, students’ attitudes towards their academics improved due to the engagement that the technology provided, which helped to address the wide spectrum of learners that encompassed the class.

It is often a challenge to improve elementary mathematics success for at-risk students, but the use of iPads can support and enhance learning for individual students (Bennett, 2011-2012). Prior research has concluded that using tablet devices in primary classrooms can help increase achievement and have a massive impact on learning due to the empowerment that mobile technology has on students (Li & Pow, 2011). The results of a study conducted by Price (2011) agrees that students who are considered at-risk learners in mathematics increased learning when
using a device while no students showed a decline in skills. McClanahan, Williams, Kennedy and Tate (2012) support the notion that the use of iPads as an intervention strategy can help students to focus their attention. In the study conducted by McClanahan, Williams, Kennedy and Tate (2012), the researchers sought to see the effect an iPad had on a fifth grader’s reading ability with Attention Deficit Hyperactivity Disorder. An action research study was employed using a pre and post assessment and observations over a six-week time period. For the duration of the study, an iPad device was used as a tool to remediate reading instruction in a self-paced, individualized format. Several application for the iPad were utilized that were useful and related to the goals of the student. Furthermore, the device was the prominent tool used for presentation of the content and reading strategies. As a result of the study, the student’s improved a full grade level in reading ability according to the reading inventory used as the data collection tool. Likewise, the student had noticeably developed control over his own reading strategies and a more positive attitude towards learning. Specific examples that emerged from this study that helped to keep the students attention were the manipulative touch screen that promoted the use of several modalities such as visual and tactile/kinesthetic. Additionally, the student recorded his own reading and was able to play it back and hear his own mistakes that helped to enable him to have a higher level of sensory stimulation that allowed the student to engage in learning tasks using technology.

In addition to requiring a revamped approach in presenting material to students, the Apple iPad can serve as a component to help students achieve and develop a more positive attitude towards the subject. It is often the case that students have a preconceived anxiety towards mathematics (Maloney & Beilock, 2012). Many students possess a lack of confidence that they are unable to do well in math and have a fear of failure. These students need another
outlet that can help alleviate such worries when learning mathematics. Tablet devices can be that enjoyable, fresh and stimulating way to encourage students’ success (Hu, 2007).

Having students operate on technological devices helps them to stay focused on tasks for a much longer time period compared to using books and paper (Huneycutt, 2013). In addition, iPads help struggling students gain confidence in the content area that they practice using the mobile device. Students can be in control of their own learning without the feeling of embarrassment when comparing themselves to others. The devices have helped to motivate even the most reluctant learners, even resulting in higher attendance rates (Hu, 2007).

Another common theme from prior studies supports the idea that iPads in the classroom help to limit off-task behaviors. A study conducted by Conn (2012) found that when using iPads as a means of instruction, students were on task, even those who are usually hard to engage for long periods of time, including special education students. The engagement the device provides and adoration of the actual iPad that students possess, serves as motivation that help students to keep their concentration. This has allowed for a broadening of knowledge while being engaging to the student.

Prior literature has also uncovered that although the iPad is a worthy tool for learning, the way in which it is used must be appropriate and strategic for optimal results. Conn (2010) communicates ways in which the iPads can be effectively integrated into instruction to engage and empower students. It is essential for classroom teachers to first introduce the device by modeling proper behaviors related to the carefulness and maintenance in relation to the iPad. This process can help to create an ownership for the students to help take care of the devices. It has been suggested by Holcomb (2009) that hosting parent nights, as part of the introduction of the technology, can be a helpful component of a technology initiative.
Supporters for Technology Integration

Students that are entering the classrooms have most likely spent their entire lives inundated with technology (Prensky, 2001). Such technologies include but are not limited to computers, videogames, cell phones and digital music players. Therefore, as a result of the excess amount of exposure to these technologies, “today’s students think and process information fundamentally differently from their predecessors” (Prensky, 2001, p. 1). As students’ learning styles are evolving, educational institutions must reexamine pedagogical approaches (Cobcroft, Towers, Smith & Bruns, 2006).

An essential component of being an educator encompasses the ability to understand the ways in which students learn. Students of the 21st century work, think, and learn very differently than those from prior generations due to the substantial influence that technology has on their lives (Oblinger, 2003). “If teachers continue to teach in the same way that they have always taught, there will be little value added…” (Frand, 2000, p. 20). Frand (2000) asserts that education needs to be transformed to make it meaningful to the information-age learner. It is necessary to utilize appropriate technologies in classrooms that will incorporate the mindset of today’s learners to effectively impact student successes.

Baya’a and Daher (2009) determined that the use of mobile technology as a learning device can help students visualize mathematics and learn more easily and efficiently. Utilizing technology in the classroom can help design instruction that takes on a more student centered approach that includes project based learning, cooperative learning and independent inquiry (Lowther, Ross & Morrison, 2003). This type of teaching must be made to accommodate the skills and interests of 21st century students. Bennet, Maton & Kervin (2008) determined that “Immersion in this technology-rich culture is said to influence the skills and interest of digital
natives in ways significant for education” (p.776). Timmermann (2010) agrees that “pedagogy needs to reflect social changes and conform to the needs and expectations of today’s students” (p. 13).

Bennet, Maton & Kervin (2008) further conclude:

They [students] are held to be active experiential learners, proficient in multitasking, and dependent on communications technologies for accessing information and for interacting with others. (p. 776)

Cobcroft, Towers, Smith & Bruns (2006) convey that as mobile technology devices are more affordable for school districts, it is important to take advantage and embrace the benefits that they can bring into classrooms. Barone and Wright (2009) support the notion that it is necessary to expose and prepare students to new technologies as it evolves. Utilizing iPad devices will help young students stay well-informed with the way of the future.

In addition to positive advantages from exposure, Barone and Wright (2009) argue that the devices lead to an increase in teacher-student and student-student communication due to the convenience and easy way to share and transfer information. In a study conducted on how youngsters use the World Wide Web, 41% use e-mails and instant messaging to contact teachers about schoolwork (Oblinger, 2003). The iPad progresses ways learners and teachers in the classroom are able to communicate and collaborate with each other (Dhir, Gahwaji & Nyman, 2013). Technological devices have built in tools that promote relationships among all learners that include emailing and communication applications (Dhir et al., 2013).

The world in which 21st century students are growing up in is significantly different than prior generations, which is why the ways in which these students communicate is not the same (Berk, 2010). Instead of reading and writing print and learning in a text only environment,
students now prefer an image-rich, visually literate setting. Students are more accustomed to images, visuals and graphics that are easily shared and transferable between technological devices. The use of technological devices in education can help students to communicate visually by capturing images and sharing knowledge in a peer-to-peer world (Berk, 2010). Berk (2010) emphasizes that this can help to encourage dialogue and knowledge in integrating ways in which 21st century students learn.

In general, many have supported the notion that in order to properly educate students for the complex world they will soon be a part of, integration of technology can be a supportive component (Hunetcutt, 2013). Students will be able to develop essential 21st century skills that they will need to be successful in their future.

**Opposition to Technology Integration**

Many stakeholders convey that the use of technology is unnecessary in the classroom. Adams (2005) reasons that it is often the case that successes from using technology in the classroom are emphasized but little is spoken about how technology may interrupt learning. Although technology can bring a wealth of opportunity to the classroom, technological devices also may bring added problems to school districts.

Donovan, Green & Hartley (2010) found that:

> It is often assumed that changing the classroom by introducing technology will result in better teaching and increased student motivation, which ultimately means more effective student learning experiences. Unfortunately, this assumption does not take into account the significant complexity that is concurrently introduced with any innovation. (p.423)
Some disbelievers consider that technology may isolate students bearing in mind that all instruction is so individualized and personalized (Oblinger & Oblinger, 2005). Morgan (2010-11) agrees that over usage of tablet devices may limit how well young students interact with other humans. Students still need to learn how to relate and work alongside and collaboratively with other people. Scheuerll (2010) conveys as students are getting more accustomed to working on the Internet and technological devices, students are becoming more comfortable and are opting to work alone. It is feared that “students will be unable to relate well to others and believe technology is to blame” (Scheuerell, 2010, p. 194).

If students are regularly receiving instruction on tablet devices, “…they may be less responsive to lessons that cannot be delivered via a mobile device’ (Morgan, 2010-11, p. 141). It is essential to maintain a balance in teaching methods in order to maintain equilibrium between the use of technology and the interaction between individuals to ensure students are able to acquire new skills in a multitude of ways (Timmermann, 2010). Timmermann (2010) also states that if tablet devices are the only means of instruction, this may create a “digital divide” in a negative manner. Gaps in student learning may occur if teaching and instruction is only presented on tablets.

Using tablet devices where there is contact to emails, watching videos on the internet and other browsing tools can provide access to everything at the fingertips of students. Such availability to information can hinder concentration and a student’s ability to pay attention (Adams, 2005). Due to the distractions that tablet devices may cause, Morgan (2010-11) conveys that such technology can lead to inappropriate usage and overstimulation.

Prior studies have found that one to one technology devices have led students to abuse their privileges. Students were found cheating on assessments and downloading inappropriate
content (Hu, 2007). Teachers associated with the same study also reported that the devices were more of an annoyance as their use was not appropriate for many of their lesson plans. In agreement, Donovan, Green & Hartley (2010) confirmed from their study that increased access to technology does not lead to an increase in student engagement.

Holcomb (2009) reports that in a research study conducted in Texas that employed a one to one laptop program, results did not increase student achievement. It was found in the study that technology initiatives go beyond the actual handing out of devices. The new technology programs must be sensitive to other factors such as demographics, training and support and teacher strategies. Hu (2007) also reports that there was no evidence found from studies conducted in California and Maine of increasing state test scores as a result of one to one devices. Overall, not all technology implementation programs are successful or have a positive impact on teaching and learning. It is necessary to implement tablet devices in classrooms in a strategic way to ensure positive benefits. Including qualitative data in this research study will highlight the strategies of this implementation to ensure that results can be replicated in other situations.

**Students’ Attitudes Towards Mathematics**

Students’ attitudes towards mathematics play a fundamental part in the learning of the subject. Attitudes for the topic are often more divided among students relative to other discipline areas (Townsend & Wilton, 2003). It has been found that negative attitudes towards a subject area may obstruct learning. The attitudes and feelings construed towards mathematics have been associated with poor math performance in schools (Beilock & Willingham, 2014). Maloney and Beilock (2012) assert that students with negative attitudes towards mathematics are less likely to excel in the subject area compared to students who hold a more positive attitude.
According to Bandura (1977), the way in which students identify themselves, also known as self-efficacy, is an indication of how well they perform on different tasks and their academic achievements. For example, Nicolaidou and Philippou (2003) studied relationships between students’ attitudes towards mathematics and their achievement. The researchers used multiple questionnaires and assessments with fifth grade students to collect data. The results showed that a significant correlation exists among students’ attitudes towards mathematics and their performance. Sanchez, Zimmerman and Ye (2004) confirmed these results in a study that collected information on students’ attitudes. This study investigated the attitudes of secondary school students towards mathematics using a student questionnaire. This research showed that secondary school students that had a more positive attitude towards mathematics had better academic performances.

The way in which the subject area is presented in the classroom affects students’ attitudes in mathematics (Farooq & Shah, 2008). Nicolaidou and Philippou (2003) found that in their study with fifth grade students, encouraging and motivational experiences provided for students to learn mathematics can help students be successful. Positive situations helped to improve students’ attitudes towards learning which facilitated the progression of students’ attitudes towards learning. Similarly, research conducted by Ellington (2004) focused on technology tools, specifically calculators and the role they play in influencing students’ attitudes towards mathematics. Outcomes revealed that students who use calculators within the classroom report more positive attitudes towards mathematics compared to students who do not use the devices. It has been suggested that mathematics should be taught using engaging materials and interactive methods to promote a more positive attitude towards math.
Santally, Boojawon and Senteni (2004) examined the use of computer aided learning on students’ attitudes towards mathematics. Using two groups of secondary school students, one group followed a computer-based curriculum while a second groups of students participated in a more traditional based learning environment. Results indicated that students had more fun and preferred learning mathematics with technology devices. Moreover, the computer aided teaching improved learners satisfaction and students attitudes towards receiving instruction. Using technology devices in educational settings can help provide students with positive experiences leading to more positive attitudes towards mathematics.

Summary

There are often assumptions construed that by introducing technology into classrooms, results will show an increase in student learning, and better instruction (Donovan, Green & Hartley, 2010). Although technology may have a positive impact on achievements, there is a deficient amount of research supporting the use of iPads in classrooms. Over the past 20 years, many new innovations have been developed in regards to digital technology for mathematics education (Drijvers & Weigand, 2010). Part of the No Child Left Behind Act, a section designated to The 21st Century Technology, concentrates on promoting teachers to integrate more technology into instruction to ultimately help students learn through the use of technology. With the introduction of the Common Core Learning Standards and the iPad tablet, school districts are forced to reassess current teaching practices.

The review of the literature provides evidence that tablet devices are becoming more prevalent in educational institutions. Due to the newness of the devices, there is a need for research studies to contribute to the knowledge of the inclusion of the iPad into classrooms. Also, it is necessary for educators to challenge instructional practices to increase student
performance. Teachers, administrators and others involved in education need to understand the outcomes they may have on students’ mathematical success.

While there is considerable research available explaining the benefits of all forms of technology on student attitudes, there is markedly less published information about the specific use of tablets in the elementary classroom, and their effect on achievement and attitudes. It is clear that students are motivated by using the devices, but since many of the mentioned studies were mostly done during times when not as many people had access to the devices, it was harder to find information that related specifically to the newer technologies. Moreover, the prior studies that the literature discloses do not address how tablet devices may benefit third grade students’ achievements. Furthermore, students’ attitudes towards math based on the type of instruction they have received has not been investigated as a factor that can help students be mathematically successful.

This study will explore the learning and attitudes of two groups of students; one group utilizing iPads, with the second group learning without the devices. A major goal of this research is to identify if the utilization of iPad devices in an elementary classroom affects student mathematical achievements and attitudes.
Chapter 3: Research Methods

This research study explored the impact that iPad devices have on student achievement and attitudes in a third grade elementary classroom. The following section will describe the research methodology used in this study. To address the research questions, an exploratory case study design that included quasi-experimental quantitative and qualitative data was used. According to Creswell (2012), this methodology consists of “collecting quantitative and qualitative information sequentially in two phases, with one form of data collection following and informing the other” (p. 542). Creswell (2012) explains that this design is a common approach in educational research because it provides a better understanding of a research problem. Likewise, this method helped to determine the impact of the iPad intervention and also understand the participating instructor and coordinating administrator’s experiences. This design used the quantitative data to provide a basis for the collection of the qualitative data (Cameron, 2009). The qualitative component helped to validate the quantitative data results.

According to Leedy and Ormrod (2001), quantitative studies are “used to answer questions about relationships among measured variables with the purpose of explaining, predicting, and controlling phenomena” (p. 101). Moreover, qualitative studies are used to “answer questions about the complex nature of phenomena, often with a purpose of describing and understanding the phenomena from the participants’ point of view” (p. 101). The purpose for choosing this research design was to statistically determine the relationship among the variables and to make sense of the experience using a qualitative approach. This exploratory case study design that incorporated quasi-experimental quantitative and qualitative data compared student academic performance and attitudes towards mathematics between students using an iPad device compared to students not using devices. To complement the quantitative
data, qualitative data was collected to provide more inclusive and holistic results. Including qualitative data of how the participating instructor and coordinating administrator makes sense of this experience with iPads as it relates back to students learning and attitudes was a worthy opportunity to highlight the iPads success, and to bring attention to a particular challenge.

Two classes of third grade students at a New York Elementary School were given a pretest to establish baseline scores for mathematics achievement. A control group of students received teaching based on traditional instructional pedagogies for the 2013-2014 academic school year while the experimental class received instruction with the integration of an iPad device for the 2014-2015 year. The same instructor educated both groups. At the end of both school years, students took a post-test that was used to compare achievement. Additionally, both classes participated in an Attitudes Towards Mathematics survey to examine students’ attitudes. At the conclusion of the quantitative data collection period, the participating instructor and coordinating administrator were interviewed to elicit in what ways the tablet device in the classroom had impacted students’ learning and attitudes. Additionally, documents in the form of teacher lessons plans also provided further information about what teachers intended to do; specifically how the iPad devices were used during lessons.

The following chapter details this methodology more explicitly, discussing the population and sampling, data collection, instruments, procedures, data analysis, validity, reliability, generalizability and the protection of human subjects.

**Research Questions/Hypothesis**

The purpose of this study was to examine and understand the process by which NPS School adopted iPads into a third grade mathematics classroom and what impact it had on elementary school students’ mathematics achievement and attitudes. Through this exploratory
case study that incorporated quasi-experimental quantitative and qualitative data, knowledge was generated to provide insight of an iPad integration experience as it relates to students’ learning and attitudes. Below are the research sub-questions addressed in this study.

Sub-Question 1: How does third grade students’ math achievement differ when using an iPad compared to the traditional-textbook based education for a unit of study?

This question was explored by evaluating student learning achievement while learning with a tablet device compared to a traditional means of instruction and by incorporating the teacher’s perceptions. For this study, traditional means of instruction is referred to as a form of instructional delivery in which the teacher uses textbooks to guide curricular and instructional decision-making. This method encompasses classrooms that are predominately using textbooks and worksheets to practice content that was transmitted from the teacher to the student.

In order to accumulate multiple perspectives, a more complete understanding and an explanation of the quantitative results, the participating instructor and coordinating administrator were interviewed to inductively explore the teacher and administrative experience using iPads in the classroom as it relates to student achievement and attitudes. The instructor was guided to discuss exactly how the iPads were implemented and utilized in the classroom. Likewise, how the students are engaging with the tool and the classroom management with the devices. The instructor was additionally asked to speak about the results that the quantitative data portrayed. For example, is what occurs in the classroom supportive or contrary of the quantitative data results? The administrator was steered to discuss the groundwork, preparation, maintenance, and experiences with the iPads in the district. Moreover, to share challenges and successes from integrating the technology in the classroom and, documents, in the form of teacher lessons plans,
were provided for further information about what the teacher intended to do; specifically how the iPad device will be used during the lessons.

The inclusion of this qualitative data collection helped to deepen the level of understanding of this problem of practice while gaining a greater insight to the reasons behind the quantitative data results (Rubin and Babbie, 1997).

As discussed previously in Chapter Two, the existing review of literature on the incorporation of tablet devices into elementary classrooms has revealed that technology integration is passionately deliberated through educational systems. Therefore, the first research question in this study aimed to determine in what ways the academic achievements of third grade students are impacted by the use of a tablet device. The findings of this study are helpful to address the integration of the Apple iPad as a learning tool into elementary classrooms. In order to carry out the study, the student performance of two groups from different academic years, one utilizing iPads while the other without, was compared. The results offer insights in implementing the most appropriate 21st century technologies into classrooms. It is often the case that schools are opting to use new technologies as a fix for gaps in education. This study is adding to the research in regards to the positive or unfavorable impact iPad devices are having on student achievement.

Sub-Question 2: How do students’ attitudes towards mathematics differ when using iPad devices compared to the traditional means of instruction?

Aforementioned in Chapter Two, the review of literature on the use of technology in the classroom has been shown to increase student attitudes towards mathematics. For that reason, the second research question explored how the specific technology iPad devices, impact student attitudes in a third grade classroom. This question was explored by administering attitude
inventories to the both groups of students, the experimental group learning with a tablet device compared to the control group of students receiving traditional means of instruction. Data regarding students’ attitudes was collected through an inventory that illustrates the various ways that students felt about mathematics and their own feelings concerning the subject. Through the research question, data revealed how students’ attitudes are impacted by the use of tablet devices in an elementary classroom.

Students who were in the group that utilized the iPads as a means for learning and instruction received instant feedback and responses from their devices, where students have an opportunity to be able to construct their own knowledge. Students who were in the group without the access to iPads learned with a different approach to education where the instructor took on the lead role within the classroom. The data from the two groups of third grade students taught by the same teacher using two different methodologies was tracked to determine the relationship.

Each group of students partook in a curriculum-aligned pre-test that is a requirement by the mathematics director for all third grade students enrolled in the school district. The purpose of this assessment is to measure a starting point of mathematics knowledge at the beginning of a new school year.

**Research Design**

A research design is necessary to establish a way in which a study collects, analyzes and interprets data (Creswell, 2012). This study utilized an exploratory case study design that incorporated quasi-experimental quantitative and qualitative data. As described by Creswell (2012), experimental designs are applied to studies to investigate a practice to determine if it has an effect on a dependent variable. Leedy and Ormrod (2001) describe quasi-experimental
designs as a study without the random assignment of participants that experience different experimental treatments. The treatments were followed up with examinations of the effects of the treatments to determine the relationships of the variables (Butin, 2010). The study employed a quasi-experimental design because it was unfeasible to create random assignments of participants to groups (Creswell, 2012). When NPS creates classes, all conscious efforts are employed to create equal classroom make-ups of student skills levels, gender, ESL and learning disabled students. There are no tracked classes in the school where an entire class is comprised of accelerated, higher achieving students or vice versa. The use of existing third grade classes were used as the participants of the study allocating one class as the experimental group whereas the other as the control group. Random assigning of students to participant groups would cause an interference of learning at the elementary level. Moreover, the control group did not come from the same group as the experimental group, which means the control and experimental groups’ pretest mean scale scores may be different. In order to match participants between the control and experimental group, the scores on the pretest were treated as a covariate to control for any pre-existing differences.

Quasi-experimental research was appropriate for this study to examine the effects of an educational program, the tablet devices on student performance. This type of experiment is largely useful in educational situations because of the ability to use whole groups such as classes (Creswell, 2012). On the other hand, this type of research design can be vulnerable to a variety of extraneous variables that may influence the relationship that tablet devices may have on student achievement (Muijs, 2011.) A disadvantage to this approach, however, is the possibility that additional variables that come into play may have a negative effect on the dependent variable, therefore invalidating the results. In order to minimize the effect of extraneous
variables, using classes that are of similar makeups and demographics including socio-economic status, gender, ethnicity, and ability (Muijs, 2011) within the same school building ensured that the classes are comparable. Classes that are within the same school building at NPS are comprised of similar makeups to the best of the administration’s ability. To guarantee teacher quality was not a factor influencing the results, both classes used for the study were taught by the same third grade instructor.

When conducting an experimental study, there is reason for concern in regards to the possibility of threats to internal validity (Fraenkel, Wallen, & Hyun, 2009). Creswell (2012) describes threats to internal validity as complications that may compromise concluding if the difference in one variable is the cause of the difference in the other variable. The primary threat to internal validity for this study was that preexisting differences rather than the effect of the treatment may have been a cause for group differences on the post-test. To alleviate this threat, a statistical technique, ANCOVA was used to reduce the effect of the initial group differences. This will be discussed in subsequent sections.

In order to limit the likelihood that any particular threat exists in this study, there were strategies that were in place to minimize the effects. Most notable, each group that was used for the research study was taught by the same instructor. This instructor was chosen for the study due to the experience level as a third grade instructor and with her proficiency with the use of technology. In addition, the location site of the research study where the data was collected was the same for the two groups. Both groups had the availability of similar resources, materials and class size. The one exception is the variable, which is the iPad device. Moreover, the data collector for both groups of students was controlled. The same instructor, using the same rubric, graded all students’ assessments. To lessen the threat of student maturation on data collection,
the instructor taught over the same period of time, and all students were at the third grade level of elementary school, therefore, student maturation was not a threat. The design of the study was intended to address the concerns in various ways that the set of variables may differ between experimental and comparison groups. These means are discussed in the following sections.

To complement the quantitative data, qualitative data was also collected to provide more inclusive and holistic results. At the culmination of the quantitative data collection phase, the participating instructor and coordinating administrator were interviewed and teacher lesson plans were collected. Including qualitative data of how the participating instructor made sense of this experience with iPads as it relates back to student’s learning and attitudes was a worthy opportunity to highlight the iPads success, and to bring attention to a particular challenge. Additionally, the qualitative data helped to provide context to the quantitative data offering a more complete picture of what materialized with the iPad intervention.

A collective criticism of employing a case study design is the difficulty of making generalizations and being transferable from one case to another. To increase the generalizability and transferability of this study, detailed explanations of the persons involved, settings, treatment variables and duration of the study are provided so the results of this study will be helpful for other school districts and educators implementing iPads into their classrooms. Generalizability and transferability will be discussed in more detail in subsequent sections.

Population and Sampling

**Research site.** This research took place in a kindergarten through fifth grade elementary school, referred to for this study as NPS Elementary School. NPS is located approximately twenty-five miles east of New York City in a suburban setting. The demographics of the school are as follows: 40% of students are black or of African American descent, 57% are Hispanic or
Latino, 2% are Asian or Pacific Islander and 1% are Caucasian ("The new york," 2013). 69% of the students receive a free or reduced-price lunch (WebSMARTT, 2014). 22% of the students are classified as Limited English Proficient (LEP) ("The new york,” 2013). For the 2012-2013 academic school year, of the 134 third grade students tested, the New York State Mathematics assessment results are as follows: 42.5% scored a level one, 39.6% scored a level 2, 13.4 scored a level 3 and 4.5% scored a level 4. Therefore, 17.9% of students passed the state assessment ("New York State Testing Program Grade 3 Common Core Mathematics Test", 2013, p. 600).

The performance level descriptions are presented below in Table one. Currently, the site at which the research took place is questioning the integrating of tablet devices into classrooms, so the results of the research have relevance to the practice at the organization.

<table>
<thead>
<tr>
<th>Performance Level Descriptions</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
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<tbody>
<tr>
<td>Students performing at this level are <strong>well below proficient</strong> in standards for their grade. They demonstrate <strong>limited</strong> knowledge, skills, and practices embodied by the New York State P-12 Common Core Learning Standards for Mathematics that are considered <strong>insufficient</strong> for the expectations at this grade.</td>
<td>Students performing at this level are <strong>below proficient</strong> in standards for their grade. They demonstrate knowledge, skills, and practices embodied by the New York State P-12 Common Core Learning Standards for Mathematics that are considered <strong>partial but insufficient</strong> for the expectations at this grade.</td>
<td>Students performing at this level are <strong>proficient</strong> in standards for their grade. They demonstrate knowledge, skills, and practices embodied by the New York State P-12 Common Core Learning Standards for Mathematics that are considered <strong>sufficient</strong> for the expectations at this grade.</td>
<td>Students performing at this level <strong>excel</strong> in standards for their grade. They demonstrate knowledge, skills, and practices embodied by the New York State P-12 Common Core Learning Standards for Mathematics that are considered <strong>more than sufficient</strong> for the expectations at this grade.</td>
<td></td>
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*Table 1: (The State Education Department, 2013, p.2)*

Although the total population of the school is approximately 750, the target population was the 119 third grade students that are enrolled within this elementary school for the 2013-
2014 academic school year and the 114 third graders registered for the 2014-2015 school year. The matriculation of the school used in the study for the 2013-2014 school year was 86 kindergarten students, 131 first graders, 126 second graders, 119 third graders, 123 fourth graders and 142 fifth graders. For the 2014-2015 school year, the student body is composed of 779 students; more specifically, 124 kindergarteners, 124 first graders, 146 second graders, 114 third graders, 133 fourth graders and 138 fifth graders. For the 2013-2014 control class of students, there were nineteen third grade participants and for the 2014-2015 experimental class of students, there were nineteen third grade students that participated.

**Instructor Selection and Participant Involvement**

**Sampling strategy.** To select participants for the study, a convenience sampling method was employed. According to Creswell (2012), this method is described as “the researcher selects participants because they are willing and available to be studied” (p. 145). For the reason that the researcher is employed at the study site, the convenience and accessibility made this location a rational choice. This type of sampling is appropriate and common for educational research where random sampling and providing treatment or intervention to an experimental group may be difficult if not impossible (Muijs, 2011).

Third grade classes at NPS are the only grade level that received iPad devices for the 2014-2015 academic year. By opting for a class on the third grade level that is comprised of similar characteristics to the other third grade classes ensured that the participants were representatives of the target population at NPS Elementary School. The convenience sampling strategy ensured that this study helped to make generalizations to the target population for future decisions at NPS Elementary School (Creswell, 2012).
Fraenkel, Wallen, & Hyun (2011) caution that this method of sampling may potentially bring the risk of researcher bias due to conducting the study at the institution where the researcher is employed. In order to mitigate potential researcher bias, the researcher had no dealings with student participants, the instructor, nor the program that was in place to see if tablet devices have an impact on student achievement. This, along with other threats to the external validity, is further explained in following sections.

In order to address the generalizability issues associated with convenience sampling, information relevant to the characteristics and demographics of the participants at the research site are necessary in order to create generalizations to other populations. The demographics of the research site and participants are previously mentioned to transmit generalizations of the findings to settings or populations beyond this study’s conditions. Even though convenience sampling may propose a threat to generalizations, the findings from this study make an important contribution in alerting school educators to the effect of tablet devices in classrooms and stimulate others to further investigate.

**Participant involvement.** The same instructor taught the two third grade classes used in this study. The instructor used for this study attended various staff development opportunities that taught educators how to instruct using iPad devices. The teacher had previous experience teaching the course by both the traditional means of instruction (without devices) and with the tablet devices. The content and curriculum that was taught to both the control and experimental groups was the same for both groups of students. The classes were measured over two different school years, both consisting of 180 instructional days.

The participating teacher for this study was selected due to the experience level as a third grade instructor and with her proficiency with the use of technology, specifically tablet devices.
The teacher has taught elementary aged students for twelve years. All teachers that participated in the district wide pilot program of integrating devices into the classrooms received extensive training, preparation and professional development on how to integrate a mobile device into instruction. The experience as a teacher and the extensive professional development with tablet devices ensured that the students received high quality instruction. Furthermore, this instructor had received highly effective or outstanding ratings according the New York State Evaluation System for the past twelve years.

The coordinating administrator that was interviewed for the collection of qualitative data was selected on the basis of being the professional in directing and managing the implementation of the iPad devices. The administrator participant is the director of Library Media Services and Instructional Integration for the school district that was used for this study.

For the sample of students used from the 2013-2014 schools year, the class of students that received teaching based on traditional instructional pedagogies was comprised of nineteen students. Of these students, twelve were female and seven were male. Twelve students were classified as African American and seven were considered Hispanic. Fifty percent of the students received free lunch while eighteen percent of the students received a reduced price lunch. Conversely, the class of students that received instruction with the integration of tablet devices consisted of nineteen students. Of these students, eleven were female and eight were male; four students were classified as African American, thirteen were considered Hispanic and two were Filipino. Fifty-four percent of these students received free and/or a reduced price lunch.

To oblige by research regulations that minimizes risks and to protect the human interests of all participants, (Creswell, 2012), Northeastern University’s Institutional Review Board (IRB)
approved this study. Students’ data was considered and included in the data analysis for this study only if all three components of the data collection instruments (pretest, post-test and ATMI) were complete. There were two adults who were considered as participants of this study. Therefore, all data analysis for this study was conducted with a total of n=40. The following table represents the number of students and adults that produced viable data to analyze for this study.

<table>
<thead>
<tr>
<th>Class</th>
<th>Total Enrolled</th>
<th>Completed Pretest</th>
<th>Completed Post-test</th>
<th>Completed ATMI</th>
<th>Total Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Group</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Experimental Group</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Adult Participants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Total Participants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40</td>
</tr>
</tbody>
</table>

Table 2: Study Participants

As specified in previous sections, the participants within each classroom were not randomly assigned in this quasi-experimental design. The students in each classroom that participated in the study were grouped together at the end of their second grade academic school years to create heterogeneous groupings. When classes are created within the school building, a similar number of more able learners, remedial students, English Language Learners, special education, and behavioral issue students are all considered. In addition, a similar number of boys and girls are allocated to each class. The basic demographics and ability levels in each classroom are comparable across all classrooms and across the school building. The way in which class makeups are composed creates an ideal situation for a quasi-experimental study.

**Quantitative Data Collection**

**Instruments.** Quantitative data was collected to measure the relationship of learning achievement and attitudes towards mathematics of students based on the methodology in which they were instructed. The learning results of students that were taught by traditional means of instruction were compared to the learning outcomes of students that were taught using tablet
devices. In addition, student attitudes towards mathematics were compared between the control and experimental groups. At the conclusion of the collection of quantitative data, interviews with the participating instructor were conducted and teacher lesson plans were collected to gather qualitative data.

**Measurement of academic achievements.** Valid and reliable instruments are required to measure student achievements. The learning outcomes for both groups of students were measured based on a pencil-and-paper test instrument using a Pearson SuccessNet® benchmark assessment. This test corresponds with the mathematics curriculum purchased by the district of the research site. To align with the New York State Mathematics assessments, these tests intend to measure student proficiency on the knowledge and skills of the third grade curriculum (engageNY.org). The pencil-and-paper test developed by Pearson SuccessNet® is a justifiable instrument to collect data for this research because students complete the assessments regardless of the study. Due to the age of the participants, it was necessary for this study to stay as close to the normal routines and procedures as possible. As previously mentioned, all students would have partaken in this mathematics pretest and post-test irrespective of the study.

The assessments that were used to collect achievement data entailed two types of questioning. The test consisted of multiple choice questions to assess standard algorithms and conceptual standards and short response questions that required students to complete a task and show their work ("New York State Testing Program Grade 3 Common Core Mathematics Test", 2013). The following are an example of each type of question that may have appeared on the assessment:
Multiple Choice Question:

Which measure best represents the distance from 0 to point $N$ on the number line below?

A  $\frac{1}{6}$ unit  
B  $\frac{1}{5}$ unit  
C  $\frac{1}{4}$ unit  
D  $\frac{1}{3}$ unit

Short Response:

A bake sale had the 3 cakes, as shown below, for sale.

Each cake was cut into 6 slices. Each slice was sold for $5.
What was the total amount earned for the sale of all the cakes?

*Show your work.*

**Measurement of student attitudes towards mathematics.** Students in both the control and treatment groups completed an Attitudes Towards Mathematics Inventory (ATMI) to determine the effects of the tablets on student attitudes towards mathematics. The Attitudes Toward Mathematics Inventory, created by Tapia and Marsh (2004), was generated to address
several areas related to mathematics attitudes including self-confidence, value, enjoyment, and motivation. The ATMI is a survey consisting of 40 questions using a five-point Likert-type scale. Survey participants were read aloud each statement and then responded on a scale with the following values: strongly agree, agree, neutral, disagree, and agree. To adapt the ATMI to the needs of elementary aged students, a pictorial representation of a face was pictured over the words. Students colored in the face that coincided with their answers (see Appendix I). Examples of questions that appear on the ATMI include statements such as “Math is one of the most important subjects to study” and “It makes me nervous to even think about having to do math work.” A sample of the inventory that students were asked to agree or disagree with is provided below.

1. Math is a very important and necessary subject.

In order to provide validity to the research, a pre-designed survey was used to assess students’ attitudes towards mathematics. The ATMI has been proven to be a reliable instrument for measuring student attitudes towards mathematics (Tapia & Marsh, 2004). The reliability coefficient alpha was 0.97 when the inventory was field tested by the instrument designers (Tapia & Marsh, 2004).
**Instrument validity.** The company that creates the pretest and post-test assessments that was used for this study aims to model the statewide assessment that is developed by the New York Department of Education. “All NYS exams are developed in accordance with national industry and professional standards for educational testing. The exams are carefully constructed to align with and assess the knowledge and skills set forth in the NYS learning standards” ("Test Development Process:OSA:P-12:NYSED", 2014). The company that creates the instrument tools, Pearson SuccessNet®, asserts that all assessments are built based on the collaboration with teachers and educational experts to develop performance tasks and to assess curriculum standards and learning goals. Gall, Gall & Borg (2007) assert that employing experts in the subject matter, in this case mathematics, to create tools to collect data is a standard procedure for validly measurement.

The administration of all data collection instruments, the paper and pencil assessments, and the Attitudes Towards Mathematics Inventory, were proctored by the participating instructor. Because the participating instructor was the classroom teacher for both the control and experimental groups, there was an established rapport between the student participants and the teacher to help to provide useful data (Fraenkel, Wallen, & Hyun, 2009). Furthermore, students in both groups took the assessments in the same classroom environment, which was familiar to the students and conducive to learning. Additionally, the assessments were all graded and scored using the same rubric by the participating instructor. The outcomes of each assessment were forwarded to the researcher to be evaluated and analyzed.

**Procedures.** The data collection took place at the research site in a third grade classroom located approximately twenty-five miles east of New York City in a suburban setting. The control group of students utilized textbooks, workbooks and worksheets as a form of instruction
for the 2013-2014 academic school year. The experimental group received mathematics instruction that included the integration of iPad devices for the 2014-2015 school year.

In order to carry out this research study, the first phase in the data collection process was to seek school approval of the research site to ensure that the research did not compromise the privacy of the students, or disrupt the work of students, teachers, and administrators. The date to administer the pretest and post-test that all students took was determined by the district wide assessment calendar created by the director of mathematics. This calendar was followed by the researcher in order to limit the disruptions to the classroom’s normal procedures.

The control group followed the district approved curriculum map and assessment calendar for mathematics. The experimental group followed the same district approved curriculum map and assessment calendar for mathematics, completed the same Pearson SussessNet® pretest at the beginning of the school year, the same Pearson SussessNet® benchmarks and Pearson SussessNet® end of the year assessment, and participated in the New York State standardized tests in the spring.

Upon authorization, the following step was to acquire the 3rd grade math pretest and post-test scores from the 2013-2014 academic school year from the participating instructor. This control group of students received math instruction by the traditional means including textbooks and workbooks. Once the list of scores was compiled, all identifiers including first and last names and student identification numbers was removed to safeguard the privacy and discretion of all participants. Afterwards, the experimental group of 3rd grade students participating in the study using the variable (iPad devices) in the fall of the 2014-2015 school year was administered the same pretest as the control group of students. This class of students included in the
experimental group progressed throughout the year receiving mathematics instruction and/or practice using a mobile device.

In compliance with the school district’s assessment calendar, in late October, early January and late March, students were given the same math benchmark assessments as the prior year’s third grade students. Data collected from the final benchmark assessment (all created by Pearson SuccessNet), was analyzed to answer questions of this research study. In addition, all students took the New York State Mathematics assessment in the spring.

At the termination of the allotted time for the study, students were given an attitude towards mathematics inventory (ATMI). This inventory was given to gather students’ thoughts of mathematics after instruction either with or without tablet devices. The purpose of this inventory was to gain information about how students’ attitudes were impacted by the method of instruction they received.

Upon the completion of the post-test and attitudes inventory by the experimental group of students, all data was collected and organized. Once again, all identifiers including first and last names and student identification numbers were removed to secure anonymity. After the collection of all necessary information, the data was input into SPSS, a statistical analysis program.

**Fidelity of implementation.** In order to create another program in an educational setting based around this research study, the way in which a program is implemented must closely mirror the design of this study (Protheroe, 2009). Burton & Kappenberg (2012) define fidelity of Implementation as “…the delivery of content and instructional strategies in the way in which they were designed and intended to be delivered: accurately and consistently” (p.107). In order to ensure fidelity of implementation, the participating instructor provided a checklist (see
Appendix L) of programs that were used in the classroom to integrate iPad devices into the lessons. This checklist served as a guide to other educators of how this participating instructor specifically used the iPads in their classroom. This checklist will ensure that the students interacted with the devices, and served to be more than an electronic textbook and notebook.

**Threats to validity.** Strategies are necessary in an experimental design in order to minimize threats to validity (Fraenkel, Wallen, & Hyun, 2011). In order to limit the likelihood that any particular threat exists in this study, both classes were taught by the same instructor who has had twelve years of experience teaching elementary aged students. This instructor was selected based on the experience level as a third grade teacher and with her proficiency with the use of technology.

Fraenkel, Wallen, & Hyun (2011) convey that location may serve as a threat to internal validity. To address this threat, the same physical building and classroom was used to instruct the two groups of students. To lessen the threat of student maturation on data collection, the instructor taught over the same period of time, and all students were at the third grade level of elementary school, therefore, student maturation was not a threat. Moreover, the two classes attended school for a total of 180 instructional days and both were on the same time schedule beginning at 8:20 in the morning and dismissing at 3:05 in the afternoon.

Another threat is associated with mortality. Creswell (2012) describes this threat as having individuals leave the experiment for a variety of reasons, which may include lack of parent consent, moving away and absence. The mortality threat for this experiment was controlled by only including students’ data that have completed the pretest, post-test and all instruction in between with the same instructor. Students who did not meet these criteria were not included in the study. Students who were not eligible will not be considered to be a
participant because they were not an equivalent measure to students who received full instruction in the participating teacher’s classroom.

In addition, the next set of threats is in reference to instrumentation (Creswell, 2012). By employing similar forms of the pretest and post-test created by Pearson SussessNet®, the instrument did not change. The scoring procedures were identical by following a provided rubric. Using the same instrument throughout the entire experiment controlled this threat.

**Quantitative Data Analysis**

The design of the study intended to compare the means of the dependent variable of students’ math academic achievement and student attitudes between an experimental and control group. The experimental group of students participated in an instructional model that included the use of iPad devices while the control group received a traditional form of mathematics instruction.

**Preparation of the data file.** Upon the completion of the post-test and attitudes inventory by the experimental group of students, all data was collected and organized. All identifiers including first and last names and student identification numbers were removed to secure anonymity. After the collection of all necessary information, the data was input into SPSS, a statistical analysis program. As soon as students’ pre and post-test scores were entered into the statistical analysis software, a distinctive identification number was assigned to all scores instead of student names. In summary, the researcher input the student scores, treatment group and Attitude towards Mathematics Inventory results into SPSS and then immediately deleted corresponding names and replaced it with unique student identification numbers to preserve anonymity.
After the data was entered into SPSS, the researcher verified that all data values were correct and all conform to reasonable values for each variable. It was necessary to identify if any of the data in the set contains any invalid characters and/or numerical data values. For example, a variable related to gender would be expected to have only two values; male or female.

According to Muijs (2011), it is essential to begin the analysis of the data by employing a frequency distribution of the variable to view how many participants scored in a certain way on the assessments. To visually represent the results of the frequency distribution, a histogram was used to show the shape of the data distribution and the normality of the data collected. The frequency distribution for continuous variables is useful when it is necessary to find out the frequency and percentage of specific scores or a cumulative percent under a specific score, for example, the percent of students’ scores that are greater than 65%. Given that the dependent variables, students’ academic performance and attitudes are continuous variables, (scores), it is necessary to check the normality before proceeding onto parametric testing.

The histograms provided a graphical representation of the data compared to a “normal” distribution so that the data collected can be compared to a normal curve. The results of the histograms show a fairly normal distribution. Results of both groups for the pre and post assessments are represented in Figures two through five.
Since the data were normally distributed, measures of central tendency were used to check how representative the final sample is compared to the population. Additionally, since the data checked out to be normal, the mean was used as a measure of central tendency and parametric testing such as ANCOVA and t-testing was used to test the hypotheses.

In this quasi-experimental, nonequivalent control group design, students were not randomly assigned to groups. Given this limitation, a test of normality was required to confirm that each group was similarly aligned and results would not be impacted by differences that pre-existed within the sample.
Normality was tested by examining the descriptive statistics. More specifically, the values of Skewness and Kurtosis were used to ensure the data met the normality assumption. Skewness of data encompasses the symmetry of the distribution while kurtosis of the data involves the peak of the distribution. Data considered to have a normal distribution has a value of 0. The farther away from 0 that the values of skewness and kurtosis depict, the more non-normal the distribution. Given that the values of skewness and kurtosis for both groups were relatively close to 0, the assumption of normality was met. The data from the figures indicate normality with skewness values close to zero. The descriptive statistics for the pretest and the post-test are represented in tables three through six below.

<table>
<thead>
<tr>
<th>Descriptive Statistics</th>
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</thead>
<tbody>
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</tr>
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<td>Statistic</td>
</tr>
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<td>VAR00001</td>
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<tr>
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<td>(listwise)</td>
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*Table 3: Descriptive Statistics of 2013-2014 Pre-Test Results*

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</tr>
<tr>
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</tr>
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<td>(listwise)</td>
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# Descriptive Statistics

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<th>Skewness</th>
<th>Kurtosis</th>
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</tbody>
</table>

Table 5: Descriptive Statistics of 2013-2014 Post-Test Results

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<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Skewness</th>
<th>Kurtosis</th>
<th>Std. Error</th>
<th>Statistic</th>
<th>Std. Error</th>
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<th>Std. Error</th>
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<td></td>
</tr>
</tbody>
</table>

Table 6: Descriptive Statistics of 2014-2015 Post-Test Results

To further test whether a single univariate sample differs significantly from a normal distribution, a Shapiro-Wilks W test was employed. For the reason that this study employed a sample size less than 2,000, a Shapiro-Wilks W test was used to test for normality. To interpret the values, standard measure of normality was applied. The standard p-value of .05 or greater determines that the data is normal. Considering that the standard p-values for the 2013-2014 and 2014-2015 classes are 0.433 and 0.752 respectively, both groups of students’ pre-test data met the criteria for normality.

**Transforming the data.** In this research study, students’ attitudes towards mathematics are theoretically considered an ordinal level of measurement because they have a natural ordering of categories (Muijs, 2011). For example, the inventories that were used to collect the data were answered using Likert-Type scales that range from “really agree” to “really disagree.” For this study, this variable will be treated as a continuous variable by transforming the data to
be able to run the t-test parametric analysis. Although this may deem problematic at times, Zumbo and Zimmerman (1993) assert that when there are five or more categories used to collect the ordinal data, there is very little harm on the outcomes of the study. The questions from the Attitudes towards Mathematics Inventory were transformed into one measure to create a continuous variable.

The ATMI survey contained 40 statements about mathematics (Appendix I) where participants responded on a five value Likert scale assigned with the following point values: (5) strongly agree, (4) agree, (3) neutral, (2) disagree, and (1) strongly disagree. The majority of the statements on this survey were written with a positive viewpoint, such as: “Math is a very important and necessary subject.” However, the ATMI includes eleven statements written with a negative take, such as “I am always worried during math class.” In order to calculate a total score, responses to the eleven statements with a negative take were reversed and recoded. For example, a response of “strongly disagree” to the statement “I am always worried during math class” is an indication that the participant does not have a positive attitude towards mathematics. Therefore, this response needs to be inverted from a value of 5 to a value of 1. Once the eleven negative statements were recoded, a total score was found by adding all of the ratings together. A higher score indicates a more positive attitude towards mathematics, while a lower score indicates a more negative attitude towards mathematics. The responses of the eleven negative statements were reversed before a total score for the inventory was calculated. The scores were transferred into SPSS for further analysis.

**Statistical analysis.** To address the first research question, the one-way ANCOVA, which is similar to the ANOVA, was used to compare the differences in the academic
achievement between the group of students that were instructed by a traditional means and the group of students that learned with tablet devices.

**ANCOVA Assumptions**

In order for a covariate to be useful in analyzing the data, there should be a reasonable correlation between the covariate and the dependent variable (Tabachnick and Fidell, 2001). Before being able to run an ANCOVA data analysis test, a series of assumptions must be met. The following sections describe more in depth the assumptions pertaining to (1) sample size, (2) outliers, (3) Linear Relationship, and (4) Homogeneity of Regression Slopes.

**1) Sample Size**

According to Tabachnick and Fidell (2001), employing a one-way ANCOVA analysis requires the size of the treatment group and the control group to be similar in size. With 19 students in the control group and 19 students in the experimental group, the sample size requirements for the one-way ANCOVA are met.

**2) Outliers**

Prior to running an ANCOVA, it is necessary to examine the data to consider whether there were any significant outliers in the numbers. If the data set contains outliers, they could have a negative effect on the testing, reducing the accuracy of the results. With a minimum score of 0 and a maximum score of 100, the mean for the 2013-2014 pre assessment equaled to 64.05 with a standard deviation of 17.354. None of the data points for the covariate were more than two standard deviations away from the mean. For the 2014-2015 pre assessment, the mean equaled to 68.42 with a standard deviation of 14.60. None of the data points for the covariate were more than two standard deviations away from the mean. With a minimum score of 0 and a maximum score of 100, the mean for the 2013-2014 post assessment equaled to 89.21 with a
standard deviation of 19. None of the data points were more than one standard deviation from the mean. For the 2014-2015 post assessment, the mean equaled to 78.68 with a standard deviation of 13.26. None of the data points were more than two standard deviation away from the mean.

(3) Linear Relationship

A linear relationship must exist between the covariate and the dependent variable to properly use an ANCOVA analysis (Tabachnick and Fidell, 2001). By means of the SPSS test of linearity, the relationship between the pre math assessment and the post math assessment scores was linear at a statistically significant level. Based on the test of linearity, the probability of the test statistic is less than the diagnostic alpha value of 0.05, the null hypothesis that there was not a linear relationship is rejected, detonating that the assumption of linearity has been met.

(4) Homogeneity of Regression Slopes

Homogeneity of regression slopes suggests that slopes between the covariate and the dependent variable are similar across the experimental and control groups. This homogeneity indicates that there is no interaction between the independent variable and the covariate. In order to meet the assumption, there needs to be no significant interaction between the covariate (pretest scores) and the post assessment scores. If a significant interaction is evident, it would be unsuitable to use the ANCOVA analysis because the correlation between the covariate and the dependent variable would differ for all combinations of the factors. Since F=3.430, p = .073, failing to reject the null hypothesis, this indicates that there is homogeneity of regression slopes.

To control for the possible effects of a cofounding variable, a covariate of the pre-test results, the one-way ANCOVA was necessary to analyze the comparison (Muijs, 2011). The scores on the pretest were used as the covariate to regulate for any pre-existing differences.
between the two groups. The one-way ANCOVA test was used to compare the differences in the mean of the dependent variable and the two groups, while also controlling for the pretest differences.

Interpreting the results of the ANCOVA analysis uncovered if there was a statistically significant difference between the group means. If the p-value or the significance level is below 0.05, the results can be interpreted as statistically significant, meaning that it would unlikely occur in the sample if there is no effect in the population (Muijs, 2011). If a larger p-value is evident, the data does not give a reason to conclude that the means differ.

To address the second research question, the effect of tablet devices on student attitudes, comparing the means of the dependent variable, students’ attitudes, between the two groups, a t-test was employed because the assumption of normality was met. Only two groups were compared, so the t-test was an applicable method to analyze the data. A t-test is a difference test for identifying if there is any significant difference between two groups on a continuous variable (Muijs, 2011). This test assessed whether the means of the two groups were statistically different from each other. This test was appropriate to use for continuous dependent variables, in this case students’ attitudes. The t-test was used to address the research question by comparing the means of the two groups, the students learning with the devices and the students without the devices. The test helped to determine whether there was a significant statistical difference in the mean scores between the two groups, which can be representative of the population. Muijs (2011) asserts that for t-tests, samples need to be randomly selected from the population, but due to the difficulties of random sampling in educational research, “research has found that the t-test is quite robust despite violations of these assumptions” (p. 119). If the assumption of normality is not met, non-parametric tests would be used instead.
Interpreting the results of the t-test revealed if the group means were significantly different. Looking at the p-value, or significant level disclosed if the difference found in the sample is related to a difference in the population. The smaller the significance level, the less likely there would be a difference in the sample if there were no difference in the population (Muijs, 2011). If a statistically significant relationship is evident, the p-value will be as small as possible. The significance level should fall below the cutoff point of 0.05 if the values that are found are very unlikely to occur if there is no difference in the population.

**Qualitative Data Collection**

A principle of case study research is that it utilizes multiple sources of evidence, which creates the process of triangulation and allows for evidence from one source to be supported with another (Yin, 2009). Qualitative data was collected to make sense of the iPad integration experience as it relates to students’ achievements and attitudes based on the experiences from the instructor. In this study, multiple sources of evidence were collected through interviews, and a review of lesson plans.

In order to provide a more complete and holistic view of the problem of practice, interviews with the participating instructor and coordinating administrator were used as an additional way to gather relevant and necessary data. According to Creswell (2012), “interviews provide useful information when you cannot directly observe participants, and they permit participants to describe detailed personal information” (p. 218). Interviews are an appropriate strategy of inquiry when examining unique organizational processes and events (Creswell, 2012). More specifically, the researcher conducted a one-on-one interview with the instructor and administrator, which is described by Creswell (2012) as the most ideal method of interviewing because only one participant in the study responds at a time.
To collect the qualitative data, the participating adults and the researcher scheduled a convenient time to discuss the happenings around the integration of the iPads. The interview was digitally recorded. The conversational interview approach was used which has been described by Patton and Patton (2002) as a flexible way to collect information based on what deems appropriate during the time of the interview. This style allows deviations from the customs of standardized interviewing and to take on a direction that emerges based on the replies of the respondents.

The design of the interview questions were structured around the themes evident in the theoretical framework that structures this research study. The results of the quantitative data was shared with the participating instructor and administrator prior to the interview to make sense of the impact of the iPad devices. This allowed for the interview questions to emerge from the interpretations of the first phase of the study. The questions consisted of open ended questions (See Appendix E and F). The interviews disclosed additional evidence about the ways in which the teacher and students utilized the iPad devices in the classroom. Moreover, the conversational interview that took place consisted of asking the instructor to explain what impact she believes using the iPad technology has had on the students and her opinions and thoughts on the integration in the classroom. Such information included in what ways the teacher used the iPads, what applications were used, how the children engaged with the tool and what a classroom teacher that uses iPads needs to be mindful of. The interview with the coordinating administrator elicited information about the implementation in general. All questions that were used during both of the interviews can be found in Appendix E and F.

Collection of evidence through documents is useful within case study research to substantiate and support evidence collected through other sources (Yin, 2009). To further
supplement the qualitative data, the participating instructor’s lesson plans were collected and explored as a source of evidence. The participating instructor provided her lesson plans to the researcher at the conclusion of the study in order to find out more about the teacher’s instructional practices and the use of teacher’s TPACK. Lesson plans were looked at to further understand and communicate how lessons are adjusted with the incorporation of technology.

**Qualitative Data Analysis**

Analysis, coding and interpretation were required to bring order and understanding to qualitative data to explore the questions of a research study (Creswell, 2012). To organize, identify key concepts and make sense of the data, a general inductive approach was used based on the transcriptions of the interviews. Thomas (2006) defines inductive analysis as “approaches that primarily use detailed readings of raw data to derive concepts, themes, or a model through interpretations made from the raw data by an evaluator or researcher” (p. 238). In other words, research findings can emerge from the themes that are derived from the interviews.

Thomas’ (2006) process of inductive analysis outlines a five step process to explore data; (1) Preparation of raw data files/transcription; (2) Close reading of the text to gain an understanding of the themes from the text; (3) Creation of categories/coding; (4) Reduce overlapping of coding and (5) Develop concepts about experiences that are evident in the text.

The qualitative data analysis occur in three phases. Phase one included the researcher transcribing the data and creating initial codes for recognized themes. The second phase incorporated prior categorized and coded data to establish and refine categories and generate new interpretations. The final segment of the qualitative data analysis was comprised of making sense of the central ideas that emerge from the data. Coding strategies for each phase will be discussed in subsequent paragraphs.
To initially analyze the data, interviews were transcribed, read several times, and coded to look for patterns and common themes that emerge from the data. Saldaña (2009) defines codes as “a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data” (p. 3). The codes that were used were derived from the categories or themes that were evident from the text. This method was used to examine the data for a descriptive purpose that identified common themes that recurred in the interview (Creswell, 2012). The codes assisted in identifying concepts that appeared likely to help in understanding and addressing the questions in this research study.

The second phase of coding the interview transcripts grouped codes from the first phase to create categories and relationships between the initial codes. Moreover, the data was further organized to ensure that all categories and codes were relevant and were significant in addressing the objective of the research study. The most central themes emerging from the data was utilized to investigate the research questions.

The third phase of the qualitative data examination made sense of the first two phases of analysis. This phase focused on creating significant themes to generate meaning from the data (Thomas, 2009). Thomas’ (2009) general inductive analysis was conducted in this third phase to create a greater generality from the raw data categories to make conclusions. Moreover, this phase focused on the central ideas that came out of the participating instructor’s interview and how this data related back to the theoretical framework that structured this study. The concepts that emerged from this third phase helped to further understand the situation around making sense of the iPad integration experience as it relates to students achievements and attitudes.
A document analysis form (Appendix K) was used to review lesson plans for elements that are related to the research questions. The participating instructor’s lesson plans were collected to gain additional information about how lessons are tweaked in order to incorporate technology and any methodologies that are used to support the integration of iPad devices.

**Validity, Reliability, Generalizability and Transferability**

**Internal validity.** When conducting an experimental study, there is reason for concern in regards to the possibility of threats to internal validity (Fraenkel, Wallen, & Hyun, 2009). Validity “refers to the appropriateness, meaningfulness, correctness, and usefulness of the inferences a researcher makes” (Fraenkel, Wallen, & Hyun, 2009, p. 147).

To make certain the internal validity of this research study, precautions were taken to reduce other possible explanations for the observed results (Leedy & Ormrod, 2001). To increase the likelihood that the explanations of the integration of tablet devices in the classroom are ones that are most likely to occur, there were strategies that were in place to minimize the effects. Potential threats to internal validity for this study were lessened by the employment of a quasi-experimental study design where (1) each group that was used for the research study was taught by the same instructor, (2) the location site of the research study where the data was collected was the same for the two groups, (3) the data collector for both groups of students was controlled, (4) the instructor taught over the same period of time, and all students were at the third grade level of elementary school, therefore, student maturation was not a threat, (5) a pretest and post-test was used and (6) the statistical procedure, ANCOVA was used to reduce the effect of the initial group differences.

Content validity of the measure of learning achievement in the two third grade classes was accomplished through the use of a post-test. The post-test administered to both groups
involved in the study was developed by Pearson SuccessNet® where mathematics experts created the exam.

**Threats to validity.** Strategies are necessary in an experimental design in order to minimize threats to validity (Fraenkel, Wallen, & Hyun, 2011). In order to limit the likelihood that any particular threat existed in this study, both classes were taught by the same instructor who has twelve years of experience teaching elementary aged students. This instructor was selected based on the experience level as a third grade teacher and with her proficiency with the use of technology.

Fraenkel, Wallen, & Hyun (2011) convey that location may serve as a threat to internal validity. To address this threat, the same physical building and classroom was used to instruct the two groups of students. To lessen the threat of student maturation on data collection, the instructor taught over the same period of time, and all students were at the third grade level of elementary school, therefore, student maturation was not a threat. Moreover, the two classes attended school for a total of 180 instructional days and both were on the same time schedule beginning at 8:20 in the morning and dismissing at 3:05 in the afternoon.

Another threat is associated with mortality. Creswell (2012) describes this threat as having individuals leave the experiment for a variety of reasons, which may include lack of parent consent, moving away and absence. The mortality threat for this experiment was controlled by only including students’ data that have completed the pretest, post-test and all instruction in between with the same instructor. Students who did not meet these criteria were excluded from the study. Students who were not eligible could not be considered to be a participant because they were not an equivalent measure to students who received a full instruction in the participating teacher’s classroom.
In addition, the next set of threats is in reference to instrumentation (Creswell, 2012). By employing similar forms of the pretest and post-test created by Pearson SuccessNet®, the instrument did change. The scoring procedures were identical by following a provided rubric. Using the same instrument throughout the entire experiment controlled this threat.

**Reliability.** Reliability “refers to the consistency of scores or answers from one administration of an instrument to another, and from one set of items to another” (Fraenkel, Wallen, & Hyun, 2009, p. 147). In order to address the reliability for this study, the pretest and post-tests were administered to the students at the same time of day in the exact same classroom location. Additionally, the pretests and post-tests were scored using the same rubrics. Since the classroom teacher had a rapport with the students, the classroom teacher proctored both of the assessments in the classes in order to make all students feel comfortable.

As mentioned in prior sections, the reliability across the data collecting instruments was ensured by employing pre-created assessments and surveys. The pretest and post-test were created by Pearson SuccessNet® which asserts that all assessments are created by educational curriculum experts. The Attitudes towards Mathematics Inventory was created and proved to be a reliable instrument (Tapia & Marsh, 2004). The reliability coefficient alpha was 0.97 when the inventory was field tested by the instrument designers (Tapia & Marsh, 2004).

**Generalizability (external validity).** As presented by Creswell (2012), generalizability, also known as external validity is defined as “quality of a research finding that justifies the inferences that it represents something more than the specific observations on which it was based” (p. G3). Moreover, the extent to which conclusions drawn can be applied to other contexts beyond the specific situation actually studied (Leedy and Ormrod, 2001).
To address concerns of threats to external validity, this study was made convenient for all participants in the population (Creswell, 2012). The classes partaking in the study were composed of a true representation of the population. The composure of the class was an accurate sample of the third grade student population at the study site. The students in each classroom were grouped together at the end of their second grade academic school years to create heterogeneous groupings. When classes are created within the school building, a similar number of more able learners, remedial students, English Language Learners, special education, and behavioral issue students are all considered. In addition, a similar number of boys and girls are allocated to each class. The basic demographics and ability levels in each classroom are comparable across all classrooms and across the school building. The way in which class makeups are composed creates an ideal situation for a quasi-experimental study.

Given that all classes at the research study site are generated to create heterogeneous groupings, the findings from this study would be generalizable to other students in the third grade, and to other schools with similar student body demographics. On the other hand, making generalizations to the target population of all third graders in differing demographics may be a risk if the characteristics of the samples do not contain similarities.

In order to address the generalizability issues associated with convenience sampling, information relevant to the characteristics and demographics of the participants at the research site have been provided in prior subsections of chapter three in order to create generalizations to other populations. The demographics of the research site and participants are previously mentioned to transmit generalizations of the findings to settings or populations beyond this study’s conditions. Even though convenience sampling may propose a threat to generalizations,
the findings from this study will be making an important contribution in alerting school educators to the effect of tablet devices in classrooms and stimulate others to further investigate.

Additional precautions were taken to decrease the threat to validity by proceeding with the normal classroom routines throughout the study. This research followed the ordinary scope and sequence of the curriculum and procedures that would typically occur at the study site. Student and teacher participants’ customary classroom procedures were preserved to maintain normality. The pretest and post-test that was administered to the students are exams that students would normally participate in regardless of the study. All students across the grade level regardless of being involved with the study will have to take the assessments used to collect the data. Therefore, there was nothing out of the ordinary that would have created a bias for the study.

**Transferability.** As presented by Lincoln and Guba (1985), transferability is the qualitative counterpart to external validity utilized within quantitative research. Transferability is defined as the ability to apply findings of a research study in one situation to different contexts, settings and groups in other conditions (Lincoln & Guba, 1985). The use of thick description is used to ensure the transferability of findings and to preserve external validity of the study. Thick descriptions refers to providing rich descriptions in specific detail so the study could transfer for use within different contexts (Lincoln & Guba, 1985).

**Protection of human subjects.** To maximize favorable outcomes, minimize risks and to protect the human interests of all participants, (Creswell, 2012) this study was approved by Northeastern University’s Institutional Review Board (IRB). This research study was designed to provide zero to minimal risks to the participants. The participants involved with this research study had no possible way to be harmed in any way. Although this study included participants
that were children, the integration of the variable, a tablet device, would only deem as being valuable and beneficial. The methodologies being compared are both currently in use throughout the school. All participants would have partaken in a mathematics pretest and post-test irrespective of the study. Additionally, all third grade students would have been using tablet devices regardless of the research. The data collection process for this study did not require any contact with current or former students, which led to the decision that parent permission would not be needed to be obtained for this study. The teacher and administrator participants of this study signed informed consent forms (Appendix C and D) so they are knowledgeable of the research and how the data will be used.

Only the researcher conducting the study had access to the data necessary for the reporting and interpretations of the findings. All teacher and student data that was consumed from the study was coded to numbers to eliminate any identifying characteristics. Student and teacher names were eliminated from the data that was used by the researcher. For the duration of the study and for a reasonable time afterward, all study data will be kept in a locked cabinet and password protected electronic folder in the researcher’s office. At the conclusion of the study, all data will be disposed of and destroyed. In addition, the actual name of the school was not used in order to keep the identity unknown.

**Role of the Researcher**

Given that the researcher is employed at the site of the research study, if all participants were aware that they were involved in a research study, participants may have had an increased motivation to work harder due to the additional attention (Muijs, 2011). For this reason, the researcher had no dealings with the program that was in place to see if tablet devices had an impact on student achievement.
For this exploratory case study design that incorporated quasi-experimental quantitative and qualitative data, the researcher was behind the scenes examining the results and describing the results (Creswell, 2012). The participating students and instructor for the study had no interaction with the researcher for the purpose of not influencing the outcome of the study. The researcher was uninvolved with the implementation within the classrooms and only worked as the collector of the data.

The researcher and the cooperating instructor for this study are colleagues. Both are educators employed at NPS Elementary School. In terms of professional levels, both are teachers who are at equal levels of authority. Therefore, the participating teacher did not feel obligated to take part and produce exceptional outcomes as a result of this intervention.

Summary

This exploratory case study design that incorporated quasi-experimental quantitative and qualitative data was implemented at a school, referred to as NPS Elementary School located approximately twenty miles east of New York City in a suburban setting. The purpose of this study was to examine and understand the effect of mobile technology devices, as an individual learning tool on third grade students’ mathematics achievement and attitudes at a predominantly minority, lower socioeconomic school. The sample for this study included data collected from thirty eight students from two third grade classes taught by one instructor. The two courses used different instructional delivery methods, one utilizing tablet devices while the other one employing traditional, textbook based instruction. Data collection consisted of pretest data to measure baseline of achievements for both the treatment and control groups, post-test data to assess student achievements and the Attitudes towards Mathematics Inventory to gauge students’ outlooks on the subject. To examine the data on academic achievement, an ANCOVA statistical
technique was utilized to compare the differences in the mean of the dependent variable and the two groups. To address students’ attitudes towards mathematics, a t-test analysis was utilized to compare means if the student attitudes dependent variable between the two groups of students was statistically significant. Measures were put in place in order to minimize threats to validity and reliability. At the culmination of the quantitative data collection phase, the participating instructor and coordinating administrator were interviewed to gather qualitative data. The interviews were transcribed and coded to see if the interview outcomes supported or contradicted the quantitative data results. The investigation and evaluation of the design of the research and the collection of the data will be presented in the subsequent chapter.
Chapter 4: Report of Research Findings

The purpose of this study was to examine and understand the effect of the iPad as an instructional tool on student mathematics achievements and attitudes in a third grade mathematics classroom by exploring the process by which NPS Elementary School introduced iPads into a math classroom. This investigation led to findings that revealed the impact iPad devices has on students’ academic achievement and attitudes towards mathematics at this elementary school.

This study employed an exploratory case study that incorporated quasi-experimental quantitative data focusing on the process by which NPS School adopted iPads into a third grade mathematics classroom and what impact it had on elementary school students’ mathematics achievement and attitudes as well as qualitative data collection. One group of students received mathematics instruction with the integration of an iPad while a control group of students did not use iPads for learning. Both groups participated in pretests to establish academic baselines and post-tests to measure student achievement. Furthermore, both groups of students participated in an Attitudes Towards Mathematics Inventory (ATMI) to measure students’ attitudes towards mathematics. This study interviewed the participating instructor and coordinating administrator about the experience the iPad integration had in relation to students’ achievement and attitudes to further understand their potential impact. Evidence was also collected through lesson plans to find out more about the teacher’s instructional practices and the teacher’s use of the TPACK framework. The findings of this study are discussed in this chapter.

In the subsequent section, the words of the coordinating administrator and participating teachers taken from interviews were used to understand the process and implementation of the iPad intervention. Information gathered from the interviews were analyzed and coded. Through
the qualitative analysis, exploration of the codes, and triangulation of all data sources, common categories emerged to form a deeper understanding of the effect that iPads had on students’ achievement and attitudes. These common categories eventually became themes used to make meaning of the data. These themes were: (1) improved student experiences and (2) improvement in instruction.

**Research Study Results**

In order to understand and make sense of the process by which NPS implemented iPad instruction into a mathematics classroom and to find out the impact using the iPads had on student achievement and students’ attitudes towards mathematics, multiple data sources were used to triangulate the data. The triangulation corroborated data from different references that provided the most accurate description of the iPad intervention (Creswell, 2012). The multiple sources of data helped to create a more complete understanding of this case study. The results of the study are organized around the central question: What is the process by which NPS School adopted iPads into a third grade mathematics classroom and what impact has it had on elementary school students’ mathematics achievement and attitudes? Each of the following sub-questions helped to provide a more complete and holistic view of the results:

1. How does third grade students’ mathematics achievement differ when using an iPad compared to the traditional-textbook based education for a unit of study?
2. How do students’ attitudes towards mathematics differ when using iPad devices compared to the traditional means of instruction?

**Central Research Question**

Implementation of iPad devices at NPS School was initiated at the beginning of the 2014-2015 academic school year. All third grade classrooms across the district were required to
incorporate the devices into the curriculum to optimize and differentiate student learning, and to further support student engagement. All teachers that were assigned to teach students with iPads received professional development opportunities to learn how to use the devices in alignment with their instruction. Teachers were given class sets of iPads, pre-loaded with applications that were to be used with students.

**Decisions behind the integration of iPads.** The district in which this study took place gave careful consideration to implementing an iPad program into the schools as a way to meet 21st century learners. The coordinating administer elicited that the district believed that integrating iPads into classrooms gave students greater opportunities to be highly engaged in their learning. Additionally, the iPads would help to increase opportunities for differentiation, using applications that are selected to meet students at their individual learning levels. The administrator commented:

The main goal for the iPad implementation was engagement. We have hopes that with the devices, learning will reach higher levels of blooms taxonomy, creating more one to one opportunities in the classroom, and meet the demands that are now placed on students to become familiar and fluent with personal devices. Having these devices in our schools will help to level the playing field for the students in this district. The digital learning is really important and there are so many resources now available online for building student skills that we need to take advantage of. The immediate access to research opportunities that these devices can provide is too valuable to pass up.

With a great deal of technology available, this school district chose Apple iPad devices because of the numerous applications that are available. In order to solidify the decision to purchase iPads, site visits were done at other schools that had successfully implemented the
devices. Additionally, a district technology committee attended Apple workshops in Manhattan, New York. Before making final decisions, the district was in contact with many educators from different parts of the country that had found success with the iPads. The district specifically took notice of one particular school that started a one-to-one initiative. They watched their program grow, followed how they built it, and wanted a model similar to what was seen.

With over 6,000 students enrolled in this school system, the district wanted to initially supply students with iPads where the most improvements could be made. For the onset of the program, the district decided to begin the implementation with the third grade population. The reason behind this decision lied in the fact that the third grade is the lowest level of students that participate in the New York State Assessments. The intentions were to determine if having iPads at this level would make a difference on how students performed on state examinations. It is the expectation to expand the program up one grade level each year.

In order to utilize the iPad devices to their greatest capacity, it was a priority for the district to select applications that were aligned with the district’s curriculum. The coordinating administrator commented that, “Application selections must be relevant and connected to the curriculum and the academic standards. The iPad is a tool to enhance the curriculum and the way that the tool is used is how the devices can connect and enrich academics.” She further stated that there were specific criteria used to assure that the applications being purchased met the learning needs of the students. Initially, applications were recommended by other districts that found success with the devices. These recommendations were used during the pilot program the previous year. This list was further evaluated and reviewed by 3rd grade teachers and final decisions were made based on this input. Additionally, if a teacher found an application during the course of the school year that deemed valuable, a request could be made and reviewed for
purchase. If funds allowed, the application would be purchased and centrally pushed out to all of the iPad devices.

The coordinating administrator stressed the importance of having the latest versions of the applications for a variety of reasons including the element that new versions of software can increase the performance productivity. For this initiative, it was at the discretion of the classroom teacher to update all of the iPads. There was no schedule that the district followed to update all of the applications. The teachers could easily instruct all students to open the Apple app store and select the “update all” option to keep the apps up to date across all devices.

**Infrastructure.** In order to accommodate all of the wireless devices, the administrator emphasized the significance of ensuring that all of the schools had enough wireless bandwidth to sustain a dense population of mobile devices. Although the schools infrastructure was suitable to withstand the new initiative, it was necessary to increase the bandwidth and wireless access points.

**Funding for the program.** All of the necessary costs to implementing the iPad programs into this school district were derived from grant funded money. The actual iPad devices were all purchased through these awards. A grant was explicitly written for this project specifying precisely what funds were needed and what was required to be purchased. Prior to writing the grant, conversations were had with the superintendent in order to get approval for certain decisions about what was included in the grant. For example, it was necessary to discuss exactly what devices would be needed and the programs that the students would be involved in.

**Teacher preparation.** A central topic that emerged from the interviews was the importance of teacher professional development. It was highlighted that in order to have a successful implementation of an iPad program in a school, it is necessary for districts to carefully
train educators. All teachers involved with the execution of the program were given the iPad devices prior to the students. The coordinating administrator for this program believed that providing teachers with the appropriate professional development opportunities is a major component of establishing an iPad program. It was communicated in the interview that the teachers were offered a great deal of staff development opportunities prior to the beginning of the school year. The district relied heavily on teachers who had piloted the iPad programs in their classrooms the year before to give assistance by turning their knowledge to other teachers. Moreover, it was expressed that the district provided the teachers with ongoing professional development events throughout the year. There were continuous workshops and in-service courses that were offered. The coordinating administrator stated:

The district had a subscription to model schools which is a program that guides schools to effectively incorporate technology into classroom curriculum. The teachers also had a subscription to Atomic Learning which provides online training resources and tutorials that teachers could use at their own convenience. This gave assistance to teachers that wanted to take learning into their own hands, on their own time. Also, there was a district created Live Binder which is a web-enabled collection of resources of online professional development that helps with integrating iPads into a classroom. There were plenty of opportunities for teachers to learn how to use the iPads with their students.

The teacher believed that learning to use the iPads and participating in professional development were instrumental for this program. The teacher spoke to the importance of learning how to use the iPad before integrating the device into her classroom instruction. Before receiving the iPad devices, the teacher participated in a number of professional development
courses from the district. She enrolled in a summer in-service session that was taught by a teacher that had used the iPads in their classroom the prior year.

Throughout the interview, the teacher communicated the desire of receiving training in her own classroom with the students present. She believed that this would have been supportive in helping set-up the programs, load class rosters, and to assist in the exploration of the applications that the district purchased. Although she was trained with the device, there were many applications that were purchased by the district that she did not know how to use. The teacher expressed that it was very time consuming to learn how to navigate the different applications that were pre-loaded and were not explored during training.

In addition to preparing the teachers for the iPads, the coordinating administrator specified the importance of having a staff to manage the technicalities to ready the devices, and a well-trained IT department to support the mobile devices. In this district, there was no specific training that was given to this department. The prerequisites for employment in the district’s technology department include having a prior set of skills with mobile devices. The lead technician of the technology unit came with a great deal of prior training and expertise that he was able to share with other specialists.

**Student preparation.** In order to prepare students with the iPad devices, it was conveyed from the coordinating administrator that it was at the discretion of the individual classroom teacher to prepare students. All teachers were given a class set of iPads, and it was the teacher’s responsibility to introduce them. The administrator commented that, “It was recommended by Apple professional developers to put the devices into the hands of the students and they would run with them. Full immersion of the iPads was suggested as being the most effective.”
The interview with the administrator revealed the importance to have a disciplinary policy for students who break the conduct rules while using the devices. The district had an acceptable use policy that spelled out the guidelines and expectations when using the devices. Students ran the risk of losing their device privileges if they refused to comply. The administrator mentioned that when implementing a program, digital citizenship work should be done with regards to students using technology appropriately inside of the classroom. The district for this study is currently working on this concept for the upcoming school year. This year it was up to the teacher to share appropriate usage.

The instructor made it known during the interview that clear expectations were set out for the students in terms of behaviors regarding the iPad devices at the start of the 2014-2015 school year. Students were first notified by their teacher in September of 2014 that they would be receiving an iPad device. The teacher took a survey to determine the number of the students that had previously used iPads. It was found that many of the students outside of school had some kind of tablet or smart phone that they were familiar with. The teacher played an important role in enforcing the set expectations to make sure the devices were constantly used in the correct manner. When speaking about the classroom expectations in regards to the use of the iPads, the teacher communicated that she personally created classroom guidelines for the use of the devices in her room. Some of the expectations included not being allowed on the internet unless the students were working on a research project. All websites that the students visited had to be pre-approved by the instructor. The teacher further explained that she constantly circulated the classroom when the students were permitted to be on the internet to monitor all activity. Moreover, the students were not allowed to password protect or lock any component of their iPads so she always had access to their devices. It was strongly enforced that students were
prohibited to log into the Apple app store on their own to prevent them from accessing applications that may be inappropriate for their age. The teacher conveyed that if and when a student was found improperly using the device, they would lose time with their iPads.

**Classroom setting.** The context that this research took place in and the management of the devices must be depicted in order to interpret and present a full understanding of the findings. The classroom design used for this research study consisted of five rectangular tables that seat four to five students at a time. The tables were arranged in a horseshoe layout centered around an Interactive Whiteboard. In order to manage the distribution and collection of the iPad devices, the participating instructor developed an organizational system. All iPad devices were contained in a secure cart provided by the school, which are locked each night and during the time the students are out of the classroom for security purposes. The carts were equipped with cords and power stripes to charge the iPads while in storage. All devices were labeled with identification numbers that were assigned to students. Each day, students were called to the iPad cart by number to retrieve their iPads at the beginning of each day. Subsequently, at the closing of the school day, students were called back to the cart by their number to plug them in systematically to be ready for the following school day.

**Management of the iPads.** Prior to the initial distribution of the devices, all iPads were equipped with the appropriate applications and wireless connections. The installation of applications was centrally managed by the district technology department. Therefore, students were unable to install any applications on their own. Similar to the management of applications, the configuration and settings on the devices was also centrally managed.

With the purpose of managing the iPads while students were in possession of them, the participating instructor instituted policies to keep the devices from being a distraction. When the
students were receiving non-iPad related instruction, all students were asked to place the protective cover over their devices.

The coordinating administrator commented that it was the responsibility of the students and the teachers that were using the iPad devices to look after and manage them. It was their obligations to clean, tend to, and preserve their well-being. The teacher elicited through the interview that students were responsible for connecting their own device to a charger if the battery percentage fell lower than 50%.

At times, the devices malfunctioned and were in need of repairs. The district was aware that when devices needed to be restored, the students’ learning would be altered without their learning tool. For this reason, there were conscious efforts made to have the device be replaced or fixed as quickly as possible. Initially, in the beginning of the school year when this initiative was first rolled out, the district did not have a solution to this issue. It took some time to figure out a resolution to having devices fixed rapidly. In response, the district partnered with the Board of Cooperative Educational Services (BOCES) to do repairs on the devices with a turnaround time of five days. If an iPad was lost, the district had a deductible that the borrower was required to pay and the district would pay for the rest.

The teacher commented:

When there was a malfunction with a device, there were some procedures I taught the children to try before deeming it broken. Students were to shut down the device and then start it up again. If that did not solve the issue, I emailed tech services to come and troubleshoot for us.
Sub Research Questions

In an attempt to more fully explain the complexity of the process by which NPS School implemented iPad instruction into a mathematics classroom and understand the impact of the use of the iPads in this classroom on student achievement and students’ attitudes towards mathematics, the triangulation of different data sources was used by collecting quantitative data. Academic achievement was measured by the use of a pretest and a post-test, while students’ attitudes were evaluated using an Attitudes Towards Mathematics Inventory.

After establishing normality and running a series of assumption tests for all quantitative data described in chapter 3, the evaluation of the actual learning outcomes was measured. The ANCOVA was used to determine whether a group of students had a higher level of academic achievement using iPad devices compared to a group of students who did not use iPads. Using ANCOVA, it was found that the students that received instruction using iPad devices did not experience significantly different results in academic achievement compared to students who received traditional means of instruction. Moreover, according to the results of this analysis, there was no significant difference among the two groups of students dependent on the utilization of iPad devices at the standard α of .05, F(1,35)=3.779, p=.060, partial $\eta^2=.097$. The results of the ANCOVA are presented in Table seven.
### Tests of Between-Subjects Effects

#### Dependent Variable: Post Test

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</tbody>
</table>

\(^a\) R Squared = .321 (Adjusted R Squared = .282)

#### Table 7: ANCOVA Results

A t-test was employed to investigate whether the means of the two groups on the Attitudes Towards Mathematics Inventory were statistically different from each other. The means of the two group’s results of the Attitudes Towards Mathematics Inventory revealed that the group means were not significantly different. The commonly recognized benchmark of statistical significance is \( p \leq .05 \). The results of the t-test are represented in Table eight.

The benchmark p-value indicates that the smaller the significance level, the less likely there would be a difference in the sample if there was no difference in the population (Muijs, 2011). In this case, since the p-value is .954, it is implied that there is not a statistical difference in the ATMI scores between the control and experimental group. This means that there is a 95% chance that the difference that has been found in the sample may be based on chance rather than a true representation of the population (\( t=.058, df=36, p=.955 \)).
Table 8: ATMI T-Test Results

**Qualitative themes.** Although it was not found that iPad devices statistically made a difference in student achievement and attitudes, the qualitative component did reveal positive changes. Often, triangulation of data results is complimentary to one another while at other times, the data may be contrary (Kennedy, 2009). The data collection from this research study elicited results regarding the implementation of iPads into a third grade classroom with themes that included (1) improved student experiences and (2) improvement in instruction.

The first theme that emerged emphasized that the integration of the iPad devices offered several advantages to student learning. The participating instructor described that iPads offered many benefits to both the students and the teacher. She believed that various benefits of the iPads included an increase in student motivation, attitudes and engagement and improved instruction.

**Improved student experiences.** The findings from this case study analysis regarding students’ attitudes towards mathematics are consistent with the literature (Haydon, et al., 2012) where students spent more time and effort on their work when using iPad devices. During the interview, the participating teacher revealed that the iPad devices increased student motivation and attitudes during mathematics lessons. It was noticed that the students were very motivated
and self-stimulated when the teaching incorporated the technology. The teacher commented that the iPads enhanced learning for the children who were unmotivated and for children who normally do not put forth much of an effort. “These students like to do their work on the iPads because it is different than writing with a pencil and paper. It is a fun way to learn new facts, it is interactive, and is a good way to increase their motivation.”

The teacher consistently spoke about the increase in attitudes towards mathematics conveying that students were more actively involved with the lesson and seemed more willing to do mathematics when the iPads were incorporated. Moreover, the teacher communicated that it was evident the students enjoyed using the iPads. Students were enthusiastic and in favor of completing their mathematics work because of the devices. They were able to easily navigate the devices, and they felt comfortable using them.

The teacher participant indicated how the engagement of students in the lessons was noticeably greater when using iPads. It was stated that students were more actively involved in lessons when they used the iPads and were apt to participate. The teacher communicated that there was a higher level of student participation in lessons that utilized the technology integration as opposed to the lessons that did not use the devices. The students liked having the responsibility of guiding their own lessons and being in charge of their learning. The teacher commented that students were more engaged because they were constantly following along with the many visual components that iPad offers. If students needed to go slower or practice a certain skill, they did that. If they knew the material, they moved faster and enriched themselves. The teacher also mentioned that the iPads offer an audio element. If students needed to plug in their ear buds to hear better, or to re-listen to something, they were able to do so.
The coordinating administrator also spoke about the higher levels of student experiences. The administrator observed that the engagement level of the students increased rapidly and that students were eager to participate. “When going into different classrooms, students were so excited to show off what they were doing, what they were creating, how they were producing their own videos, and involving themselves in research. The students were engaged in their own learning in a way that was refreshing.”

**Improved instruction.** Another common theme that emerged from the interview included the improvement of mathematics instruction. During the conversation, the teacher spoke to the ease of differentiating instruction and being able to reach all of the different academic levels of the students. She communicated that the use of iPads in the classroom has changed teaching by digitizing instruction. The teacher stated that, “Everything that I upload on eBackpack, they have in front of them. It was easier for me as well. I don’t have to make as many charts, they have everything they need right in front of them.” The teacher further commented that:

The class uses eBackpack daily. I use it with the math modules by loading different assessments and reviews the students need to complete. It is very helpful. Everything is right there in front of the children. They follow along with the lessons, and they submit their work electronically. They track their own learning. I do not have to be on top of them as much. They can self-assess and work at their own pace.

The participating instructor expressed that with the iPads, it was very easy to differentiate instruction to reach all of the different academic levels of the students. The devices provided many different options as far as the applications they were able to use. Students were able to work at their own pace. Even if they were all working on the same application, students had the
option to work at different levels. The teacher commented, “I do not even have to differentiate instruction myself anymore, it is all provided for the teacher.”

Additional information was used to find out more about the teacher’s instructional practices and the use of her TPACK. It was evident through collected data that the teacher devoted equal attention to technology, pedagogy, and content (Mishra and Koehler, 2009). More specifically, the participating instructor used a pedagogical approach that was more focused on students’ problem solving and using the devices to learn rather than a teacher directed environment. Additionally, the teacher demonstrated technological pedagogical knowledge through well-planned classroom management practices.

Although the actual lesson plans that were collected from the participating instructor were concise, the triangulation of the all data sources provided indications of the instructor’s TPACK. Through the analysis of lesson plans and discussions in the interview, data was provided that helped to recognize the teacher’s instructional practices.

The teacher commented:

My instructional design and lesson planning did not really change much as a result of the iPad. I do not include the use of the iPad in my plans, the devices are just used and are part of our class routine. The technology integration is not planned, we use the iPads as a tool and whatever comes along, we go with it. If a question comes up, we can address it immediately with the iPads and we get immediate feedback. We share with each other. Nothing specific is planned expect for using eBackpack as our starting point.

Additionally, the applications used helped to improve students’ basic skills. The teacher believed that students in the class that used iPads had a solid foundation of their basic addition, subtraction, multiplication and division facts because of the devices. The apps helped students to
memorize and learn, and they were motivated to do it because of the interactions with the programs. For example, using a multiplication bingo app helped students to practice and memorize their facts while playing an interactive game. Not only would students be practicing their academics, but they also were competing with their highest results to attain a greater score.

The teacher conveyed that the devices helped to activate students’ prior knowledge of certain topics. “If a lesson called for prior knowledge and the students did not have it, they were able to learn prerequisite skills on certain apps before introducing a new lesson.” The iPads served as another resource and a different approach that really met the visual and hands on learners. The learning needs of certain students were met with the help of the iPad device.

The teacher believed that the iPads made learning very visual. Students were able to see new content and interact with it. For example, when students saw charts and pictures, they were able to zoom in to obtain an enhanced version. With textbooks, many images are small, making it harder to learn from the pictures.

The immediate feedback that the iPad devices provided was another focus that developed throughout the interview. Students were able to download an assignment from eBackpack, complete and annotate the work on their iPads, and turn the work into the applications submissions area. Teachers were able to grade, comment on students' work, and return it back in one application. Additionally, applications also provided immediate feedback for students. The instantaneous responses helped to create independence for students as far as not relying as much on the teacher. Students received immediate feedback from the device which allowed them to self-check. Students no longer had to wait on a teacher to review their work. If students got something wrong, they were able to know right away, and it was often the case that solutions to wrong answers were available.
**Constructivism.** An outcome of the qualitative information gathered from the interviews with the coordinating administrator and participating instructor incorporates the concepts evident in the constructivist learning theory that provided conceptual underpinnings for this research study. The teacher believed that students were able to construct their own learning when they interacted with the iPad devices. The instructor noted that children were able to learn new material in the classroom by actively performing tasks using the iPads. The teacher acknowledged that instead of showing students everything, they had all necessary resources right there in front of them, at their fingertips. Moreover, students were in control of their own learning. If they were struggling with certain concepts, they were able to navigate and use programs that reinforced the skills that needed extra practice.

The iPads helped to create a more student centered environment. The devices provided student choice with all of the applications that were offered. Students had the ability to select which application they needed to use for their learning, particularly with mathematics. There were several skills that students needed to gain knowledge of in mathematics where they were able to navigate themselves through based on what they needed to practice and what they excelled in.

The teacher generally expressed a sense of satisfaction associated with the iPads in regards to students taking control of their own learning. “It is no longer the teacher standing at the front of the classroom and telling the students what to do. Students are now able to take the lead in their learning. They are good with that, we are learning together. They are becoming well versed in facilitating their own learning and using the iPads to accomplish that.”

Additionally, students’ collaboration for learning opportunities with the iPads also contributed to students constructing knowledge through their interactions and engagements with
others. Based on the social constructivism theory, this type of learning helps to create shared meaning where students are solving problems with others that keep students engaged in their learning. The teacher conveyed that the iPad devices were better able to support students’ collaboration and interactions more than computers due to the organization of the devices. The portable nature of the iPads enabled more opportunities for teamwork. The teacher commented that, “Students share what they discover on the iPads with each other and myself. I have learned a lot of them as well. Since this is our first year using the devices, the students are allowed to use any of the preloaded applications. If they find something new, they share it with me and the rest of the students.” The teacher also found that the students shared applications with one another. “The students enjoyed being able to work on the same programs as other students in the class simultaneously to test each other and compare results.”

Although the teacher believed that the iPads were a great asset to the classroom, it was made clear that the device was not a tool to entirely improve learning but served more as an instrument that enhanced the productivity in the classroom. The devices enriched the possible learning opportunities and made information more easily accessible. The teacher commented, “If the class was stuck on a problem or the students did not have any prior knowledge, we were able to open an app and research it on the internet to solve it together. Everything we needed was right in front of each student. There was no more of the, ‘Let’s find out the answer later for extra credit.’ Everything was immediate.” The teacher also commented that the iPads were not an end all, be all. The low level students still functioned at a low level while the higher level students still learned the new knowledge at a quicker pace. The teacher commented that the devices were just a tool that met all students exactly where they were academically.
Summary

Through analysis and coding of interview data, statistical examinations of pretests, post-tests and attitude inventories and the evaluation of teacher lesson plans, the process by which NPS School adopted iPads into a third grade mathematics classroom was described and the impact the devices had on student achievement and attitudes towards mathematics was uncovered. The data showed that the results from the post-test and ATMI did not show a statistically significant difference while the interviews with the participating adults created a picture of a noticeable increase in student engagement, attitudes and productivity for students that used iPads for instruction compared to students who did not use the devices. The data uncovered that the teacher and administrator in this study believed there were numerous advantages of iPad use in the classroom, including the ability to increase student engagement, enhance instruction, and create independent learners in the classroom. Additionally, the data demonstrated that the iPads supported the differentiation of instruction to reach the various academic levels of the students. The teacher in this study utilized various instructional practices to demonstrate her TPACK (Mishra and Koehler, 2009). Teaching methods used a pedagogical approach that was more focused on students’ problem solving and using the devices to learn rather than a teacher directed environment.
Chapter 5: Discussion of Findings

This study investigated the effect of iPad devices as an instructional tool on student mathematics achievement and attitudes in a third grade mathematics classroom in a public elementary school located twenty miles east of New York City. After assessing students at the beginning of their third grade school year in mathematics, implementing a technology integration program, reassessing students on their math skills with a post-test, and administering an Attitudes Towards Mathematics Inventory, a one-way ANCOVA was used (after testing necessary assumptions) to compare the differences in academic achievement between the group of students that were instructed with iPad devices and the group of students who were not. A t-test was employed to determine whether the means of the two groups for the Attitudes Towards Mathematics Inventory were statistically different from each other.

In addition to the quantitative data collection, the participating instructor and coordinating administrator were interviewed to provide more in-depth opportunities to learn about the experiences and understandings of teachers in relation to students’ achievements and attitudes when using iPad devices. The results that emerged from this study exposed inconsistencies between the quantitative and qualitative data. Specifically, the results from the post-test and ATMI did not show a statistically significant difference while the interviews with the participating adults disclosed that there was a noticeable increase in student engagement for students that used iPads for instruction compared to the students who did not use the devices.

The following chapter discusses the findings presented in Chapter 4, considers possible explanations for the results, considers the results in relation to the literature and theoretical framework, evaluates the implications of the outcomes, explores limitations, and suggests further research.
Results and Discussion of Research Questions

The central research question for this exploratory case study that incorporated quasi-experimental quantitative and qualitative data was as follows: What is the process by which NPS School adopted iPads into a third grade mathematics classroom and what impact did it have on elementary school students’ mathematics achievement and attitudes? The succeeding sub-questions helped to provide a more complete and holistic view of the problem of practice.

Sub-Question One: How did third grade students’ math achievement differ when integrating an iPad into instruction compared to the traditional-textbook based education for a unit of study?

Sub-Question Two: How did students’ attitudes towards mathematics differ when using tablet devices compared to the traditional means of instruction?

This study contributed to the literature and practice because it (1) added to the knowledge of the inclusion of the iPad into classrooms explicitly outlining classroom management, procedures and training, (2) used valid and reliable assessment tools to measure student growth and attitudes, (3) focused on elementary aged students and mathematics instruction.

Discussion of Findings in Relationship to the Literature

Mixed outcomes are evident in the academic literature regarding the effect of iPad devices on academic achievement and student attitudes. The rapidly increasing popularity of using one-to-one iPad devices to support academics in the United States has led to a need to study the impact they have on students’ learning and attitudes. There are several practices that can be implemented to mitigate any potential impact of the integration of iPad devices in an elementary classroom setting. Although this research study revealed that iPads increase the productivity in the classroom even though the instruments did not support those findings, the
teacher and administrator reinforced the positive impact that iPads had in the classroom. The results from this study can provide insights for improved educational practices and should be taken into consideration.

Despite the lack of statistical significance in the findings, the results from the qualitative data revealed positive changes in students’ classroom attitudes, engagement and productivity. The results of the interviews conveyed the general sense of students’ positive feelings towards mathematics were greater when using iPads.

**Increased attitudes, engagement and productivity.** Prior literature reveals there are several prospective benefits with integrating technology into educational systems. A study incorporating iPads in a high school setting found that there were higher levels of active engagement when students utilized iPads compared to students who did not use iPads (Haydon, et al., 2012). In another study, Lage et al. (2000) demonstrated that students at a public university favored using tablet devices as a way to invert the classroom to listen to lectures outside of the physical classroom. The use of technology increased students’ attitudes and engagement throughout the course due to the technology. There are many studies throughout the literature that reported an increase of students’ attitudes, engagement and motivation when utilizing technology as a tool for learning.

Likewise, in this study, the teacher and administrator similarly communicated their beliefs that the experience for their students that used iPads for their learning increased attitudes, motivation and productivity. Li and Pow (2011) conveyed that this user-friendly device facilitated an environment that motivated learners to succeed. Conn (2012) believed that when using technology as a means for instruction, students were more on task, even those who are usually hard to engage for long periods of time. This study discovered that the iPads helped to
motivate students to work and helped to keep students focused. The applications that students used to learn were interactive and stimulated individuals to interact with their own personal hands-on learning tool that the iPads provided.

**Improved instruction.** In conjunction with an increase in attitudes, engagement and productivity, many studies also support the notion of how technology helps teachers to improve classroom instruction. Research conducted by Amin (2010) found that iPad devices allow for many different lessons to materialize within one classroom at all times. In conjunction with the constructivist beliefs, the use of technology as a tool for instruction can promote students to create new knowledge rather than memorizing already known knowledge (Amin, 2010). In another study conducted by Enriquez (2010), tablet devices were used in a higher education setting to study the impact on student performance and student perception of their own learning experience. This study highlighted that technology provides students with a more interactive and collaborative learning experience.

In the same way, the teacher in this study expressed the notion that the iPads improved her instruction. It was communicated that the iPads allowed all of the information that students needed for their learning to be at their fingertips, on their devices. She further described the simplicity of differentiating instruction and being able to reach all of the different academic levels of the students. Moreover, the iPads provided many options of applications for the students to work on. She added how students were able to work at their own pace on the same concepts, but at different levels. Similar to the ideas of Takahashi (2011), students were able to receive personalized instruction based on their own learning needs. For example, students that needed to practice and memorize their multiplication facts were using applications focused on that specific skill. Students that had previously mastered their facts were able to challenge
themselves with other topics that was specific to their learning needs. Prior to the iPads, it was a tremendous task for the instructor to differentiate to individual students’ levels, but with the devices, the differentiation is provided.

In agreement with research conducted by Falloon (2013), a central outcome that was elicited from this study involved the constant access to important educational resources. Students in this study were able to easily access the internet to find answers to questions that came up during lessons. The real time solutions led students to deeper understandings of new concepts that would not have been possible without the iPad devices. Moreover, students were involved with interactive, engaging experiences to complement their learning.

**Professional development.** To effectively integrate iPads into the classroom, teachers need to learn and know how to appropriately use the devices with the students. The results of this study are consistent with prior research that the implementation of iPad devices in the classroom warrants a great deal of faculty training and development (Kiger, Herro & Prunty, 2012). In order to have a successful implementation of an iPad program in a school, it is necessary for districts to carefully train educators by providing adequate professional development. As previously studied, when implementing technology into classrooms, Holcomb (2009) supports the notion that teachers need time and training for a program to be successful and effective.

The initial training that districts need to provide include insuring that teachers know how to operate the iPad. It should not be an assumption that teachers are familiar with the basic operations of technology devices in which educators need to be proficient for a valuable implementation. In agreement with prior studies, Drijvers and Weigand (2010) communicate
that a lack of knowledge and readiness on the teachers’ part can delay the great possibilities the devices can have on student achievement.

A study conducted by Ifenthaler and Schweinbenz (2013) revealed that instructors may be hesitant to implement technology in classrooms because they are unclear on how mobile technology can actually facilitate learning and instruction. Not only do teachers need to receive professional development on how iPads can be integrated into the classrooms, but also need to be coached on positive results and impacts such devices have made. “Teachers’ technology integration needs to go not just beyond utilization, but will go along a change in their concept about a teacher’s role in classroom instruction” (Ifenthaler and Schweinbenz, 2013, p.533).

In agreement with prior literature, the interviews in this study revealed that hands on training in classrooms would be the most beneficial preparation for a smooth implementation. Having trainers walk through the devices with teachers in regards to all of the settings, programs and applications available is necessary. In addition, coaching teachers on how to trouble shoot the devices is crucial to keep the program running smoothly. This notion coincides with a prior study where Murray and Olcese (2011) found that models of teaching with technology need to be taught in addition to just funding and supplying devices. Murray and Olcese (2011) highlight that it is necessary to provide examples of how iPads are used in classrooms to help to produce high student achievement and essential teacher preparation.

In addition to training teachers, students also need to be prepared for future implementations. Research conducted by Hay (2012) conveyed the importance of equipping teachers, students and administrators with the proper resources and learning needs when implementing new technology into education. Hay’s (2012) literature discusses an iCentre instituted in Australian schools that provides a learning center that helps technology become a
successful learning tool within educational systems. Another piece of literature by Kolb (2014) supports the notion of preparing a class for technology before putting the devices in students’ hands. Kolb (2014) further suggests practice handling the devices as a class in addition to demonstrating how to properly use the devices, and enforcing digital citizenship.

Similar to prior literature, this study found that it would be supportive for the students to have guidance and an introduction to technology devices. Providing students with certified training and digital citizenship classes would be the optimal situation to bringing devices into a district for the first time. Suggested by the administrator interviewed in this study, students involved with using the iPads in the classrooms should be given some variety of education in proper ways to use the devices for educational purposes.

**Classroom management.** In this study, the data collection showed that the classroom management of the devices is an exceptionally important factor when implementing iPad technology into classrooms. While studies in the research focused on the actual implementation of technology, the literature reviewed did not put an extreme emphasis on the management of the devices. Specific techniques are necessary to keep students on task and using applications that are supportive for students learning. Without the appropriate organization and management of devices, proper execution of technology-based learning may not be able to reach its full potential.

A key factor that emerged from this study was to ensure that teachers established a clear purpose for the use of iPads in their classroom. Conn (2012) proposed having students brainstorm appropriate behaviors with technology devices to create a sense of ownership for the students. Likewise, this research study revealed that the school district and classroom teachers needed to set clear expectations prior to the first use of the devices. The instructions for using
the technology and the directions of the learning tasks must be clear in order to maintain a well-organized, technology infused classroom. Moreover, it is important to communicate to the students the connection the devices have with their studies to ensure that they are aware that the devices will be used as an educational tool in the classroom. This study also exposed that it was important to have regulations that if students break the rules of the iPad expectations, students may lose their iPad privileges at the discretion of the teacher.

In research conducted by Conn (2012), results suggested that students should be assigned the same iPad daily to help care for and personalize learning experiences. Similarly suggested by the participating instructor, there was a defined management of the iPad devices that students became accustomed to following each day. These procedures specifically included a check in/check out procedure and being assigned to a particular device. This consisted of students being called up by tables in the morning to receive their device, and in the same systematic way, returning the iPads at the conclusion of the school day.

**Technology set up considerations.** In addition to learning how to manage and integrate iPad devices into the classroom, a common theme found throughout prior literature (Conn, 2012) and this study includes having an onsite resource technology team. Before an iPad implementation, districts must have the necessary infrastructure in place to support connectivity.

Preceding studies (Crichton, Pegler & White, 2012) conveyed that prior to rolling out new technology implementations, it is necessary to ensure that a school’s wireless network has the required bandwidth in place. The administrator interviewed for this study commented that the infrastructure, which includes the proper bandwidth and Wi-Fi, must be prepared by the technology team to host devices within the building. Without the appropriate wireless network
infrastructure to support all of the devices, the iPads would not be able to be used to their greatest capacity.

During the conversation with the administrator, it was made clear to be prepared for technical challenges. Schools must be equipped to contend with technological issues such as losing connection to wireless networks. There must be a plan in place for technical and mechanical interventions.

It is essential to have a help team for teacher support, device management, trouble shooting and application selections (Kiger, Herro & Prunty, 2012). Accidents and maintenance happen whether using technological devices in the classroom, businesses or at home. Similar to all other technology, devices may crack, break, and components may fail to work properly. A support team needs to be present to address all of these issues that also includes the configurations and re-configurations of such devices needed throughout the school year.

Discussion of the Findings in Relationship to the Theoretical Frameworks

To meet the goals of this research in investigating the academic performance and attitudes of students in a third grade mathematics class, the study relied and was framed by the Constructivist Learning Theory and the Technological Pedagogical Content Knowledge (TPACK) theory. These theories provided direction for the research, as well as findings about how iPads can successfully be integrated into elementary classrooms.

Constructivism. An element portrayed by the constructivist learning theory includes the belief that learners create new knowledge for themselves through experiences (Liu & Chen, 2010). A research question asked the participating teacher to describe student learning and experiences with using iPad devices in an elementary classroom. In agreement with the constructivist learning theory discussed in chapter 1, students learning in this study involved
interaction, collaboration, and real world situations as part of their learning process (Zhang and Kou, 2012). Students interacted with the iPad devices and with each other to learn new content. The findings in this study revealed that the teacher believed that students were able to construct their own knowledge when they used iPads as a tool for learning. In describing the learning within the classroom, the results showed that the iPads helped to create a more student centered environment. The teacher believed that the devices helped students to take the lead in their own education.

The iPad devices are implements that are strongly based on constructivist principles. The constructivist principles are grounded in the belief that students succeed when they take on an active role in their learning to create their own knowledge (Liu & Chen, 2010). Students used strategies that promoted ways in which they experienced learning by participating rather than passively receiving information. These qualities are supported by the constructivist learning theory.

Another component of constructivism consists of the teacher taking on the role of a facilitator who provides information and organizes activities for learners (Liu & Chen, 2010). Through the comments made during interviews, the teacher participant for this study found the constructivist philosophy closely aligned with the instructional approach when iPad devices were used in the classroom. It was noted that the devices no longer required the teacher to be standing in front of the classroom transmitting knowledge to students and telling them what to do. Students could discover and build their own understandings. The role of the teacher according to the constructivist theory is more of an organizer of the learning as opposed to the master of the subject being taught. Using the iPads helped the teacher to enable questions and act as a guide to student learning, but promoted the involvement of the individual student in their education.
Inclusively, the research study exposed that a constructivist learning environment was established by integrating iPad devices into an elementary classroom. Students and the instructor built new understandings on prior knowledge, created new learning experiences and collaborated with one another to create a learner-centered classroom (Kopelman & De Ville, 2001). This relates with how Liu & Chen (2010) viewed constructivism in which students are the most successful when they take an active role in the construction of their own knowledge. Additionally, these results are in agreement with Barone and Wright (2009) where they found that devices led to an increase in teacher-student and student-student communication due to the convenience and easy way to share and transfer information.

**TPACK.** The impact of technology, specifically iPads on the teacher’s instruction was framed using Mishra and Koehler’s (2006) concept of Technological Pedagogical Content Knowledge (TPACK). A teacher applies their TPACK in teaching students which focuses around content, pedagogy and technology, and the correlation between them (Mishra & Koehler, 2009). The use of this framework was supportive in following how a teacher’s knowledge about iPads effected their capacity to effectively teach with the devices. This theory facilitated an understanding in how the participating instructor’s TPACK was used to recognize instructional decisions regarding technology use in the classroom.

Through interviews, the participating instructor revealed that throughout the school year, the use of the iPad became more of a second nature to integrate into the classroom. Both the instructor and students became more familiar with the programs and applications that were used on a daily basis. Specific strategies were used by the instructor to educate the students, especially using the program, eBackpack. For example, the teacher would upload a lesson onto eBackpack with slides and questions. Students would either follow along as a whole class or
they had the freedom to navigate through the presentation at their own pace. The teacher gained a better understanding of ways in which the technology can be successfully integrated to instruct students with new content. More specifically, the use of the eBackpack presentations helped the teacher to gain a better awareness of how to use self-paced lessons in the classroom. These findings relate to how Jang (2010) found that teachers must have the ability to apply technological strategies to promote student learning.

Another component of this research that was framed by this theory included the impact that teaching with the iPads had on student attitudes and motivation towards mathematics. Although there was no statistical significance found using the Attitudes Towards Mathematics Inventory, the interview with the participating instructor revealed the influence the devices had on student attitudes and motivation. This study supported the notion that the iPads enhanced the learning for children who are unmotivated or for students who usually do not put forth much of an effort. More specifically, the technology provided a different way to learn. When practicing basic multiplication facts, students were able to practice using engaging applications in a game format. Students were able to interact with their learning. The interviews revealed that the iPads provided students with motivation and self-stimulation to continue practicing skills. The devices delivered the engagement to maintain students’ focus and attention while learning.

**Discussion of Student Achievement and Attitudes**

In addition to the case study findings, a statistical analysis of academic achievement and attitudes data provided a summary of results for participating in the iPad intervention. The findings are provided in the following section.

**Impact on student achievement.** The essential question that guided this study was to understand the process and what impact using the iPad as an instructional tool had on student
mathematics achievements and attitudes in a third grade mathematics classroom. To determine results, comparison groups were established and pretests, post-tests and attitude inventories were evaluated using measures of central tendency, an ANCOVA test and a t-test. The purpose of calculating these statistics were to provide more concrete data to support the findings. The data helped to complete the description of integrating iPad devices into elementary classrooms.

In the evaluation between the two comparison groups, it was found that each group was similarly aligned and that the results would not be impacted by differences that pre-existed within the sample. The comparisons made between the two groups’ academic achievements revealed that students that were taught with the integration of iPad devices overall growth was similar to those students who learned by a traditional means of education.

The students’ performance on the post-test, which measured student success was supported by the theoretical framework that created a basis for this study. The constructivist framework claims that there is a connection between the environment in which humans are in and the psychological process (Liu & Chen, 2004). Additionally, this theory is based on the assumption that learning is advanced when children construct their own new knowledge. Moreover, the TPACK framework also conveys the notion that successful integration of technology in the classroom relies on the interactions between what teachers know and how that can be applied in the classroom.

**Impact on student attitudes.** In conjunction with the effect of the iPad device on student achievement, results of this research also disclosed that students’ attitudes towards mathematics were constant when using iPads devices and when receiving traditional instruction. As stated in earlier sections, the quantitative data showed that students that worked with devices did not have different attitudes compared to students who did not use the devices. Alternatively,
the participating teacher and coordinating administrator did not support these findings. The results of the interviews conveyed the general sense of students’ positive feelings towards mathematics were greater when using iPads.

While the reported outcomes with the iPads were not meaningful enough to significantly influence students’ mathematics achievement and attitudes, the results from the interviews with the teacher and the administrator portrayed positive impacts in attitudes, engagement and productivity. These results can be an outcome of certain limitations that may have existed in this study.

**Limitations**

This study was limited to a single elementary class in one district in New York. The information collected consisted of data from thirty eight students and two adults. Therefore, the results cannot be generalized to all teachers within the district or to other elementary schools. The larger the sample size, the more confidently the results of the sample may represent the population. A larger sample size would have helped for the results of this study to be more of a representative of the population and would have limited the influence of outliers in the data. Further larger studies may be beneficial to confirm these results.

Additionally, as discussed in previous chapters, random assignment of students was not possible in this study due to the nature of the makeup of an elementary school setting. Although there were parameters that were put in place to make reasonable generalizations from the results of the sample back to the population, employing a pretest as a covariate does not completely compensate for a proper experimental design. A true experimental design that includes random sampling of students to the treatment and control groups may have provided more generalizable outcomes.
The teacher used in this study is an experienced elementary educator instructing students for twelve years in the school district. Her ability to integrate new methodologies and adapt new components into her teaching style may have been more proficient than could be anticipated from a more novice teacher in a similar setting. Moreover, the skill level of the participating instructor may have allowed her to more effectively integrate the iPad devices into the classrooms generating an environment where students flourished with the technology.

Implications for Practice

The totality of the results provided insights into areas that can be used to support the success of integrating iPad devices into classrooms. By means of quantitative data, interviews and teacher lesson plans, students’ data, a teacher and an administrator captured components of the integration of iPad devices that were the most essential based upon their individual experiences. Triangulation of the data from all of the sources revealed recommendations to successfully implement iPads into a school district.

Professional development. When preparing for an integration initiative with iPads, a fundamental consideration includes professional development and support for teachers and students. Providing teachers with ample time to become familiar with the technology and plan appropriately will permit for a greater chance of a successful program.

The substance of workshops provided for teachers must be effective. As a finding from this research, it is preferable that one of the most useful trainings to help teachers successfully integrate iPads into the classroom would be to hold trainings inside the classrooms. This technique would be useful to help teachers set the devices up in its entirety where they will be used. This recommended training would be able to show the teachers how to actually integrate the devices into their classrooms and instruction as opposed to only being shown programs and
how to navigate the iPads. Moreover, ample time is recommended for teachers to learn and practice incorporating technology into their classrooms after learning about it. Additionally, training should be an on-going learning process throughout the school year to constantly reinforce best teaching practices.

**Student development.** School districts should also consider providing students with training on how to use iPad devices in an educational setting. It is evident that many students have devices for their personal use outside of the classroom, but need to be educated on how to use the devices for learning purposes. There are different uses for devices that are necessary for students to be aware of. Students could participate in an assembly focusing on device management procedures, care and user agreement information, digital citizenship expectations and opportunities to discuss digital etiquette. Students would benefit from learning the expectations of utilizing the devices as a tool for education.

**Implications for Further Research**

There are mixed outcomes that are evident in the academic literature regarding the impact of iPad devices on academic achievement and student attitudes. The findings from this study are particularly relevant to the times and ways in which elementary school students are currently educated. As our society is moving towards a more technology rich culture, methodologies within the classroom are shifting to best fit the needs of the students. To delve further into the investigation of how student achievement and attitudes are effected by the integration of iPad devices, there are multiple aspects that warrant further research and analysis.

Since this study solely focused on one teacher participant from one school, it is recommended that future studies investigate the use of iPads in elementary classrooms in other districts. This future study should focus on districts that have implemented iPads into the
classrooms for a few years to explore whether the devices have transformed the educational experience for students. The study should use qualitative and quantitative data to determine if the results align with one another.

The specific discipline of mathematics was the only content area that was assessed in this study. Further studies into other elementary disciplines including English Language Arts, Science and Social Studies would be valuable. A future study evaluating all content areas of an elementary classroom to explore if iPads have an impact on all subjects is suggested.

Another recommendation for a future study would be to focus more on teaching methods utilizing iPads. For this study, due to the novelty of the devices at this school, there were only a small amount of programs that were used in the teacher’s instruction. It is suggested that future studies investigate other methods, programs and applications that are effective for student learning using iPad devices.

**Conclusion**

The analysis of all data revealed that although it was not found that iPad devices statistically made a difference in student achievement and attitudes, the qualitative component did reveal positive changes. Overall, the findings demonstrated that the use of iPad devices in a third grade mathematics classroom promoted student motivation, engagement and attitudes towards the subject area. From the data, the process by which NPS School integrated iPad devices into classrooms was detailed to provide insights and understandings that went into the implementation. Results from the data led to recommendations on how to integrate iPads into a classroom along with suggestions for future studies.
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Dear Colleagues,

I hope this e-mail finds you well. As you may know, I am a student at Northeastern University working towards a doctorate degree in education. I have finally finished my coursework and have moved onto my research phase in order to write my dissertation.

I would like you to consider participating in my research study. The purpose of my study is to examine and understand the effect of Apple iPads, as an individual learning tool on third grade students’ mathematics achievement and attitudes towards math. I am looking for a third grade teacher that is willing to share test scores from Uniondale mandated assessments from two academic years, 2013-2014 and 2014-2015. Additionally, to be a participant, you will be interviewed one time at the conclusion of the study to inquire your thoughts about the integration of the iPads and how you believe they may affect your students. The interview is expected to last about an hour, would occur in the school building and would be held at a time convenient to you. Please know that the decision to participate in this study is completely voluntary.

Your part in the study will be completely confidential and there are no known risks to you for your participation. The direct benefits from this study will provide you with understandings of how the iPads effect students in your specific classroom. All references to you, your students, classroom, school and district will use pseudonyms and you will not be identified.

If you are interested in participating or have any further questions, please respond to this email at singer.j@husky.neu.edu.

Thank you for your consideration,

Jaclyn Singer
Dear Administrators,

I hope this e-mail finds you well. As you may know, I am a student at Northeastern University working towards a doctorate degree in education. I have finally finished my coursework and have moved onto my research phase in order to write my dissertation. I would like you to consider participating in my research study. The purpose of my study is to examine and understand the effect of Apple iPads, as an individual learning tool on third grade students’ mathematics achievement and attitudes towards math. I am looking for an administrator in this school district that is willing to be interviewed to discuss the groundwork, preparation, maintenance, and experiences with the iPads in the district. The interview is expected to last about an hour, would occur in the school building and would be held at a time convenient to you. Please know that the decision to participate in this study is completely voluntary.

Your part in the study will be completely confidential and there are no known risks to you for your participation. The direct benefits from this study will provide you with understandings of how the iPads effect students in this school district. All references to you and the district will use pseudonyms and you will not be identified.

If you are interested in participating or have any further questions, please respond to this email at singer.j@husky.neu.edu.

Thank you for your consideration,

Jaclyn Singer
Teacher Signed Consent Form

You are being invited to take part in a research study. This form will tell you about the study, but the researcher will explain it to you first. You may ask the researcher any questions or concerns that you have. When you are ready to make a decision, you may tell the researcher if you would like to or not to participate. You do not have to participate if you do not want to. If you do decide to participate, you will be asked to sign this statement. Upon signature, you will receive a copy to keep for yourself.

Northeastern University, College of Professional Studies

Name of Investigator(s):
• Jaclyn E. Singer, Student Investigator
• Dr. Kelly Conn, Principal Investigator

Title of Project:
The Effects of Tablet Devices on Elementary School Students’ Mathematics Achievement and Attitude towards Mathematics

Why are you being asked to take part in this research?
You are being asked to participate in this research study because you are a third grade teacher who utilizes iPad devices in your classroom as a component of your mathematics instruction.

Why is this research being done?
The purpose of this research study is to gather information about the effect of iPad devices on students’ academic achievements and attitudes towards mathematics.

**What will I be asked to do?**

If you decide to take part in this study, you will be asked to provide the researcher with the pretest and post-test data and Attitudes towards Mathematics Inventory from your 2013-2014 and 2014-2015 classes. Additionally, you will be asked to follow a checklist comprised of appropriate methods to integrate mobile devices into the lessons. This checklist will serve as a guide in ways in which are considered appropriate methods to integrate the devices into the classroom as an asset, not just as a tool to take notes on. This check list will ensure that the students will be interacting with the devices, and will serve to be more than an electronic textbook and notebook.

At the conclusion of the 2014-2015 group of students completing the post-test, you will be asked to have a one-on-one audio taped interview with the researcher. The interview will be audiotaped for transcription purposes only.

**Where will this take place and how much time will it take?**

The exchange of quantitative data and one-on-one interview will take place at the research site at a time convenient for you. The interview will last approximately one hour.

**Will there be any risk or discomfort to me?**

There is extremely minimal distress for participating in this research study. Therefore, there is no foreseeable risk or discomfort anticipated.

**Will I benefit by being in this research?**

There will be no direct benefit to you for participating in this study. However, the information learned from this study may help educators integrate iPad devices into classrooms more effectively.

**Who will see the information about me?**

As a participant in this research, your part in this study will be confidential. Only the researcher of this study will see the collected data and information about you. No reports or publications will use information that can identify you or your school district in any way. A pseudonym will be used to protect your identity. The data collected for this study will be kept by the researcher in a password protected file and will not be shared with others. Audiotapes from the interview will be destroyed following data analysis. All documents and data will be destroyed within six months of the final approval of the dissertation.

In rare instances, authorized people may request to see research information about you and others involved in this study. This is done only to be sure that the research is done properly. The
researcher would only permit people who are authorized by organizations such as the Northeastern University Institutional Review board to see this information.

**Can I stop my participation in this study?**

Your participation in this research study is completely voluntary. You do not have to participate if you do not want to. Even if you begin the study, you may quit at any time. You may also refuse to answer any questions. If you do not participate, or decide to resign, you will not suffer any negative consequences.

**Who can I contact if I have questions or problems?**

Student Investigator: Jaclyn Singer, Doctor of Education Student  
440 Northern Parkway  
Uniondale, New York 11553  
516.918.1700  
Email: singer.j@husky.neu.edu

Principal Investigator: Dr. Kelly Conn, Assistant Academic Specialist  
College of Professional Studies  
Northeastern University  
360 Huntington Avenue, 42BV  
Boston, MA 02115  
857.205.9585  
Email: kconn@neu.edu

**Who can I contact about my rights as a participant?**

Inquiries regarding your rights as a participant may be referred to Nan C. Regina, Director, Human Subject Research Protection, 960 Renaissance Park, Northeastern University, Boston, MA 02115. Tel: 617.373.4588, email: irb@neu.edu. You may call anonymously if you wish.

**Will I be paid for my participation?**

There is no compensation for being a participant in this research study.

**Will it cost me anything to participate?**

There is no cost to participate in this research study.

I have read, understood, and had the opportunity to ask questions regarding this consent form. I fully understand the nature and character of my involvement in this research as a participant and the potential risks. I agree to participate in this study on a voluntary basis.

____________________________________________________  ________________  ____________  ________________
Research Participant (signature)  Date
Research Participant (printed)

Research who explained the study to the participant above and obtained consent (signature)  

Date  

Research Participant (printed)
APPENDIX D: Administrator Signed Consent Form

Administrator Signed Consent Form

You are being invited to take part in a research study. This form will tell you about the study, but the researcher will explain it to you first. You may ask the researcher any questions or concerns that you have. When you are ready to make a decision, you may tell the researcher if you would like to or not to participate. You do not have to participate if you do not want to. If you do decide to participate, you will be asked to sign this statement. Upon signature, you will receive a copy to keep for yourself.

Administrator Signed Consent Form

Northeastern University, College of Professional Studies

Name of Investigator(s):

- Jaclyn E. Singer, Student Investigator
- Dr. Kelly Conn, Principal Investigator

Title of Project:

The Effects of iPad Devices on Elementary School Students’ Mathematics Achievement and Attitudes

Why are you being asked to take part in this research?

You are being asked to participate in this research study because you are the coordinating administrator for the implementation of the iPad program at the site of this research study.

Why is this research being done?
The purpose of this research study is to gather information about the effect of iPad devices on students’ academic achievements and attitudes towards mathematics.

**What will I be asked to do?**

If you decide to take part in this study, you will be asked to have a one-on-one audio taped interview with the researcher. The interview will be audiotaped for transcription purposes only.

**Where will this take place and how much time will it take?**

The one-on-one interview will take place at the research site at a time convenient for you. The interview will last approximately one hour.

**Will there be any risk or discomfort to me?**

There is extremely minimal distress for participating in this research study. Therefore, there is no foreseeable risk or discomfort anticipated.

**Will I benefit by being in this research?**

There will be no direct benefit to you for participating in this study. However, the information learned from this study may help educators integrate iPad devices into classrooms more effectively.

**Who will see the information about me?**

As a participant in this research, your part in this study will be confidential. Only the researcher of this study will see the collected data and information about you. No reports or publications will use information that can identify you or your school district in any way. A pseudonym will be used to protect your identity. The data collected for this study will be kept by the researcher in a password protected file and will not be shared with others. Audiotapes from the interview will be destroyed following data analysis. All documents and data will be destroyed within six months of the final approval of the dissertation.

In rare instances, authorized people may request to see research information about you and others involved in this study. This is done only to be sure that the research is done properly. The researcher would only permit people who are authorized by organizations such as the Northeastern University Institutional Review board to see this information.

**Can I stop my participation in this study?**

Your participation in this research study is completely voluntary. You do not have to participate if you do not want to. Even if you begin the study, you may quit at any time. You may also refuse to answer any questions. If you do not participate, or decide to resign, you will not suffer any negative consequences.
Who can I contact if I have questions or problems?

Student Investigator: Jaclyn Singer, Doctor of Education Student  
440 Northern Parkway  
Uniondale, New York 11553  
516.918.1700  
Email: singer.j@husky.neu.edu

Principal Investigator: Dr. Kelly Conn, Assistant Academic Specialist  
College of Professional Studies  
Northeastern University  
360 Huntington Avenue, 42BV  
Boston, MA 02115  
857.205.9585  
Email: kconn@neu.edu

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Will I be paid for my participation?

There is no compensation for being a participant in this research study.

Will it cost me anything to participate?

There is no cost to participate in this research study.  
I have read, understood, and had the opportunity to ask questions regarding this consent form. I fully understand the nature and character of my involvement in this research as a participant and the potential risks. I agree to participate in this study on a voluntary basis.

____________________________________________________  
Research Participant (signature)  
Date
c

____________________________________________________  
Research Participant (printed)

____________________________________________________  
Research who explained the study to the participant above and obtained consent (signature)  
Date

____________________________________________________  
Research Participant (printed)
APPENDIX E: Teacher Interview Questions

Teacher Interview Questions

- How did you use the iPads in your classroom?
- How did you learn how to use the iPads?
- What kind of professional development did you receive?
- What kind of professional development do you wish you received for this program?

Instruction:

- Can you speak about how students construct learning themselves when they interacted with the iPad devices?
- Do the devices enrich the possible learning opportunities and make information more easily accessible?
- Do you believe students’ knowledge of math increased because the use of the iPads?
- Were students more engaged in lessons when using iPads?
- How do you feel the iPads contributed to students’ academic achievements?
- How do you believe students attitudes towards math were effected by using iPads for math lessons?
- Has the use of iPads helped to improve math instruction to your students?
- Has the iPads helped to organize student’s school work? If so, how?
- What can the iPad do for learning that is not possible without it?
- What sort of instructional planning are you using—traditional units, project-based learning, game-based learning, or something else? That is, what style of learning are you expecting the iPad to stimulate?
- How has your instructional design and lesson planning changed as a result of the iPad?
- Are you more motivated to teach math because of the iPad?
- What is the role of learner in iPad use? Can they choose which apps they use to solve a problem? Suggest better apps for better problem-solving? Switch between tasks, assignments, and activities freely, or a follow-only approach?
- Is the learning environment you design and manage technology-centered, standards-centered, data-centered, or student-centered?
  - *How do you believe the iPad can facilitate a more student-centered approach?*
- Has using the iPads for math made the content more relevant to their everyday lives?
- Please speak about the ease of differentiating instruction and being able to reach all of the different academic levels of the students.
  - Do you use eBackpack? How has this app made it easier?
  - Do you use edmodo?
  - What specific apps did you use and find most helpful?
  - How has the immediate feedback that students receive from working on the iPads helped students?

**Management:**

- How were students prepared for receiving the iPad devices?
  - What rules were set for student use on the iPads?
  - Were the rules created by you or are they district guidelines?
  - What expectations were set for use of the iPads?
- How were the iPads distributed each morning?
- How were the iPads secured every night?
- How were they charged?
• What do you do when you find a student inappropriately using the iPads, example on an app when they shouldn’t be?
• What was the procedure when there was a malfunction with a device?

What changes would you make in the future with implementing an iPad program?
• Describe various advantages of the iPads?
  o More specifically around student motivation and attitudes and engagement and improved instruction.
• Were students more actively involved in lessons that incorporated the iPads?
• Were they more willingly active participants?
• Was there a higher level of student participation?
• How has the immediate feedback students received from the iPads helped in the classroom?
• How has the iPads helped to create a more student centered classroom where students construct their own learning?
• How has the iPads promoted student collaboration?
APPENDIX F: Administrator Interview Questions

Administrator Interview Questions

Planning the Implementation

- Why did the district decide to implement an iPad program into their curriculum?
- What are the goals for iPad implementation?
  - (Engagement, access to digital textbooks, access to digital environments, primarily media consumption, media production, or a blend of everything?)
- Why iPads and not laptops?
- How were students/grades selected to participate in the implementation?
- What infrastructure investments are important for districts to be successful?
  - Does Uniondale have enough wireless bandwidth to sustain dense populations of mobile devices?
- How did the district afford all of this technology?
- Did teachers receive devices before students?
  - How were students prepared for the iPads?
  - How were parents prepared for the iPads?
- How does/did the district work with teachers who may be nervous or reluctant to change their teaching practices to integrate technology?
- Why did you choose iPads and not laptops or other devices?
- Why did the iPad best fit for the instructional goals for Uniondale?
- Does the district allow teachers or students to install apps on the devices? Or is it centrally managed?
• Does the district allow teachers or students to configure settings on the devices? Or is it also be centrally managed?
  o What criteria is used to assure that the apps being purchased meet the learning needs of students?
  o How often will the apps be updated?
• Was the IT staff trained on how to support mobile devices?

How will the devices be taken care of?

• How and by whom will the devices be cleaned?
• Where will the devices be stored?
• What is the policy regarding teachers taking the devices off campus?

Decide what will happen if an iPad is broken or lost.

• Who will have to pay for it?
• How will they be charged?
• Under what circumstances will the school cover the replacement cost?
• How quickly must the device be replaced so that learning time will not be lost?
• What is the disciplinary policy for students who break the conduct rules?

During the Implementation

• How do the iPads align with the district’s curriculum?
  o Is there a curriculum vision for the iPads?
• How do you provide ongoing professional development for teachers? Did teachers receive devices before students?

• Have you done any work with digital citizenship with regards to students using technology appropriately in and out of the classroom?

• How do you control the cost of apps if programs requires them?

• How have the devices changed what happens in class?

• How has the devices changed the learning in the classroom?

• Has the iPads helped to organize students’ school work? If so, how?

• What are the key barriers to the technology infusion of tablets, meaning iPads of course, in K-12?

• In order to have a successful implementation of an iPad program in a school, is it necessary for districts to carefully train educators?
  
  o How did Uniondale train the educators?

• What can the iPad do for learning that is not possible without it?

• How does the district hold teachers accountable to using the devices?

• What excited you the most in using mobile technology in the classroom?

After the Implementation

• How is the effectiveness of the iPad program measured?
  
  o Do teacher’s data results show that students are more successful using the iPad devices?

• Under what conditions does the iPads work the best? How do you know?

• What is the biggest challenge you faced in year one of your iPad rollout?
• If other schools are considering implementing iPads into their classrooms, what would you suggest as essential considerations?

• Is the iPad doing things we could not do without it?

• Does the district have data and assessment tools built into the iPads to gather quality data of student achievement?

• What is the cycle for updating devices and what does it depend on?

• What advice do you have for district leaders trying to get support from their school board?
APPENDIX G: Pre-Assessment

Name ____________________________________________

Mark the best answer.

1. \( 5 + 9 = \) ____
   - A 12
   - B 13
   - C 14
   - D 15

2. \( 53 + \) ____ = 100
   - A 52
   - B 50
   - C 49
   - D 47

3. Penny sent 5 letters two weeks ago. She sent 10 letters last week. She sent 15 letters this week. Look for a pattern to tell how many letters she will send next week.
   - A 10
   - B 15
   - C 18
   - D 20

4. \( 9 + \) ____ = 14
   \( 14 - 9 = \) ____
   - A 9; 9
   - B 7; 7
   - C 5; 5
   - D 3; 3

5. Subtract any way you choose.
   \( 563 - 451 = \) ____
   - A 914
   - B 314
   - C 112
   - D 92
Name ________________________________

Which number sentence matches the model?

6. [Diagram of 5 objects divided into 2 groups]
   - A) 6 - 5 = 1
   - B) 6 - 1 = 5
   - C) 5 + 5 = 10
   - D) 6 + 5 = 11

7. [Diagram of 8 objects grouped together]
   - A) 2 + 2 = 4
   - B) 2 + 2 + 2 = 6
   - C) 4 + 4 = 8
   - D) 5 + 5 = 10

8. Which group of coins has the value of 31¢?
   - A) [Image of coins]
   - B) [Image of coins]
   - C) [Image of coins]
   - D) [Image of coins]

Use the chart and line plot to solve the problem.

<table>
<thead>
<tr>
<th>Object</th>
<th>Length in Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Go-Kart</td>
<td>2</td>
</tr>
<tr>
<td>Car</td>
<td>4</td>
</tr>
<tr>
<td>Boat</td>
<td>6</td>
</tr>
</tbody>
</table>

9. How much longer is the boat than the go-kart?
   - A) 2
   - B) 3
   - C) 4
   - D) 5
10. Kenny traces a circle using a solid figure. Which solid figure did he use?

A  

B  

C  

D  

11. Which clock is showing half past 10?

A  

B  

C  

D  

12. Tyler is 39 inches tall. Peter is 48 inches tall. How much taller is Peter than Tyler?

A  10 inches  
B  9 inches  
C  8 inches  
D  7 inches  

13. Joaquin has 65¢. Ted has 28¢. How many cents more does Joaquin have than Ted?

A  37¢  
B  38¢  
C  47¢  
D  48¢  

14. How many children voted for football?

A  1  
B  3  
C  4  
D  6  

<table>
<thead>
<tr>
<th>Favorite Sport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Football</td>
</tr>
<tr>
<td>Soccer</td>
</tr>
<tr>
<td>Baseball</td>
</tr>
</tbody>
</table>

Each = 2 votes
15. Find $28 - 9$ using the number line.

- A) 9
- B) 18
- C) 19
- D) 20

16. Tina makes a sandwich. Which shows how she could cut it into halves?

- A
- B
- C
- D

17. Abbey sees 38 fish in a pond. She sees 17 frogs. Which shows how to compare the numbers?

- A) $17 < 38$
- B) $17 = 38$
- C) $38 < 17$
- D) $17 > 38$

18. Which number is odd?

- A) 8
- B) 16
- C) 21
- D) 24

19. Ezra is measuring the length of the classroom. Will it take more inches, more feet, or more yards to measure the length of the classroom?

- A) more inches
- B) more yards
- C) more feet
- D) All are the same
Directions: Carefully read each question and solve each problem. Be sure to show your work.

20. Daniel had 55 peanuts. He ate 7 of them. How many peanuts does he have left?

Show your work.  

<table>
<thead>
<tr>
<th>Tens</th>
<th>Ones</th>
</tr>
</thead>
</table>

Answer: _________ peanuts left

21. Sue buys a folder for 45 cents. She buys a pencil for 29 cents. How much does she spend in all?

Show your work.  

<table>
<thead>
<tr>
<th>Tens</th>
<th>Ones</th>
</tr>
</thead>
</table>

Answer: _________ cents in all
APPENDIX H: Post-Assessment

Name _______________________

Mark the best answer.

1. What is the value of the 8 in 5,897?
   A 8 thousands or 8,000
   B 8 hundreds or 800
   C 8 tens or 80
   D 8 ones or 8

2. The school chorus is made up of 57 third grade students, 69 fourth grade students, and 123 fifth grade students. What is the total number of students in the chorus?
   A 349
   B 249
   C 239
   D 139

3. Mrs. Carter spent $204 at the store. She bought a desk and a chair. The desk cost $136. What was the cost of the chair?
   A $68
   B $78
   C $132
   D $340

4. Mu-Ling is putting strawberries in each bowl. She made the groups below.

   Which could be used to find the total number of strawberries?
   A $4 \times 2 = \square$
   B $4 \times 3 = \square$
   C $3 \times 3 = \square$
   D $4 \times 4 = \square$

5. Which of these best describes all the lengths?

<table>
<thead>
<tr>
<th>Camper Name</th>
<th>Length in Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traveler</td>
<td>27</td>
</tr>
<tr>
<td>Explorer</td>
<td>18</td>
</tr>
<tr>
<td>Road Runner</td>
<td>36</td>
</tr>
</tbody>
</table>

   A They are all odd numbers.
   B They are all less than 30.
   C They are all multiples of 9.
   D They are all multiples of 2.

6. Each row in the school parking lot has 7 spaces. There are 6 rows of parking spaces. What is the total number of parking spaces in the school parking lot?
   A 42
   B 36
   C 35
   D 13
7. The rows in the array shown below can be separated into two smaller arrays.

Which new facts could represent the smaller arrays?

A (4 \times 4) + (1 \times 4)
B (2 \times 5) + (3 \times 5)
C (2 \times 5) + (4 \times 5)
D (3 \times 5) + (3 \times 5)

8. Allie has 15 beads. She will put an equal number of beads in each of 3 jars. Which number sentence is in this fact family?

A 15 \div 3 = 5
B 3 \times 15 = 45
C 18 - 3 = 15
D 15 + 3 = 18

9. Which whole numbers are missing from this number line?

A 2, 10, 12
B 4, 10, 16
C 4, 12, 16
D 6, 10, 12

10. Which is 763 rounded to the nearest ten?
A 760
B 763
C 770
D 800

11. Look at the fraction model below.

Which choice gives the unit fraction for each part of the whole and the fraction of the whole that is shaded?

A \frac{1}{8} \frac{2}{8}
B \frac{1}{4} \frac{1}{4}
C \frac{1}{2} \frac{2}{4}
D \frac{1}{2} \frac{1}{4}

12. Which is a quadrilateral that has exactly one pair of parallel sides?
A Parallelogram
B Trapezoid
C Square
D Rhombus
13. Look at the number lines below.

Which is a correct statement?
A $\frac{2}{4} = \frac{2}{3}$
B $\frac{2}{4} > \frac{2}{3}$
C $\frac{2}{4} < \frac{2}{3}$
D $\frac{2}{4} < \frac{1}{3}$

14. Which is closest to the perimeter of the magnet shown below?

A 9 cm  C 18 cm
B 16 cm  D 24 cm

15. Which measurement best describes the mass of a cat?
A 6 grams  C 6 kilometers
B 6 kilograms  D 6 liters

16. Kento wants to paint a tabletop. The shaded part of the figure below shows the part of the tabletop that needs paint.

What is the area of the shaded part of the tabletop?
A 9 square feet
B 23 square feet
C 26 square feet
D 35 square feet

17. Look at the number line below.

Which benchmark fraction is closest to Point C?
A $\frac{1}{3}$
B $\frac{1}{2}$
C $\frac{2}{3}$
D $\frac{3}{4}$

18. Look at the fraction strip diagram below.

Which fraction is equivalent to $\frac{3}{4}$?
A $\frac{2}{8}$
B $\frac{1}{2}$
C $\frac{5}{8}$
D $\frac{6}{8}$
19. Two classes want to go on a trip together. Each class voted for the trip it wants to take. The results are shown below.

<table>
<thead>
<tr>
<th>Mrs. Neal’s Class Vote</th>
<th>Mr. Vega’s Class Vote</th>
</tr>
</thead>
<tbody>
<tr>
<td>Art Museum</td>
<td>Art Museum</td>
</tr>
<tr>
<td>Farm</td>
<td>Farm</td>
</tr>
<tr>
<td>Nature Park</td>
<td>Nature Park</td>
</tr>
<tr>
<td>Space Museum</td>
<td>Space Museum</td>
</tr>
</tbody>
</table>

Each ◯ = 4 students  ◯ = 2 students

How many more students voted for the farm trip in Mr. Vega’s class than in Mrs. Neal’s class?

A 2  C 5  B 3  D 6

20. Which clock’s hands form an obtuse angle?

A  B  C  D

21. What is the area of the irregular figure?

A 15 square units  B 16 square units  C 20 square units  D 25 square units

22. Which division sentence is shown by the repeated subtraction?

24 − 8 = 16
16 − 8 = 8
8 − 8 = 0

A 24 ÷ 8 = 3  C 16 ÷ 2 = 8  B 24 ÷ 8 = 4  D 16 ÷ 4 = 4

23. Which value for n will make the equation true?

18 + n = 24

A n = 5  C n = 7  B n = 6  D n = 8

24. Ed arrived at the theater at 1:15 P.M. He was 18 minutes late for the start of the movie. At what time did the movie start?

A 1:03 P.M.  C 12:53 P.M.  B 1:33 P.M.  D 12:57 P.M.
Directions:

Carefully read each question and solve each problem. Be sure to show your work.

25. Daniel had 55 toy cars. He gave 7 of them to his brother. How many cars does Daniel now have?

26. Sarah went shopping for new school supplies. She bought pencils for 59 cents and a folder for 33 cents. How much money did Sarah spend?
APPENDIX I: Attitudes Towards Mathematics Inventory (ATMI)

Attitude towards Math

Color the face that describes your opinion on each question:

Girl □         Boy □

1. Math is a very important and necessary subject.

2. I want my math skills to grow.

3. I get happy when I solve a math problem.

4. Math helps to grow my mind and teaches me to think.

5. Math is important in everyday life.

6. Math is one of the most important subjects to study.

7. Learning math will be helpful in any job I want to get when I am older.
8. I can think of many ways that I use math outside of school.

<table>
<thead>
<tr>
<th>Really Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Really Disagree</th>
</tr>
</thead>
</table>

9. Math is my most feared subject.

<table>
<thead>
<tr>
<th>Really Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Really Disagree</th>
</tr>
</thead>
</table>

10. My mind goes blank and I am unable to think clearly when I am doing math.

<table>
<thead>
<tr>
<th>Really Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Really Disagree</th>
</tr>
</thead>
</table>

11. Doing math makes me nervous.

<table>
<thead>
<tr>
<th>Really Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Really Disagree</th>
</tr>
</thead>
</table>

12. Math makes me feel uncomfortable.

<table>
<thead>
<tr>
<th>Really Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Really Disagree</th>
</tr>
</thead>
</table>

13. I am always worried during math class.

<table>
<thead>
<tr>
<th>Really Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Really Disagree</th>
</tr>
</thead>
</table>

14. When I hear the word math, I get a bad feeling.

<table>
<thead>
<tr>
<th>Really Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Really Disagree</th>
</tr>
</thead>
</table>

15. It makes me nervous to even think about having to do math work.

<table>
<thead>
<tr>
<th>Really Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Really Disagree</th>
</tr>
</thead>
</table>
16. Math does not scare me at all.

17. I have a lot of confidence when it comes to math.

18. I am able to solve math problems without too much difficulty.

19. I expect that I will get good grades in math.

20. I am always confused when doing math.

21. I am unsure when attempting my math work.

22. I learn math easily.

23. I am confident that I could learn harder math.
24. I have enjoyed studying math in school.

- [ ] Really Agree
- [ ] Agree
- [ ] Neutral
- [ ] Disagree
- [ ] Really Disagree

25. Math is boring.

- [ ] Really Agree
- [ ] Agree
- [ ] Neutral
- [ ] Disagree
- [ ] Really Disagree

26. I like to solve new problems in math.

- [ ] Really Agree
- [ ] Agree
- [ ] Neutral
- [ ] Disagree
- [ ] Really Disagree

27. I would choose to do math work over ELA.

- [ ] Really Agree
- [ ] Agree
- [ ] Neutral
- [ ] Disagree
- [ ] Really Disagree

28. When I get older, I would rather not have a job where I need to do math.

- [ ] Really Agree
- [ ] Agree
- [ ] Neutral
- [ ] Disagree
- [ ] Really Disagree

29. I really like math.

- [ ] Really Agree
- [ ] Agree
- [ ] Neutral
- [ ] Disagree
- [ ] Really Disagree

30. I am happier when we do math than any other subject.

- [ ] Really Agree
- [ ] Agree
- [ ] Neutral
- [ ] Disagree
- [ ] Really Disagree

31. Math is a very interesting subject.

- [ ] Really Agree
- [ ] Agree
- [ ] Neutral
- [ ] Disagree
- [ ] Really Disagree
32. I am willing to do more math work than my teacher assigns me.

33. I plan to get a job when I grow up that I have to do math.

34. The challenge of math excites me.

35. I believe learning harder math is useful.

36. I believe studying math helps me with problem solving in other areas of my life.

37. I am happy to find my own ways to solve math problems.

38. I am comfortable answering questions during math time.

39. Learning math now will help me get a good job.

40. I believe I am good at solving math problems.
APPENDIX J: Research Site Permission

NORTHERN PARKWAY SCHOOL
Uniondale Public Schools
440 Northern Parkway
Uniondale, New York 11553-2796
(516) 918-1700 • FAX (516) 918-1794
Visit us at http://nps.uniondaleschools.org Follow us @northernparkway

"Where Greatness Begins"

Mr. Alejandro Rivera
PRINCIPAL

Dr. Sheila Jefferson-Isaac
ASSISTANT PRINCIPAL

Dr. Bilal Pakoa
ASSISTANT PRINCIPAL

January 12, 2015

Dear Jadyn Singer,

Based on my review of your proposed research, you have permission to conduct the study entitled The Effects of iPad Devices on Elementary School Students' Mathematics Achievement and Attitudes towards Mathematics within NPS Elementary School. As part of this study, you are authorized to recruit a third grade instructor, use student data from multiple years and use the results to draw conclusions. Individuals' participation will be voluntary and at their own discretion.

It is understood that our own organization's responsibilities include: having a staff member participate and sharing our student data. We reserve the right to withdraw from the study at any time if any circumstances change.

The research will include typical classroom instruction, a pretest, a posttest, an attitude inventory and an interview with the participating instructor. This authorization covers the time period of the 2014-2015 academic school year and access to prior student data from earlier years.

I confirm that I am authorized to approve research in this setting.

I understand that the data collected will remain entirely confidential and may not be provided to anyone outside of the research team without permission from the Northeastern University IRB Committee.

Sincerely,

[Signature]

Alejandro Rivera
Principal
<table>
<thead>
<tr>
<th>Lesson Content</th>
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<table>
<thead>
<tr>
<th>Instructional Strategies Used</th>
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<table>
<thead>
<tr>
<th>Resources Used</th>
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<table>
<thead>
<tr>
<th>Evidence of Technology Integration</th>
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<table>
<thead>
<tr>
<th>Other Notes</th>
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APPENDIX L: List of Programs Used for iPad Intervention

eBackpack

- Assign, Collect, Review, Annotate, and Return student work, assignments, and assessments easily with eBackpack to support your paperless classroom and student/teacher collaboration. Integrates with your calendar and more. eBackpack includes multimedia PDF support, layered PDF, annotation edit, voice, and video capabilities!
- Offline access so you can complete homework and grade papers without access to the internet!
- Grade anything turned in, grade missing work, or quickly grade all submissions!
- View all your assignments on your calendar! Connect with Google Calendar, Google Drive, Dropbox, Box, and OneDrive (consumer and business/school).
- eBackpack is an assignment, assessment, storage, and collaboration service. eBackpack provides teachers, students, and administrators personal and group storage for assignments, handouts, and homework and the ability to do the entire homework workflow process without the need to print any paper.

Splash Math

- 3rd Grade app is a collection of fun and interactive math problems aligned to Common Core Standards. The app reinforces math concepts with self-paced and adaptive practice anytime, anywhere (works on iPhone, iPod, iPad, laptops and desktops).

Amazing Coin

- Amazing Coin is a fun and educational game for kids to practice identifying and solving math problems with coins. It will teach your kids how to recognize, count, add, pay and make change with coins.
Operation Math

- Defeat Dr. Odd and earn the latest spy gear in the award-winning game that transforms math drills into a global learning adventure. From the streets of Paris to the pyramids of Egypt, Operation Math includes more than 100 timed missions that help players learn addition, subtraction, multiplication and division. Play it for fun or use in the classroom as an awesome supplement to homework and traditional flash card drills.

Geo Pad IXL

- Make learning a multi-sensory delight with IXL - Math and English! Over 4,000 skills in math and English language arts mean you will be able to find the content your children are learning in school. Interactive question types, vibrant graphics, and enchanting audio create an engaging learning environment that connects with students both mentally and physically. Help your students excel by taking IXL on the go today!
- Over 3,200 standards-aligned skills provide comprehensive coverage of K-12 math. Hundreds of colorful awards celebrate important milestones and motivate students. From skip-counting with pictures to graphing quadratic functions, IXL's interactive practice formats bring the joy of learning to students’ fingertips.

Math Bingo

- 5 BINGO games: Addition, Subtraction, Multiplication, Division and Mixed
- 3 Different levels of difficulty: Easy, Medium and Hard

Kahoot

- Game-based platform enables more meaningful, playful and powerful experiences, in classrooms and beyond.
APPENDIX M: IRB Approval

NOTIFICATION OF IRB ACTION

Date: April 16, 2015
IRB #: CPS15-03-15

Principal Investigator(s): Kelly Conn
Jadyn Singer

Department: Doctor of Education Program
College of Professional Studies

Address: 20 Belvidere
Northeastern University

Title of Project: The Effects of iPad Devices on Elementary School
Students' Mathematics Achievement and Attitudes
Towards Mathematics

Participating Sites: Permission letter on file

DHHS Review Category: Expedited #6, #7

Informed Consents: Two (2) signed consent form

Monitoring Interval: 12 months

APPROVAL EXPIRATION DATE: APRIL 15, 2016

Investigator's Responsibilities:

1. The informed consent form bearing the IRB approval stamp must be used when
recruiting participants into the study.

2. The investigator must notify IRB immediately of unexpected adverse reactions, or new
information that may alter our perception of the benefit-risk ratio.

3. Study procedures and files are subject to audit any time.

4. Any modifications of the protocol or the informed consent as the study progresses must
be reviewed and approved by this committee prior to being instituted.

5. Continuing Review Approval for the proposal should be requested at least one month
prior to the expiration date above.

6. This approval applies to the protection of human subjects only. It does not apply to any
other university approvals that may be necessary.

C. Randall Colvin, Ph.D., Chair
Northeastern University Institutional Review Board

Nan C. Regina, Director
Human Subject Research Protection

Northeastern University FWA #4630