COMPARING MATHEMATICS ACHIEVEMENT SCORES:
FACE-TO-FACE VERSUS ONLINE DELIVERY

by

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DEDICATION

For God from whom all blessings flow;

Dedicated to my loving family: Shaun, Brooklyn, London, Salem, Ashton, Mom, Dad,
Wayne, Wanda, and Hattie;

In loving memory of my Grandparents: William, Wilma, Ronald, and Francis Leona;

In loving memory of Dr. Harriet Anne Hathaway and Mr. Steve Monday;

I can do all things through Christ who gives me Strength.
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ABSTRACT

AMI LENDERMAN
COMPARING MATHEMATICS ACHIEVEMENT SCORES:
FACE-TO-FACE VERSUS ONLINE DELIVERY
Under the direction of VINCENT W. YOUNGBAUER, Ph.D.

The purpose of this quantitative study was to explore the relationship between the use of online courseware at Georgia Virtual School as an instructional delivery method and student achievement of 9th and 10th grade mathematics students as measured by Mathematics I and Mathematics II End of Course Test (EOCT) scores. The knowledge of an increase, a decrease, or having no statistically significant difference in student mathematics achievement of students who satisfy the Mathematics I or Mathematics II course requirements through online courseware when compared to students who satisfy the same requirements in the traditional, face-to-face classroom setting would be beneficial to many educational stakeholders.

The two research questions that drove this study were: 1) How does 9th grade student achievement on the Mathematics I EOCT of students in the traditional classroom setting compare to the scores of students taking Mathematics I through online courseware in Georgia?; and 2) How does 10th grade student achievement on the Mathematics II EOCT of students in the traditional classroom setting compare to the scores of students taking Mathematics II through online courseware in Georgia?
To address these research questions, the researcher selected the chi-square contingency table as the statistical test. The statistically significant results indicate that there is an association or relationship between mode of instruction for Mathematics I and Mathematics II and student achievement.
CHAPTER 1
INTRODUCTION TO THE STUDY

Education is continuously changing from generation to generation. Currently, one of the most prominent changes being experienced is in technology. Technology is advancing rapidly and its advances are affecting every aspect of our daily lives. The use of instructional technology in education is no exception as it is common to see the use of several technological tools, such as computers, tablets, and cell phones, in classrooms around the country and at all grade levels. It is also becoming more prominent for school districts to allocate increased funds to make the above said technological tools more available in schools. Another trend in education is an increase in college course offerings using online instruction as the primary mode of instruction. These advancements have forced K-12 school districts to begin to explore the potential benefits of having high school courses offered partially or solely using an online delivery method.

The Georgia Department of Education (GADoE) has responded to the expansion of content delivery through online courseware by offering Georgia Virtual School to the students in the state. State Superintendent Dr. John Barge claims that his “vision is to make education work for all Georgians” (Pauly, 2011, p. 1). According to Pauly (2011), Georgia Virtual School increases accessibility and flexibility in their educational experience by offering full course content online and the ability for students to receive credit for those courses taken. Georgia Virtual School students must report to their local
school or assigned testing site to complete the End of Course Tests for the required courses (Georgia Virtual School, 2015). Some of those exams are taken electronically while others are administered with paper and pencil. The host school or testing site determines the use of the electronic or paper option.

This study explored the relationship, if any, between the use of online courseware at Georgia Virtual School as an instructional delivery method and student achievement of 9th and 10th grade mathematics students as measured by Mathematics I and Mathematics II End of Course Test scores when compared to the same student achievement measure of students taught in the traditional, face-to-face classroom environment. Research and test scores show that mathematics is a weak subject for many students (Stevenson et al., 1990). Stevenson et al. (1990) explain “these studies document the profound underachievement in mathematics of American students compared to their peers in other countries” (p. 1053). As a mathematics teacher, this researcher was looking for ways to help students better understand and apply mathematical concepts. With the knowledge of the above information, the researcher of this study began to ponder if there were any benefits to high school students satisfying their mathematics credit requirements through content delivery with online courseware such as what is offered through Georgia Virtual School as opposed to the traditional, face-to-face classroom setting.

Purpose of the Study

The purpose of this quantitative study was to explore the relationship between instructional delivery method (traditional, face-to-face and the use of online courseware at Georgia Virtual School), and student achievement of 9th and 10th grade mathematics
students as measured by Mathematics I and Mathematics II End of Course Tests (EOCT) scores. The knowledge and understanding of the difference between student mathematics achievement of students who satisfy the Mathematics I or Mathematics II course requirements through online courseware when compared to students who satisfy the same requirements in the traditional, face-to-face classroom setting would be beneficial to many educational stakeholders. These stakeholders include students, parents, teachers, administrators, and local and state board of education members, among others. Teachers, administrators, and board members would benefit from the knowledge of the outcome because if there was significant improvement shown in academic achievement when using online delivery, they could work together to make appropriate adjustments to the delivery of mathematics content instruction to include online courseware. If there was a significant deficit in academic achievement when using online delivery of mathematics as compared to achievement scores of students who took the courses in the traditional, face-to-face classroom, then teachers, administrators, and board members could make appropriate adjustments to improve the online delivery. Parents and students would benefit from the knowledge of the outcome because they could make research based decisions on which mode of instruction may be best for them or their student.

Furthermore, this study has contributed to the body of research on effectiveness of technology on student achievement in response to the need for further research in that area.
Statement of the Problem

Georgia’s previous Superintendent of Schools, Kathy Cox, said, “Our mathematics scores are like an anchor – they are weighing us down and keeping us from moving up as a state” (Cardoza, 2008, p. 1). Furthermore, Cardoza (2011a) explained the weakness in mathematics, as measured by the EOCT scores, shows that students struggle with the rigor of Georgia Performance Standards (GPS). According to Georgia’s Superintendent, Dr. John Barge, this weakness and struggle “underscores the need for different instructional delivery methods” (as cited in White, 2011, p. 1). While Cardoza’s observation -- that weak scores indicate the need for different delivery model -- is problematic because the low test scores observed in mathematics could be caused by an abundance of factors including but not limited to delivery method, online learning is an alternative instructional delivery method that may offer a possible solution to the weak scores on standardized mathematics tests for some students. Although research supports that technology fosters positive change in the learning environment, there is a need for more research on the effectiveness of technology on student achievement in mathematics (Noeth & Volkov, 2004; Protheroe, 2005: Schrum et al., 2007; Roblyer, 2005; Roschelle, Pea, Hoadley, Gordin, and Means, 2001; Voogt & Knezek, 2008).

Roschelle et al. (2001) provided a meta-analysis of major studies on the effectiveness of computers as learning tools in kindergarten through twelfth grade classrooms. In that meta-analysis, mixed results were shown but the strongest evidence shows positive gains (Roschelle et al., 2001). One particular study (Apple Computers of Tomorrow) that was a part of the meta-analysis showed positive effects from computers
on student attitudes, but the students did not perform better on standardized tests (Roschelle et al., 2001). Roschelle et al. (2001) also explained that according to a meta-analysis of 254 controlled evaluation studies conducted by C. Kulik and J.A. Kulik involving students from kindergarten through higher education levels showed a moderate but significant effect computer based instruction had on achievement. Finally, Roschelle et al. (2001) included a summary of a meta-analysis of more than 500 studies conducted by J. A. Kulik also involving students from kindergarten through higher education with results indicating students who used computer based instruction scored higher on achievement tests, learned at a fast pace, and were more likely to develop positive attitudes about the instruction.

Research Questions

1. How does 9th grade student achievement on the Mathematics I EOCT of students in the traditional classroom setting relate to the scores of students taking Mathematics I through online courseware in Georgia?
2. How does 10th grade student achievement on the Mathematics II EOCT of students in the traditional classroom setting relate to the scores of students taking Mathematics II through online courseware in Georgia?

Research Hypotheses

1. $H_0$: Students taking Mathematics I through online courseware will exhibit no statistically different achievement than students taking Mathematics I in the traditional classroom setting based on scores on the Mathematics I EOCT.
2. \( H_0 \): Students taking Mathematics II through online courseware will exhibit no statistically different achievement than students taking Mathematics II in the traditional classroom setting based on scores on the Mathematics II EOCT.

Theoretical Framework

The basis of the research question was founded from a documented struggle that high school students have in mathematics and the rapid evolution of technology. The researcher’s thoughts were to investigate the effect of using online courseware as the content delivery method of mathematics courses to see if there are any potential benefits of the online delivery method in mathematics based on student achievement in mathematics. This study has widespread significance in the field of education and to many stakeholders within the field. The theoretical frameworks at the foundation of this research were Bandura’s social cognitive theory, Gardner’s theory of multiple intelligences, and learning styles theory.

Bandura’s social cognitive theory “acknowledges the social origins of much human thought and action” and “recognizes the influential causal contribution of thought processes to human motivation, affect, and action” (Merriam, Caffarella, & Baumgartner, 2007, p. 289). The social cognitive theory accounts for both the learner and their environment because “behavior is a function of the interaction of the person with the environment” (Merriam et al., 2007, p. 289). Bandura (1993) presents diverse ways that perceived self-efficacy could contribute to cognitive functioning. Bandura and Locke (2003) support that “efficacy beliefs contribute significantly to the level of motivation and performance” (p. 87). This contributed to the researcher’s thoughts that if a student
is comfortable in their environment, whether it be in a traditional, face-to-face classroom or in a virtual learning setting such as Georgia Virtual School, then the student may be more motivated and thus perform better based on their comfort level with their learning environment.

Gardner’s theory of multiple intelligences (MI Theory) also contributed to the theoretical underpinnings of this research study. The major component of this research was the method of content delivery: traditional, face-to-face versus the use of online courseware. The use of online courseware in mathematics has roots in Gardner’s theory of multiple intelligences. Gardner’s MI Theory claims that “all humans possess all” intelligences discussed in the MI Theory and “that just as we all look different and have unique personalities and differences, we also have different patterns of intelligence” (Merriam et al., 2007, p. 375). Gardner (2006) explains three conclusions of MI Theory are that every human has a full range of intelligences, there are no two intellectual profiles that are exactly the same, and “having a strong intelligence does not mean that one necessarily acts intelligently” (pp. 29-30).

Gardner’s theory of multiple intelligences was at the foundation of the researcher’s idea of investigating what impact using online courseware in the delivery of mathematics content may have on mathematical achievement when compared to mathematics achievement of students in the traditional, face-to-face classroom. Previous research suggests that using the multiple intelligences Gardner outlines in teaching strategies can increase student achievement levels (Blackwell, Trzesniewski, & Dweck, 2007; Campbell & Campbell, 1999; Gardner & Hatch, 1989). Gardner (2006) also
explains that culture influences student learning and achievement. Technology is a part of today’s culture, and thus, has an influence on and may affect student learning and achievement. There are no two learners that are exactly alike and therefore, the teacher should integrate a variety of teaching strategies in meaningful ways to better meet the needs of their students. The use of computers is a fairly new teaching strategy that can be used to meet the needs of learners with various preferences in ways of learning.

Gardner (2003) pointed out that by the middle 1990s he noticed “a number of misinterpretations of the theory” one of which is the confusion of intelligences with learning styles (p. 8). Gardner (1995) points out common myths associated with his theory of multiple intelligences and then retaliates with the realities linked to the myths. The third myth Gardner (1995) presents is that an intelligence is the same as a learning style. The reality he reverberates with is that “the concept of style designates a general approach that an individual can apply equally to every conceivable content. In contrast, an intelligence is a capacity, with its competent processes, that is geared to a specific content in the world” (Gardner, 1995, p. 3). While the researcher understands the difference in multiple intelligences and learning styles, they both have theoretical underpinnings in this study.

Not all teachers prefer to use the same methods to teach, just like not all students prefer the same styles in which to learn. Diaz and Carnal (1999) suggest “there are probably as many ways to teach as there are to learn” and “the most important thing is to be aware that people do not all see the world in the same way” (p. 130). Furthermore, not all teachers limit their teaching methods to just one method for the delivery of all content
and not all students have one learning style preference. Üğur, Akkoyunlu, & Kurbanoğlu (2011) suggest students and teachers alike prefer blended methods or learning styles. Rani and Shukla (2012) explain that the most efficient learning occurs when the teacher is aware of their students’ preferences of learning styles and match their methods to produce suitable learning conditions for all students. If a student’s learning style lends itself to be more successful in a virtual classroom setting, such as Georgia Virtual School, and if they are receiving the same quality of instruction, then this should be an available option to those students. Furthermore, the purpose of education is and should be to give the student the maximum benefit from their learning efforts (Rani & Shukla, 2012). This cannot be achieved if the teaching method used is stagnant or is at odds with the student’s preferred learning style. Here again, if a student’s circumstances lead to a student being able to receive the maximum benefit from leaning at home through an online classroom, then this option should be available to them as long as they are receiving the same quality of instruction.

This study was not exploring the impact that using a variety of learning styles in mathematics content delivery may have on mathematics achievement, but learning style preference and current research of learning styles was at the theoretical foundations driving this study. A portion of the theoretical frameworks of this study was recognizing that not all students are alike and have different learning styles and thus they have various instructional needs.
Significance of the Study

This study has widespread significance in the field of education and to many stakeholders within the field. This study may have uncovered a successful alternative method of content delivery in mathematics, which would be of importance to students, parents, teachers, school administrators, district boards of education, and state departments of education. If the results showed a significant increase in mathematics achievement as measured by EOCT scores in Mathematics I and Mathematics II, the online content delivery method may attract more funding for further implementation of the use of online courseware and be made available to more students in the state of Georgia.

Development and growth involve change. Educators foster positive change through relying on research and someone doing trials first. There is an obvious need for a change in secondary mathematics education in middle Georgia, so the researcher of this study will investigate this new, emerging idea to see if it is a possible supplemental tool for a positive change in mathematics education. The need for improvement in mathematics and the strength of technology in Georgia’s schools are evident, and the literature suggests that more research is needed to show the effectiveness of technology on student mathematics achievement or lack thereof. Therefore, a study that investigates the effects of technology on mathematics achievement is significant to researchers and stakeholders in both areas.
Limitations and Delimitations

This study did have its share of limitations and delimitations that needed to be addressed or at least mentioned. Limitations are factors that limited the study and are out of the control of the researcher while the delimitations are the factors the researcher was not seeking or intending to address in the study. Both are equally important to share to gain a better understanding of what exactly the researcher’s intentions were with this body of work.

Limitations

The limitations of this study include the use of technology in the traditional, face-to-face classrooms, permissions, or lack of permissions, granted by the state in which the study is taking place, and lack of information about the student. Some teachers in the traditional, face-to-face classroom already utilize technology to supplement their instruction. This limited the study because the data reported did not distinguish the traditional classrooms that did and did not use technology as a supplemental, instructional tool. The study is further limited by the state of Georgia’s board of education in what the researcher was allowed to access and report about the students within the state. For example, the researcher was unable to identify students who were first time test takers and those who were not. Finally, a potential limitation of this study is the academic achievement level of the students who selected the virtual route to satisfying the Mathematics I or Mathematics II credit requirements. The researcher did not know why the students who opt to take Mathematics I or Mathematics II online chose the online route rather than the traditional, face-to-face classroom or the academic achievement
level. If the lower performing students tend to select the online route then it would make sense for the students who opted for the traditional, face-to-face route to outperform the virtual school students. The opposite is true if the higher performing students selected the virtual school route; it would make sense that they would outperform the traditional, face-to-face students.

Delimitations

This study did not address the effectiveness of online learning on academic achievement in subjects other than mathematics. The researcher teaches mathematics and, therefore, was only looking at the effects of online learning in that subject area. Furthermore, this study did not address student motivation and attitudes towards technological tools. These factors were not used to determine effects of the technology on academic achievement. This study also did not address the reasons why a student selected to take the Mathematics I course or Mathematics II course through Georgia Virtual School. There are a multitude of reasons why a student may be enrolled in Georgia’s Virtual School rather than the traditional classroom, but this study did not address those reasons. Finally, this study did not address the advantages, disadvantages, or difference in student achievement based on the specific online courseware compared to Georgia Virtual School. While schools around the state may use several different online courseware systems to implement the online delivery of mathematics content, the differences were not examined in this study. The only online courseware considered in this study was that which is used by Georgia Virtual School.
Although there were several limitations and delimitations the researcher planned to take appropriate actions and extensive measures to protect the validity and reliability of this study, which will be discussed further in chapter three.

Definition of Terms

1. Common Core State Standards (CCSS): “a set of high-quality academic standards in mathematics and English language arts/literacy. These learning goals outline what a student should know and be able to do at the end of each grade” (Core Standards, 2017, para. 2).

2. Does Not Meet Standards: Cox (2009) defines this performance level as:

   Students performing at this level demonstrate a minimal understanding of and proficiency with the procedures and concepts in the content domains of algebra, geometry, and data analysis. They are occasionally able to make connections, reason, communicate, use representations, and solve problems. Problem solving is based on their ability to memorize some key concepts and perform routine procedures. (p. 5)

3. End of Course Test (EOCT): a test given to Georgia high school students at the end of selected courses throughout their high school careers. Tests are used to assess specific content knowledge and skills in the given content area. EOCTs are administered both electronically and in paper and pencil form. The host school or testing site determines if the test is administered using the electronic or paper option. Scores are categorized as Does Not Meet, Meets, and Exceeds standards.
4. Exceeds Standards: Cox (2009) defines this performance level as:

Students performing at this level demonstrate a comprehensive understanding and mastery of the procedures and concepts in the content domains of algebra, geometry, and data analysis. They routinely apply their understanding by making connections, reasoning, communicating, using representations, and solving problems. Performance at this level is indicated by the use of complex strategies and higher-level cognitive skills to analyze and solve mathematical and real-world problems. (p. 1)

5. Georgia High School Graduation Test (GHSGT): a test given to all Georgia high school students for the first time in the spring semester of their junior year and covers English language arts, science, social studies, and mathematics.

6. Georgia Performance Standards (GPS): the current set of state standards for all public schools in the state of Georgia. The standards incorporate the content standards and add to these concepts by providing three additional items: suggested tasks, sample student work, and teacher commentary on that work (Georgia Department of Education, 2011).

7. Mathematics I: The Georgia Department of Education (2006) defines this as: the first course in a sequence of courses designed to provide students with a rigorous program of study in mathematics. It includes radical, polynomial and rational expressions, basic functions and their graphs, simple equations, fundamentals of proof, properties of polygons,
coordinate geometry, sample statistics, and curve fitting. **Prerequisite:**

*Successful completion of 8th Grade Mathematics.* (p. 1)

8. Mathematics II: The Georgia Department of Education (2006) defines this as:

the second course in a sequence of courses designed to provide students with a rigorous program of study in mathematics. It includes complex numbers; quadratic, piecewise, and exponential functions; right triangles, and right triangular trigonometry; properties of circles; and statistical inference. **Prerequisite:** *Successful completion of Mathematics 1.* (p. 1)

9. Meets Standards: Cox (2009) defines this performance level as:

Students performing at this level demonstrate an understanding of and proficiency with the procedures and concepts in the content domains of algebra, geometry, and data analysis. They generally apply their understanding by making connections, reasoning, communicating, using representations, and solving problems. Performance at this level is indicated by the use of effective strategies and some higher-level cognitive skills to analyze and solve mathematical and real-world problems. (p. 3)

10. Online courseware: academic courseware available online which students can access at school and at home.

11. Online learning: “the use of Internet to access learning materials; to interact with the content, instructor, and other learners; and to obtain support through the learning process, in order to acquire knowledge” (Ally, 2004, p. 17).
12. Traditional learning: face-to-face classroom setting where the instructor and students meet synchronously in the same room.

Summary

This chapter has provided some background knowledge of the current trend of technology and education, defined the purpose of the study as determining what effect, if any, online instruction has on achievement in mathematics at the high school level, identified the problem of subpar mathematics achievement test scores in the state of Georgia, presented the research questions, hypotheses, limitations, and delimitations of the study, explained the theoretical framework at the foundation of this study, and has provided definitions of key terms used in this study.

Chapter two provides, examine and discuss the existing literature related to the topic and all variables included in this study. The literature review includes background information about mathematics curriculum and the inclusion of technology in education, evidence of the need for higher mathematics achievement scores in the state of Georgia, identify the variables known to affect mathematics achievement, show that there is a lack of evidence on the effectiveness of technology on academic achievement, and identify advantages and disadvantages to online learning.

Chapter three addresses the research design, participants, instrumentation, procedures, and limitations of this study in terms of validity threats, reliability, and data analysis of this research that will be used to accomplish the contribution of evidence to the body of literature available in this area.
CHAPTER 2

LITERATURE REVIEW

The purpose of this study was to determine the association, if any, between the traditional, face-to-face content delivery and the use of online courseware as an instructional delivery method for mathematics based on student achievement of 9th and 10th grade mathematics students as measured by Mathematics I and Mathematics II End of Course Tests (EOCT) scores. The possibility of an increase, a decrease, or having no statistically significant difference in student mathematics achievement of students who satisfy the Mathematics I or Mathematics II course requirements through online courseware when compared to students who satisfy the same requirements in the traditional, face-to-face classroom setting would be beneficial to many educational stakeholders. The previous chapter has described the problem being addressed in this study, the research questions and hypotheses, the limitations and delimitations of this study, the theoretical framework at the foundation of this study, and provided the definitions of key terms used in this study. This chapter will take a closer look at all variables included in this study and provide insight to what the current literature says about those variables. The following sections will provide some background information, provide evidence for the need to increase high school mathematics achievement scores, explore the known variables that are influential to mathematics achievement, discuss the history, advantages, and disadvantages of online learning, and
provide scholarly evidence indicating the need for additional research on the
effectiveness of technology.

Research Questions

1. How does 9\textsuperscript{th} grade student achievement on the Mathematics I EOCT of students
   in the traditional classroom setting relate to the scores of students taking
   Mathematics I through online courseware in Georgia?
2. How does 10\textsuperscript{th} grade student achievement on the Mathematics II EOCT of
   students in the traditional classroom setting relate to the scores of students taking
   Mathematics II through online courseware in Georgia?

Research Hypotheses

1. $H_0$: Students taking Mathematics I through online courseware will exhibit no
   statistically different achievement than students taking Mathematics I in the
   traditional classroom setting based on scores on the Mathematics I EOCT.
2. $H_0$: Students taking Mathematics II through online courseware will exhibit no
   statistically different achievement than students taking Mathematics II in the
   traditional classroom setting based on scores on the Mathematics II EOCT.

Background

According to Klein (2003) “the education wars of the past century are best
understood as a protracted struggle between content and pedagogy” (para. 7). The
historical perspective of mathematics curriculum in the United States (U.S.) may shed
some light on the known weakness in mathematics achievement.
Throughout the 20th century the mathematics curriculum in U.S. schools experienced a tug of war between focusing on skills and procedures to increasing emphasis and focus on logic and reasoning behind the mathematical content. The lack of consistency in mathematics curriculum may be a contributing factor to the weakness of student achievement in mathematics. With roots in education going back to the guidance of John Dewey, progressive education has dominated American schools since the early 20th Century (Klein, 2003). Many histories of the development of curriculum and curriculum movements have been written (Cuban, 1993; Tanner & Tanner, 1990; Willis, Schubert, Bullough, Kridel, & Holton, 1994). This study will focus on how mathematics curricula have changed.

Most educators are aware of the poor performance on standardized mathematics tests in the United States. According to the Organization of Economic Co-operation and Development’s (OECD) 2003 Programme for International Student Assessment (PISA), the rank of the United States is 28 out of 41 participating countries around the world (2003). Georgia ranks 40 out of all 50 states in the United States according to the National Center for Educational Statistics’ 2003 Nation’s Report Card (2003). Most districts and schools in Georgia have included some sort of mathematics remediation in their school improvement plans to address the students’ weaknesses in mathematics. It would appear that weakness in mathematics is a statewide concern.

In addition to the weakness in mathematics achievement “the field of educational technology is under external pressure to provide evidence of identifiable learning outcomes that can be attributed to technology” (Schrum, Thompson, Maddux, Sprague,

Naturally, as technology has become more prominent to society, instructional technology has also become more prominent in education. “In the 1980s, the United States experienced dramatic growth in the use of computer-based technology for instructional purposes” (Sivin-Kachala & Bialo, 1994, p. 8). Computer-based technology was originally credited with student motivation and students’ attitudes towards learning, but in the 1990s studies supporting technology’s effects on student academic achievement began to surface (Sivin-Kachala & Bialo, 1994, p. 8).

Schacter (1999) explains, “Jay Sivin-Kachala (1998) reviewed 219 research studies from 1990 to 1997 to access the effect of technology on learning and achievement across all learning domains and all ages of learners” (p. 5). From his meta-analysis, Sivin-Kachala identified many positive findings and some inconclusive findings (Schacter, 1999). The positive findings demonstrate that students of all ages, both regular education and special needs, showed an increase in achievement and positive effects of technology in all major subject areas (Schacter, 1999). Sivin-Kachala and Bialo (1994) further support the positive effects of educational technology by stating “educational technology has been shown to stimulate more interactive teaching, effective grouping of students, and cooperative learning” (p. 33). Sivin-Kachala and Bialo (1994) claim that research strongly supports technology being a catalyst for positive change in the learning environment.
Kay (2006) explains, “over the past 10 years, researchers, educators, and administrators have debated the value and effect of technology in elementary and secondary education” (p. 385). He reviewed and provided a detailed analysis of “68 studies examining the use of technology in preservice education” only to conclude that “the jury is still out on which strategies work best” (Kay, 2006, p. 397). Within the 68 studies Kay (2006) reviewed there were some comprehensive studies that had minor or negative effects on student learning but there were more large-scale meta-analyses which reported “significant improvement in achievement scores, attitudes towards learning, and depth of understanding when computers were integrated with learning” (p. 385). In conclusion Kay (2006) found “that more rigorous and comprehensive research is needed to fully understand and evaluate the effect of key technology strategies” (p. 385).

Cheung and Slavin (2013) explain “the use of educational technology in K-12 classrooms has been gaining tremendous momentum across the country since the 1900s” (p. 2). Cheung and Slavin (2013) conducted a meta-analysis to examine the effectiveness of educational technology applications for enhancing mathematics achievement in K-12 classrooms. Their conclusion was that “educational technology applications produce a positive but small effect on mathematics achievement” (Cheung & Slavin, 2013, p. 17). Cheung and Slavin (2013) went on to say that “educational technology is making a modest difference in learning of mathematics” (p. 20).

Voogt and Knezek’s (2008) handbook “aims to provide an overview of major directions of research in the field for researchers, policy makers, and practitioners” (p. xxix). Voogt and Knezek (2008) claim:
Due to rapid technological developments the field is continuously changing in intriguing ways. There is a vast amount of research on IT in primary and secondary education, yet most if it is scattered, and a synthesis of the research from a broad international perspective has not yet been achieved. (p. xxix)

Voogt and Knezek (2008) continue by addressing the potential technology has to improve education through both the curriculum and the physical infrastructure for learning. Furthermore, Voogt and Knezek (2008) explain the increased availability of technology has attracted education to go beyond the walls of a classroom and provide learning opportunities anywhere at any time through virtual school which, to secondary education, is a relatively new phenomenon. Voogt and Knezek (2008) boast “the rapid increase of virtual high schools, particularly in the USA is a success story in the history of IT in education” (p. xxxvii).

Theoretical Framework

The basis of the research question was founded from a documented struggle that high school students have in mathematics and the rapid evolution of technology. The researcher’s thoughts were to investigate the effect of using online courseware as the content delivery method of mathematics courses to see if there are any potential benefits of the online delivery method in mathematics based on student achievement in mathematics. This study has widespread significance in the field of education and to many stakeholders within the field. The theoretical frameworks at the foundation of this research were Bandura’s social cognitive theory, Gardner’s theory of multiple intelligences, and learning styles theory.
Bandura’s social cognitive theory “acknowledges the social origins of much human thought and action” and “recognizes the influential causal contribution of thought processes to human motivation, affect, and action” (Merriam, Caffarella, & Baumgartner, 2007, p. 289). The social cognitive theory accounts for both the learner and their environment because “behavior is a function of the interaction of the person with the environment” (Merriam et al., 2007, p. 289). Bandura (1993) presents diverse ways that perceived self-efficacy could contribute to cognitive functioning. Bandura and Locke (2003) support that “efficacy beliefs contribute significantly to the level of motivation and performance” (p. 87). This contributed to the researcher’s thoughts that if a student is comfortable in their environment, whether it be in a traditional, face-to-face classroom or in a virtual learning setting such as Georgia Virtual School, then the student may be more motivated and thus perform better based on their comfort level with their learning environment.

Gardner’s theory of multiple intelligences (MI Theory) also contributed to the theoretical underpinnings of this research study. The major component of this research was the method of content delivery: traditional, face-to-face versus the use of online courseware. The use of online courseware in mathematics has roots in Gardner’s theory of multiple intelligences. Gardner’s MI Theory claims that “all humans possess all” intelligences discussed in the MI Theory and “that just as we all look different and have unique personalities and differences, we also have different patterns of intelligence” (Merriam et al., 2007, p. 375). Gardner (2006) explains three conclusions of MI Theory are that every human has a full range of intelligences, there are no two intellectual
profiles that are exactly the same, and “having a strong intelligence does not mean that one necessarily acts intelligently” (pp. 29-30).

Gardner’s theory of multiple intelligences was at the foundation of the researcher’s idea of investigating what impact using online courseware in the delivery of mathematics content may have on mathematical achievement when compared to mathematics achievement of students in the traditional, face-to-face classroom. Previous research suggests that using the multiple intelligences Gardner outlines in teaching strategies can increase student achievement levels (Blackwell, Trzesniewski, & Dweck, 2007; Campbell & Campbell, 1999; Gardner & Hatch, 1989). Gardner (2006) also explains that culture influences student learning and achievement. Technology is a part of today’s culture, and thus, has an influence on and may affect student learning and achievement. There are no two learners that are exactly alike and therefore, the teacher should integrate a variety of teaching strategies in meaningful ways to better meet the needs of their students. The use of computers is a fairly new teaching strategy that can be used to meet the needs of learners with various preferences in ways of learning.

Gardner (2003) pointed out that by the middle 1990s he noticed “a number of misinterpretations of the theory” one of which is the confusion of intelligences with learning styles (p. 8). Gardner (1995) points out common myths associated with his theory of multiple intelligences and then retaliates with the realities linked to the myths. The third myth Gardner (1995) presents is that an intelligence is the same as a learning style. The reality he reverberates with is that “the concept of style designates a general approach that an individual can apply equally to every conceivable content. In contrast,
an intelligence is a capacity, with its competent processes, that is geared to a specific content in the world” (Gardner, 1995, p. 3). While the researcher understands the difference in multiple intelligences and learning styles, they both have theoretical underpinnings in this study.

Not all teachers prefer to use the same methods to teach, just like not all students prefer the same styles in which to learn. Diaz and Cartnal (1999) suggest “there are probably as many ways to teach as there are to learn” and “the most important thing is to be aware that people do not all see the world in the same way” (p. 130). Furthermore, not all teachers limit their teaching methods to just one method for the delivery of all content and not all students have one learning style preference. Uğur, Akkoyunlu, & Kurbanoğlu (2011) suggest students and teachers alike prefer blended methods or learning styles. Rani and Shukla (2012) explain that the most efficient learning occurs when the teacher is aware of their students’ preferences of learning styles and match their methods to produce suitable learning conditions for all students. If a student’s learning style lends itself to be more successful in a virtual classroom setting, such as Georgia Virtual School, and if they are receiving the same quality of instruction, then this should be an available option to those students. Furthermore, the purpose of education is and should be to give the student the maximum benefit from their learning efforts (Rani & Shukla, 2012). This cannot be achieved if the teaching method used is stagnant or is at odds with the student’s preferred learning style. Here again, if a student’s circumstances lead to a student being able to receive the maximum benefit from leaning at home through an online classroom,
then this option should be available to them as long as they are receiving the same quality of instruction.

This study was not exploring the impact that using a variety of learning styles in mathematics content delivery may have on mathematics achievement, but learning style preference and current research of learning styles was at the theoretical foundations driving this study. A portion of the theoretical frameworks of this study was recognizing that not all students are alike and have different learning styles and thus they have various instructional needs.

Need for Increase in High School Mathematics Test Scores

As previously mentioned, most educators are aware of the poor performance on standardized mathematics tests in the United States. Lowenberg (2003) paints this picture of desperation in the area of mathematics achievement in the U.S. by reporting only 17% of U.S. 12th grade students in the 2000 National Assessment of Educational Progress performed above a basic competency level. According to the National Assessment of Educational Progress (2015) data released publically in April of 2016 25% of U.S. 12th grade students performed at or above the proficient level. In response to this concern most districts and schools in Georgia have included mathematics remediation in their school improvement plans to address the resident students’ weaknesses in mathematics.

According to Georgia’s Department of Education, there was a rise in test scores on the science, social studies, and English language arts sections of the 2011 Georgia High School Graduation Test (Cardoza, 2011b). The Georgia High School Graduation
Test was a test given to all Georgia high school students for the first time in the spring semester of their junior year and covers English language arts, science, social studies, and mathematics. The test scores on the mathematics portion of the graduation test, however, went down. Eighty-four percent of students passed the mathematics portion in 2011 compared to ninety-one percent who passed that portion in the previous year (Cardoza, 2011b). The Georgia Department of Education discontinued the administration of the Georgia High School Graduation Test in 2015 and the 2011 administration is the final year for which summary data is available (Georgia Department of Education, 2015b).

Georgia has addressed the weakness in mathematics and has worked to reform their curriculum during the past few years. The newly implemented Georgia Performance Standards offers a more rigorous curriculum than the previous Quality Core Curriculum standards (Cardoza, 2011b). The intention of this new curriculum is to raise mathematics performance while promoting higher mathematics standards. Cardoza (2008) states that the 2008 SAT scores for Georgia’s students “demonstrated the need to continue to implement more rigorous standards, especially in mathematics” (p. 1). Thus Cardoza (2008) continues:

Georgia's students were 22 points under the national average in mathematics -- the largest difference of any of the three parts of the test. Even Georgia students who took higher-level mathematics classes trailed the national average when compared to other advanced math students. (p. 1)

Georgia’s high school students were also required to take an End of Course Test (EOCT) at the end of certain courses in every content area throughout their high school
careers. Cardoza (2011a) explains the weakness in mathematics shown on the EOCT scores as well when he quotes Superintendent Barge:

Our Mathematics EOCT results are showing us that some students are struggling with the more rigorous standards, which underscores the need for different instructional delivery methods. While our Mathematics II results increased, those scores are still significantly lower than other content areas. (p. 1)

The weakness in Georgia’s students’ mathematics ability is apparent on a variety of standardized tests: The Georgia High School Graduation Test, the SAT, and the EOCTs. If the weakness is this vivid in each of these standardized tests in the state of Georgia, surely more attention and change is needed in the delivery of mathematics instruction to address this weakness and make improvements in this area.

Based on the content presented above where the researcher is showing the need for an increase in mathematics test scores in the state of Georgia, it is clear that there were several standardized test administered to the students in the state of Georgia which display weakness in mathematics performance. The poor performance on these tests provides evidence that a change in mathematics instruction would be beneficial to Georgia’s students, teachers, and administrators. A good place to start when implementing change for improvements is in what is already known. The next section will explain the Georgia Mathematics End of Course Tests and then the following section will explore the variables known to be influential on mathematics achievement.
Georgia Mathematics End of Course Tests

The testing instrument used in this study was Georgia’s Mathematics I and Mathematics II End of Course Tests (EOCT). The Mathematics I and Mathematics II End of Course Tests were a part of the Georgia Student Assessment Program. Fincher (2014) explains the purposes of the Georgia Student Assessment Program:

- to measure student achievement relative to the state-mandated content standards,
- to identify students failing to achieve mastery of content, to provide teachers with diagnostic information, and to assist school systems in identifying strengths and weaknesses in order to establish priorities in planning educational programs. (p. 1)

The End of Course Tests were one instrument used by the Georgia Student Assessment Program. According to Georgia State’s Superintendent, Dr. John D. Barge (2011), the purposes of End of Course Tests are “to improve student achievement through effective instruction and assessment of the standards” and “to ensure that all Georgia students have access to a rigorous curriculum that meets high performance standards” (p. 6). Barge (2011), provides some general information about the End of Course Tests:

The A+ Education Reform Act of 2000, O.C.G.A. §20-2-281, mandates that the State Board of Education (SBOE) adopt end-of course assessments in grades nine through twelve for core high school subjects to be determined by the SBOE. The EOCT program assesses student achievement in the following eight courses:

- English Language Arts
- Ninth Grade Literature and Composition
• American Literature and Composition

Mathematics

• Mathematics I: Algebra/Geometry/Statistics
• Mathematics II: Geometry/Algebra II/Statistics

Science

• Biology
• Physical Science

Social Studies

• United States History
• Economics/Business/Free Enterprise (p. 5)

Georgia’s Department of Education, Testing Division followed a process of sequenced steps to develop new assessments. The first step was to determine the purpose. Next, “committees of Georgia educators were formed to review the curriculum and establish how concepts, knowledge, and skills will be assessed” (Cox, 2005, p. 1). This committee specifies which standards will be measured and how they will be represented on the assessment. Next an assessment contractor from the state board of education thoroughly reviews the state curriculum and domain specifications produced by the committee of educators. Assessment specialists then create the test items. “Committees of Georgia educators review the items for alignment with the curriculum, suitability, and potential bias or sensitivity issues” (Cox, 2005, p. 2). The committees can accept, reject, or revise the test items. The accepted test items are placed on field tests and trail runs are designed and administered. Following the field test data collection, a
second committee of Georgia Educators is formed to review the test items along with the data collected from the field tests. Once again, the committee can accept the test items, reject the test items, or revise them for re-field testing. The test items that are accepted at this stage are placed in a test bank for possible inclusion on operational test forms. The next stage begins the development of the actual tests students will take. If multiple forms of one test are created the tests must be equated to ensure all forms are equally difficult. After administering the test for the first time, the committee of educators must decide the number of test items a student must answer correctly in order to meet or exceed expectations. “The final stage in test development is to produce scores and distribute results” (Cox, 2005, p. 2).

Nash (2007) explains:

The development of the EOCT includes a contracted nationally recognized test development company and Georgia educators. All test items on the EOCT are approved by Georgia teachers as suitable and relevant to each course. Each EOCT includes a variety of items ranging from basic understanding to high achieving. This broad range of test items aids in the assessment of student knowledge and instructional strategies. The validity of the EOCT begins with test development and involves continuous review by content experts and Georgia educators for alignment and quality. Georgia DOE states that the reliability coefficient for all EOCTs is well above .70. (p. 47)

All End of Course Tests were administered during three main administrations each year: winter, spring, and summer. There are also midmonth administrations of the
End of Course Tests available to accommodate the various school schedules around the state (Barge, 2011). The End of Course Tests can be taken in the classroom with paper and pencil, or web-based if the school system can support the online administration. The form of test administration was not compared in this study. Each system can opt to give the test in one day or spread the test administration out over two days. This study used a collection of each administration from each year included in this study, 2011, 2012, and 2013. Refer to Appendices A and B to view the performance level descriptors of the Mathematics I and Mathematics II EOCTs respectively. Refer to Appendices C and D to view all Mathematics I and Mathematics II standards respectively that the EOCTs from each course covered and measured students’ performance level of.

Influential Variables of Achievement in Mathematics

Now that the need for an increase in high school mathematics test scores has been established and discussed, the researcher will discuss some already identified variables, strategies, and mathematical pedagogies that influence mathematics achievement. Some of the variables are factors controlled by the teacher, some are controlled by the student, while some cannot be controlled at all. Some known variables that influence mathematics achievement, whether the influence is positive or negative, are gender, race, socioeconomic status, in-home educational level, parental involvement, involvement in extracurricular activities, and student attitude towards learning mathematics. Singh, Granville, and Dika (2002) suggest:

achievement in mathematics and science in secondary school is a function of many interrelated variables: students’ ability, attitudes and perceptions,
socioeconomic variables, and so forth. Many of these variables are home- and family-related and thus are difficult to change and are outside the control of educators. However, there are school-related variables such as students’ (a) academic engagement, (b) perceptions and attitudes, and (c) knowledge of the role of mathematics/science achievement in future career opportunities that can be influenced and are amenable to change by educational interventions. (pp. 323-324)

As previously mentioned, Kay (2006) reported significant positive effects on student achievement and attitudes toward learning when computers were incorporated into the learning environment. However, this study will not be addressing or considering any of those variables. This study will be comparing the effects, if any, of two delivery methods used for mathematics content. Therefore, the literature below will focus on known, effective mathematics pedagogies, which are teacher-influenced variables.

According to Anthony and Walshaw (2009):

Mathematics is the most international of all curriculum subjects, and mathematical understanding influences decision making in all areas of life—private, social, and civil. Mathematics education is a key to increasing the post-school and citizenship opportunities of young people, but today, as in the past, many students struggle with mathematics and become disaffected as they continually encounter obstacles to engagement. It is imperative, therefore, that we understand what effective mathematics teaching looks like—and what teachers can do to break this pattern. (p. 6)
Harper, Chen, & Yen (2004) state, “the growth of, and the interest in, distance learning is great, but the question remains how distance learning will impact education” (p. 590). Harper et al. (2004) continues by explaining “some of the more pressing issues such as curriculum, faculty/student interactions, and choice of applications often take precedence over the creation of an appropriate pedagogy” (p. 590).

Anthony and Walshaw (2009b) continue by providing “ten principles as a starting point for discussing change, innovation and reform” in mathematics instruction (p. 27). Those ten principles are:

1. An ethic of care
2. Arranging for learning
3. Building on students’ thinking
4. Worthwhile mathematical tasks
5. Making connections
6. Assessment for learning
7. Mathematical communication
8. Mathematical language
9. Tools and representations
10. Teacher knowledge
The principles above should be viewed and implemented as a whole, not in isolation and “major innovation and genuine reform require aligning efforts of all of those involved in students’ mathematical development: teachers, principals, teacher educators, researchers, parents, special support services, school boards, policy makers, and the students themselves” (Anthony & Walshaw, 2009b, p. 27).

The content covered in this section shows that teaching is very complex. Mathematics achievement is effected by much more than just the behaviors and practices of students and teachers. There are more internal and external variables that can have a
positive or negative effect on student achievement. The teacher can control some variables, the student can control some variables, and some cannot be controlled at all. Overall, every stakeholder in education can affect the achievement of students and educational success should be a joint effort.

Online Learning

Harper, Chen, and Yen (2004) explain how “distance learning has undeniably changed the way people are educated” (p. 596). Not only has distance learning changed the physical infrastructure of a classroom and expanded the geographical boarders, but distance learning has also shown positive effects on student attitudes and motivation. Singh, Granville, and Dika (2002) explain “empirical support for the positive effect of motivation, interest, and attitude on mathematics/science achievement would provide impetus for the development of more specific and inclusive strategies to create a supportive and more effective teaching/learning environment for all students” (p. 331). For some students the most supportive and effective learning environment may be in the traditional, face-to-face classroom, while for others it may be in the form of online learning. The content of this section will explore the history, identify and discuss the known advantages, and identify and discuss the known disadvantages of online learning.

History

“Distance learning is an old idea with a new name” (Harper et al., 2004, p. 588). Harper et al. (2004) explains the foundations of distance learning dating back to the 1700s and Valentine (2002) states, “although it is thought of as a new term, distance learning has been around for well over 100 years” (p. 1). Online learning is a new form
of distance learning. The history of distance learning is outlined in table one below borrowed with permission from Harper et al. (2004). Refer to Appendix F for granted permission to reprint.

Table 1

*The History of Distance Learning*

<table>
<thead>
<tr>
<th>Years</th>
<th>Characteristics</th>
<th>Milestone</th>
</tr>
</thead>
</table>
| 1700 – 1900 | Use of mail to deliver course material  
Correspondence education | Establishment of US Postal System  
Use of correspondence education in higher education                      |
| 1920 – 1960 | Use of radio and television for correspondence education | States pass laws requiring students to attend school  
Use of correspondence education in the military                         |
| 1970 – 1980 | Use of pre-recorded video recordings  
Use of Cassette recordings  
Use of “collections”  
Limited number of broadcast channels  
Mainly used in research and sciences to share information | Emergence of Arpanet, which became the World Wide Web                     |
| 1980 – 1990 | Teleconferencing  
Video Conferencing  
Less expensive video recorders  
Cable networks start programming for K – 12 students  
More televised programs | Dominance of World Wide Web  
Emergency of wireless technology  
More financing from private industry and universities                     |
| 1990 – Present | Less expensive computers  
Greater access to technology  
Internet in classrooms  
More educational institutions and businesses utilize distance learning  
Computer based training (CBTs)  
Synchronous and asynchronous communication |                                                                 |
Means, Toyama, Murphy, Bakia, and Jones (2009) claim “online learning – for students and teachers – is one of the fastest growing trends in educational use of technology” (p. xi). Harper et al. (2004) explain “if distance-learning courses are properly designed and delivered, students can learn as much as in traditional on-campus courses” (p. 590). The sections below will explore the known advantages and disadvantages of distance learning.

Advantages

According to Valentine (2002) many of the advantages, or promises as he states, of distance learning tend to be financial in nature. “The theory is that class sizes increase while the overhead remains the same” (Valentine, 2002, p. 1). Valentine furthers his argument for advantages of distance learning by explaining:

The convenience of time and space is a big promise made by distance learning. Students do not have to physically be with the instructor in space and, depending on the method used, they do not have to be together in time as well. This is a great advantage of non-traditional students who cannot attend at regular times. (p. 2)

Distance learning can expand the previous existing geographical boundaries that may have hindered educational opportunities for some in the past. Harper et al. (2004) explain:

If used correctly, distance learning holds a great promise for education. A frequently cited advantage of distance learning is the potential reduction of financial burdens for colleges, universities and other educational institutions.
Distance learning allows remote classrooms to reduce overcrowding and improve teacher to student ratios. It also gives students the opportunity to interact with a diverse group of fellow students. (p. 587)

According to Pauly (2011), Georgia Virtual School increases accessibility and flexibility in their educational experience by offering full course content online and the ability for students to receive credit for those courses taken. Furthermore, according to Means et al. (2009) online learning has potential to provide “more flexible access to content and instruction at any time, from any place” (p. 1). Means et al. (2009) further identify the following as potential advantages of online learning:

- Increasing the availability of learning experiences for learners who cannot or chose not to attend traditional face-to-face offerings.
- Assembling and disseminating instructional content more cost-efficiently.
- Enabling instructors to handle more students while maintaining learning outcome quality that is equivalent to that of comparable face-to-face instruction. (p. 1)

At the conclusion of their study, Singh, Granville, and Dika (2002) suggest “because our findings confirm that attitudes and interest affect achievement, we believe that developing policies and strategies to improve attendance and participation in classroom activities worthy of consideration” (p. 330). The information provided above supports that an advantage to distance learning is making the classroom more accessible to students which would in turn increase attendance. The attendance may not be in a
traditional, face-to-face classroom, but this may be an issue at the root of the problem; students not being able to get to the physical classroom.

Disadvantages

Although there are several advantages as discussed above, distance learning also has its share of disadvantages to be addressed as well. Valentine (2002) explains, “despite the promises and obvious advantages to distance learning, there are problems that need to be resolved” (p. 3). These problems he mentions include quality of instruction, hidden costs, misuse of technology, and attitudes of the partied involved such as students, instructors, and administrators. Valentine (2002) further explains “each one of these has an effect on the overall quality of distance learning as a product” and “in many ways, each of these issues relates to the others” (p. 3).

Harper et al. (2004) say:

The most important issue is instructor preparedness and student attitudes. If distance-learning courses are properly designed and delivered, students can learn as much as in traditional on-campus courses. But if students do not perceive the technology as useful, they will not be receptive to distance education. There are also geographic issues that must be addressed. While distance learning can cross geographic boundaries, it also has the potential to break cultural rules, norms, and educational learning systems. (p. 590)

There are four issues related to distance learning in education as outline by Harper et al. (2004): “(a) curricula change, (b) new patterns of interaction, (c) changes in structure of organizations, and (d) roles and activities of participants” (p. 590).
Harper et al. (2004) expand on the issues related to distance learning by first pointing out that some of the advantages of distance learning, such as the time saved to commute may be “offset by the additional time and effort spent on the technology, asynchronous and synchronous communications, and other course activities” (p. 591). They explain how the time instructors must spend on things like e-mail correspondence, preparing the lessons, and supporting the students is disproportionate when compared with traditional course delivery methods.

Georgia Virtual School

The Georgia Virtual School (GAVS) has been available to the students of Georgia since 2005. GAVS offers the complete high school curriculum including Advanced Placement (AP) courses to public, private, and homeschool students in both block and semester formats to meet the various scheduling needs of the local school districts across the state of Georgia. All GAVS courses are not leased by other institutions, but are developed or revised by trained, highly qualified teachers (Georgia Virtual School, 2016). Furthermore, all GAVS teachers are highly qualified and specially trained to teach in the online learning environment (Georgia Virtual School, 2016). Georgia Virtual School (2016) further describes its requirements and standards for online instructors as follows:

In addition, Georgia Virtual School, Georgia Department of Education and Georgia Professional Standards commission convened a task force to develop standards for online instructors. In December 2006, these standards were passed by the Georgia Professional Standards Commission and are now the basis for Georgia teachers to earn an online teaching endorsement. Because of this, all
teachers in Georgia are able to complete a series of online courses to obtain the add-on endorsement to their Georgia certification. (p. 3)

One of the primary goals of GAVS was to provide smaller school systems within the state of Georgia the opportunity to expand its course offerings (Georgia Virtual School, 2016). Georgia Virtual School (2016) describes many of the local school districts as being too small and “too understaffed to be able to offer the kind of variety they’d like to their diverse student populations… and are forced to limit their course titles since they do not have highly qualified teachers to put in their classrooms” (p. 4).

Furthermore, according to Georgia Virtual School (2016) “approximately 77 of Georgia’s high schools (22 percent) offer no AP courses at all, and 19 of them offer only one” AP course (p. 3). The higher achieving students in those districts are at a huge disadvantage when applying for colleges because they have not had the “opportunity to experience college-level content or apply college-level skills” (Georgia Virtual School, 2016, p. 3).

Georgia Virtual School (2016) goes on to explain that there are a variety of reasons why students choose to take GAVS courses:

- To increase their content choices.
- To relieve scheduling conflicts.
- To get ahead in their course work.
- To retake a previously failed class so they can graduate on time.
- To catch up on missing, required courses after transferring from another school system.
- They are homebound.
Georgia Virtual School is SACS accredited through Advanc-Ed. There are currently more than 125 core curriculum, AP, and elective courses with 281 course variations offered, each meeting the Georgia Performance Standards (GPS) or College Board Standards (Georgia Virtual School, 2016).

Need for Further Research on the Effectiveness of Technology

“Georgia is a national leader in the use of educational technology to enhance both teaching and learning, according to a report released today” (Tofig, 2009, p. 1). If Georgia is leading the nation in educational technology but lacking in student performance in mathematics, then why not utilize the strength in technology to help improve the area of weakness, mathematics? The only problem is that according to many scholars [see Schrum et al. (2007) and Roblyer (2005)], more research is needed on the effectiveness of technology in improving student achievement.

Voogt and Knezek (2008) explain “the ever-changing technology environment makes effective research into IT in education difficult, complex, and challenging” (p. xxxiv). However, “from the perspective of policymakers, higher scores on standardized tests attributed to the use of IT are a relatively easy and reliable way of determining the success of IT in education” (p. xxxv).

Although, as previously stated, there is a need for further research on the effectiveness of technology; the research that does exist is inconsistent in the effects of computer use. “While not all reviews show outcomes in favor of computer use, the vast majority reach positive conclusions about their efficacy” (Fouts, 2000, p. 7). Fouts (2000) further reports the following about the use of computers to supplement instruction:
• When combined with traditional instruction, the use of computers can increase student learning in the traditional curriculum and basic skills areas.

• The integration of computers with traditional instruction produces higher academic achievement in a variety of subject areas than does traditional instruction alone.

• Students learn more quickly and with greater retention when learning with the aid of computers.

• Students like learning with computers and their attitudes toward learning and school are positively affected by computer use.

• The use of computers appears most promising for low achieving and at-risk students.

• Effective and adequate teacher training is an integral element of successful learning programs based on or assisted by technology. (pp. 7-8)

As a teacher, one of this researcher’s biggest struggles is motivating her students, especially since she teaches mathematics. Since research shows, as Fouts (2000) suggests, that the use of computers promotes positive attitudes in the students and offers greater retention, the use of online courseware as an alternate delivery method for mathematics content is an appropriate intervention to examine further.

Protheroe (2005) contends that computer technology has been shown to improve student achievement when implemented properly. Protheroe (2005) identified four principles used to guide effective integration of technology:
1. Teachers, not technology, are the key to unlocking success and a teacher’s training in, knowledge of, and attitudes toward technology are essential in effective technology integration;

2. Curriculum design is critical to success;

3. Technology design largely determines the impact of integration efforts on student achievement;

4. Ongoing formative evaluations are necessary for continued improvements in technology integration. (p. 47)

These principles are the key to successful implementation of technology. If a teacher is not properly trained, then what good is the technology in his or her classroom? The first principle may be the single most important. Teachers should be properly trained to utilize the technological tools they are given in the intended, most effective ways possible.

Voogt and Knezek (2008) explain, “research has shown that the most successful students in the virtual high school in the USA are those who are most capable of regulating their own learning” (p. xxxvii). So not only are there particular criteria for the educators implanting the use of technology in the classroom and in the virtual environment as previously mentioned, more desirable characteristics for the students in the virtual environment seem to exists as well.

Noeth and Volkov (2004) hold that technology should be a tool used to help educators meet the educational needs of all children, and that technology can serve as an enabler to teaching and learning. Noeth and Volkov (2004) focus on using technology to
contribute to high achievement for all students and offer recommendations on how to evaluate the effectiveness of technology. They also reiterate what Protheroe suggested in that technology has the potential to be a great tool when implemented properly (Noeth and Volkov, 2004). However, more research is needed to determine the effectiveness of technology on student achievement on mathematics test scores.

Several scholars suggest that more research is needed to support or disprove that instructional technology has a positive effect on student achievement (Noeth & Volkov, 2004; Protheroe, 2005; Schrum et al., 2007; Roblyer, 2005; Roschelle, Pea, Hoadley, Gordin, and Means, 2001; Voogt & Knezek, 2008). Furthermore, most previous studies suggest that instructional technology can have a positive effect on student achievement when implemented properly. Several scholars remind their readers to be mindful of proper implementation and evaluation when integrating technology into instruction delivery. This study will test if replacing the traditional, face-to-face delivery method of mathematics instruction with delivery through online courseware can be a useful tool in increasing mathematics test scores.

Summary

This chapter has provided, examined and discussed the existing literature related to the topic and all variables included in this study. This review of existing literature includes background information about mathematics curriculum and the inclusion of technology in education, evidence of the need for higher mathematics achievement scores in the state of Georgia, identified the variables known to effect mathematics achievement,
support that there is a lack of evidence on the effectiveness of technology on academic achievement, and identified advantages and disadvantages to online learning.

The following chapter will address the research design, participants, instrumentation, procedures, limitations of this study in terms of validity threats, reliability, and data analysis of this research that will be used to accomplish the contribution of evidence to the body of literature available in this area.
CHAPTER 3
METHODOLOGY

The problem was that there is a weakness of students’ test scores in mathematics at the high school level (Cardoza, 2011a; Lowenberg, 2003). Existing research suggests that the implementation of technology can be successful if there is proper teacher training available (Fouts, 2007; Harper et al., 2004; Noeth & Volkov, 2004). However, more research is needed to determine the effectiveness of technology on student achievement. The purpose of this quantitative study was to determine the effect, if any, of the use of online courseware at Georgia Virtual School as an instructional delivery method on student achievement of 9th and 10th grade mathematics students as measured by Mathematics I and Mathematics II End of Course Tests (EOCT) scores. This study has contributed to the evidence investigating what impact, if any, online instruction has on student achievement in mathematics as compared to the traditional face-to-face mode of instruction. This chapter will address the research design, participants, instrumentation, procedures, and data analysis of this research that will be used to accomplish the contribution of evidence to the body of literature available in this area.

Research Questions

1. How does 9th grade student achievement on the Mathematics I EOCT of students in the traditional classroom setting relate to the scores of students taking Mathematics I through online courseware in Georgia?
2. How does 10th grade student achievement on the Mathematics II EOCT of students in the traditional classroom setting relate to the scores of students taking Mathematics II through online courseware in Georgia?

Research Hypotheses

1. \( H_0 \): Students taking Mathematics I through online courseware will exhibit no statistically different achievement than students taking Mathematics I in the traditional classroom setting based on scores on the Mathematics I EOCT.

2. \( H_0 \): Students taking Mathematics II through online courseware will exhibit no statistically different achievement than students taking Mathematics II in the traditional classroom setting based on scores on the Mathematics II EOCT.

Research Design and Variables

This study had an independent variable and one dependent variable. The independent variable was two modes of instruction used for the delivery of mathematics content and the one dependent variable was mathematics achievement score retrieved from the Mathematics I and Mathematics II End of Course Tests. The independent variable was the traditional, face-to-face mode of instruction for mathematics content delivery and online instruction of the same mathematics content. For the purposes of this quasi-experimental study the traditional, face-to-face instruction served as the control group, while the online instruction was the treatment for the experimental group.

The dependent variable, as previously stated, was the mathematics achievement scores of the participants. The achievement scores in mathematics were collected by the Georgia Department of Education on the Mathematics I and Mathematics II End of
Course Tests from the years 2011, 2012, and 2013. Due to the data having already been collected by the state of Georgia’s Department of Education, the data were considered to be archival data. The researcher collected archival data from the Georgia Department of Education. The dependent variable was broken down into three categories: does not meet expectations (or standards), meets expectations (or standards), and exceeds expectations (or standards). Table two below shows the breakdown of End of Course Test scores for each category of the dependent variable provided by the Georgia Department of Education (Barge, 2011).

Table 2

<table>
<thead>
<tr>
<th>Dependent Variable Categories</th>
<th>Performance Level 1 Does Not Meet Expectations</th>
<th>Performance Level 2 Meets Expectations</th>
<th>Performance Level 3 Exceeds Expectations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Scale Score</td>
<td>Grade Conversion</td>
<td>Scale Score</td>
</tr>
<tr>
<td>Mathematics I</td>
<td>200 to 399</td>
<td>0 to 69</td>
<td>400 to 449</td>
</tr>
<tr>
<td>Mathematics II</td>
<td>200 to 399</td>
<td>0 to 69</td>
<td>400 to 449</td>
</tr>
</tbody>
</table>

Refer to appendices A and B to view more specific performance level descriptors in greater detail and broken down by content for Mathematics I and Mathematics II End of Course Tests (Cox, 2009). These appendices may provide a better understanding of
how a student would achieve a score in the categories Does Not Meet, Meets, and Exceeds.

Participants

This study was investigating math achievement scores of students in the state of Georgia. According to the 2010 Census data for the state of Georgia, it is reported that Georgia has a total population of 9,497,667 with 18.80% of the population being between the ages of five and 17 or considered school age, 62.11% white, 29.68% black, 0.25% American Indian/Alaska Native, 2.83% Asian, 0.05% Native Hawaiian/Pacific Islander, and 7.74% Hispanic (Proximity, 2014). Furthermore, the median household income for Georgia residents is $49,466 per year, the median family income $58,842 per year, and reportedly has 15.0% of the total population within the poverty level (Proximity, 2014). The Georgia Department of Education (2014) reports there are 181 school districts in the state of Georgia with more than 2,200 schools.

The intended population for this study to represent were the students in the state of Georgia taking Mathematics I and Mathematics II. Mathematics I is “the first” and Mathematics II is “the second course in a sequence of courses designed to provide students with a rigorous program of study in mathematics” and is intended for 9th grade (Mathematics I) and 10th grade (Mathematics II) students (Georgia Department of Education, 2006, p. 1). If a student is on track for graduation and did not previously skip or repeat a grade they are between 14 and 16 years of age. The sample used for this study was taken from the population data provided by the Georgia Department of Education testing division. There were significantly fewer students enrolled to take Mathematics I
and II through Georgia Virtual School compared to all other Mathematics I and II students from all districts combined in 2011, 2012, and 2013. Therefore, the total number of students taking Mathematics I and II at Georgia Virtual School determined the sample size for the students receiving online instruction. The researcher used the data from every Georgia Virtual School student, and then took a random sample of students who took Mathematics I and II through the traditional, face-to-face mode of instruction. The sample size of students who took Mathematics I and II through the traditional, face-to-face mode of instruction was determined by the number of Georgia Virtual School students. The stratified random sample was taken to match as closely as possible the same number of Georgia Virtual School students. The researcher first separated the data into Mathematics I and Mathematics II. Then the researcher isolated the data by year (2011, 2012, and 2013). There were 360 students who took Mathematics I through Georgia Virtual School so the researcher used a random number generator to select data from school districts with assigned numbers for the traditional, face-to-face students until there were about the same number of students who took Mathematics I in the traditional, face-to-face classroom in 2011. As the districts were selected, the researcher ensured that the districts included in the sample were representative of the population of districts in the state of Georgia (some urban, some suburban, and some rural). The researcher repeated the process for Mathematics I in 2012 and 2013 then used the same process for Mathematics II in 2011, 2012, and 2013. The total number of students in Georgia who took Mathematics II online and face-to-face in 2011, 2012, and 2013 are shown in table three below.
Table 3

*Number of Students Taking Mathematics I and Mathematics II in Georgia*

<table>
<thead>
<tr>
<th></th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mathematics I</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Georgia Virtual School</td>
<td>360</td>
<td>391</td>
<td>348</td>
</tr>
<tr>
<td>Traditional, Face-to-Face</td>
<td>132,585</td>
<td>108,620</td>
<td>13,419</td>
</tr>
<tr>
<td><strong>Mathematics II</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Georgia Virtual School</td>
<td>351</td>
<td>544</td>
<td>748</td>
</tr>
<tr>
<td>Traditional, Face-to-Face</td>
<td>113,414</td>
<td>109,448</td>
<td>100,009</td>
</tr>
</tbody>
</table>

All students in this sample took Georgia’s Mathematics I and/or Mathematics II course in at least one of the three years used in the data collection. Georgia’s Department of Education provided a Curriculum Map for teachers to follow when teaching the Mathematics I and Mathematics II courses outlined in the Georgia Performance Standards. Table four below shows the Mathematics I Curriculum Map and table five below shows the Mathematics II Curriculum Map. Both maps were provided by the Georgia Department of Education (2009).
Table 4

*Georgia Performance Standards: Mathematics I Curriculum Map*

<table>
<thead>
<tr>
<th>1st Semester</th>
<th>2nd Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1</td>
<td>Unit 2</td>
</tr>
<tr>
<td>Function Families</td>
<td>Algebra Investigations</td>
</tr>
<tr>
<td>4 Weeks</td>
<td>5 Weeks</td>
</tr>
<tr>
<td>MM1A1</td>
<td>MM1A2</td>
</tr>
<tr>
<td>MM1G2</td>
<td>MM1A3</td>
</tr>
</tbody>
</table>

Table 5

*Georgia Performance Standards: Mathematics II Curriculum Map*

<table>
<thead>
<tr>
<th>1st Semester</th>
<th>2nd Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1</td>
<td>Unit 2</td>
</tr>
<tr>
<td>Quadratics and Complex Numbers</td>
<td>Right Triangle Trigonometry</td>
</tr>
<tr>
<td>6 Weeks</td>
<td>4 Weeks</td>
</tr>
<tr>
<td>MM2N1</td>
<td>MM2G1</td>
</tr>
<tr>
<td>MM2A3</td>
<td>MM2G2</td>
</tr>
<tr>
<td>MM2A4</td>
<td></td>
</tr>
</tbody>
</table>
The final rows in tables four and five above show the breakdown of standards covered in each unit using abbreviations provided by the Georgia Department of Education. See appendices C and D to view all Mathematics I and Mathematics II Georgia Performance Standards expanded and their abbreviations (Georgia Department of Education, 2006).

Instrumentation

The testing instrument used in this study was Georgia’s Mathematics I and Mathematics II End of Course Tests (EOCTs). The Mathematics I and Mathematics II End of Course Test were a part of the Georgia Student Assessment Program. Fincher (2014) explains the purposes of the Georgia Student Assessment Program:

- to measure student achievement relative to the state-mandated content standards,
- to identify students failing to achieve mastery of content, to provide teachers with diagnostic information, and to assist school systems in identifying strengths and weaknesses in order to establish priorities in planning educational programs. (p. 1)

The End of Course Tests were one instrument used by the Georgia Student Assessment Program. According to Georgia State’s Superintendent, Dr. John D. Barge (2011), the purposes of End of Course Tests are “to improve student achievement through effective instruction and assessment of the standards” and “to ensure that all Georgia students have access to a rigorous curriculum that meets high performance standards” (p. 6). Barge (2011), provides some general information about the End of Course Tests:
The A+ Education Reform Act of 2000, O.C.G.A. §20-2-281, mandates that the State Board of Education (SBOE) adopt end-of-course assessments in grades nine through twelve for core high school subjects to be determined by the SBOE. The EOCT program assesses student achievement in the following eight courses:

**English Language Arts**

- Ninth Grade Literature and Composition
- American Literature and Composition

**Mathematics**

- Mathematics I: Algebra/Geometry/Statistics
- Mathematics II: Geometry/Algebra II/Statistics

**Science**

- Biology
- Physical Science

**Social Studies**

- United States History
- Economics/Business/Free Enterprise (p. 5)

Georgia’s Department of Education, Testing Division followed a process of sequenced steps to develop new assessments. The first step was to determine the purpose. Next, “committees of Georgia educators were formed to review the curriculum and establish how concepts, knowledge, and skills will be assessed” (Cox, 2005, p. 1). This committee specifies which standards will be measured and how they will be represented on the assessment. Next an assessment contractor from the state board of
education thoroughly reviews the state curriculum and domain specifications produced by
the committee of educators. Assessment specialists then create the test items.

“Committees of Georgia educators review the items for alignment with the curriculum,
suitability, and potential bias or sensitivity issues” (Cox, 2005, p. 2). The committees can
accept, reject, or revise the test items. The accepted test items are placed on field tests
and trail runs are designed and administered. Following the field test data collection, a
second committee of Georgia Educators is formed to review the test items along with the
data collected from the field tests. Once again, the committee can accept the test items,
reject the test items, or revise them for re-field testing. The test items that are accepted at
this stage are placed in a test bank for possible inclusion on operational test forms. The
next stage begins the development of the actual tests students will take. If multiple forms
of one test are created the tests must be equated to ensure all forms are equally difficult.
After administering the test for the first time, the committee of educators must decide the
number of test items a student must answer correctly in order to meet or exceed
expectations. “The final stage in test development is to produce scores and distribute
results” (Cox, 2005, p. 2).

Nash (2007) explains:

The development of the EOCT includes a contracted nationally recognized test
development company and Georgia educators. All test items on the EOCT are
approved by Georgia teachers as suitable and relevant to each course. Each EOCT
includes a variety of items ranging from basic understanding to high achieving.
This broad range of test items aids in the assessment of student knowledge and
instructional strategies. The validity of the EOCT begins with test development and involves continuous review by content experts and Georgia educators for alignment and quality. Georgia DOE states that the reliability coefficient for all EOCTs is well above .70. (p. 47)

All End of Course Tests were administered during three main administrations each year: winter, spring, and summer. There are also midmonth administrations of the End of Course Tests available to accommodate the various school schedules around the state (Barge, 2011). The End of Course Tests can be taken in the classroom with paper and pencil, or web-based if the school system can support the online administration. The form of test administration was not compared in this study. Each system can opt to give the test in one day or spread the test administration out over two days. This study used a collection of each administration from each year included in this study, 2011, 2012, and 2013.

Data Collection Procedures

The researcher conducting this study used archival data provided by the Georgia Department of Education Assessment Research, Development and Administration department. The data used in this study was taken from the 2011, 2012, and 2013 administration of the End of Course Tests (EOCT) in Mathematics I and Mathematics II. The dependent variable of the research question was the Mathematics I and Mathematics II EOCT scores, which was collected for the independent variable, traditional face-to-face instruction and online instruction.
The researcher, with the aid of an attorney in the state of Georgia who drafted and sent a request letter on the researcher’s behalf, was able to retrieve the Mathematics I and Mathematics II EOCT scores for every student in the state of Georgia for the 2011, 2012, and 2013 test administration years before they were publically released and in a different format then released. The data provided by the Georgia Department of Education was more specific than what can be accessed by the general public. The data provided by the Georgia Department of Education was broken down by year and district and separated first by Georgia Virtual School and Non-Georgia Virtual School test takers and then by does not meet, meets, and exceeds standards. The data provided was not separated by each individual student but rather a frequency for each performance level indicator (does not meet, meets, and exceeds) for both Georgia Virtual School students and traditional, face-to-face students was provided.

Limitations

This study was a quasi-experimental study so there were potential threats to the internal validity in terms of the participants, treatments, and procedures (Creswell, 2012). According to Creswell (2012) the potential threats to the participants of a quasi-experimental study are history (time passing between the beginning and end of the experiment), maturation (participants develop or change during the length of the experiment), regression (selecting participants base on extreme scores), selection (purposefully selecting participants who are more receptive), morality (when participants drop out during the experiment), and interactions with selection (when the previously mention threats interact with the selection of participants). The data being collected in
this study were archival data so the researcher had nothing to do with the selection of the participants prior to the administration of the instrument used. Therefore, these potential threats were not a threat to the validity of this study.

The potential threats related to treatments described by Creswell (2012) are diffusion of treatments (participants in the experimental and control groups can communicate with each other), compensatory equalization (the experimental group reaps the benefits of a treatment which is unequal to other groups), compensatory rivalry (when the participants know if they are a part of the control group or the treatment group and a rivalry develops between the groups), resentful demoralization (members of the control group become resentful because they feel as though they are not receiving the desired treatment). Once again, since this study was utilizing archival data, each of these potential threats to validity in relation to the treatment are accounted for. The experiment was not taking place at the time when the participants were taking the Mathematics II courses in either the traditional, face-to-face setting or the online setting so the participants could not know that they are involved in a research study and therefore could not know which group they were a part of, interact with other participants, or develop a rivalry with other groups.

The potential threats to the internal validity related to the procedures of this study were testing (when participants are tested more than once and remember the responses for later testing) and instrumentation (the instrument used in the data collection changes during the experiment) (Creswell, 2012). These potential threats were not valid threats to
this study because there was only one administration of the test, a post-test, and the instrument did not change during the experiment.

There are also external threats to validity the researcher must consider. For this study, the two potential threats, according to Creswell (2012), to external validity were the interaction of selection and treatment (the inability to generalize beyond the groups in the experiment based on demographics) and the interaction of setting and treatment (the inability to generalize from the setting in the experiment to another setting). This study took a sample to represent the state of Georgia. Therefore, this study may only apply to other states with similar demographics as those in Georgia. The interaction of setting and treatment was not a threat to the validity of this study, but rather what was being compared in this study. The researcher was comparing the difference in academic achievement based on difference in mode of instruction, or setting at which the student received instruction and content delivery.

Other factors that limited this study but were out of the control of the researcher were that the Georgia Department of Education was only willing to release frequency counts of students who do not meet, meets, and exceeds standards on the Mathematics I and Mathematics II End of Course Tests separated by mode of instruction, district, and year. This created a situation where the researcher could only use nominal data to compare the achievement scores based on mode of instruction.

The Georgia Department of Education was also not able to guarantee that all non-Georgia Virtual School students received the same type of instruction without the use of any supplementary use of instructional, technological tools. However, all teachers have
their own style of teaching, just like all students have their preferred learning style. The use of technological tools in the traditional, face-to-face classroom setting does not change the setting from traditional to an online setting, and, thus does not affect what the researcher was attempting to achieve from this study.

Data Analysis

The research questions and hypotheses of this study were:

How does 9th grade student achievement on the Mathematics I EOCT of students in the traditional classroom setting relate to the scores of students taking Mathematics I through online courseware in Georgia?

\( H_0: \) Students taking Mathematics I through online courseware will exhibit no statistically different achievement than students taking Mathematics I in the traditional classroom setting based on scores on the Mathematics I EOCT.

How does 10th grade student achievement on the Mathematics II EOCT of students in the traditional classroom setting relate to the scores of students taking Mathematics II through online courseware in Georgia?

\( H_0: \) Students taking Mathematics II through online courseware will exhibit no statistically different achievement than students taking Mathematics II in the traditional classroom setting based on scores on the Mathematics II EOCT.

Field (2009) explains that calculating the descriptive statistics such as mean and standard deviation one would usually calculate and report in the initial stage of data analysis is “completely meaningless because the numeric values you attach to different categories are arbitrary” (p. 687). Therefore, the first stage of the data analysis was to
use computer software such as SPSS to create a 3x2 contingency table reporting the frequencies of each independent variable, traditional, face-to-face delivery of instruction and online delivery of instruction. The frequencies and percentages of each independent variable previously described were reported to identify differences in these variables. This information can provide useful insight in how many students in the state of Georgia are taking Mathematics I and Mathematics II through the traditional mode of face-to-face instruction and the alternative mode of instruction being studied, online courses.

The second stage of the data analysis was a chi-square contingency table and specifically a 3x2 design. The quasi-experimental design being used was a “between groups design” (Creswell, 2012, p. 307). More specifically than between groups, this was a quasi-experimental design because the participants are not being randomly assigned to their groups as Creswell (2012) explains as a requirement for quasi-experimental designs. Using archival data removed the random assignment of participants from the equation. Therefore, based on Creswell’s (2012) description the design was a quasi-experimental. The researcher only collected the EOCT scores, which was administered at the end of the Mathematics I and Mathematics II courses so the study’s design was a posttest only quasi-experimental design. This study was conducted with between-groups, quasi-experimental, posttest only design.

The researcher selected the chi-square contingency table as the statistical test for this study because Sprinthall (2012) explains that if a researcher has nominal data, a hypothesis of difference, independent selection with two or more measures then the most appropriate test is the chi-square contingency table. Due to the researcher only being
able to receive frequency data from the Georgia Department of Education, the data she had access to was nominal. Furthermore, the researcher was interested in whether or not there was a relationship between these categorical data. Field (2009) explains that “if you want to see whether there’s a relationship between two categorical variables” you use Pearson’s chi square test (p. 688). Field further explains, “this is an extremely elegant statistic based on the simple idea of comparing the frequencies you observe in certain categories to the frequencies you might expect to get in those categories by chance” (2009, p. 688). If the results were statistically significant then this would indicate that there was an association or relationship between mode of instruction for Mathematics I and Mathematics II and student achievement (Field, 2009).

Summary

The basis of the research question was founded from a documented struggle that high school students have in mathematics and the rapid evolution of technology. The researcher was investigating the alternate route of satisfying high school mathematics credit through online mathematics courses to see if there were any benefits in doing so based on student achievement in mathematics.

The results of this study may contribute to the body of empirical evidence to either support or refute the notion that the alternative of online instruction as a replacement for the traditional face-to-face delivery of mathematics courses increases student mathematics achievement.

This chapter has described the research design, participants, instrumentation, procedures, and data analysis to be used in this research to be able to contribute to the
body of empirical evidence as previously stated. The next chapter will report the statistical findings of this study in response to the research questions and hypotheses driving the study, and provide an analysis of the data collected.
CHAPTER 4
RESULTS OF DATA ANALYSIS

The purpose of this quantitative study was to determine the effect, if any, of the use of online courseware at Georgia Virtual School as an instructional delivery method on student achievement of 9th and 10th grade mathematics students as measured by Mathematics I and Mathematics II End of Course Tests (EOCT) scores. This study contributed to the evidence investigating what impact, if any, online instruction has on student achievement in mathematics as compared to the tradition face-to-face mode of instruction. The previous chapter addressed the research design, participants, instrumentation, procedures, and data analysis procedures of this research that was used to accomplish the contribution of evidence to the body of literature available in this area. This chapter will report the statistical findings of this study in response to the research questions and hypotheses driving the study. An analysis of the data collected will be presented in this chapter.

The intended population for this study to represent was the students in the state of Georgia taking Mathematics I and Mathematics II in the 2011 through 2013 school years. Mathematics I is “the first” and Mathematics II is “the second course in a sequence of courses designed to provide students with a rigorous program of study in mathematics” and is intended for 9th grade (Mathematics I) and 10th grade (Mathematics II) students
(Georgia Department of Education, 2006). The analysis of the data was based on the sample taken from the population data provided by the Georgia Department of Education testing division. There were significantly fewer students enrolled to take Mathematics I and II through Georgia Virtual School compared to all other Mathematics I and II students from all districts combined in 2011, 2012, and 2013. Therefore, the researcher used the data from every Georgia Virtual School student, and then took a stratified random sample of students who took Mathematics I and II through the traditional, face-to-face mode of instruction. The sample size of students who took Mathematics I and II through the traditional, face-to-face mode of instruction was determined by the number of Georgia Virtual School students. A stratified random sample of students in the traditional, face-to-face classes was taken to match as closely as possible the same number of Georgia Virtual School students. The researcher first separated the data into Mathematics I and Mathematics II. Then the researcher isolated the data by year (2011, 2012, and 2013). There were 360 students who took Mathematics I through Georgia Virtual School so the researcher used a random number generator to select data from school districts for the traditional, face-to-face students until there were about the same number of students who took Mathematics I in the traditional, face-to-face classroom in 2011. The researcher repeated the process for Mathematics I in 2012 and 2013 then used the same process for Mathematics II in 2011, 2012, and 2013. The total sample for the Mathematics I students addressed in research question one was 1,104 traditional, face-to-face and 1,099 Georgia Virtual School. The total sample for Mathematics II students
addressed in research question two was 1,726 traditional, face-to-face and 1,643 Georgia Virtual School.

Research Questions

1. How does 9th grade student achievement on the Mathematics I EOCT of students in the traditional classroom setting relate to the scores of students taking Mathematics I through online courseware in Georgia?

2. How does 10th grade student achievement on the Mathematics II EOCT of students in the traditional classroom setting relate to the scores of students taking Mathematics II through online courseware in Georgia?

Research Hypotheses

1. $H_0$: Students taking Mathematics I through online courseware will exhibit no statistically different achievement than students taking Mathematics I in the traditional classroom setting based on scores on the Mathematics I EOCT.

2. $H_0$: Students taking Mathematics II through online courseware will exhibit no statistically different achievement than students taking Mathematics II in the traditional classroom setting based on scores on the Mathematics II EOCT.

Descriptive Statistics

Field (2009) explains that calculating the descriptive statistics such as mean and standard deviation one would usually calculate and report in the initial stage of data analysis is “completely meaningless because the numeric values you attach to different categories are arbitrary” (p. 687). Therefore, the only descriptive statistics being reported were the frequencies and percentages of each independent variable: traditional, face-to-
face delivery of instruction and online delivery of instruction. The frequencies, expected counts, and percentages within the test score (does not meet, meets, and exceeds), within the method (Georgia Virtual School and Traditional, Face-to-Face), and of the total of each independent variable are shown in tables six and seven below. Table six shows the crosstabulation of test score and delivery method for the Mathematics I data used in response to research question one and table seven shows crosstabulation of test score and delivery method for Mathematics II data used in response to research question two.
Table 6

*Crosstabulation of Test Score and Delivery Method for Mathematics I Data*

<table>
<thead>
<tr>
<th>Test Score*Method Crosstabulation</th>
<th>Method</th>
<th>Georgia Virtual School</th>
<th>Traditional Face-to-Face</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does Not Meet</td>
<td>Count</td>
<td>711</td>
<td>442</td>
<td>1153</td>
</tr>
<tr>
<td></td>
<td>Expected Count</td>
<td>575.2</td>
<td>577.8</td>
<td>1153.0</td>
</tr>
<tr>
<td></td>
<td>% within Test Score</td>
<td>61.7%</td>
<td>38.3%</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>% within Method</td>
<td>64.7%</td>
<td>40.0%</td>
<td>52.3%</td>
</tr>
<tr>
<td></td>
<td>% of Total</td>
<td>32.3%</td>
<td>20.1%</td>
<td>52.3%</td>
</tr>
<tr>
<td></td>
<td>Std. Residual</td>
<td>5.7</td>
<td>-5.6</td>
<td></td>
</tr>
<tr>
<td>Meets</td>
<td>Count</td>
<td>361</td>
<td>421</td>
<td>782</td>
</tr>
<tr>
<td></td>
<td>Expected Count</td>
<td>390.1</td>
<td>391.1</td>
<td>782.0</td>
</tr>
<tr>
<td></td>
<td>% within Test Score</td>
<td>46.2%</td>
<td>53.8%</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>% within Method</td>
<td>32.8%</td>
<td>38.1%</td>
<td>35.5%</td>
</tr>
<tr>
<td></td>
<td>% of Total</td>
<td>16.4%</td>
<td>19.1%</td>
<td>35.5%</td>
</tr>
<tr>
<td></td>
<td>Std. Residual</td>
<td>-1.5</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Exceeds</td>
<td>Count</td>
<td>27</td>
<td>241</td>
<td>268</td>
</tr>
<tr>
<td></td>
<td>Expected Count</td>
<td>133.7</td>
<td>134.3</td>
<td>268.0</td>
</tr>
<tr>
<td></td>
<td>% within Test Score</td>
<td>10.1%</td>
<td>89.9%</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>% within Method</td>
<td>2.5%</td>
<td>21.8%</td>
<td>12.2%</td>
</tr>
<tr>
<td></td>
<td>% of Total</td>
<td>1.2%</td>
<td>10.9%</td>
<td>12.2%</td>
</tr>
<tr>
<td></td>
<td>Std. Residual</td>
<td>-9.2</td>
<td>9.2</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Count</td>
<td>1099</td>
<td>1104</td>
<td>2203</td>
</tr>
<tr>
<td></td>
<td>Expected Count</td>
<td>1099.0</td>
<td>1104.0</td>
<td>2203.0</td>
</tr>
<tr>
<td></td>
<td>% within Test Score</td>
<td>19.9%</td>
<td>50.1%</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>% within Method</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>% of Total</td>
<td>49.9%</td>
<td>50.1%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>
Table 7

*Crosstabulation of Test Score and Delivery Method for Mathematics II Data*

<table>
<thead>
<tr>
<th>Test Score*Method Crosstabulation</th>
<th>Method</th>
<th>Georgia Virtual School</th>
<th>Traditional Face-to-Face</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test_Score</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does Not Meet</td>
<td>Count</td>
<td>1132</td>
<td>720</td>
<td>1852</td>
</tr>
<tr>
<td></td>
<td>Expected Count</td>
<td>903.2</td>
<td>948.8</td>
<td>1852.0</td>
</tr>
<tr>
<td></td>
<td>% within Test_Score</td>
<td>61.1%</td>
<td>38.9%</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>% within Method</td>
<td>68.9%</td>
<td>41.7%</td>
<td>55.0%</td>
</tr>
<tr>
<td></td>
<td>% of Total</td>
<td>33.6%</td>
<td>21.4%</td>
<td>55.0%</td>
</tr>
<tr>
<td></td>
<td>Std. Residual</td>
<td>7.6</td>
<td>-7.4</td>
<td></td>
</tr>
<tr>
<td>Meets</td>
<td>Count</td>
<td>496</td>
<td>913</td>
<td>1409</td>
</tr>
<tr>
<td></td>
<td>Expected Count</td>
<td>687.1</td>
<td>721.9</td>
<td>1409.0</td>
</tr>
<tr>
<td></td>
<td>% within Test_Score</td>
<td>35.2%</td>
<td>64.8%</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>% within Method</td>
<td>30.2%</td>
<td>52.9%</td>
<td>41.8%</td>
</tr>
<tr>
<td></td>
<td>% of Total</td>
<td>14.7%</td>
<td>27.1%</td>
<td>41.8%</td>
</tr>
<tr>
<td></td>
<td>Std. Residual</td>
<td>-7.3</td>
<td>7.1</td>
<td></td>
</tr>
<tr>
<td>Exceeds</td>
<td>Count</td>
<td>15</td>
<td>93</td>
<td>108</td>
</tr>
<tr>
<td></td>
<td>Expected Count</td>
<td>52.7</td>
<td>55.3</td>
<td>108.0</td>
</tr>
<tr>
<td></td>
<td>% within Test_Score</td>
<td>13.9%</td>
<td>86.1%</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>% within Method</td>
<td>0.9%</td>
<td>5.4%</td>
<td>3.2%</td>
</tr>
<tr>
<td></td>
<td>% of Total</td>
<td>0.4%</td>
<td>2.8%</td>
<td>3.2%</td>
</tr>
<tr>
<td></td>
<td>Std. Residual</td>
<td>-5.2</td>
<td>5.1</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Count</td>
<td>1643</td>
<td>1726</td>
<td>3369</td>
</tr>
<tr>
<td></td>
<td>Expected Count</td>
<td>1643.0</td>
<td>1726.0</td>
<td>3369.0</td>
</tr>
<tr>
<td></td>
<td>% within Test_Score</td>
<td>48.8%</td>
<td>51.2%</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>% within Method</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>% of Total</td>
<td>48.8%</td>
<td>51.2%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

**Statistical Results**

The researcher selected the chi-square contingency table as the statistical test for this study because Sprinthall (2012) explains that if a researcher has nominal data, a hypothesis of difference, independent selection with two or more measures then the most
appropriate test is the chi-square contingency table. Due to the researcher only being able to receive frequency data from the Georgia Department of Education, the data she had access to was nominal. Furthermore, the researcher was interested in whether or not there is a relationship between these categorical data. Field (2009) explains that “if you want to see whether there’s a relationship between two categorical variables” you use Pearson’s chi square test (p. 688). Field (2009) further explains, “this is an extremely elegant statistic based on the simple idea of comparing the frequencies you observe in certain categories to the frequencies you might expect to get in those categories by chance” (p. 688).

Research Question One

Research question one examined the relationship, if any, of mathematics achievement based on Mathematics I End of Course Test Scores has when comparing traditional, face-to-face and online modes of instruction. Pearson’s Chi-Square was used to test hypothesis one:

\[ H_0: \text{Students taking Mathematics I through online courseware will exhibit no statistically different achievement than students taking Mathematics I in the traditional classroom setting based on scores on the Mathematics I EOCT.} \]

The Pearson Chi-Square was used to examine the association between delivery method (online versus traditional, face-to-face) and Mathematics I student achievement as measured by Mathematics I EOCT scores. The null hypothesis will be rejected if the \( p \) value for the chi-square test is less than or equal to .05. According to Field (2009), there are two assumptions to be met for the chi-square test: The data are independent of each
other and the expected frequencies in each cell are at least five. According to the results there is a significant association between delivery method and Mathematics I achievement score. Table eight below shows the chi-square tests for the Mathematics I data.

Table 8

Results of the Mathematics I Chi-Square Test

<table>
<thead>
<tr>
<th>Chi-Square Tests</th>
<th>Value</th>
<th>df</th>
<th>Asymp. Sig. (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>238.233</td>
<td>2</td>
<td>.000</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>264.343</td>
<td>2</td>
<td>.000</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>2203</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 133.70.

All assumptions for a $\chi^2$ analysis have been met. First, the researcher assumes the data are independent of each other based on what is known about the data collection process. Second, the expected frequency for each cell was at least five because the minimum expected count is 133.70 as indicated in the note under Table 8. The observed chi-square test shows there is a significant association between the delivery method and the Mathematics I achievement score $\chi^2 (2) = 238.233, p < .001$. Therefore, the null hypothesis is rejected.
The most common effect size to report for a categorical data analysis is an odds ratio: The odds of an event occurring divided by the odds of an event not occurring. Field (2009) explains, “odds ratios are most interpretable in 2x2 contingency tables and are probably not useful for larger contingency tables” (p. 699). However, Field (2009) goes on to explain “if…your variables have more than two categories, it is worth trying to break these effects down into logical 2x2 tables and calculating odds ratios that reflect the nature of interaction” (p. 720). This study had a 3x2 contingency table so the researcher broke down the effects as suggested by Field (2009). Later in this chapter the researcher also collapsed the 3x2 table in to a 2x2 table to make the odds ratio more interpretable and meaningful. The odds ratios were calculated for the associations between does not meet and meets, does not meet and exceeds, and meets and exceeds. The odds ratio for the association between does not meet and meets was 1.88, indicating a Mathematics I, Georgia Virtual School student was 1.88 times more likely to receive a score of does not meet than a traditional, face-to-face student when compared to receiving a score of meets. The odds ratio for the association between does not meet and exceeds was 14.36, indicating a Mathematics I, Georgia Virtual School student was 14.36 times more likely to receive a score of does not meet than a traditional, face-to-face student when compared to receiving a score of exceeds. The odds ratio for the association between meets and exceeds was 7.65, indicating a Mathematics I, Georgia Virtual School student was 7.65 times more likely to receive a score of meets than a traditional, face-to-face student when compared to receiving a score of exceeds. Table nine below shows the odds ratios calculated for the Mathematics I data.
Table 9

*Mathematics I Odds Ratios*

<table>
<thead>
<tr>
<th>Association Between:</th>
<th>Odds Ratio:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does Not Meet and Meets</td>
<td>1.88</td>
</tr>
<tr>
<td>Does Not Meet and Exceeds</td>
<td>14.36</td>
</tr>
<tr>
<td>Meets and Exceeds</td>
<td>7.65</td>
</tr>
</tbody>
</table>

Research Question Two

Research question two examined the relationship, if any, of mathematics achievement based on Mathematics II End of Course Test Scores has when comparing traditional, face-to-face and online modes of instruction. Pearson’s Chi-Square was used to test hypothesis two:

\[ H_0: \text{Students taking Mathematics II through online courseware will exhibit no statistically different achievement than students taking Mathematics II in the traditional classroom setting based on scores on the Mathematics II EOCT.} \]

The Pearson Chi-Square was used to examine the association between delivery method (online versus traditional, face-to-face) and Mathematics II student achievement as measured by Mathematics II EOCT scores. The null hypothesis will be rejected if the \( p \) value for the chi-square test is less than or equal to .05. According to Field (2009), there are two assumptions to be met for the chi-square test: The data are independent of each other and the expected frequencies in each cell are at least five. According to the results there was a significant association between delivery method and Mathematics II
achievement score. Table ten below shows the chi-square Tests for the Mathematics II data.

Table 10

*Results of the Mathematics II Chi-Square Test*

<table>
<thead>
<tr>
<th>Chi-Square Tests</th>
<th>Value</th>
<th>df</th>
<th>Asymp. Sig. (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>269.520</td>
<td>2</td>
<td>.000</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>278.346</td>
<td>2</td>
<td>.000</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>3369</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 52.67.

All assumptions for a $\chi^2$ analysis have been met. First, the researcher assumed the data are independent of each other based on what is known about the data collection process. Second, the expected frequency for each cell was at least five because the minimum expected count is 52.67 as indicated in the note under Table 10. The observed chi-square test shows there was a significant association between the delivery method and the Mathematics I achievement score $\chi^2 (2) = 269.520, p < .001$. Therefore, the null hypothesis was rejected.

The most common effect size to report for a categorical data analysis is an odds ratio: The odds of an event occurring divided by the odds of an event not occurring. Field (2009) explains, “odds ratios are most interpretable in 2x2 contingency tables and
are probably not useful for larger contingency tables” (p. 699). However, Field (2009) goes on to explain “if…your variables have more than two categories, it is worth trying to break these effects down into logical 2x2 tables and calculating odds ratios that reflect the nature of interaction” (p. 720). This study had a 3x2 contingency table so the researcher broke down the effects as suggested by Field (2009). Later in this chapter the researcher also collapsed the 3x2 table in to a 2x2 table to make the odds ratio more interpretable and meaningful. The odds ratios were calculated for the associations between does not meet and meets, does not meet and exceeds, and meets and exceeds. The odds ratio for the association between does not meet and meets was 2.89, indicating a Mathematics II, Georgia Virtual School student was 2.89 times more likely to receive a score of does not meet than a traditional, face-to-face student when compared to receiving a score of meets. The odds ratio for the association between does not meet and exceeds was 9.75, indicating a Mathematics II, Georgia Virtual School student was 9.75 times more likely to receive a score of does not meet than a traditional, face-to-face student when compared to receiving a score of exceeds. The odds ratio for the association between meets and exceeds was 3.37, indicating a Mathematics II, Georgia Virtual School student was 3.37 times more likely to receive a score of meets than a traditional, face-to-face student when compared to receiving a score of exceeds. Table 11 below shows the odds ratios calculated for the Mathematics II data.
Table 11

*Mathematics II Odds Ratios*

<table>
<thead>
<tr>
<th>Association Between:</th>
<th>Odds Ratio:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does Not Meet and Meets</td>
<td>2.89</td>
</tr>
<tr>
<td>Does Not Meet and Exceeds</td>
<td>9.75</td>
</tr>
<tr>
<td>Meets and Exceeds</td>
<td>3.37</td>
</tr>
</tbody>
</table>

Ancillary Findings

While the researcher initially decided to create a 3x2 chi-square contingency table because the Mathematics I and Mathematics II EOCT scores were reported as does not meet, meets, or exceeds, many stakeholders in education are more concerned with simply pass or fail achievement scores and not necessarily driven by the does not meet, meets, and exceeds categories. Does not meet is equivalent to a failing grade of 69 or below while meets and exceeds both correspond to passing scores. Meets is equivalent to 70 to 89 and exceeds is equivalent to 90 to 100. Furthermore, Field (2009) states “odds ratios are most interpretable in 2x2 contingency tables and are probably not useful for larger contingency tables” (p. 699). For these reasons the researcher ran additional tests by collapsing the meets and exceeds categories into one category for an achievement score that is considered to be passing to compare to the does not meet category or fail category. This created a 2x2 contingency table making the odds ratio for the reporting of effect size more “interpretable” as suggested by Field (2009, p. 699). The researcher ran an additional chi-square test for both Mathematics I and Mathematics II data based on the
collapsed pass or fail data to respond to both research questions. After collapsing the meets and exceeds data into one category labeled as pass and the does not meets category labeled as fail, two additional crosstabulation tables were created. Those tables are shown below. Table 12 below shows the crosstabulation of test score (pass/fail) and delivery method for Mathematics I data and table 13 below shows the crosstabulation of test score (pass/fail) and delivery method for Mathematics II data. After the crosstabulation tables were created the additional Pearson chi-square tests were ran for Mathematics I and Mathematics II data. Those results are shown in the section following the crosstabulation tables.
Table 12

*Crosstabulation of Test Score (Pass/Fail) and Delivery Method for Mathematics I Data*

<table>
<thead>
<tr>
<th>Test Score</th>
<th>Method</th>
<th>Georgia Virtual School</th>
<th>Traditional Face-to-Face</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pass Count</td>
<td></td>
<td>388</td>
<td>662</td>
<td>1050</td>
</tr>
<tr>
<td>Expected Count</td>
<td></td>
<td>523.8</td>
<td>526.2</td>
<td>1050.0</td>
</tr>
<tr>
<td>% within Test_Score</td>
<td></td>
<td>37.0%</td>
<td>63.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td>% within Method</td>
<td></td>
<td>35.3%</td>
<td>60.0%</td>
<td>47.7%</td>
</tr>
<tr>
<td>% of Total</td>
<td></td>
<td>17.6%</td>
<td>30.0%</td>
<td>47.7%</td>
</tr>
<tr>
<td>Std. Residual</td>
<td></td>
<td>-5.9</td>
<td>5.9</td>
<td></td>
</tr>
<tr>
<td>Fail Count</td>
<td></td>
<td>711</td>
<td>442</td>
<td>1153</td>
</tr>
<tr>
<td>Expected Count</td>
<td></td>
<td>575.2</td>
<td>577.8</td>
<td>1153.0</td>
</tr>
<tr>
<td>% within Test_Score</td>
<td></td>
<td>61.7%</td>
<td>38.3%</td>
<td>100.0%</td>
</tr>
<tr>
<td>% within Method</td>
<td></td>
<td>64.7%</td>
<td>40.0%</td>
<td>52.3%</td>
</tr>
<tr>
<td>% of Total</td>
<td></td>
<td>32.3%</td>
<td>20.1%</td>
<td>52.3%</td>
</tr>
<tr>
<td>Std. Residual</td>
<td></td>
<td>5.7</td>
<td>-5.6</td>
<td></td>
</tr>
<tr>
<td>Total Count</td>
<td></td>
<td>1099</td>
<td>1104</td>
<td>2203</td>
</tr>
<tr>
<td>Expected Count</td>
<td></td>
<td>1099.0</td>
<td>1104.0</td>
<td>2203.0</td>
</tr>
<tr>
<td>% within Test_Score</td>
<td></td>
<td>49.9%</td>
<td>50.1%</td>
<td>100.0%</td>
</tr>
<tr>
<td>% within Method</td>
<td></td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td>% of Total</td>
<td></td>
<td>49.9%</td>
<td>50.1%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>
Table 13

*Crosstabulation of Test Score (Pass/Fail) and Delivery Method for Mathematics II Data*

<table>
<thead>
<tr>
<th>Test_Score</th>
<th>Pass Count</th>
<th>Expected Count</th>
<th>% within Test_Score</th>
<th>% within Method</th>
<th>% of Total</th>
<th>Std. Residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fail</td>
<td>1132</td>
<td>903.2</td>
<td>61.1%</td>
<td>68.9%</td>
<td>33.6%</td>
<td>-8.4</td>
</tr>
<tr>
<td></td>
<td>720</td>
<td>948.8</td>
<td>38.9%</td>
<td>41.7%</td>
<td>21.4%</td>
<td>8.2</td>
</tr>
<tr>
<td>Total</td>
<td>1643</td>
<td>1643.0</td>
<td>48.8%</td>
<td>100.0%</td>
<td>48.8%</td>
<td>-7.4</td>
</tr>
</tbody>
</table>

Research Question One

Research question one examined the relationship, if any, of mathematics achievement based on Mathematics I End of Course Test Scores has when comparing traditional, face-to-face and online modes of instruction. Pearson’s Chi-Square was used to test hypothesis one:

\[ H_0: \text{Students taking Mathematics I through online courseware will exhibit no statistically different achievement than students taking Mathematics I in the traditional classroom setting based on scores on the Mathematics I EOCT.} \]
The Pearson Chi-Square was used to examine the association between delivery method (online versus traditional, face-to-face) and Mathematics I student achievement as measured by Mathematics I EOCT scores. The null hypothesis will be rejected if the $p$ value for the chi-square test is less than or equal to .05. According to Field (2009), there are two assumptions to be met for the chi-square test: The data are independent of each other and the expected frequencies in each cell are at least five. According to the results there was a significant association between delivery method and Mathematics I achievement score. Table 14 below shows the chi-square tests for the Mathematics I data.

Table 14

*Results of the Mathematics I Chi-Square Test (Pass/Fail)*

<table>
<thead>
<tr>
<th>Chi-Square Tests</th>
<th>Value</th>
<th>df</th>
<th>Asymp. Sig. (2-sided)</th>
<th>Exact Sig. (2-sided)</th>
<th>Exact Sig. (1-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>134.249a</td>
<td>1</td>
<td>.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuity Correctionb</td>
<td>133.262</td>
<td>1</td>
<td>.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>135.665</td>
<td>1</td>
<td>.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fisher’s Exact Test</td>
<td></td>
<td></td>
<td>.000</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>N of valid Cases</td>
<td>2203</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 523.81.

b. Computed only for a 2x2 table
All assumptions for a $\chi^2$ analysis have been met. First, the researcher assumed the data are independent of each other based on what is known about the data collection process. Second, the expected frequency for each cell was at least five because the minimum expected count is 523.81 as indicated in the note under Table 14. The observed chi-square test showed there was a significant association between the delivery method and the Mathematics I achievement pass or fail score $\chi^2 (1) = 134.249, p < .001$. Therefore, the null hypothesis was rejected. The odds ratio for this association was 2.74, indicating a Mathematics I student taught in the traditional, face-to-face was 2.74 times more likely to receive a passing score than an online, Georgia Virtual School student.

Research Question Two

Research question two examined the relationship, if any, of mathematics achievement based on Mathematics II End of Course Test Scores has when comparing traditional, face-to-face and online modes of instruction. Pearson’s Chi-Square was used to test hypothesis two:

$H_0$: Students taking Mathematics II through online courseware will exhibit no statistically different achievement than students taking Mathematics II in the traditional classroom setting based on scores on the Mathematics II EOCT.

The Pearson Chi-Square was used to examine the association between delivery method (online versus traditional, face-to-face) and Mathematics II student achievement as measured by Mathematics II EOCT scores. The null hypothesis will be rejected if the $p$ value for the chi-square test is less than or equal to .05. According to Field (2009), there are two assumptions to be met for the chi-square test: The data are independent of
each other and the expected frequencies in each cell are at least five. According to the results there was a significant association between delivery method and Mathematics II achievement score. Table 15 below shows the chi-square Tests for the Mathematics II data.

Table 15

*Results of the Mathematics II Chi-Square Test (Pass/Fail)*

<table>
<thead>
<tr>
<th>Chi-Square Tests</th>
<th>Value</th>
<th>df</th>
<th>Asymp. Sig. (2-sided)</th>
<th>Exact Sig. (2-sided)</th>
<th>Exact Sig. (1-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>251.282</td>
<td>1</td>
<td>.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuity Correction</td>
<td>250.185</td>
<td>1</td>
<td>.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>254.896</td>
<td>1</td>
<td>.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fisher’s Exact Test</td>
<td></td>
<td></td>
<td></td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>N of valid Cases</td>
<td>3369</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 739.81.
b. Computed only for a 2x2 table

All assumptions for a $\chi^2$ analysis have been met. First, the researcher assumed the data are independent of each other based on what is known about the data collection process. Second, the expected frequency for each cell was at least five because the minimum expected count is 739.81 as indicated in the note under Table 15. The
observed chi-square test showed there was a significant association between the delivery method and the Mathematics II achievement pass or fail score $\chi^2 (1) = 251.282, p < .001$. Therefore, the null hypothesis was rejected. The odds ratio for this association was 3.10, indicating a Mathematics II student taught in the traditional, face-to-face (indicated as Non Georgia Virtual School on the table) was 3.10 times more likely to receive a passing score than a Georgia Virtual School student.

Summary

This chapter has reported the statistical findings of this study in response to the research questions and hypotheses driving the study, and provided an analysis of the data collected. The next and final chapter will provide a discussion of the conclusions, revisit the limitations, and provide recommendations for policy, practice and future research.
CHAPTER 5
DISCUSSION, IMPLICATIONS, AND RECOMMENDATIONS

Education is continuously changing from generation to generation. Currently, one of the most prominent changes being experienced is in technology. Technology is advancing rapidly and its advances are affecting every aspect of our daily lives. The use of instructional technology in education is no exception as it is common to see the use of several technological tools, such as computers, tablets, and cell phones, in classrooms around the country and at all grade levels. It is also becoming more prominent for school districts to allocate increased funds to make the above said technological tools more available in schools. Another trend in education is an increase in college course offerings using online instruction as the primary mode of instruction. These advancements have forced K-12 school districts to begin to explore the potential benefits of having high school courses offered partially or solely using an online delivery method.

The Georgia Department of Education (GADoE) has responded to the expansion of content delivery through online courseware by offering Georgia Virtual School to the students in the state. State Superintendent Dr. John Barge claims that his “vision is to make education work for all Georgians” (as cited in Pauly, 2011, p. 1). According to Pauly (2011), Georgia Virtual School increases accessibility and flexibility in their educational experience by offering full course content online and the ability for students to receive credit for those courses taken. Georgia Virtual School students must report to
their local school or assigned testing site to complete the End of Course Tests for the required courses (Georgia Virtual School, 2015).

This study has explored the relationship between the use of online courseware at Georgia Virtual School as an instructional delivery method and student achievement of 9th and 10th grade mathematics students as measured by Mathematics I and Mathematics II End of Course Test scores when compared to the same student achievement measure of students taught in the traditional, face-to-face classroom environment. Research and test scores show that mathematics is a weak subject for many students (Stevenson et al., 1990). Stevenson et al. (1990) explain “these studies document the profound underachievement in mathematics of American students compared to their peers in other countries” (p. 1053). As a mathematics teacher, this researcher was looking for ways to help students better understand and apply mathematical concepts. With the knowledge of the above information, the researcher of this study began to ponder if there are any benefits to high school students satisfying their mathematics credit requirements through content delivery with online courseware such as what is offered through Georgia Virtual School opposed to the traditional, face-to-face classroom setting.

The purpose of this quantitative study was to determine the association, if any, of the use of online courseware at Georgia Virtual School as an instructional delivery method on student achievement of 9th and 10th grade mathematics students as measured by Mathematics I and Mathematics II End of Course Tests (EOCT) scores. This study has contributed to the evidence investigating what impact, if any, online instruction has on
student achievement in mathematics as compared to the tradition face-to-face mode of instruction. The previous chapters have described the problem being addressed in this study, the research questions and hypotheses, the limitations and delimitations of this study, the theoretical framework at the foundation of this study, provided the definitions of key terms used in this study, provided a closer look at all variables included in this study and provided insight to what the current literature says about those variables, addressed the research design, participants, instrumentation, procedures, and data analysis procedures of this research that was used to accomplish the contribution of evidence to the body of literature available in this area, reported the statistical findings of this study in response to the research questions and hypotheses driving the study, and provided an analysis of the data collected. This chapter will provide a discussion of the conclusions, revisit the limitations, and provide recommendations for policy, practice and future research.

Research Questions

1. How does 9th grade student achievement on the Mathematics I EOCT of students in the traditional classroom setting relate to the scores of students taking Mathematics I through online courseware in Georgia?
2. How does 10th grade student achievement on the Mathematics II EOCT of students in the traditional classroom setting relate to the scores of students taking Mathematics II through online courseware in Georgia?
Research Hypotheses

1. \( H_0 \): Students taking Mathematics I through online courseware will exhibit no statistically different achievement than students taking Mathematics I in the traditional classroom setting based on scores on the Mathematics I EOCT.

3. \( H_0 \): Students taking Mathematics II through online courseware will exhibit no statistically different achievement than students taking Mathematics II in the traditional classroom setting based on scores on the Mathematics II EOCT.

Conclusions and Discussion

The purpose of this study was to determine the association, if any, between the traditional, face-to-face content delivery and the use of online courseware as an instructional delivery method for mathematics based on student achievement of 9th and 10th grade mathematics students as measured by Mathematics I and Mathematics II End of Course Tests (EOCT) scores. To achieve this, the researcher selected the chi-square contingency table as the statistical test for this study because Sprinthall (2012) explains that if a researcher has nominal data, a hypothesis of difference, independent selection with two or more measures then the most appropriate test is the chi-square contingency table. Due to the researcher only being able to receive frequency data from the Georgia Department of Education, the data she had access to was nominal. Furthermore, the researcher was interested in whether or not there is a relationship between these categorical data. Field (2009) explains that “if you want to see whether there’s a relationship between two categorical variables” you use Pearson’s chi square test (p
Field (2009) further explains, “this is an extremely elegant statistic based on the simple idea of comparing the frequencies you observe in certain categories to the frequencies you might expect to get in those categories by chance” (p. 688). The statistically significant results indicate that there is an association or relationship between mode of instruction for Mathematics I and Mathematics II and student achievement (Field, 2009).

The researcher initially created a 3x2 chi-square contingency table because the Mathematics I and Mathematics II End of Course Test (EOCT) scores are reported as does not meet, meets, and exceeds. However, many stakeholders in education are more concerned with simply pass or fail achievement scores and not necessarily driven by the does not meet, meets, and exceeds categories. Furthermore, Field (2009) states “odds ratios are most interpretable in 2x2 contingency tables and are probably not useful for larger contingency tables” (p. 699). Therefore, in the previous chapter the researcher not only provided chi-square results for the data split between does not meet, meets, and exceeds, but also as pass or fail results. The following discussion of these conclusions will address both the 3x2 and the collapsed 2x2 tables for each research question and hypothesis.

Research Question One

Research question one examined the relationship, if any, of mathematics achievement based on Mathematics I End of Course Test Scores has when comparing...
traditional, face-to-face and online modes of instruction. Pearson’s Chi-Square was used to test hypothesis one:

\[ H_0: \text{Students taking Mathematics I through online courseware will exhibit no statistically different achievement than students taking Mathematics I in the traditional classroom setting based on scores on the Mathematics I EOCT.} \]

3x2 chi-square contingency table results

The Pearson Chi-Square was used to examine the association between delivery method (online versus traditional, face-to-face) and Mathematics I student achievement as measured by Mathematics I EOCT scores. The null hypothesis was rejected because the \( p \) value for the chi-square test was less than or equal to .05. All assumptions for a \( \chi^2 \) analysis were met. First, the researcher assumed the data are independent of each other based on what is known about the data collection process. Second, the expected frequency for each cell was at least five because the minimum expected count is 133.70 as indicated in the note under Table 8. The observed chi-square test showed there was a significant association between the delivery method and the Mathematics I achievement score \( \chi^2 (2) = 238.233, p < .001 \). The odds ratios were calculated for the associations between does not meet and meets, does not meet and exceeds, and meets and exceeds. The odds ratio for the association between does not meet and meets was 1.88, indicating a Mathematics I, Georgia Virtual School student was 1.88 times more likely to receive a score of does not meet than a traditional, face-to-face student when compared to receiving a score of meets. The odds ratio for the association between does not meet and
exceeds was 14.36, indicating a Mathematics I, Georgia Virtual School student was 14.36 times more likely to receive a score of does not meet than a traditional, face-to-face student when compared to receiving a score of exceeds. The odds ratio for the association between meets and exceeds was 7.65, indicating a Mathematics I, Georgia Virtual School student was 7.65 times more likely to receive a score of meets than a traditional, face-to-face student when compared to receiving a score of exceeds.

The overall conclusion the researcher formed from this data analysis was that Mathematics I students who were taught in the traditional, face-to-face classroom were more academically successful that Georgia Virtual School students based on the standardized, Mathematics I End of Course Test scores. When comparing each score-reporting category to the other, the traditional, face-to-face classroom students outperformed the Georgia Virtual School students.

2x2 chi-square contingency table results

The Pearson Chi-Square was used to examine the association between delivery method (online versus traditional, face-to-face) and Mathematics I student achievement as measured by Mathematics I EOCT scores. The null hypothesis was rejected because the p value for the chi-square test is less than or equal to .05. All assumptions for a $\chi^2$ analysis have been met. First, the researcher assumed the data are independent of each other based on what is known about the data collection process. Second, the expected frequency for each cell was at least five because the minimum expected count was 523.81 as indicated in the note under Table 12. The observed chi-square test showed there was a
significant association between the delivery method and the Mathematics I achievement pass or fail score $\chi^2 (1) = 134.249$, $p < .001$. The odds ratio for this association was 2.74, indicating a Mathematics I student taught in the traditional, face-to-face was 2.74 times more likely to receive a passing score than an online, Georgia Virtual School student.

The overall conclusion the researcher formed from this data analysis was that Mathematics I students who were taught in the traditional, face-to-face classroom were more academically successful that Georgia Virtual School students based on the standardized, Mathematics I End of Course Test scores when collapsed into pass or fail scores because they are 2.74 times more likely to pass if they satisfy the course requirements in the traditional, face-to-face environment.

With all things considered from both the 3x2 and 2x2 contingency tables, it appears that the results from research question one are different from what the researcher expected based on the information found in previous studies. When reflecting back upon the studies reviewed in the literature review, one might expect to see positive effects on student achievement of the students who took Mathematics I through Georgia Virtual School in the online environment. While the researcher understands the results appear to be negative on the surface, she believes that there are possible explanations that would uncover the positive side of these results. Georgia Virtual School (2016) offers a variety of reasons why students choose to take GAVS courses from expanding their course options and relieving scheduling conflicts, to getting ahead, catching up if behind, and retaking courses they have previously failed. With some of these reasons in mind, even
though these students did not perform better on the End of Course Tests in Mathematics I these students are earning credit for this mathematics course when they may not have otherwise been able to.

Research Question Two

Research question two examined the relationship, if any, of mathematics achievement based on Mathematics II End of Course Test Scores has when comparing traditional, face-to-face and online modes of instruction. Pearson’s Chi-Square was used to test hypothesis two:

\( H_0: \) Students taking Mathematics II through online courseware will exhibit no statistically different achievement than students taking Mathematics II in the traditional classroom setting based on scores on the Mathematics II EOCT.

3x2 chi-square contingency table results.

The Pearson Chi-Square was used to examine the association between delivery method (online versus traditional, face-to-face) and Mathematics II student achievement as measured by Mathematics II EOCT scores. The null hypothesis was rejected because the \( p \) value for the chi-square test is less than or equal to .05. All assumptions for a \( \chi^2 \) analysis have been met. First, the researcher assumed the data are independent of each other based on what is known about the data collection process. Second, the expected frequency for each cell was at least five because the minimum expected count was 52.67 as indicated in the note under Table 9. The observed chi-square test showed there was a significant association between the delivery method and the Mathematics II achievement
score $\chi^2 (2) = 269.520, p < .001$. The odds ratios were calculated for the associations between does not meet and meets, does not meet and exceeds, and meets and exceeds.

The odds ratio for the association between does not meet and meets was 2.89, indicating a Mathematics II, Georgia Virtual School student was 2.89 times more likely to receive a score of does not meet than a traditional, face-to-face student when compared to receiving a score of meets. The odds ratio for the association between does not meet and exceeds was 9.75, indicating a Mathematics II, Georgia Virtual School student was 9.75 times more likely to receive a score of does not meet than a traditional, face-to-face student when compared to receiving a score of exceeds. The odds ratio for the association between meets and exceeds was 3.37, indicating a Mathematics II, Georgia Virtual School student was 3.37 times more likely to receive a score of meets than a traditional, face-to-face student when compared to receiving a score of exceeds.

The overall conclusion the researcher formed from this data analysis was that Mathematics II students who were taught in the traditional, face-to-face classroom were more academically successful that Georgia Virtual School students based on the standardized, Mathematics II End of Course Test scores. When comparing each score-reporting category to the other, the traditional, face-to-face classroom students outperformed the Georgia Virtual School students.

2x2 chi-square contingency table results.

The Pearson Chi-Square was used to examine the association between delivery method (online versus traditional, face-to-face) and Mathematics II student achievement
as measured by Mathematics II EOCT scores. The null hypothesis was rejected because the $p$ value for the chi-square test is less than or equal to .05. All assumptions for a $\chi^2$ analysis have been met. First, the researcher assumed the data are independent of each other based on what is known about the data collection process. Second, the expected frequency for each cell was at least five because the minimum expected count was 739.81 as indicated in the note under Table 13. The observed chi-square test showed there was a significant association between the delivery method and the Mathematics I achievement pass or fail score $\chi^2 (1) = 251.282, p < .001$. Therefore, the null hypothesis was rejected.

The odds ratio for this association was 3.10, indicating a Mathematics II student taught in the traditional, face-to-face (indicated as Non Georgia Virtual School on the table) was 3.10 times more likely to receive a passing score than a Georgia Virtual School student.

The overall conclusion the researcher formed from this data analysis was that Mathematics II students who were taught in the traditional, face-to-face classroom were more academically successful that Georgia Virtual School students based on the standardized, Mathematics II End of Course Test scores when collapsed into pass or fail scores because they were 3.10 times more likely to pass if they satisfy the course requirements in the traditional, face-to-face environment.

With all things considered from both the 3x2 and 2x2 contingency tables, it appears that the results from research question two are also different from what the researcher expected based on the information found in previous studies. When reflecting back upon the studies reviewed in the literature review, one might expect to see positive
effects on student achievement of the students who took Mathematics II through Georgia Virtual School in the online environment when compared to the students in the traditional, face-to-face classroom environment. While the researcher understands the results appear to be negative on the surface, she believes that there are possible explanations that would uncover the positive side of these results. Georgia Virtual School (2016) offers a variety of reasons why students choose to take GAVS courses from expanding their course options and relieving scheduling conflicts, to getting ahead, catching up if behind, and retaking courses they have previously failed. With some of these reasons in mind, even though these students did not perform better on the End of Course Tests in Mathematics I these students are earning credit for this mathematics course when they may not have otherwise been able to.

Limitations

The limitations of this study included the use of technology in the traditional, face-to-face classrooms, permissions, or lack of permissions, granted by the state in which the study is taking place, and lack of information about the student. Some teachers in the traditional, face-to-face classroom already utilize technology to supplement their instruction. This limited the study because the data reported does not distinguish the traditional classrooms that did and did not use technology as a supplemental, instructional tool.

The study was further limited by the state of Georgia’s board of education in what the researcher was allowed to access and report about the students within the state. For
example, the researcher was unable to identify students who were first time test takers and those who were not.

Additionally, a potential limitation of this study was the academic achievement level of the students who selected the virtual route to satisfying the Mathematics I or Mathematics II credit requirements. The researcher did not know why the students who opt to take Mathematics I or Mathematics II online chose the online route rather than the traditional, face-to-face classroom or the academic achievement level. If the lower performing students tend to select the online route then it would make sense for the students who opted for the traditional, face-to-face route to outperform the virtual school students. The opposite is true if the higher performing students selected the virtual school route; it would make sense that they would outperform the traditional, face-to-face students.

Other factors that limited this study but were out of the control of the researcher were that the Georgia Department of Education was only willing to release frequency counts of students who do not meet, meets, and exceeds standards on the Mathematics I and Mathematics II End of Course Tests separated by mode of instruction, district, and year. This created a situation where the researcher could only use nominal data to compare the achievement scores based on mode of instruction.

The Georgia Department of Education was also not able to guarantee that all non-Georgia Virtual School students received the same type of instruction without the use of any supplementary use of instructional, technological tools. However, all teachers have
their own style of teaching, just like all students have their preferred learning style. The use of technological tools in the traditional, face-to-face classroom setting does not change the setting from traditional to an online setting, and, thus does not affect what the researcher is attempting to achieve from this study.

Recommendations for Policy or Practice

As a teacher, the researcher was concerned by these results because, truth be told, any educator wants every student to be given an equal opportunity for education in the least restrictive environment possible. Cheung and Slavin (2013) explain:

Technology has infiltrated every aspect of modern life. Classrooms are no exception. School districts across the country have been investing a substantial amount of their annual budgets on educational technology in an effort to boost academic performance in the past two decades. In addition, compared to the situation a couple of decades ago, schools are in a much better position to implement educational technology in their classrooms. Many teachers now are more experienced and willing to use educational technology in their classroom instruction, and educational technology is more affordable compared to a decade ago. Undoubtedly, educational technology will continue to play an increasingly important role in the years to come. So the question is no longer whether teachers should use educational technology or not, but rather how best to incorporate various educational technology applications into classroom settings. (pp. 19-20)
Some students need to attend Georgia Virtual School as their least restrictive environment for whatever reason and the use of online courses is becoming more prevalent, so the results of those students being less likely to earn a passing score on the EOCT is concerning. This brought the researcher to a few recommendations for policy or practice.

First, the results of this study suggest districts should revisit the training and implementation of Georgia Virtual School’s curriculum. As discussed in chapter two Protheroe (2005) contends that computer technology has been shown to improve student achievement when implemented properly. Cheung and Slavin (2013) also support proper implementation of technological tools and explained that by stating, “adhering to program usage guidelines suggested by technology providers may be helpful in improving student achievement” (p. 20). Being that the results of this study did not show an improvement in student achievement of students who satisfy the requirements of Mathematics I and Mathematics II through Georgia Virtual School, perhaps Georgia districts should review Protheroe’s (2005) four principles used to guide effective integration of technology in comparison to Georgia Virtual School:

1. Teachers, not technology, are the key to unlocking success” and a teacher’s training in, knowledge of, and attitudes toward technology are essential in effective technology integration;

2. Curriculum design is critical to success;
3. Technology design largely determines the impact of integration efforts on student achievement;

4. Ongoing formative evaluations are necessary for continued improvements in technology integration. (p. 47)

Since these principles are the key to successful implementation of technology, policy makers should consider using these principles as a guide to review and make changes to the curriculum delivery of Georgia Virtual School. Georgia Virtual School teachers should be properly trained to utilize the technological tools they are given in the intended, most effective ways possible.

A second suggestion for policy or practice that has emerged from this study is based on Voogt and Knezek’s (2008) explanation that “research has shown that the most successful students in the virtual high school in the USA are those who are most capable of regulating their own learning” (p. xxxvii). So maybe some sort of evaluation of students who wish to satisfy mathematics course requirements through Georgia Virtual School should be administered to determine if students are capable of self-regulating their learning. An assessment could be used to determine if a student possesses those more desirable characteristics for success in the virtual environment.

Recommendations for Future Research

Throughout the duration of this study, ideas for future research surfaced. Based on the findings of this study the researcher developed several recommendations for future research to offer.
First, the researcher suggests that future quantitative studies are needed to further explore the impact online content delivery has on mathematics achievement when actual raw scores are reported rather than nominal data, as was the case in this study. This study was limited by the type of data the state of Georgia released for use in this study. Having raw scores to analyze through a different statistical test may be valuable to many stakeholders in the field of education.

Second, the researcher suggests that future quantitative studies are needed to explore the relationship of online versus traditional, face-to-face delivery methods and student achievement in other subject areas. Several scholars suggest that more research is needed to support or disprove that instructional technology has a positive effect on student achievement (Noeth & Volkov, 2004; Protheroe, 2005; Schrum et al., 2007; Roblyer, 2005; Roschelle, Pea, Hoadley, Gordin, and Means, 2001; Voogt & Knezek, 2008). While this study has offered some additional insight into the mathematics content area, other subject areas were not considered in this study. Therefore, further research is still needed in other content areas.

The researcher also suggests that future research is needed to identify the reasons why students choose to satisfy high school, mathematics course requirements in the online setting rather than through the traditional, face-to-face classroom setting and compare results based on the different reasons that emerge. Georgia Virtual School (2016) offers a variety of reasons why students choose to take GAVS courses:
• To increase their content choices.
• To relieve scheduling conflicts.
• To get ahead in their course work.
• To retake a previously failed class so they can graduate on time.
• To catch up on missing, required courses after transferring from another school system.
• They are homebound.

Although the results of this study appear to be negative and thus contradictory of what was expected based on previous research, the researcher of this study believes that the reasons why the students selected to take their mathematics courses online would possibly shed some light on this issue. The researcher wonders if the students who were taking their mathematics courses online are students who would have otherwise not been able to graduate. If that is true, the results do not appear so negative. Maybe these students did not test as well, but maybe they gained credit for their mathematics courses when they would not have had other opportunities to do so.

The researcher also suggests that future research is needed to compare academic achievement of students in different online virtual school settings and what the differences are within those online settings. This study online considered Georgia Virtual School. There are other online school setting available and a comparison may prove to be beneficial to several stakeholders in education. Such research may be able to identify
what works well in an online setting and what does not which could essentially lead to the revision and development of more effective online programs.

As previously discussed, the existing research suggests educational technology has more positive effects on student achievement than negative effects. However, scholars suggest that the potential to increase student achievement is linked to the proper training and implementation of those technologies (Noeth and Volkov, 2004; Protheroe, 2005). With that being said, the researcher suggests that future research is needed to explore the impact of a teacher’s technology training and the impact it has on student achievement in the online setting. The seemingly negative outcome of this study may be due to improper technology implementation or lack of efficient training for the online teachers.

Finally, the researcher suggests that future research is needed to explore the use of technology in the traditional, face-to-face classroom setting and how student achievement compares with the different levels of technological implementation. The researcher has previously pointed out that the study is limited by the lack of knowledge of which teachers in the traditional, face-to-face classrooms supplemented their instruction with technological tools. Knowing that limitation, the researcher wonders if there is a level of technological implementation that is most efficient or more successful at increasing student achievement.

Teaching, in any capacity, is hard: rewarding, but hard. Educational practices are continually evolving and classroom settings are advancing. Anyone in the field of
education should be trying their best to keep up with the advancements of society to better prepare all students for their future.
REFERENCES


Campbell, L., & Campbell, B. (1999). Multiple intelligences and student achievement: Success stories from six schools. ASCD.


APPENDICES
APPENDIX A

GEORGIA END-OF-COURSE MATHEMATICS I:
ALGEBRA/GEOMETRY/STATISTICS PERFORMANCE LEVEL DESCRIPTORS
Georgia Department of Education (2015a)

Georgia End-of-Course
Mathematics I: Algebra/Geometry/Statistics
Performance Level Descriptors

EXCEEDS STANDARD

General Performance Level Descriptors

Students performing at this level demonstrate a comprehensive understanding and mastery of the procedures and concepts in the content domains of algebra, geometry, and data analysis. They routinely apply their understanding by making connections, reasoning, communicating, using representations, and solving problems. Performance at this level is indicated by the use of complex strategies and higher-level cognitive skills to analyze and solve mathematical and real-world problems.

Specific Performance Level Descriptors

Students at this level are able to do the following:

Algebra

- Analyze and evaluate the characteristics of basic functions and transformations of functions.
- Interpret and apply the characteristics of a function in a given context.
- Analyze and evaluate both constant and variable rates of change within the basic function families.
- Analyze and evaluate sequences as functions.
- Evaluate, simplify, translate, and apply complex expressions or equations using a variety of appropriate, equivalent forms.
- Use a variety of techniques to analyze and solve quadratic equations, including those containing radicals, square roots, and rational expressions.
Geometry

- Create proofs and solve for unknowns by analyzing and evaluating the characteristics of complex geometric figures in a coordinate plane.
- Evaluate logical arguments and draw appropriate conclusions in complex situations.
- Analyze and apply the properties of and relationships among special quadrilaterals.
- Understand and apply triangle theorems and postulates in complex situations.

Data Analysis and Probability

- Use principles of counting, permutations, and/or combinations to analyze and evaluate the number of outcomes in a given situation.
- Understand and apply the basic laws of probability, including expected value, in complex situations.
- Compare and evaluate summary statistics in a variety of complex situations.
- Analyze and evaluate the mean absolute deviation of a complex data set.
MEETS STANDARD

General Performance Level Descriptors

Students performing at this level demonstrate an understanding of and proficiency with the procedures and concepts in the content domains of algebra, geometry, and data analysis. They generally apply their understanding by making connections, reasoning, communicating, using representations, and solving problems. Performance at this level is indicated by the use of effective strategies and some higher-level cognitive skills to analyze and solve mathematical and real-world problems.

Specific Performance Level Descriptors

Students at this level are able to do the following:

**Algebra**

- Describe, graph, and identify the characteristics of basic functions and their transformations.
- Describe and explain the characteristics of functions with and without simple contexts.
- Describe and explain both constant and variable rates of change within the basic function families.
- Recognize sequences as functions with domains that are whole numbers.
- Evaluate, simplify, factor, and operate with expressions or equations using appropriate, equivalent forms.
- Solve simple quadratic equations, including those containing radicals, square roots, and rational expressions.

**Geometry**

- Create proofs and solve for unknowns by describing and explaining the characteristics of simple geometric figures in a coordinate plane.
- Use logical reasoning to draw appropriate conclusions.
- Describe and use the properties of and relationships among special quadrilaterals.
- Explain and use triangle theorems and postulates.
Data Analysis and Probability

- Use principles of counting, permutations, and/or combinations to determine the number of outcomes in a given situation.
- Describe and use the basic laws of probability, including expected value.
- Compare summary statistics in a variety of situations.
- Determine the mean absolute deviation of a simple data set.

DOES NOT MEET STANDARD

General Performance Level Descriptors

Students performing at this level demonstrate a minimal understanding of and proficiency with the procedures and concepts in the content domains of algebra, geometry, and data analysis. They are occasionally able to make connections, reason, communicate, use representations, and solve problems. Problem solving is based on their ability to memorize some key concepts and perform routine procedures.
Specific Performance Level Descriptors

Students at this level are able to do the following:

**Algebra**

- Recognize and identify some of the characteristics of some basic functions in function notation or graph form.
- Identify some of the characteristics of some basic functions.
- Recognize a constant rate of change in some simple functions.
- Recognize and extend some simple sequences.
- Simplify and perform basic operations with simple algebraic and numeric expressions.
- Recognize solutions to some simple linear and quadratic equations.

**Geometry**

- Solve for unknowns by identifying some characteristics of simple geometric figures in a coordinate plane.
- Recognize appropriate conclusions in some simple situations.
- Recognize and identify some properties of and relationships among special quadrilaterals in simple situations.
- Recognize and use some triangle theorems and postulates in simple situations.

**Data Analysis and Probability**

- Use principles of counting, permutations, and/or combinations to recognize the number of outcomes in some simple situations.
- Find the probability of an event in a simple situation.
- Recognize and identify some simple summary statistics.
- Recognize the mean absolute deviation in a simple situation in which all needed information is given.
APPENDIX B

GEORGIA END-OF-COURSE MATHEMATICS II:
ALGEBRA/GEOMETRY/STATISTICS PERFORMANCE LEVEL DESCRIPTORS
Georgia Department of Education (2015a)

Georgia End of Course Test
Mathematics II: Geometry/Algebra II/Statistics
Performance Level Descriptors

EXCEEDS STANDARD

General Performance Level Descriptors

Students performing at this level demonstrate comprehensive understanding and mastery of the procedures and concepts in the content domains of algebra, geometry, and data analysis. They routinely apply their understanding by making connections, reasoning, communicating, using representations, and solving problems. Performance at this level is indicated by the use of complex strategies to analyze and solve mathematical and real-world problems using higher-level cognitive skills.

Specific Performance Level Descriptors

Students at this level are able to do the following:

Algebra

- Analyze and evaluate the characteristics of step, piecewise, exponential, and quadratic functions, as well as inverses of functions.
- Interpret and apply the characteristics of functions with regard to a given context.
- Analyze and evaluate rates of change, both constant and variable, within the basic function families.
- Analyze and evaluate geometric and arithmetic sequences as functions.
- Analyze and solve quadratic equations using a variety of techniques.
- Represent, simplify, and operate with complex numbers.

Geometry

- Understand and apply right triangle relationships, including trigonometric relationships in complex situations.
- Analyze and apply the properties of and relationships among circles and associated lines, segments, and angles.
- Analyze and solve complex problems involving measures related to spheres.
Data Analysis and Probability

- Analyze and evaluate sample data, making inferences about population means and standard deviations and using these inferences to compare data sets.
- Understand and apply the distinctions between sample data and population data.
- Understand and apply algebraic models to quantify the association between two quantitative variables.
- Understand and describe in-depth issues that arise when using data to explore the relationship between two variables.

MEETS STANDARD

General Performance Level Descriptors

Students performing at this level demonstrate understanding of and proficiency with the procedures and concepts in the content domains of algebra, geometry, and data analysis. They generally apply their understanding by making connections, reasoning, communicating, using representations, and solving problems. Performance at this level is indicated by the use of effective strategies to analyze and solve mathematical and real-world problems using some higher-level cognitive skills.

Specific Performance Level Descriptors

Students at this level are able to do the following:

Algebra

- Describe and graph basic functions and their transformations, as well as identify their characteristics.
- Describe and explain the characteristics of functions with simple context.
- Describe and explain rates of change, both constant and variable, within families of functions.
- Recognize and represent geometric and arithmetic sequences as functions with domains that are whole numbers.
- Evaluate, simplify, factor, and operate with expressions or equations, recognizing appropriate equivalent forms.
- Solve quadratic equations expressed in any form.
- Perform basic arithmetic operations with complex numbers.
Geometry

- Describe and apply right triangle relationships, including trigonometric relationships in routine situations.
- Describe and apply the properties of and relationships among circles and associated lines, segments, and angles.
- Solve problems involving measures related to spheres.

Data Analysis and Probability

- Calculate population means and standard deviations and use them to compare data sets.
- Recognize the distinction between sample data and population data.
- Use algebraic models to model the association between two quantitative variables.
- Recognize some of the issues that arise when using data to explore the relationship between two variables.

DOES NOT MEET STANDARD

General Performance Level Descriptors

Students performing at this level demonstrate minimal understanding of and proficiency with the procedures and concepts in the content domains of algebra, geometry, and data analysis. They are occasionally able to make connections, reason, communicate, use representations, and solve problems. Problem solving is based on their ability to memorize some key concepts and perform routine procedures.

Specific Performance Level Descriptors

Students at this level are able to do the following:

Algebra

- Recognize and identify some functions and their transformations, as well as identify their characteristics.
- Identify some of the characteristics of some functions and their inverses.
- Recognize constant and variable rates of change in some functions.
- Recognize and extend some geometric and arithmetic sequences.
- Simplify and perform basic operations with algebraic and numeric expressions.
- Recognize solutions to linear and some quadratic equations.
Geometry

- Identify and use some right triangle trigonometry relationships.
- Recognize and identify some properties of and relationships among circles and lines.
- Compute volume and surface areas of spheres in routine contexts.

Data Analysis and Probability

- Compute population means and standard deviations in routine contexts.
- Recognize that sample data and population data are different.
- Recognize and identify quantitative relationships between two variables that are modeled by linear and nonlinear functions.
- Recognize some issues that arise when using data to explore the relationship between two variables.
APPENDIX C

MATHEMATICS I GEORGIA PERFORMANCE STANDARDS
**Georgia Performance Standards**  
**Mathematics I**

**ALGEBRA**  
Students will explore functions and solve simple equations. Students will simplify and operate with radical, polynomial, and rational expressions.

**MM1A1.** Students will explore and interpret the characteristics of functions, using graphs, tables, and simple algebraic techniques.
- Represent functions using function notation.
- Graph the basic functions \( f(x) = x^n \), where \( n \) is 1 to 3, \( f(x) = \sqrt{x} \), \( f(x) = |x| \), and \( f(x) = \frac{1}{x} \).
- Graph transformations of basic functions including vertical shifts, stretches, and shrinks, as well as reflections across the \( x \)- and \( y \)-axes.
- Investigate and explain the characteristics of a function: domain, range, zeros, intercepts, intervals of increase and decrease, maximum and minimum values, and end behavior.
- Relate to a given context the characteristics of a function, and use graphs and tables to investigate its behavior.
- Recognize sequences as functions with domains that are whole numbers.
- Explore rates of change, comparing constant rates of change (i.e., slope) versus variable rates of change. Compare rates of change of linear, quadratic, square root, and other function families.
- Determine graphically and algebraically whether a function has symmetry and whether it is even, odd, or neither.
- Understand that any equation in \( x \) can be interpreted as the equation \( f(x) = g(x) \), and interpret the solutions of the equation as the \( x \)-value(s) of the intersection point(s) of the graphs of \( y = f(x) \) and \( y = g(x) \).

**MM1A2.** Students will simplify and operate with radical expressions, polynomials, and rational expressions.
- Simplify algebraic and numeric expressions involving square root.
- Perform operations with square roots.
- Add, subtract, multiply, and divide polynomials.
- Expand binomials using the Binomial Theorem.
- Add, subtract, multiply, and divide rational expressions.
- Factor expressions by greatest common factor, grouping, trial and error, and special products limited to the formulas below.


\[(x + y)^2 = x^2 + 2xy + y^2\]
\[(x - y)^2 = x^2 - 2xy + y^2\]
\[(x + y)(x - y) = x^2 - y^2\]
\[(x + a)(x + b) = x^2 + (a + b)x + ab\]
\[(x + y)^3 = x^3 + 3x^2y + 3xy^2 + y^3\]
\[(x - y)^3 = x^3 - 3x^2y + 3xy^2 - y^3\]

g. Use area and volume models for polynomial arithmetic.

**MM1A3. Students will solve simple equations.**

a. Solve quadratic equations in the form \(ax^2 + bx + c = 0\), where \(a = 1\), by using factorization and finding square roots where applicable.

b. Solve equations involving radicals such as \(\sqrt{x} + b = c\), using algebraic techniques.

c. Use a variety of techniques, including technology, tables, and graphs, to solve equations resulting from the investigation of \(x^2 + bx + c = 0\).

d. Solve simple rational equations that result in linear equations or quadratic equations with leading coefficient of 1.

**GEOMETRY**

Students will explore, understand, and use the formal language of reasoning and justification. Students will apply properties of polygons and determine distances and points of concurrency.

**MM1G1. Students will investigate properties of geometric figures in the coordinate plane.**

a. Determine the distance between two points.

b. Determine the distance between a point and a line.

c. Determine the midpoint of a segment.

d. Understand the distance formula as an application of the Pythagorean theorem.

e. Use the coordinate plane to investigate properties of and verify conjecture related to triangles and quadrilaterals.

**MM1G2. Students will understand and use the language of mathematical argument and justification.**

a. Use conjecture, inductive reasoning, deductive reasoning, counterexamples, and indirect proof as appropriate.

b. Understand and use the relationships among a statement and its converse, inverse, and contrapositive.
MM1G3. Students will discover, prove, and apply properties of triangles, quadrilaterals, and other polygons.
   a. Determine the sum of interior and exterior angles in a polygon.
   b. Understand and use the triangle inequality, the side-angle inequality, and the exterior-angle inequality.
   c. Understand and use congruence postulates and theorems for triangles (SSS, SAS, ASA, AAS, HL).
   d. Understand, use, and prove properties of and relationships among special quadrilaterals: parallelogram, rectangle, rhombus, square, trapezoid, and kite.
   e. Find and use points of concurrency in triangles: incenter, orthocenter, circumcenter, and centroid.

DATA ANALYSIS AND PROBABILITY
Students will use counting techniques and determine probability. Students will demonstrate understanding of data analysis by posing questions to be answered by collecting data. Students will organize, represent, investigate, interpret, and make inferences from data.

MM1D1. Students will determine the number of outcomes related to a given event.
   a. Apply the addition and multiplication principles of counting.
   b. Calculate and use simple permutations and combinations.

MM1D2. Students will use the basic laws of probability.
   a. Find the probabilities of mutually exclusive events.
   b. Find the probabilities of dependent events.
   c. Calculate conditional probabilities.
   d. Use expected value to predict outcomes.

MM1D3. Students will relate samples to a population.
   a. Compare summary statistics (mean, median, quartiles, and interquartile range) from one sample data distribution to another sample data distribution in describing center and variability of the data distributions.
   b. Compare the averages of the summary statistics from a large number of samples to the corresponding population parameters.
   c. Understand that a random sample is used to improve the chance of selecting a representative sample.

MM1D4. Students will explore variability of data by determining the mean absolute deviation (the average of the absolute values of the deviations).
Terms/Symbols:
function, domain, range, zero of function, quadratic function, even function, odd function, radical expression, rational expression, area model for polynomial arithmetic, volume model for polynomial arithmetic, monomial, binomial, trinomial, radical conjugates, conjecture, inductive reasoning, deductive reasoning, definition, axiom, theorem, counterexample, indirect proof, converse, inverse, contrapositive, kite, incentre, orthocentre, circumcentre, centroid, points of concurrence, angle bisectors, medians of triangle, altitudes of triangle, permutations (\(nP\)), combinations (\(nC\)), mutually exclusive events, dependent events, conditional probability, expected value, quartile, interquartile range, deviation, mean absolute deviation

Process Standards
The following process standards are essential to mastering each of the mathematics content standards. They emphasize critical dimensions of the mathematical proficiency that all students need.

MM1P1. Students will solve problems (using appropriate technology).
   a. Build new mathematical knowledge through problem solving.
   b. Solve problems that arise in mathematics and in other contexts.
   c. Apply and adapt a variety of appropriate strategies to solve problems.
   d. Monitor and reflect on the process of mathematical problem solving.
MMIP2. Students will reason and evaluate mathematical arguments.
   a. Recognize reasoning and proof as fundamental aspects of mathematics.
   b. Make and investigate mathematical conjecture.
   c. Develop and evaluate mathematical arguments and proofs.
   d. Select and use various types of reasoning and methods of proof.

MMIP3. Students will communicate mathematically.
   a. Organize and consolidate their mathematical thinking through communication.
   b. Communicate their mathematical thinking coherently and clearly to peers, teachers, and others.
   c. Analyze and evaluate the mathematical thinking and strategies of others.
   d. Use the language of mathematics to express mathematical ideas precisely.

MMIP4. Students will make connections among mathematical ideas and to other disciplines.
   a. Recognize and use connections among mathematical ideas.
   b. Understand how mathematical ideas interconnect and build on one another to produce a coherent whole.
   c. Recognize and apply mathematics in contexts outside of mathematics.

MMIP5. Students will represent mathematics in multiple ways.
   a. Create and use representations to organize, record, and communicate mathematical ideas.
   b. Select, apply, and translate among mathematical representations to solve problems.
   c. Use representations to model and interpret physical, social, and mathematical phenomena.
APPENDIX D

MATHEMATICS II GEORGIA PERFORMANCE STANDARDS
NUMBER AND OPERATIONS
Students will use the complex number system.

MM2N1. Students will represent and operate with complex numbers.
   a. Write square roots of negative numbers in imaginary form.
   b. Write complex numbers in the form $a + bi$.
   c. Add, subtract, multiply, and divide complex numbers.
   d. Simplify expressions involving complex numbers.

ALGEBRA
Students will investigate piecewise, exponential, and quadratic functions, using
numerical, analytical, and graphical approaches, focusing on the use of these functions in
problem-solving situations. Students will solve equations and inequalities and explore
inverses of functions.

MM2A1. Students will investigate step and piecewise functions, including greatest
integer and absolute value functions.
   a. Write absolute value functions as piecewise functions.
   b. Investigate and explain characteristics of a variety of piecewise functions
      including domain, range, vertex, axis of symmetry, zeros, intercepts,
      extrema, points of discontinuity, intervals over which the function is
      constant, intervals of increase and decrease, and rates of change.
   c. Solve absolute value equations and inequalities analytically, graphically, and
      by using appropriate technology.

MM2A2. Students will explore exponential functions.
   a. Extend properties of exponents to include all integer exponents.
   b. Investigate and explain characteristics of exponential functions, including
      domain and range, asymptotes, zeros, intercepts, intervals of increase and
      decrease, rates of change, and end behavior.
   c. Graph functions as transformations of $f(x) = a^x$.
   d. Solve simple exponential equations and inequalities analytically, graphically,
      and by using appropriate technology.
   e. Understand and use basic exponential functions as models of real
      phenomena.
f. Understand and recognize geometric sequences as exponential functions with domains that are whole numbers.
g. Interpret the constant ratio in a geometric sequence as the base of the associated exponential function.

**MM2A3. Students will analyze quadratic functions in the forms** $f(x) = ax^2 + bx + c$ and $f(x) = a(x - h)^2 + k$.

a. Convert between standard and vertex form.
b. Graph quadratic functions as transformations of the function $f(x) = x^2$.
c. Investigate and explain characteristics of quadratic functions, including domain, range, vertex, axis of symmetry, zeros, intercepts, extrema, intervals of increase and decrease, and rates of change.
d. Explore arithmetic series and various ways of computing their sums.
e. Explore sequences of partial sums of arithmetic series as examples of quadratic functions.

**MM2A4. Students will solve quadratic equations and inequalities in one variable.**

a. Solve equations graphically using appropriate technology.
b. Find real and complex solutions of equations by factoring, taking square roots, and applying the quadratic formula.
c. Analyze the nature of roots using technology and using the discriminant.
d. Solve quadratic inequalities both graphically and algebraically, and describe the solutions using linear inequalities.

**MM2A5. Students will explore inverses of functions.**

a. Discuss the characteristics of functions and their inverses, including one-to-one, domain, and range.
b. Determine inverses of linear, quadratic, and power functions and functions of the form $f(x) = \frac{a}{x}$, including the use of restricted domains.
c. Explore the graphs of functions and their inverses.
d. Use composition to verify that functions are inverses of each other.

**GEOMETRY**

Students will explore right triangles and right-triangle trigonometry. They will understand and apply properties of circles and spheres, and use them in determining related measures.
MM2G1. Students will identify and use special right triangles.
   a. Determine the lengths of sides of 30°-60°-90° triangles.
   b. Determine the lengths of sides of 45°-45°-90° triangles.

MM2G2. Students will define and apply sine, cosine, and tangent ratios to right triangles.
   a. Discover the relationship of the trigonometric ratios for similar triangles.
   b. Explain the relationship between the trigonometric ratios of complementary angles.
   c. Solve application problems using the trigonometric ratios.

MM2G3. Students will understand the properties of circles.
   a. Understand and use properties of chords, tangents, and secants as an application of triangle similarity.
   b. Understand and use properties of central, inscribed, and related angles.
   c. Use the properties of circles to solve problems involving the length of an arc and the area of a sector.
   d. Justify measurements and relationships in circles using geometric and algebraic properties.

MM2G4. Students will find and compare the measures of spheres.
   a. Use and apply surface area and volume of a sphere.
   b. Determine the effect on surface area and volume of changing the radius or diameter of a sphere.

DATA ANALYSIS AND PROBABILITY
Students will demonstrate understanding of data analysis by posing questions to be answered by collecting data. Students will organize, represent, investigate, interpret, and make inferences from data. They will use regression to analyze data and to make inferences.

MM2D1. Using sample data, students will make informal inferences about population means and standard deviations.
   a. Pose a question and collect sample data from at least two different populations.
   b. Understand and calculate the means and standard deviations of sets of data.
   c. Use means and standard deviations to compare data sets.
d. Compare the means and standard deviations of random samples with the corresponding population parameters, including those population parameters for normal distributions. Observe that the different sample means vary from one sample to the next. Observe that the distribution of the sample means has less variability than the population distribution.

**MM2D2. Students will determine an algebraic model to quantify the association between two quantitative variables.**

- a. Gather and plot data that can be modeled with linear and quadratic functions.
- b. Examine the issues of curve fitting by finding good linear fits to data using simple methods such as the median-median line and "eyeballing."
- c. Understand and apply the processes of linear and quadratic regression for curve fitting using appropriate technology.
- d. Investigate issues that arise when using data to explore the relationship between two variables, including confusion between correlation and causation.

**Terms/Symbols:**
- piecewise function, exponential function, step function, extrema, point of discontinuity, asymptote, geometric sequence, standard form, vertex form, quadratic formula, discriminant, root, inverse of a function, one-to-one function, composition of functions, $f^{-1}$, sine, cosine, tangent, trigonometric ratio, complementary angles, trigonometry, chord, tangent, secant, central angle, inscribed angle, arc, sector, inference, population mean, standard deviation, curve fitting, linear regression, median-median line, algebraic model, quadratic regression

**Process Standards**
The following process standards are essential to mastering each of the mathematics content standards. They emphasize critical dimensions of the mathematical proficiency that all students need.

**MM2P1. Students will solve problems (using appropriate technology).**

- a. Build new mathematical knowledge through problem solving.
- b. Solve problems that arise in mathematics and in other contexts.
- c. Apply and adapt a variety of appropriate strategies to solve problems.
- d. Monitor and reflect on the process of mathematical problem solving.
MM2P2. Students will reason and evaluate mathematical arguments.
   a. Recognize reasoning and proof as fundamental aspects of mathematics.
   b. Make and investigate mathematical conjectures.
   c. Develop and evaluate mathematical arguments and proofs.
   d. Select and use various types of reasoning and methods of proof.

MM2P3. Students will communicate mathematically.
   a. Organize and consolidate their mathematical thinking through communication.
   b. Communicate their mathematical thinking coherently and clearly to peers, teachers, and others.
   c. Analyze and evaluate the mathematical thinking and strategies of others.
   d. Use the language of mathematics to express mathematical ideas precisely.

MM2P4. Students will make connections among mathematical ideas and to other disciplines.
   a. Recognize and use connections among mathematical ideas.
   b. Understand how mathematical ideas interconnect and build on one another to produce a coherent whole.
   c. Recognize and apply mathematics in contexts outside of mathematics.

MM2P5. Students will represent mathematics in multiple ways.
   a. Create and use representations to organize, record, and communicate mathematical ideas.
   b. Select, apply, and translate among mathematical representations to solve problems.
   c. Use representations to model and interpret physical, social, and mathematical phenomena.
APPENDIX E

EMAIL CORRESPONDANCE FOR PERMISSION TO REPRINT FIGURE
From: "Walshaw, Margaret" <M.A.Walshaw@massey.ac.nz>
Date: January 29, 2017 at 4:33:47 PM EST
To: Ami Lenderman <amilenderman@me.com>, "Anthony, Gienda" <G.J.Anthony@massey.ac.nz>
Subject: RE: Reprint Permissions

Hi Ami

Thank you for your message and your interest in our work. I am happy to give my permission for you to reprint the design.

Wishing you every success with your dissertation.

Kind regards
Margaret

From: Ami Lenderman [mailto:amilenderman@me.com]
Sent: Monday, 30 January 2017 10:23 a.m.
To: Anthony, Gienda; Walshaw, Margaret
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