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Mathematics Curricula and Their Impact on Students' Mathematic Achievement

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MATHEMATICS CURRICULA AND THEIR IMPACT ON STUDENTS' MATHEMATIC ACHIEVEMENT

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ABSTRACT

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There is a broad consensus across the political spectrum on the need for K-12 education reform. The Obama administration focused on early childhood programs, common standards, charter schools, and more effective teachers. As school districts align curriculum and teaching practices with common core standards, standards-based mathematics programs are replacing traditional curriculum. The purpose of this study was to examine different types of curricula used to teach mathematics and its impact on student academic achievement. This research study analyzed the results of the 2013 Fourth Grade Mathematics, National Assessment of Educational Progress (NAEP). Variables were developed from responses to school surveys that are part of this dataset. Variables used were the school reported use of curriculum in the classroom. The participants in this study consist of fourth grade mathematics students across the United States, including English Language Learners (Ells), both male and female, attending public and private schools. The research design of this study was a non- experimental cross-sectional explanatory design (Johnson, 2001) that used a multiple regression analysis to measure the relationship of the predictive variables (commercially designed math curriculum, math curriculum structured by teacher discretion, math curriculum structured by state standards, math curriculum structured by district standards) and the dependent variable of student achievement on the 2013 NAEP mathematics assessment in

4th grade. A multiple regression analysis was conducted to explore the relationship between fourth grade, 2013 NAEP mathematics test scores and four different types of mathematics curricula. The selection of curriculum materials was an important undertaking. The significance of this study is to provide information concerning the effects of curricula on student mathematics achievement.

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CHAPTER 1

Introduction

During the past half century, arguably, no discipline has been the focus of more intense public scrutiny than school mathematics. For decades, educational reform initiatives have incited debate over what mathematics should be learned, by whom it should be learned, and when it should be learned (Romberg, 2010). Over the years there have been many changes to mathematical practices, from No Child Left Behind's research-based programs for teaching and learning (No Child Left Behind [NCLB], 2002), and most recently the Common Core State Standards for Mathematics (National Governors Association Center for Best Practices [NGA Center] and the Council of Chief State School Officers [CCSSO], 2010a). Each of these initiatives has tried to increase the extensiveness or depth of mathematics to be taught in order to raise student achievement, better prepare students for college success, and increase our competitive status in an increasingly global economy. Curriculum materials, such as textbooks, have the potential to be instruments of reform for most educators.

Mathematics curricular effectiveness has been identified as a high-priority area in need of further research (NCTM Research Committee, 2008). In this study, the researcher looked at 4 different types of curricula: Commercially designed math curriculum, math curriculum structured by teacher discretion, math curriculum structured by state standards, and math curriculum structured by district standards. This study examined how each type of curriculum impacts mathematic achievement on 4^{th} grade National Assessment of Educational Progress (NAEP) mathematics scores.

Purpose of the Study

The purpose of this study was to examine the impact of four different types of 4^{th} grade mathematics curricula: Commercially designed mathematics curriculum, mathematics curriculum structured by teacher discretion, mathematics curriculum structured by state standards, and mathematics curriculum structured by district standards for 4^{th} grade mathematic achievement as measured by the National Assessment of Educational Progress (NAEP) mathematic scores for 2013. The selection of curriculum materials was an important undertaking. This study allowed educators to discover which one of the four types of mathematics curricula has a significant impact on students' mathematics achievement.

Significance/Importance of the Study

The challenge of how to create and sustain improvement in our nation's mathematics achievement continues as a point of national debate among parents, mathematics educators, and researchers. Views of how students learn mathematics and the manner in which instruction should take place have evolved over time based on a combination of experience, theory, and research. Advances in cognitive research have led to greater understanding of the way in which students learn. These developments have shifted the instructional emphasis away from rote learning to the need for students to connect new skills and concepts with past learning and to develop habits of mind that involve exploring, inventing, estimating, reasoning, and problem solving (Schoen, Fey, Hirsch, & Cosford, 1999). This type of curriculum requires teachers to be more than presenters of content; it requires teachers to actively and continuously interact with the students' construction of mathematical concepts and ways of reasoning (Confrey et al, 2008).

This study will help educators in their search for effective mathematics curricula. The success of curricula is analyzed by the improvement of student achievement. With the implementation of the common core state standards many published mathematics curricula being used by educators are not aligned with the new standards. What is becoming increasingly complicated is how teachers and school districts attempt to align existing textbooks or other curriculum materials with the Common Core State Standards. Using a more standards based curriculum (textbook), a teacher may devote more time to a concept, teach it more deeply, and use a student-centered approach (Van de Walle, Karp, & Bay-Williams, 2015). Writing, speaking, working in groups, and problem solving are more likely to be commonplace components in current curriculum offerings (Van de Walle, Karp, & Bay-Williams, 2015).

The selection of curriculum materials is an important undertaking. The significance of this study is to provide information concerning the effects of curricula on student mathematics achievement. As this study intends to interpret, compare, and summarize the achievement effects of four different types of mathematics curricula, it will contribute to current studies that attempt to identify the essential organization, structure, and treatment of topics in mathematics that serve as the necessary foundation for success as students progress toward more complex topics in mathematics. In a system where educational decision-making is undertaken primarily at the state and local levels, state and local decision makers will need valid, informative, and credible data on curricular effectiveness. The results from this study could inform school district's central administration of the potential impact of mathematics curriculum on student performance and teacher practice, particularly in urban environments where reducing achievement gaps and improving mathematics achievement are often district-wide priorities.

Research Questions

This study investigated the following research questions:

1. Is there a statistically significant relationship between commercially designed curriculum and student achievement as measured by the 4th grade National Assessment of Educational Progress (NAEP) mathematics assessment?

2. Is there a statistically significant relationship between mathematics curriculum structured by teacher discretion and student achievement as measured by the 4th grade National Assessment of Educational Progress (NAEP) mathematics assessment?

3. Is there a statistically significant relationship between mathematics curriculum structured by district standards and student achievement as measured by the 4th grade National Assessment of Educational Progress (NAEP) mathematics assessment?

4. Is there a statistically significant relationship between mathematics curriculum structured by state standards and student achievement as measured by the 4th grade National Assessment of Educational Progress (NAEP) mathematics assessment?

Definition of Terms

The following operational definitions used in this research appear here as a resource for clarifying educational terminology and describing the problem:

National Assessment of Educational Progress (NAEP): NAEP is also known as "the Nation's Report Card," is the only nationally representative and continuing assessment of what America's students know and can do in various subject areas. Since

1969, assessments have been conducted periodically in mathematics, reading, science, writing, U.S. history, geography, civic, the arts, and other subjects (NCES

Curriculum: Curriculum can be seen as a blend of goals, content, instruction, assessment and materials (Kilpatrick, 1996).

Intended Curriculum: It refers to what the curriculum designers plan to accomplish. It refers to those documents such as curriculum frameworks, which are developed by state educational agencies and define what students need to know at particular grades (Thompson & Usiskin, 2014).

Enacted Curriculum: This curriculum is defined as interactions between teachers and students around the mathematical tasks of each lesson and accumulated lessons on a unit of instruction (Thompson & Usiskin, 2014).

Mathematics Achievement: The mathematical success of students in academic coursework (Benner & Hatch, 2009). The NAEP in 2007 reported mathematical achievement to be "students' understanding of mathematics concepts and their ability to apply mathematics to everyday situations." (p.2).

Commercially Designed Curriculum: This curriculum is defined as four interacting components, namely, teaching objective, teaching material, teaching method, and assessment created by commercial publishers (Remillard, 1999).

Mathematics curriculum structured by teacher discretion: teacher involvement is important for successful and meaningful curriculum development. Teacher's knowledge, experiences and competencies, are central to any curriculum development effort. Curriculum structured by teacher discretion is curriculum developed with the involvement of teachers (Alsubaie, 2016).

Mathematics curriculum structured by district standards: alignment of curriculum with district standards (Edglossary, 2014).

Mathematics curriculum structured by state standards: alignment of curriculum with state standards (Edglossary, 2014).

CHAPTER 2
Review of Related Research

This chapter will present research literature relevant to the question of whether the use of different types of curricula impacts mathematic achievement. This chapter will set the background of how children learn mathematics and develop an understanding of mathematics. A history of mathematics education in the United States is presented, including the National Council of Teachers of Mathematics standards, the adoption of Common Core State Standards for Mathematics and the need for shifts in mathematics curricula and instruction. Finally a description of curriculum categories: Intended, Implemented, Attained, and Enacted. Studies have been included focusing on the impact of the enacted curriculum on student's mathematic achievement.

Theoretical Framework

Throughout history, individuals in education continued to disagree on the variables that influence student achievement. The most well known variables that tend to influence student achievement tend to be categorized as school, student, and teacher. The quality of curriculum is vital to provide students with experience and knowledge to become successful students. Students engage in processes of cognitive development as they solve mathematic problems or tasks and construct mathematical knowledge. The theoretical framework of constructivism provides a clear perspective on higher cognitive processes that can develop through social interaction. The ideas of Shoenfeld, Vygotsky, and Bruner provide an important framework for this study.

Constructivism

Constructivism is an underlying theory of the National Council of Teachers of Mathematics (NCTM) standards and it is also promoted as an alternative to traditional instruction. Constructivism, as presented by Confrey and Kazak (2006), "served as a means of prying mathematics education from its sole identification with the formal structure of mathematics as the sole guide to curricular scope and sequence. It created a way to examine mathematics from a new perspective, the eyes, mind, and hands of the child" (p. 306). "Constructivism evolved and became, in practice, a way of addressing students' weak conceptual understanding with over-developed procedures and students demonstrated difficulties with recall and transfer to new tasks" (p. 306). Constructivism focused teaching on the active involvement and participation of children and the strengths and resources they brought to the tasks.

Learning Mathematics

The National Council of Teachers of Mathematics (NCTM) recommendations to make problem solving the focus of school mathematics posed fundamental questions about the nature of school mathematics. The art of problem solving is the heart of mathematics. Thus, mathematics instruction should be designed so that students experience mathematics as problem solving (Wilson, 2003).

Children enter school with previous experiences and knowledge, including knowledge of mathematics. Primary and elementary classroom teachers explore this knowledge in order to develop the foundation in which future mathematics learning will be built. At the elementary level five building blocks of mathematics are taught: numbers, place value system, whole number operations, fractions and decimals, and problem solving. In order for students to succeed in algebra and beyond they will need a solid foundation in the building blocks of mathematics.

Developing Understanding of Mathematics

With the implementation of the CCSSM, helping students develop mathematical understanding is a major goal of mathematics teachers. This has caused a change in the way mathematics must be taught. The way in which teachers teach mathematics has changed from the way it was taught in the past and is also different from the way teachers were taught themselves (Barlow & Harmon, 2012). Teachers need to shift mathematic instruction from teaching procedure to teaching for a deeper understanding of concepts.

In order to develop a deeper understanding of mathematics concepts, students need to be given an adequate amount of time to explore and discuss concepts. According to Burns (2007) the process of abstract concepts and relationships that students learn through sense making and constructing understanding are involved in mathematics. This type of learning is internal. This type of learning cannot be explicitly taught, but children can be guided and supported as they construct meaning and make sense of the structures (Burns, 2007). Providing students with opportunities to interact with mathematical ideas, with the main goal of building meaning and understanding, are one-way teachers can support students (Burns, 2007).

Metacognition warrants special attention because of the significant role it plays in problem solving. Schoenfeld (1985) stated explicitly, metacognitive behavior could be the difference between success and failure for the problem solver. The NCTM (2000) claimed that the development of students' metacognitive abilities is an important part of classroom instruction: Students should be encouraged to monitor and assess themselves. Good problem solvers realize what they know and don't know, what they are good at and not so good at. Teachers are responsible for creating classroom environments in which they encourage metacognitive behavior and give students opportunities to reflect on their work. Teachers encourage metacognition by modeling metacognitive behavior, for example, by thinking aloud and by asking metacognitive questions.

In *Mathematical Problem Solving*, Schoenfeld's core theoretical argument elaborates four categories of problem solving: a) The individual's knowledge; b) The individual's use of problem solving strategies known as heuristic strategies; c) The individual's monitoring and self-regulation, control (an aspect of metacognition); and d) The individual's belief system (about him- or herself, about mathematics, about problem solving) and their origins in the student's mathematical experiences. Schoenfeld views problem solving strategies as, a form of knowledge students can access through gathering information, asking questions, seeking data, building models and drawing inferences. He places emphasis on the importance of metacognition and the cultural components of learning mathematics (i.e., belief systems). To sum up, he believed, successful solution of mathematics problems depends upon a combination of resource knowledge, heuristics, control processes and belief, all of which must be learned and taught (Shoenfeld, 1985).

Jerome Bruner, a social constructivist, expresses that learning is an active process in which learners construct new ideas or concepts based upon their current/past knowledge. He stressed that the goal of education should be intellectual development as opposed to rote memorization of facts. Bruner theorized that learning occurs through three stages of representation: enactive, iconic, and symbolic. In order to help the learner truly understand the concept, it is important to go through each stage. Each stage is a way in which information or knowledge is stored and encoded in memory (McLeod, 2008).

Bruner's theory lets teachers engage all students in the learning process regardless of their cognitive level of the concept at the moment.

In order to build a foundation for which students can fall back on as they encounter increasingly difficult problems, they will need to go through each of Bruner's stages. It is essential for the teacher to go through each of the stages with the whole class; however the teacher can differentiate time spent on each stage depending on the student and topic. The first is the concrete or enactive stage where students work with manipulatives or other concrete materials. Students need many experiences using hands-on materials to make sense of abstract ideas. The second stage is the iconic or pictorial stage. Students are able to draw a model or a pictorial representation of the concept. The third stage is the abstract or symbolic stage. Students represent their knowledge through the use of numbers and symbols.

The development and use of academic language is crucial for successfully learning the concept (Bruner, 1960). This first takes place when moving from the iconic stage to the abstract, language-based, symbolic stage (Bruner, 1960). Bruner places great importance to language in determining cognitive development. Academic language needs to be taught and used in the symbolic stage in order for students to explain that not only can they find the correct answer, but they also understand the problem and process. In this context academic language involves vocabulary and mathematical terms as well as mathematical symbols.

Often, students use more than one model of representation or engagement, so it is important for students to be familiar with all levels of representation. The use of multiple representations demonstrates a higher level of understanding. Learning occurs when multiple representations are used, because it allows students to make connections within, as well as between, concepts. Providing options for representation is essential. Learners differ in the ways that they can navigate a learning environment and express what they know.

Both Bruner and Vygotsky give emphasis to a child's environment, especially the social environment. They both agree that adults should play an active role supporting a child's learning. Lev Vygotsky has become the foundation of much research and theory in cognitive development. Vygotsky's theories stress the fundamental role of social interaction in the development of cognition (McLeod, 2014). Vygotsky stressed that social learning tends to precede development. He stated that young children are curious and actively involved in their own learning and the discovery and development of new understandings/schema.

Vygotsky views interaction with peers as an effective way of developing skills and strategies. He suggests that teachers' use cooperative learning exercises where less competent children develop with help from more skillful peers – within the zone of proximal development (McLeod, 2014). Vygotsky (1978) defines the zone of proximal development as, "The distances between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or collaboration with more capable peers" (p.86). Vygotsky considered that when a student is in the ZPD for a particular task, providing the appropriate assistance will give the student enough of a "boost" to achieve the task (McLeod, 2014).

Vygotsky's zone of proximal development is essential to instructional development and classroom change in Mathematics. In Mathematics teaching, the tasks given should be challenging to an extent that facilitated by the teacher or a knowledgeable peer is needed. After a student has accomplished mastery of a concept with the assistance from others, he/she should be able to do the task independently. If the student accomplishes the task individually through that process, then the learner's ZPD for that particular task will have been raised (Christmas, Kuszai, & Josiah 2013). This process is then repeated at the higher level of task difficulty that the learner's new ZPD requires.

Teaching each learner Mathematics according to his/her ZPD has two main advantages: the tasks are made simpler for the learner and the learner's intellectual ability to deal with the task is considered (Christmas, Kuszai, & Josiah 2013). Teaching therefore stops being a mechanical practice where it is apparently for the purpose of covering the syllabus or teaching to the test at the expense of understanding. When teachers are dealing with a large class, it may be difficult to identify every learner's zone of proximal development.

These educational theorists had an impact on learning that occurs today. Education is a field in which ideas continue to resurface as research is studied and used to improve instruction. The curriculum has continually changed to reflect different historical ideas. However, in math education, "the standards movement has been one of the most significant educational reforms of the last half of the 20th century and will continue its influence well into the 21st century" (Marzano, 2004, p. 107).

Educators need to create a more cohesive and streamlined curriculum that will allow students to develop a deeper understanding of mathematics beginning at the elementary school level. Published curriculums and instruction in the United States do not always allow students to move through the stages of engagement at an individual and developmentally appropriate pace; rather, the movement between engagement stages is often rushed through to get to the problems in the textbook. Schmidt, Houang, and Cogan (2002) discovered that the enacted mathematics curriculum in the United States was a "mile wide and an inch deep" (p.3). It was unclear, repetitive, simple, and illogical. The CCSSM were cognizant of how students learn math. The standards are more focused, understandable, and rigorous than previous standards. They introduced significant changes to mathematics instruction and the way the curriculum is enacted.

Related Literature

Mathematics Education in the United States

Mathematics education in the United States is influenced by three factors: the needs of the subject, the needs of the child, and the needs of society (Reys, Lindquist, Lambdin, & Smith, 2012). The needs of society primarily drove mathematics education in the late nineteenth century. As the country became more industrialized, it became clear that it was important for everyone to learn mathematics. The curriculum expanded to include percentages, ratios, powers, and roots, although it still remained focused on social utility (Reyes et al., 2012). In the past, children were taught math to build discipline and train their thinking (Reyes et al., 2012).

NCTM Standards

The National Council of Teachers of Mathematics was the first professional group to develop explicit and extensive standards for instruction. They moved away from rote learning of computation towards building a deeper understanding of mathematical concepts. They stressed the need to foster proficient problem solvers, and they recognized the need for students to apply problem-solving skills to real world situations.

The National Council of Teachers of Mathematics standards (1989, 2000) presented opportunities for systemic improvement in mathematics education in the United States and influenced new curriculum projects and changes to existing state standards. Simultaneously emerging during this time was a renewed interest in cognitive theories and social aspects of learning, thus paving the way for more qualitative, student-centered, inquiry-based approaches in mathematics education.

The reauthorization of the NCTM standards in 2000 placed increased emphasis on critical thinking and problem solving and encouraged the development of reform-based curriculum programs. These reform programs were designed to increase students' conceptual understandings within the five content standards–numbers and operations, algebra, geometry, measurement, and data analysis and probability–and through five process standards–problem solving, reasoning and proof, communication, connections, and representation (NCTM, 2000).

Common Core State Standards

In 2009, under President Obama's administration, Secretary of Education Arne Duncan tied eligibility for the four billion dollar Race to the Top program of competitive federal grants to participate in the Common Core effort. The federal government invested additional financial support to the Common Core Initiative by setting aside $350 million for the Common Core State Standards' accountability measure, assessments tied to national standards (U.S. Department of Education, 2009). The aim of this bipartisan movement was to upgrade and unify elementary and secondary school standards to ensure college and career readiness, offering the benefits of shared expectations and improved focus and efficiency that would extend to other sectors of education; e.g., teacher development, the development of curricular materials, pre-service teacher education, and the delivery of quality electronic and computer-adaptive assessments (Hwang, McMaken, Porter, & Yang, 2011).

Managed by the National Governors Association Center for Best Practices (NGA) and the Council of Chief State School Officers (CCSSO) and prompted by the United States Department of Education and support from the Bill and Melinda Gates Foundation, by June 1, 2011, the Common Core State Standards Initiative [CCSSI], had been adopted by 44 states, the District of Columbia, and the U.S. Virgin Islands (CCSSI, 2010). The initiative represented the first significant attempt in the nation's history to systematically align common K-12 mathematics standards across the states, building upon previous efforts to create a national vision for mathematics education, including that of the National Council of Teachers of Mathematics' standards documents (NCTM, 1989, 2000, 2006).

Implementing the CCSSM has been difficult for many teachers because, the standards required major changes in instructional methods. For example, in grades K-5, there are fewer standards at each grade level, so topics are developed and taught for deeper understanding and at a greater depth. The focus has shifted to mastery rather than proficiency (Coleman & Zimba, 2008). The CCSSM required three major shifts: focus, coherence and rigor. In addition to the three shifts, the CCSSM included eight standards of mathematical practices. These include making sense of the problems and persevering to solve them, reasoning abstractly and quantitatively, and constructing viable arguments as well as critiquing others. These practices represent the way students do math and think about math. Mathematical practices were to be integrated within the instruction of the math content standards, not taught in isolation (Rothman, 2012).

The CCSSM represent a significant change in how mathematics is taught in the United States. In the past, mathematics curriculum was perceived as a “mile wide and an inch deep” covering many topics repeated over several years. Proficiency was the goal rather than mastery, causing deep understanding of concepts to be sacrificed in order to cover a variety of topics. The CCSSM allowed for a deeper understanding of mathematical concepts to be at the forefront of mathematical learning by creating less topics to be covered at each grade level and building upon prior knowledge from school year to school year within each topic.

Curriculum

Teachers’ use of curricular materials has a greater influence on student learning than teacher characteristics such as education level, experience, and knowledge of mathematics teaching (Stein & Kaufman, 2010). The term curriculum has multiple meanings. It is used to refer to what is enacted in the classroom as well as an overarching framework for what should be taught, such as a curriculum framework.

Curriculum theorists recognize differences between the curriculum as outlined in a guide and that enacted in the classroom, by describing categories to explain each type.

Formal or planned curriculum, for example, refers to the goals and activities outlined by school policies or designed in textbooks (Gehrke, Knapp & Sirotnik, 1992). The intended curriculum refers to teachers' objectives, whereas the enacted curriculum refers to what is actually happening in the classroom (Gehrke, 1992). Researchers have shown interest in the enacted curriculum because it recognizes the role of teachers in designing curriculum (Snyder, Bolin, & Zumalt, 1992). The view of enacting the curriculum assumes that the teacher is an active designer of the curriculum, rather than just the implementer.

The Intended Curriculum

The intended curriculum represents what designers planned to accomplish. Common Core State Standards for Mathematics (CCSSM) was intended to move the nation to a common understanding of what children need to know and when, even if the standards were not identically the same from state to state (Dossey, McCrone, & Halvorsen, 2016). The present total of states that have adopted the CCSSM stands at 43 states and the District of Columbia. Twenty-two states and the District of Columbia adopted the Common Core standards verbatim, while the remaining 21 states adopted them with minor modifications (Dossey, McCrone, & Halvorsen, 2016). Many of the non-adopting states have strong goals that parallel both the NCTM and CCSSM standards, and they have strengthened them over the years. These states are unwilling to move their teachers and schools through another curricular change for little perceived gain in the alignment of their curricula or professional development programs.

CCSSM focuses on developing deep student understanding of a set of concepts less than those currently contained in most state standards. Teachers can focus on core, or focal, topics for longer periods of study in a single year. The change from the NCTM

Standards-based curriculum to the CCSSM-based curriculum is more than an evolution in the U.S. school mathematics curriculum. The impact of quick change has yet to be determined, since most teachers and schools have not had a chance to work through the full implications of the necessary curricula and assessment methods (Dossey, McCrone, & Halvorsen, 2016).

Some educators and researchers find the emphasis on published curriculum as a medium to promote improvement in teaching to be a reminder of the curriculum reforms of the late 1950's and early 1960's. During this period, mathematicians and scientists wanted to reach students through creating a new and inventive curriculum intended to surpass teachers. These efforts failed to work in the United States due to the reformers failure to appreciate the central role of the teacher in classroom practice or recognize the power of the teachers to misinterpret, even ignore unfamiliar curriculum (Sarason, 1982). The similarities between the present reform in mathematics and past reforms that created the "New Math" incite relevant questions about whether or not present day curriculum developers and reformers learned from the mistakes of the past.

The development, implementation, or impact of the New Math curriculum was done with little systematic research (S.M. Wilson, 2003). Over the past 25 years, scholars have investigated how teachers use curriculum materials and what role textbooks and curriculum materials play in mathematics classrooms (Remillard, 2005). However, teachers use of curricula range from undermining or rejecting, adapting and revising, to wholeheartedly teaching the curriculum to fidelity.

Historically, mathematics has been associated with textbooks and curriculum materials, tools that are critical for students in American classrooms (Reys & Reys, 2006). Studies of textbooks should be conducted since textbooks dominate the curriculum and are embedded in the U.S. classrooms (Walsh, 2009). The study of commercially published math curricula is more important at the elementary level than middle or high school level. Textbooks tend to equalize weak teacher mathematics preparation and differences across classrooms. The 2000 National Survey of Mathematics and Science Education found 87% of K-4 mathematics classrooms use published textbooks/programs (Weiss, Banilower, McMahon, & Smith, 2001). Textbooks serve to deliver consistency across classrooms by providing the scope and sequence of instruction, which ultimately impacts student achievement (Reys & Reys, 2006). Since teachers rely heavily on textbooks, it is beneficial for school districts to determine the extent to which published curricula impact student achievement.

The Implemented Curriculum

The implemented curriculum describes how the teachers use the curriculum as part of their instruction. Historically the implemented curriculum in school mathematics has been dictated by a mixture of individual state expectations for the topics to be taught within mathematics classes at various levels of education and, in some districts, associated student abilities and expected outcomes (Dossey, McCrone, & Halvorsen, 2016). Varying from state to state these expectations have been established at the state level, and sometimes, local school district levels. As a result, the quality of mathematics education received by a given U.S. student has historically been determined in a large part by the quality of expectations set by state and local school authorities (Dossey, McCrone, & Halvorsen, 2016). Instructional materials selected by the state, the school district, or the individual schools have also set on these expectations. The content and representations of that content have been heavily influenced by the individual classroom teacher's mathematical knowledge and pedagogical knowledge.

Depending on the decisions made by individual states in lieu of The Every Child Succeeds Act, the implemented mathematics curriculum in the U.S. schools remains dictated to a large degree by the contents of textbooks or other instructional materials, the assessments used locally and by state governments, the sequencing of the topics in those materials, and the overall alignment of the materials to the assessments with the standards in place.

The Attained Curriculum

The attained curriculum also known as the experienced curriculum corresponds to how students undergo, understand, and interpret the curriculum, which can be influenced by their prior knowledge and experiences (Thompson & Usiskin, 2014). Central to the measure of the success of a curriculum is the academic attainment of the students who have participated in the instructional experiences associates with it. Unfortunately, outside of the test-item data from the mathematics tests administered through NAEP, little information is offered throughout the United States. Outside of NAEP, the national and state-level data from the two major college entrance examinations, the ACT and the SAT programs, provide stable achievement outcomes (Dossey, McCrone, & Halvorsen, 2016).

A current concern across all grade levels for Main NAEP is the rapid movement to the Common Core State Standards, a revolutionary change to common standards across the 43 adopting states and the District of Columbia. These standards differ significantly from a curriculum that has been in place for essentially the previous 20 years, since the time when state standards changed to become some version of the NCTM Standards as delineated in Curriculum and Evaluation Standards (1989) (Dossey, McCrone, & Halvorsen, 2016). The biggest issue is the specific grade placement of particular content. For example, CCSSM expects students to demonstrate procedural knowledge in number and operations later, at a higher grade level than recommended in the NCTM Standards. Also the CCSSM places less emphasis than the NCTM Standards on geometry and data analysis, probability and statistics from the early grades through grade 8. Over a short period of time, these differences can lead to a discontinuity in the assessment results. NAEP is supposed to be a test of what students have learned from the curriculum that they encounter in their classrooms. Changes in the assessments makes evaluating the changes over years in student performance more difficult from a policy point of view (Dossey, McCrone, & Halvorsen, 2016).

The Enacted Curriculum

The enacted mathematics curriculum interacts with numerous elements of the educational system, from curriculum frameworks at a state or district level to adopt textbook materials at a school or classroom level to assessments for accountability purposes at the student level (Thompson & Usiskin, 2014). Classrooms differ far more than would be expected by chance, and teachers and schools differ on so many different variables that a textbook or curriculum that works best in one place cannot be predicted with certainty to work better in another. The emphasis teachers place in different learning goals and different topics, the expectations for learning they set, the time they allocate for particular topics, the kinds of tasks they pose all are part of teaching and all influence the opportunities students have to learn (Thompson & Usiskin, 2014). The way in which the curriculum is enacted likely facilitates the potential of a given curriculum to influence student achievement (Remillard, Harris, & Agodini, 2014).

The enacted curriculum involves interaction among texts, teachers, and students. Remillard (2005) in a synthesis of research about teachers' use of curriculum materials, identified a number of views about the teacher-curriculum interaction: teachers follow or subvert the text; teachers draw on the text to construct their instruction; teachers interpret the text and the authors' intentions in light of their own beliefs and experiences; and teachers collaboratively interact with the text in a dynamic relationship.

Studies on the Enacted Curriculum

National achievement data show that elementary school students in the United States, particularly those from low socioeconomic backgrounds, have weak mathematical skills (National Center for Education Statistics 2009). Drawing a direct link from curriculum to student learning is difficult because many other factors influence what students learn, including teacher choices and actions, school and classroom organization, and student readiness and willingness to learn.

Schoen, Cebulla, Finn, and Fi (2003) attempted to connect teacher behaviors aligned with the curriculum's design and various demographic variables to student achievement. They worked with 40 teachers who were field-testing Course 1 of the Core-Plus Mathematics Project curriculum during their students' first introduction to the curriculum. Evidence of curriculum enactment was collected using classroom observations and both mid-year and end-of-year teacher surveys. Classroom observations noticed practices aligned to the curriculum. The mid-year survey focused on teachers' perceptions of their classroom practices, including the amount of class time spent with students working on different formats, use of curriculum features, assessment practices, and the degree to which they supplemented or revised the curriculum materials. Teachers' concerns about, and preparation for curriculum implementation was measured by the end-of-year survey. The Iowa Test of Educational Development, a test that measures conceptual understanding, problem solving, applications, and quantitative thinking was used as a pre-test post-test measure of students' mathematics achievement.

The researchers used regression techniques within logical categories of predictor variable to identify school, class, and teacher preparation, concern and practice variables that were associated with achievement. The strongest predictor of student achievement among teacher variables was whether or not the teachers' completed a curriculum workshop. The teacher observation results signify that adjusted mean student achievement was higher for teachers whose teaching practices were aligned with the CMPM developers' recommendations. Data from the mid-year survey indicated that teachers' high expectations for homework, high grading standards, and the degree to which curriculum was implemented as designed were significantly correlated with student achievement. Teachers' who reported the least amount of supplementing, replacing, or revising the curriculum and assessments experienced the highest gains in student achievement.

Jong, Pedulla, Reagan, Salomon-Fernandez and Cochran-Smith (2010) examined the relationship between reformed classroom practices of beginning elementary school teachers' instruction of mathematics and how it connected to students' academic achievement. They used the Reformed Teaching Observation Protocol (RTOP) an instrument that measures active learning, inquiry-based instruction, and problem solving strategies, to determine whether the goals of the two study curricula were consistent with the teachers' enactment. The two curricula implemented were Investigations in grades K through 5th and Connected Mathematics Project in grade 6. The participants consisted of 22 teachers in a large, urban school district with a high percentage of students of color, English language learners, and students receiving free/reduced lunch.

During the study each teacher was observed twice during the unit by trained observers using the RTOP to evaluate the lesson design and implementation, lesson focus knowledge, and classroom culture. A district-developed test consisting of seven multiple-choice and three constructed-response items was used to assess student achievement. The correlation between teachers' RTOP scores and their pupils' posttest content scores was 0.56 ($p < 0.05$), indicating that teacher practices aligned with the respective curricula were positively and significantly related to students mathematic learning.

Pierce, Cassady, Adams, Speirs, Neumeister, Dixon, and Cross (2011) studied the influence of varying levels of curricular implementation on clustered groupings of gifted third-grade students in urban elementary schools. In this urban district, in each grade, gifted students are clustered in a single classroom along with non-gifted students. A cluster is defined as 3 to 10 gifted students in a classroom of 20 to 25 students. This was a multi-year study, but only Year 1 report compares student achievement based on varying levels of enactment.

Teachers in the study were placed in one of two groups: implementers or non-implementers based on attendance at a summer training institute as well as teaching observations and self-reports of their implementation of the curriculum and procedures. Teachers replaced their regular curriculum with the treatment curriculum for each of two nine-week units. The treatment curriculum used in this study was, Into the Unknown for algebra and Math By All Means for geometry. A pretest and posttest was used to measure student achievement.

A repeated measures ANOVA was used for the algebra unit. The results showed a statistically significant main effect for implementation status and gifted students. The gifted students outperformed their non-gifted peers. Students in classrooms with the teachers who implemented the curriculum to fidelity outperformed those in classrooms where the teachers who did not. The interaction effect by implementation status showed interesting results. Growth in student achievement was influenced more strongly by level of implementation of the curriculum than by gifted status. Gifted students outscored non-gifted students on the pretest, however posttest scores were higher for non-gifted students in classrooms where the curriculum was implemented than gifted students in classrooms where the curriculum was not implemented. Similar results were found the geometry unit.

Tarr, Reys, Reys, Chavez, Shih, and Osterlind (2008) studied achievement in a large group of middle school students over three years in ten different schools who were using either published textbook series or one of three textbooks developed with funding from the National Science Foundation. These textbooks were titled: Connected Mathematics, MathThematics, and Mathematics in Context. Prior to this study all schools in the district had implemented the curriculum for at least one year.

The researchers collected a variety of implementation data from teachers to determine how they used the curriculum material to plan and enact instruction. They used teacher questionnaires, textbook use diaries in which teachers recorded specific information about the use of the textbook for three intervals of ten days each, and a table of contents record keeping track of the lessons taught. They also used classroom observations to determine the extent to which the classroom environment modeled practices recommended by the NCTM Standards and aligned with the philosophical approach of the NSF funded curricula. An implementation index was developed, by combining different aspects of implementation.

Mathematic achievement was measured using two tests: the TerraNova Survey, a multiple-choice test that assesses knowledge across all five content standards identified by the NCTM; and the Balanced Assessment in Mathematics, a criterion-referenced constructed-response test to assess reasoning, problem solving, and communication. The researchers were interested in the extent to which the curriculum was implemented in terms of curriculum type or classroom-learning environment would influence student achievement.

The researchers found that teachers using both types of curriculum were strong implementers of their curriculum and used the textbooks appropriately. They used a hierarchical linear model and found no differences in student achievement for either of the two tests in relation to teachers' implementation index. They did find an interaction in terms of student achievement, curriculum type and level of standards-based learning environment on the Balanced Assessment. When students studied from one of the NSF-funded curricula and were in classrooms in which teachers developed a moderate or high standards-based learning environment, achievement was positively influenced. No significant relationship was found for NSF-funded curricula and low levels of a standard-based learning environment or for publisher developed textbooks and the learning environment.

Researchers theorized that the interaction observed between curriculum and the learning environment only for the Balanced Assessment was perhaps due to the consistency between the assessment, a standards-based learning environment, and the philosophical stance of the NSF-funded curricula.

Kurz, Elliot, Wehby, and Smithson (2010) examined the content of planned and enacted eight-grade mathematics curriculum for 18 general and special education teachers and the curriculum alignment to state standards via the Surveys of the Enacted Curriculum. They also analyzed the relation between alignment and student achievement for three formative assessments and state tests in which corresponded within each school year. The following research questions were addressed in this study: To what extent is there a difference in alignment between the state's intended curriculum and the teachers' planned curriculum for eighth-grade general and special education mathematics teachers? To what extent is there a difference in alignment between the states' intended curriculum and the teachers' enacted curriculum for eighth-grade general and special education mathematics teachers? Is there a relation between the alignment of the intended to the enacted curriculum and achievement outcomes for general and special education students in eighth-grade mathematics? The participants consisted of 18 teachers from 10 middle schools located in a large metropolitan school district in the state of Tennessee.

In order to address questions 1 and 2 they used 3 instructional content surveys containing the most recent K-12 content language for mathematics standards administered three times throughout the year: beginning, middle, and end. All participating teachers completed the survey. Teachers received training throughout the year in how to fill out the surveys. In order to address question 3 they used three formative mathematic assessments and respective state tests to determine the achievement of eighth-grade students taught in each participant's target class. The formative assessment, Discovery Education Assessment (DEA) was part of their contracted Predictive Assessment Series (PAS). The assessments were administered in the fall, winter, and spring to predict student achievement on the Tennessee Comprehensive Assessment Program (TCAP), the state test. The TCAP achievement test, developed by CTB/McGraw-Hill, was the state's annual achievement test used for accountability purposes. The test was administered in the spring of 2007 in Grades 3 through 8.

Researchers examined the difference in alignment between general and special education teachers, by calculating the average alignment index for each group using the total of four matrix pairings. The first alignment analysis related to content alignment between state's intended curriculum and teachers' planned curriculum from beginning of the year surveys. The second, content alignment between teachers' planned curriculum and teachers' enacted curriculum from beginning of the year and mid-year surveys. The third, content alignment between state's intended curriculum and the teachers' enacted curriculum from mid-year surveys. The fourth alignment analysis related to content alignment between the state's intended curriculum and the teachers' enacted curriculum from end of year surveys. Researchers found no significant differences between general and special education teachers in regards to differences in alignment between state intended curriculum and the teachers' planned and enacted curriculum. They did find a limited appropriateness of t-test procedures for such a small sample does not allow them to draw population inferences. Research questions one and two remain unanswered.

Researchers also examined the relationship between alignment and student achievement. They used four tests of student achievement. They converted raw scores from the three formative assessments into *z* scores using the district mean and standard deviation for Test Z (*M* = 16.94, *SD* = 6.59), Test A (*M* = 15.61, *SD* = 5.71), and Test B (*M* = 16.57, *SD* = 6.78). Special education students performed worse than general education students on all three formative assessments as well as on the corresponding state test (Kurz, Elliot, Wehby, & Smithson, 2010). Independent-samples *t*-test was significant at the .05 levels for all four tests.

Researchers also calculated achievement averages for each classroom to corresponding alignment indices at the classroom level to compute a Pearson correlation coefficient. They found medium correlations between midyear (A1 3) and end of year (A1 4) alignment indices and B Test achievement averages and large correlation between midyear and end-of-year alignment indices and TCAP achievement averages. A1 3 measured the alignment between the state's intended curriculum and teachers' enacted midyear curriculum. Midyear alignment (A1 3) accounted for approximately 23% of the variance in Test B achievement averages and approximately 41% of the variance in TCAP achievement averages (Kurz, Elliot, Wehby, & Smithson, 2010). A1 4 measured the alignment between the state's intended curriculum and teacher's enacted end-of-year curriculum. End-of-year alignment (A1 4) accounted for approximately 11% of the variance in Test B achievement averages and approximately 34% of the variance in TCAP achievement averages (Kurz, Elliot, Wehby, & Smithson, 2010). The present data suggest the longer students are exposed to the enacted curriculum that is aligned with standards, the greater the potential achievement benefits of assessments that are also aligned with the same standards (Kurz, Elliot, Wehby, & Smithson, 2010).

Agodini, Harris, Thomas, Murphy, and Gallagher (2010) examined the relative student achievement effects of four elementary school mathematics curricula during the first year of implementation in first grade and in second grade. The results of this large-scale study, was aimed at understanding the relative student achievement effects of four elementary school math curricula: Investigations in Number, Data, and Space (Investigations); Math Expressions; Saxon Math; and Scott Foresman-Addison Wesley Mathematics (SFAW).

Investigations used a student-centered approach encouraging metacognitive reasoning and drawing constructivists learning theory (Agodini et al., 2010). Math Expressions blends student-centered and teacher-directed approaches to mathematics. Saxon is a scripted curriculum that blends teacher-directed instruction of new material with a daily-distributed practice of previously learned concepts and procedures (Agodini et al., 2010). SFAW is a basal curriculum that combines teacher-directed instruction with a variety of differentiated materials and instructional strategies (Agodini et al., 2010). These four curricula differ in which they emphasize student-centered or teacher-directed approaches.

The study used randomized controlled-trial techniques to compare the effects of the above-mentioned curricula on math achievement of early elementary school students (Agodini et al., 2010). The evaluation is based on a school-level random-assignment design, in which participating schools in each participating district are randomly assigned to the curricula included in the study (Agodini et al., 2010). Hierarchical linear modeling

(HLM) techniques, which account for the extent to which students are clustered in classrooms and schools were used to calculate the relative curriculum effects

The study included a total of 110 elementary schools recruited by the study team, geographically scattered in areas with different levels of urbanicity. The schools selected served a higher percentage of students eligible for free and reduced lunch than the average U.S. elementary school. The first cohort consisted of 39 schools (cohort one) in which participated during the 2006-2007 school year. The curriculum was implemented in first grade. The second cohort consisted of the remaining 71 schools (cohort two) in which participated during the following school year, 2007-2008. The curriculum was implemented in both first and second grades (Agodini et al., 2010).

The math assessment developed for the Early Childhood Longitudinal Study-Kindergarten Class of 1998-99 (ECLS-K) was used to measure the achievement effects of the curricula. The study team tested students at the beginning and end of the school year. A teacher survey was used to interpret measured achievement effects. The surveys were given in the fall and the spring. Teacher observations of the study team once in first grade and once in second grade were also used to interpret measured achievement effects. Both the surveys and the observation data were useful for assessing teacher participation in curriculum training, use of the assigned curriculum, supplementation of the assigned curriculum with other materials, and fidelity to the curriculum (Agodini et al., 2010).

The first school year of the study examined first-grade effects during the first year of curriculum implementation among the 39 cohort-one schools. Implementation analysis indicated that all teachers received training on the assigned curriculum as reported by teacher surveys, and they used their assigned curriculum as their core curriculum (99 percent in the fall, and 98 percent in the spring) (Agodini et al., 2010). The spring survey revealed 88 percent of teachers reported completing at least 80 percent of the curriculum lessons. One difference was noted in math instruction between curriculum groups, on average, Saxon teachers reported spending one more hour on math instruction per week than did teachers in the other curriculum groups (Agodini et al. 2010).

Key findings of the report were as follows:

Teachers used the assigned curriculum, and instructional approaches of the four curriculum groups differed as expected. According to the fall and spring surveys, at least 98 percent of the teachers reported using their assigned curriculum (Agodini et al., 2010). The classroom observations conducted by the study teams revealed the instructional approaches differed. Student-centered instruction and peer collaboration was highest in the Investigation classroom. Teacher-directed instruction was highest in the Investigation classrooms. These group differences are statistically significant at the 5 percent level of confidence (Agodini et al., 2010).

Math instruction varied in other notable ways across the curriculum groups. Saxon teachers reported spending an average of one hour more on mathematics instruction per week than did teachers in the other groups. The number of lessons taught differed as well across the curriculum groups. In first-grade classrooms, the number of lessons taught in 15 of the 20 content areas examined was significantly different across curriculum groups (Agodini et al., 2010). In second-grade classrooms, the number of lessons taught in 19 of the 20 content areas examined was significantly different across the curriculum groups. The pairwise comparisons revealed there is no clear pattern to which curriculum pair differences are consistently significant across content areas (Agodini et al., 2010).

The curriculum used by the study schools affected students mathematic achievement. Math Expressions used in first-grade classrooms was 0.11 standard deviations higher than both Investigations and SFAW students. Math Expressions and Saxon students in second-grade classrooms average mathematic achievement were 0.12 and 0.17 standard deviations higher than that of SFAW students respectively (Agodini et al., 2010).

The curriculum used in different contexts also mattered and findings are consistent with findings based on all students whereas others are not. The relative effects of curricula for subgroups of schools and teachers with different characteristics and for schools and teachers in each study district were examined by this study (Agodini et al., 2010). Among the first-grade subgroups, 22 curriculum differentials are statistically significant, of which 14 are consistent with the finding based on all first-graders, that is, average mathematics achievement of Math Expression students was higher than Investigations and SFAW students (Agodini et al., 2010). Between the second grade subgroups, 23 curriculum differentials are statistically significant, of which 16 are consistent with the findings based on all second-graders, that is, average mathematics achievement of Math Expressions and Saxon students was higher than that of SFAW students.

The results suggest evidence of mediation for three of the four curriculum-pair differentials that are statistically significant (Math Expressions- Investigations in first grade; Math Expressions-SFAW in first grade; and Saxon-SFAW in second grade)

(Agodini et al., 2010). These analyses are based on correlations between the implementation measures and student achievement. They do not necessarily deliver hard evidence of the influences that account for the significant differences in student achievement between some of the curriculum pairs. The results are best used as informative for assisting to influence future studies designed to provide hard evidence of mediation.

Conclusion

Classrooms differ far more than would be expected by chance, and teachers and schools differ on so many different variables that a textbook or curriculum that works best in one place cannot be predicted with certainty to work better in another. Making predictions about curriculum effectiveness will require more causal and correlational studies if we want to gain insight into the question “How does curriculum A work compared to curriculum B with a given set of students and teachers in a given context?” Investigating student achievement data related to curricular materials without some insight into how those materials are enacted and what factors influence the nature of the enactment is telling only part of the curriculum story (Thompson & Usiskin, 2014). The complete story requires insights into what happens between the intended curriculum of state standards, the written or implemented curriculum of the textbook and the assessed curriculum.

This study examines the relationship between the type of curriculum being enacted and student achievement, which is only part of the student achievement story. It can be a starting point for future research.

CHAPTER 3
Methods

Introduction

The purpose of the present study was to evaluate the impact of mathematics curriculum on student achievement, as measured by fourth grade NAEP mathematic scores from 2013. This chapter describes the methods and procedures that were used in this study. The chapter is divided into the following sections: Hypotheses, Research Design, Sample, Instrument, NAEP data collection, Validity and Reliability, and Data analyses used to test the hypotheses.

Hypotheses

1. H_1: There will be a statistically significant relationship between commercially designed curriculum and student achievement as measured by the 4^{th} grade National Assessment of Educational Progress (NAEP) mathematics assessment.

2. H_1: There will be a statistically significant relationship between mathematics curriculum structured by teacher discretion and student achievement as measured by the 4^{th} grade National Assessment of Educational Progress (NAEP) mathematics assessment.

3. H_1: There will be a statistically significant relationship between mathematics curriculum structured by district standards and student achievement as measured by the 4^{th} grade National Assessment of Educational Progress (NAEP) mathematics assessment.

4. H_1: There will be a statistically significant relationship between mathematics curriculum structured by state standards and student achievement as measured by the 4^{th} grade National Assessment of Educational Progress (NAEP) mathematics assessment.

Research Design

The research design of this study was a non-experimental cross-sectional explanatory design (Johnson, 2001) that used a multiple regression analysis to measure the relationship of the predictive variables (commercially designed math curriculum, math curriculum structured by teacher discretion, math curriculum structured by state standards, math curriculum structured by district standards) and the dependent variable of student achievement on the 2013 NAEP mathematics assessment in 4th grade. “Non-experimental research has been frequently an important and appropriate mode of research in education” (Johnson, 2001, p.3) due in part to the inability to perform randomized experiments and quasi-experiments. The researcher chose to use a multiple regression analysis because, according to Field (2009) “Regression analysis… enables us to predict future (outcomes) based on values of predictive variables” (p.198). This research explored the relationship between different types of mathematics curricula and fourth grade student mathematics achievement on 2013 NAEP mathematic scores. The curricula included in this study are commercially designed math curriculum, math curriculum structured by teacher discretion, math curriculum structured by state standards, and math curriculum structured by district standards. It examined whether the use of each curriculum mentioned above had an impact on fourth grade mathematics achievement.

The researcher performed data analysis and conducted descriptive analysis using SPSS software, followed by regressions and a multiple regression using AM software. The analysis was run to determine which curricula have a statistically significant effect on students’ mathematics achievement, as measured by the 2013 National Assessment of

Education Progress (NAEP) mathematics 4th grade assessment. The school survey from the National Assessment of Education Progress (NAEP) 2013 4th grade data set were used, allowing the researcher to identify specific curricula and their effect on mathematics achievement. The variables used in the present study are organized in table 3.1 below.

DV = Student Achievement 4th grade NAEP mathematics assessment.

IV = Commercially Designed Math Curriculum, Math Curriculum Structured by Teacher Discretion, Math Curriculum Structured by State Standards, Math Curriculum Structured by District Standards.

Table 3.1 – Curricula Variables

NAEP Variable #	Variable Description
CO60901	Math program structured per state standards
CO60902	Math program structured per district standards
CO60907	Math program structured per discretion of teachers
CO60908	Math program structured per commercial program

Sample

The student sample size and target population was obtained from the NAEP database using data collected from the 4th grade mathematics assessment of students from both private and public schools across the United States. The 2013 mathematics assessment results were based on nationally representative samples of 186,500 4th grade students across 7,930 elementary schools (public and private). The sample of students varies depending on the type of curricula being implemented (Commercially Designed Math Curriculum, Math Curriculum Structured by Teacher Discretion, Math Curriculum

Structured by State Standards, Math Curriculum Structured by District Standards). For the current study the sample size is 174,937, this sample was dependent on the impact of curriculum on 4th grade mathematics achievement. The sample represents the entire United States, including the Northeast, Midwest, South and Western regions of the country. The sample included approximately 51% male and 49% female students, the student reported race/ethnicity percentages are as follows: White, non-Hispanic 53.5%, African American 16.9%, Hispanic 19.6%, Asian 5.1%, American Indian or Alaskan Native 2.0 %, Unclassified 2.8%. Of the 174,937 students included in the sample for this study 93,745 (53.6%) were eligible for the National School Lunch program. The population and samples are represented in Table 3.2 below.

Table 3.2 – Description of Participants

Category	Number	%
Grade Level		
4	174,937	100
Gender		
Male	88,759	50.7
Female	86,178	49.3
Race/Ethnicity		
White, non-Hispanic	93,910	53.7
African American	29,521	16.9
Hispanic	34,351	19.6
Asian	8,881	5.1
American Indian/ Alaskan	3,442	2.0
Unclassified	4,832	2.8

Population

Schools and students participating in the NAEP assessments are selected to be representative of all schools nationally. The results are combined to provide accurate estimates of the overall performance of students in public, private, and other types of schools in the United States. Because each school that participated in the assessment, and each student assessed represents only a portion of the larger population of interest, the results are weighted to make appropriate inferences between student samples and the respective populations from which they are drawn. Sampling weights are adjusted for the disproportionate representation of some groups in the selected sample. This includes oversampling of schools with high concentration of students from certain racial/ethnic groups and the lower sampling rates of students who attend small schools (NCES, 2011).

Instrument

In this study, archival data were used. Even though data were previously collected and archived, the use of these data were appropriate for secondary analysis. Teachers, principals, parents, policymakers, and researchers cooperatively and individually use NAEP results to assess student progress across the country and develop future research interests for educational improvements in the United States (Olsen, 2005).

The fourth grade mathematics NAEP is administered every other year from the last week of January through the first week of March by NAEP. Field staff received extensive training to help safeguard data, guarantee its accuracy, and assure the integrity of the measures (NCES, 2013)

The NAEP mathematics assessment measures students' knowledge and skills in mathematics and students' ability to apply their knowledge in problem-solving situations. It consists of two sections: multiple choice and constructed response questions. These questions were designed to measure students' ability across five mathematics content areas: Number properties and operations, Measurement, Geometry, Data analysis, statistics, and probability, and Algebra (NAEP, 2013).

The NAEP Mathematics Assessment is complex. The design demands that multiple features stay in balance. The test items are balanced at each grade level according to the required distribution for each content area and adequately cover a broad range of content (NAEP, 2013). On the 4th grade assessment 40% of the questions are in the content area of number properties and operations, 20% of the question are the content area of measurement, 15% are in the content area of geometry, 10% are in the content area of data analysis, statistics, and probability, and 15% are in the content area of algebra.

To ensure a design of a valid and reliable assessment NAEP includes sampling, the use of calculators, and the use of manipulatives and other tools (NAEP, 2013). NAEP's design allows for matrix sampling, meaning that there are multiple forms of test booklets. Items are distributed across test booklets so that students are not all receiving the same questions. Matrix sampling greatly increases the capacity to obtain information across a much broader range of objectives than would otherwise be possible (NAEP, 2013). At each grade level about two-thirds of the blocks of items are not allowed to be solved using a calculator and one-third are to be solved using a calculator. Items are categorized according to the degree to which a calculator is useful in responding to the item. The assessment uses reasonable manipulative materials where possible in measuring the students' ability to represent their understanding and to use tools to solve problems. The manipulative materials and accompanying tasks are, carefully chosen to cause minimal disruption of the test administration process (NAEP, 2013).

The issue of accessibility for all students is of critical importance and addressed in many ways. The test is designed to measure the achievement of students across the nation. NAEP uses two methods to design an accessible assessment program. They are developing the standard assessment so that it is accessible, and providing accommodations for students with special needs (NAEP, 2013).

The assessment is administered in two blocks of time, 25 minutes each. About half of the questions are multiple-choice and the other half consists of both short answer and extended constructed response items. Questions of different degrees of difficulty were evenly distributed in a matrix-sampled test (NAEP, 2013).

Students' performance on the mathematics NAEP assessment is reported as average scores on separate 0 to 500 scales in mathematics and as the percentage of students performing at or above three achievement levels: Basic, Proficient, and Advanced (NAEP, 2013). These levels are intended to provide descriptions of what students should know and be able to do in mathematics.

Precautions are taken to ensure the reliability of NAEP findings. Congress calls for an ongoing evaluation of the assessment as a whole. In response to these mandates, the National Center for Education Statistics (NCES) has established various panels of technical experts to study NAEP, and panels are formed periodically by NCES or external organizations to conduct evaluations.

Data Collection

According to Cochran (1977), good sampling involves a statement of the research objective. Good sampling also requires a definition of the population to be sampled, explanation of the data to be collected, and a reflection of the process for gathering the data. As generalizability is a consideration for data gathering and interpretation, Cochran's sampling criteria have been used for the NAEP data gathering and assessment process since its initiation. The selection of participants is comprised of a sampling variation described as stratified random sampling (Saikali & Jain, 1997). Data from a national stratified sample of public and private school students and their teachers gives educators and researchers access to abundant nationwide results.

In combination with the sampling of schools and student assessment, NAEP collects information from teachers housed in selected schools across the United States. According to NAEP, subject-specific background information related to instructional practices and other contextual data is gathered at the same time that achievement in a subject is assessed. In view of this, school personnel and teachers are asked to complete questionnaires describing education practices and other contextual information. While completion of the questionnaire is voluntary, NAEP encourages their participation to enhance the accuracy and completeness of the NAEP assessment. Based upon the researchers' research questions and the need for appropriate contextual information related to fourth graders who were previously assessed, it was necessary to consider questionnaire information supplied by their school. The school reported data relating to curriculum contributed needed data for analysis.

NAEP originates its population values directly from the replies to each question answered by a representative sample of students, without computing their individual test scores. In NAEP research, the population values are known first. Plausible values are used to generate and retrieve valid estimates of population characteristics from this data. Plausible values are constructed explicitly to provide valid estimates of population effects. The twenty sets of plausible values represent a distribution of possible scores (NAEP, 2013).

Advantages of using plausible values statistics instead of the individual scores are the individual scores can produce flawed estimates of population characteristics. The twenty plausible values are not individual scores, they represent a distribution of possible scores, but they also apply to students taken as representative of the measured population groups to which they belong (NAEP, 2013).

Reliability and Validity

Moskal & Leydens (2000) defined validity as "the degree to which evidence supports correct data interpretations and the manner in which interpretations are used appropriately." (p.1). Reliability is defined as the extent to which the results are consistent over time and can be replicated using similar methodology (Moskal & Leydens 2000). The NAEP website documents the application of rigorous reliability and validity standards and measurements prior to administration of the NAEP 4th grade math assessments and completion of accompanying questionnaires. In order to meet a growing need for data to inform educational reform, NAEP assessments and questionnaires undergo strenuous reliability and validity measurements. As NAEP recognizes that validity and reliability are two important components needed to validate quantitative research for generalizability of results, NAEP questionnaires and assessments have demonstrated the ability to measure teacher, school, and student responses consistently and repeatedly (Moskal & Leyden, 2000).

To improve reliability of the assessment results, public schools are grouped together into strata by specific characteristics determined by NAEP. The schools are grouped based on several characteristics; geographical location, percentage of minority students, state assessment results, and median income. Student selection is calculated per state by allocating the population. The resulting strata make up a proportion of the population. Stratification of public schools occurs within each state. Grouping schools within strata by such selected characteristics provides a more ordered selection process generating a nationally representative sample and improving the reliability of the assessment results (NCES 2013).

Beginning in 2013 NAEP used twenty plausible values to measure student assessment scores. Plausible measurements are intricate and intended to minimize threats to validity, they are not perfect measurements and error still exists (NCES, 2013). Plausible values are derived from responses to the questions from a sample of students instead of a student's actual score (NCES, 2013).

As each component of the NAEP data set appears to have met rigorous requirements for reliability and validity, the researcher feels confident that the data obtained accurately represents nationwide school responses to questions representative of the use of different types of curriculum associated with 4th grade mathematics achievement. In order to answer the study's research questions, 4th grade assessment performance level data were simultaneously categorized with study related school questionnaire results for subsequent numerical and descriptive analysis.

Data Analysis

The researcher completed the National Institutes of Health (NIH) web-based training course "Protecting Human Research Participants" prior to conducting her study. The researcher was granted the human subject protocol approval from the St. John's IRB committee before beginning the research study. Access to the NAEP database was given through an *Affidavit of Non-disclosure*, which required the researcher to comply with federal regulations and use of the restricted data set.

This non-experimental study analyzed mathematics achievement as it related to curriculum. The purpose was to determine if different types of curricula used had a statistically significant relationship with mathematics achievement based on the sample. Participating school districts, teachers, and students that complete the NAEP assessment process also participate in a survey every two years. Surveys and questionnaires consist of variables in which can be analyzed to conduct educational research. The researcher reviewed the NAEP variables, selecting the items pertaining to the focus of the study to support the research questions. The variables chosen supported the independent variables for the study: commercially designed math curriculum, math curriculum structured by teacher discretion, math curriculum structured by state standards, and math curriculum structured by district standards.

These items were obtained from the restricted-use data files of the NAEP 4th grade mathematics assessment using the NAEPEX software provided with the NAEP Data Toolkit. The researcher then imported the 4 original variables into SPSS Predictive Analytics Software (SPSS) to conduct descriptive statistics. The data were then screened and the missing values and omitted vales were removed. After analyzing the descriptive statistics, the dependent variable, student academic achievement on the 4th grade NAEP mathematics assessment was computed using twenty plausible math values created by NAEP. The mean score value was 241 and the standard deviation was 30. The data was then imported into AM – the American Institute for Research Statistical Software to be analyzed. The AM software was developed by NCES to work with complex samples, especially large-scale assessments such as the National Assessment of Educational Progress (NAEP) and the Trends in International Mathematics and Science Studies (TIMMS) (NCES, 2013).

The AM Statistical software allows the researcher to conduct a multiple regression model using twenty plausible math composite values. The multiple regression model can then be used to determine if statistically significant relationships exist between the researcher's independent variables: commercially designed math curriculum, math curriculum structured by teacher discretion, math curriculum structured by state standards, and math curriculum structured by district standards and the dependent variable. The dependent variable for the researcher's study was the 4th grade mathematics assessment in which was represented using the twenty plausible values in AM, this began the regression analysis and finally a multiple regression analysis.

In the first regression model, the factor – Math Program Structured by State was used for the independent variable allowing the researcher to determine the variance attributed to the dependent variable. The second regression model used the factor – Math Program Structured by District for the independent variable allowing the researcher to determine the variance attributed to the dependent variable. The third regression model, the factor – Math Program Structured by Teacher was used for the independent variable allowing the researcher to determine the variance attributed to the dependent variable. The fourth regression model, the factor – Math Program Structured per Commercial Program was used for the independent variable allowing the researcher to determine the variance attributed to the dependent variable. Finally a multiple regression was used to learn more about the relationship between curricula (independent variables) and mathematic achievement (dependent variable). An in-depth analysis of the results will be discussed in Chapter 4.

CHAPTER 4
Results

Introduction

This chapter presents the detailed findings from the regression models. The purpose of this study was to identify if the different types of curricula being used had an effect on students' academic achievement on the 4th grade NAEP mathematics assessment. The results of each regression used to test the hypotheses will be discussed. The researcher selected four NAEP variables to address the four research questions presented below

1. Is there a statistically significant relationship between commercially designed mathematics curriculum and student achievement as measured by the 4th grade National Assessment of Educational Progress (NAEP) mathematics assessment?
2. Is there a statistically significant relationship between mathematics curriculum structured by teacher discretion and student achievement as measured by the 4th grade National Assessment of Educational Progress (NAEP) mathematics assessment?
3. Is there a statistically significant relationship between mathematics curriculum structured by district standards and student achievement as measured by the 4th grade National Assessment of Educational Progress (NAEP) mathematics assessment?
4. Is there a statistically significant relationship between mathematics curriculum structured by state standards and student achievement as measured by the 4th grade National Assessment of Educational Progress (NAEP) mathematics assessment?

Regression Analysis

A regression analysis was used to analyze the relationship between the type of curriculum implemented and 4th grade mathematics achievement on the 2013 NAEP national assessment. The 2013 NAEP assessment used twenty plausible values to assess 4th grade mathematics achievement, these twenty plausible values are the dependent variable in the present study and used to measure the degree to which the type of curriculum affects mathematics achievement.

To test the researcher's hypotheses the data were entered into the AM statistical software to create a regression model for each hypothesis. The researcher investigated the significance level (set at $p< .001$) of each independent variable and dependent variable using the Root Means Square Error (RMSE), R^2, and corresponding effect size f^2. The significance level – p value allows the researcher to determine whether they should or should not reject the null hypothesis (Meyers, Gamst, & Guarino, 2013). The coefficient of determination, R^2, is a value used to indicate the proportion of the achievement variance attributed to the variables in the present study (Meyers, Gamst, & Guarino, 2013). The main concept of using R^2 statistic is to test the research hypothesis. The Root Mean Square Error (RMSE) is used to measure the differences between values of a sample or population predicted by a model and the values observed (Meyers, Gamst, & Guarino, 2013). Furthermore, effect size is a quantitative measure of the strength of a relationship (Meyers, Gamst, & Guarino, 2013). Effect size complements statistical hypothesis testing, and play an important role in power analyses, sample size planning, and in meta-analysis (Meyers, Gamst, & Guarino, 2013). The reporting of effect size simplifies the interpretation of the results of a study and is common practice when presenting empirical research findings (Meyers, Gamst, & Guarino, 2013).

Research Question 1

Is there a statistically significant relationship between commercially designed mathematics curriculum and student achievement as measured by the 4th grade National Assessment of Educational Progress (NAEP) mathematics assessment? A regression analysis determined the extent to which commercially designed mathematics curriculum predicted students mathematic achievement. After removal of missing and omitted values a sample size of 174,937 was used in the analysis. For $p = 0.001$, the overall test for the model was determined to be significant (see table 4.1). The model produced an R^2 value of 0.002; therefore, the variable commercially designed mathematics curriculum in this model predicted 0.2% of the variance in the 2013 NAEP fourth grade mathematics results in participating schools nationwide. As the model was found to be significant at this alpha level, the alternate hypothesis $H_1 1$: there will be a statistically significant relationship between commercially designed mathematics curriculum and student achievement as measured by the 4th grade National Assessment of Educational Progress (NAEP) mathematics assessment was accepted. Furthermore, commercially designed mathematics curriculum made a significant contribution to the model at $p<.0001$. The greater number of schools using commercially designed mathematics curriculum predicted an increase in NAEP mathematics scores. $f^2=0.002$ was recorded indicating a small effect size (see Table 4.1).

Table 4.1
Regression Analysis #1 – Commercially Designed Mathematics Curriculum

Parameter Name	Estimate	Standard Error	*z* Score	*p*>|z|
Constant	238.671	0.884	270.107	0.000
Commercially Designed Mathematics Curriculum	1.267	0.337	3.764	0.000
Root Mean Square Error	29.539			

$p<0.001$
$R^2=0.002$, $F(1,191)=14.1641$, $p<.0.0001$, $f^2=0.002$

Research Question 2

Is there a statistically significant relationship between mathematics curriculum structured by teacher discretion and student achievement as measured by the 4th grade National Assessment of Educational Progress (NAEP) mathematics assessment? A regression analysis determined the extent to which mathematics curriculum structured by teacher discretion predicted students mathematic achievement. After removal of missing and omitted values a sample size of 174,937 was used in the analysis. For $p = 0.001$, the overall test for the model was determined to not be significant (see table 4.1). The model produced an R^2 value of 0.000; therefore, the variable mathematics curriculum structured by teacher in this model predicted 0% of the variance in the 2013 NAEP fourth grade mathematics results in participating schools nationwide. As the model was found to be not significant at this alpha level, the alternate hypothesis $H_1$2: there will be a statistically significant relationship between mathematics curriculum structured by teacher discretion and student achievement as measured by the 4th grade National Assessment of Educational Progress (NAEP) mathematics assessment was rejected. Furthermore, mathematics curriculum structured by teacher did not make a significant contribution to the model at p=0.744. (see Table 4.2)

Table 4.2
Regression Analysis #2 – Mathematics Curriculum Structured by Teacher

Parameter Name	Estimate	Standard Error	*z* Score	*p*>|z|
Constant	242.036	0.84	288.05	0.000
Mathematics curriculum structured by teacher discretion	-0.104	0.32	-0.326	0.744
Root Mean Square Error	29.567			

$p<0.001$
$R^2=0.00$, $F(1,191)=0.106383$, p=0.744, $f^2=0.00$

Research Question 3

Is there a statistically significant relationship between mathematics curriculum structured by district standards and student achievement as measured by the 4th grade National Assessment of Educational Progress (NAEP) mathematics assessment?

A regression analysis determined the extent to which mathematics curriculum structured by district standards predicted students mathematic achievement. After removal of missing and omitted values a sample size of 174,937 was used in the analysis. For p = 0.05, the overall test for the model was determined to be significant (see table 4.3). The model produced an R^2 value of 0.00; therefore, the variable mathematics curriculum structured by district standards in this model predicted 0.0% of the variance in the 2013 NAEP fourth grade mathematics results in participating schools nationwide. As the model was found to be significant at this alpha level, the alternate hypothesis $H_1$3: there will be a statistically significant relationship between mathematics curriculum structured by district standards and student achievement as measured by the 4th grade National Assessment of Educational Progress (NAEP) mathematics assessment was accepted. Furthermore, mathematics curriculum structured by district standards made a significant contribution to the model at $p<0.05$. The greater number of schools using mathematics curriculum structured by district standards predicted a decrease in NAEP mathematics scores. f^2=0.000 was recorded indicating a small effect size (see Table 4.3).

Table 4.3
Regression Analysis #3 – Mathematics Curriculum Structured by District Standards

Parameter Name	Estimate	Standard Error	*z* Score	*p*>|z|
Constant	244.544	1.431	170.885	0.000
Mathematics Curriculum Structured by District Standards	-0.778	0.394	-1.974	0.048
Root Mean Square Error	29.561			

$p<0.05$
R^2=0.00, $F(1,191)$=3.899495, $p<0.048$, f^2=0.00

Research Question 4

Is there a statistically significant relationship between mathematics curriculum structured by state standards and student achievement as measured by the 4th grade National Assessment of Educational Progress (NAEP) mathematics assessment? A regression analysis determined the extent to which mathematics curriculum structured by state standards predicted students mathematic achievement. After removal of missing and omitted values a sample size of 174,937 was used in the analysis. For $p = 0.001$, the overall test for the model was determined to be significant (see table 4.4). The model produced an R^2 value of 0.002; therefore, the variable mathematics curriculum structured by state standards in this model predicted 0.2% of the variance in the 2013 NAEP fourth grade mathematics results in participating schools nationwide. As the model was found to be significant at this alpha level, the alternate hypothesis $H_1$4: there will be a statistically significant relationship between mathematics curriculum structured by state standards and student achievement as measured by the 4th grade National Assessment of Educational Progress (NAEP) mathematics assessment was accepted. Furthermore, mathematics curriculum structured by state standards made a significant contribution to the model at $p<0.001$. The greater number of schools using mathematics curriculum structured by state standards predicted a decrease in NAEP mathematics scores. $f^2=0.002$ was recorded indicating a small effect size (see Table 4.4).

Table 4.4

Regression Analysis #4 – Mathematics Curriculum Structured by State Standards

Parameter Name	Estimate	Standard Error	*z* Score	*p*>|z|
Constant	250.733	2.122	118.173	0.000
Mathematics Curriculum Structured by State Standards	-2.353	0.554	-4.249	0.000
Root Mean Square Error	29.544			

$p<0.001$

$R^2=0.002$, $F(1,191)=18.0522$, $p<0.000$, $f^2=0.002$

Multiple Regression

A multiple regression was conducted on the following independent variables in the study: *Commercially designed mathematics curriculum, curriculum structured by state standards, and curriculum structured by district standards.* This allowed the researcher to examine how the multiple independent variables were related to the dependent variable. It also allowed the researcher to make a more powerful and accurate prediction about how the different types of curricula implemented in each classroom affect students' academic achievement on the 2013 NAEP fourth grade mathematics assessment.

A multiple regression was calculated to predict 2013 NAEP fourth grade mathematic scores based on commercially designed mathematics curriculum, curriculum designed by state standards, and curriculum designed by district standards (see Table 4.5). The multiple regression model was significant (p < 0.001) with an actual p-value of $p = 0.001$, $R^2 = 0.003$, F (3, 389) = 10.0636, $p < 0.001$, $f^2 = 0.003$. The regression model created for the present study predicted 0.3% of the variance on the 2013 4^{th} grade NAEP mathematics assessment. The effect size ($f^2 = 0.003$), determined the combined effect of the independent variables (commercially designed mathematics curriculum, curriculum designed by state standards, and curriculum designed by district standards) had an extremely small proportion of variance in 4^{th} grade mathematic achievement scores. In this regression model, $R^2 = 0.003$, therefore, 0.3% of the student mathematics achievement variance can be attributed to the independent variables examined in this study. The overall effect size, $f^2 = 0.003$, indicates an extremely small relationship between the variables in the sample population and mathematic achievement.

Table 4.5
Multiple Regression Analysis

Parameter Name	Estimate	Standard Error	*z* Score	*p*>|z|
Constant	247.376	2.508	98.631	0.000
Mathematics Curriculum Structured by State Standards	-2.018	0.548	-3.684	0.000
Mathematics Curriculum Structured by District Standards	-0.232	0.388	-0.599	0.549
Commercially Designed Mathematics Curriculum	1.189	0.338	3.516	0.000
Root Mean Square Error	29.519			

$p<0.001$
$R^2=0.003$, $F\ (3,389)=10.0636$, $p<0.000$, $f^2=0.003$

As a result of the multiple regression analysis, the following two variables: Mathematics Curriculum Structured by State and Commercially Designed Curriculum had significant results. The first had a significant negative impact on academic achievement and the second had a significant positive impact on academic achievement. The achievement variance for both variables is extremely small. The researcher can conclude mathematics curriculum does not impact academic achievement.

CHAPTER 5
Discussion

Introduction

In this chapter, the researcher will discuss the implications of each of the major findings and how they relate to both the theoretical framework and existing literature review presented previously in Chapter 2. The researcher will also address the limitations of the study and questions for future research on the topic. Lastly, the researcher will provide recommendations and suggestions for future research and future practice to practitioners and policy makers.

The general question underlying this study has to do with the relationship between mathematics curricula and 4th grade mathematics achievement, and whether the relationship is dependent upon commercially designed mathematics curriculum, mathematics curriculum designed by state standards, mathematics curriculum structured by teachers discretion, and mathematics curriculum designed by district standards.

Implications

The results of the multiple regression analysis indicate that commercially designed mathematics curriculum as well as mathematics curriculum designed by state standards, has a minimal effect on academic achievement on the 2013 NAEP Mathematics Assessment. The findings of the regression analysis of the variables, mathematics curriculum structured by teachers discretion and mathematics curriculum designed by district standards was insignificant.

The results of this study indicate that the type of mathematics curriculum implemented in the classroom has minimal impact on student achievement. Although great attention in educational research is often given to the specific strategies or curriculum implementation employed in a curriculum study, there is the inescapable reality that regardless of the chosen activities or methods employed to effect change in the setting, the commitment and investment of the school staff are a significant determinant in the final effectiveness of the outcomes (Hertberg-Davis & Brighton, 2006). Stakeholders need to recognize the importance of the implementation of curriculum to fidelity by teachers in order to see results in academic achievement.

The statistical findings of the study are consistent with prior research that states, emphasis teachers place on different learning goals and different topics, the expectations for learning they set, the time they allocate for particular topics, the kinds of tasks they pose all are part of teaching and all influence the opportunities students have to learn (Thompson & Usiskin, 2014). Curriculum alone does not strongly affect student achievement. The way in which the curriculum is enacted likely facilitates the potential of a given curriculum to influence student achievement. The way in which teachers teach mathematics has changed and teachers need to shift mathematic instruction from teaching procedure to teaching for a deeper understanding of concepts. Curriculum alone will not accomplish this task. Providing students with opportunities to interact with mathematical ideas, with the main goal of building meaning and understanding, is one example of how teachers can support students (Burns, 2007). According to the NCTM (2000), students should be encouraged to monitor and assess themselves. Good problem solvers realize what they know and don't know, what they are good at and not so good at.

While this research indicates, mathematics, curricula has a minimal effect on academic achievement, without the ability of monitoring the implementation of curriculum in each classroom we can only assume "the curriculum is being taught with fidelity." Over the past 25 years, scholars have investigated how teachers use curriculum materials and what role textbooks and curriculum materials play in mathematics classrooms (Remillard, 2005). However, teachers use of curricula range from undermining or rejecting, adapting and revising, to wholeheartedly teaching the curriculum to fidelity. Common Core State Standards for Mathematics (CCSSM) was intended to improve the quality of mathematics teaching, allowing teachers to develop deep student understanding of a set of concepts. Teachers can focus on core, or focal, topics for longer periods of study in a single year. Most teachers and schools have not had a chance to work through the full implications of the necessary curricula and assessment methods (Dossey, McCrone, & Halvorsen, 2016). Therefore the strong relationship between mathematics curriculum and academic achievement has been difficult to establish.

The results of this study also signify a very small relationship between commercially designed mathematics curriculum, mathematics curriculum structured by state standards and student academic achievement. Textbooks (commercially designed curriculum) serve to deliver consistency across classrooms by providing the scope and sequence of instruction, which ultimately impacts student achievement (Reys & Reys, 2006). More importantly, the way in which a teacher implements mathematics curriculum plays an important role in how curriculum impacts student achievement. The way in which mathematics curriculum is implemented has been dictated by a mixture of individual state expectations for the topics to be taught within mathematics classes at various levels of education and, in some districts, associated student abilities and expected outcomes (Dossey, McCrone, & Halvorsen, 2016). The enacted mathematics curriculum interacts with numerous elements of the educational system, from curriculum frameworks at a state or district level to adopted textbook materials at a school or classroom level to assessments for accountability purposes at the student level (Thompson & Usiskin, 2014).

Drawing a direct link from curriculum to student learning is difficult because many other factors influence what students learn, including teacher choices and actions, school and classroom organization, and student readiness and willingness to learn. The enacted curriculum involves interaction among texts, teachers, and students. There have been few studies on the enacted curriculum. The researchers used different methods to collect data to determine whether the goals of the curricula were consistent with the teachers' enactment. Jong, Pedulla, Reagan, Salomon-Fernandez and Cochran-Smith (2010) examined the relationship between reformed classroom practices of beginning elementary school teachers' instruction of mathematics and how it connected to students' academic achievement. They used the Reformed Teaching Observation Protocol (RTOP) an instrument that measures active learning, inquiry-based instruction, and problem solving strategies, to determine whether the goals of the two study curricula were consistent with the teachers' enactment.

Tarr, Reys, Reys, Chavez, Shih, and Osterlind (2008) studied achievement in a large group of middle school students over three years in ten different schools who were using either published textbook series or one of three textbooks developed with funding from the National Science Foundation. The researchers collected a variety of implementation data from teachers to determine how they used the curriculum material to plan and enact instruction. They used teacher questionnaires, textbook use diaries in which teachers recorded specific information about the use of the textbook for three intervals of ten days each, and a table of contents record keeping track of the lessons taught. They also used classroom observations to determine the extent to which the classroom environment modeled practices recommended by the NCTM Standards and aligned with the philosophical approach of the NSF funded curricula. Determining whether the goals of the curricula are consistent with the teachers' enactment plays an important role in making a connection between curriculum and academic achievement.

This study focuses on mathematics curricula and its impact on students' academic achievement. In order to determine how mathematics curricula impacts students' academic achievement, collecting data to determine whether the goals of the curricula are consistent with the teachers' enactment is an important component that must be included in any study searching for strong significant results.

Limitations of the Study

This study contained numerous limitations. The research focused solely on 4^{th} grade mathematics results; this could impact the study's external validity, as generalizations of the results were limited to the use of curriculum in this specific grade level. The effect of curriculum in the classroom on student achievement may vary based on grade-level, and the results should not be used to generalize outcomes about middle school or high school mathematics.

The data in this study reflect access, frequency, and curriculum usage and the relationship they have on mathematics achievement for 2013. This study analyzes data from nearly four years ago. Considering certain types of curriculum have changed significantly in the past 5 years due to common core state standards for mathematics, the present state of curriculum might provide different results thereby impacting upon the study's internal validity.

Another possible limitation and threat to internal validity of this study is only one source of data was used to analyze the relationship between curriculum and student achievement. Furthermore, it is difficult to monitor the quality of the implementation of curriculum to each classroom. The sample is extensive from many different districts and states nationwide. Pulling from a large sample limits the researcher's ability to evaluate the implementation of curriculum in many schools across the nation from which NAEP data were collected. It is possible that the curriculum was not implemented with fidelity and this would make it difficult to detect any effects on academic achievement.

It is also important to note that NAEP is not designed to reveal the underlying cause between student achievement and another variable, which may be influenced by a number of other variables. It is important to consider the influence of unmeasured variables when using NAEP data, such as classroom observation and curriculum use diaries to mention a few. It is important for accurate interpretation of the outcomes to provide information about teacher instructional practices. It may have been useful to collect observational data on the identification process of the fidelity to the curriculum. Future research using qualitative data can assist in providing the depth curriculum has on mathematics academic achievement.

Recommendations for Future Research

The improving mathematics achievement of students, above all at the elementary level will continue to be a major concern of public schools. While this study focused on curricula and its impact on students' academic achievement, it was assumed that mathematics curricula alone could not improve mathematics achievement. It is vital to conduct research on other variables that may impact student mathematics achievement and closing the achievement gap. Ladd (2011) concluded one major variable was socioeconomic status. This issue must be addressed if public schools have a chance of closing the achievement gaps. Policies must be established in order to reduce poverty and other attributes of low-socioeconomic status. Socioeconomic status (SES) was one characteristic that was not addressed in this study. A recommendation to replicate this study and include variables such as ethnicity, gender, SES, and prior mathematic ability is suggested.

Another recommendation for future research would be to compare the quality of instruction and the implementation of curriculum materials through classroom observations and coding techniques. Although students may have had a teacher who was implementing the curricula, the manner and degree of implementation may not have been consistent across teachers.

As stated in the limitations section of this study, the use of NAEP is not designed to reveal the underlying cause between student achievement and another variable, which may be influenced by a number of other variables. Therefore, a smaller scale study, including qualitative data, such as classroom observations is encouraged to more accurately evaluate the impact of mathematics curricula and its effects on academic achievement.

Furthermore, due to the limited amount of research focused on mathematics curricula and how it affects academic achievement, it is important for future research to be conducted on this topic. For decades, educational reform initiatives have incited debate over what mathematics should be learned, by whom it should be learned, and when it should be learned (Romberg, 2010). According to NCTM Research Committee (2008), mathematics curricular effectiveness has been identified as a high-priority area in need of further research.

Recommendations for Future Practice

Given the results of the present study educational stakeholders should interpret the findings from the current study as an opportunity to investigate further the implementation of the current mathematics curriculum in each classroom. More research is needed on mathematics curriculum, but the evidence to date suggests surprising conclusions despite all the heated debates about the content of mathematics, there is limited high-quality evidence supporting affects of different math curricula (Slavin & Lake, 2008).

The relationship between mathematics curricula and student learning are complex with multiple variables involved in determining student achievement. It is recommended that school leaders explore multiple methods for improving students' mathematics learning. For example, professional development and improvement of teachers' instructional process strategies (cooperative learning, mastery learning, math content knowledge, direct instruction), and collecting data concerning the fidelity of curriculum implementation over a sustained period of time. The way in which the curriculum is enacted likely facilitates the potential of a given curriculum to influence student achievement (Remillard, Harris, & Agodini, 2014).

Conclusion

Researching the effect of mathematics curriculum on academic achievement is a complex endeavor that is difficult to conduct for many reasons. These reasons, including gaining access to schools, documenting the extent to which teachers follow the curriculum with fidelity, collecting data over a sustained period of time, identifying appropriate comparison groups, isolating variables, and accessing valid measures of student achievement. Curriculum is a vital part of the educational process. Combined with effective instructional strategies, implementation fidelity, and student's intrinsic desire to learn, student achievement should be expected. Based on the results of this study, the conclusion was reached that mathematics curricula has a minimal effect on students' academic achievement.

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Appendix A

Signed form of IRB approval to conduct the study within the involved institution(s)

ST. JOHN'S UNIVERSITY

MEMO

Institutional Review Board

Federal Wide Assurance: FWA00009066

Date: March 17, 2017

To: Rossana Nargi

CC: Dr. Mary Ellen Freeley

Dr. Rene Parmar

Dr. Raymond DiGiuseppe

Chair, Institutional Review Board

Tel 718-990-1955

digiuser@stjohns.edu

Dr. Marie Nitopi

IRB Coordinator

Tel 718-990-1440

Protocol # 0317-183

Protocol Title: Mathematics Curricula and Their Impact on Students' Mathematic Achievement

Please be advised that your human subject protocol has been reviewed by the IRB and is considered approved/exempt. You are free to begin your project.

Since the proposal is exempt, no further follow-up by the IRB is required. Please notify the IRB of <u>any</u> deviation from your proposal since any change may require IRB review and approval.

Best wishes for successful pursuit of this research.

****It is imperative that you keep this on file where it can easily be accessed. You will need to provide copies of this document when involved in further correspondence with the IRB. The IRB will provide you with an additional copy of this document only in the case of an emergency.****

Appendix B

National Institute of Health (NIH) Certificate of Completion

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **ROSANNA NARGI** successfully completed the NIH Web-based training course "Protecting Human Research Participants".

Date of completion: 12/29/2016.

Certification Number: 2260872.

Appendix C

School Survey Question from 2013 NAEP Mathematics Assessment

To what extent is your school's mathematics program structured according to the following resources? (VC311202)
Variable
State curriculum standards or frameworks (VC311204)
District curriculum standards or curriculum guide (VC311209)
Discretion of individual teachers (VC311214)
Commercially designed programs (VC311215)