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A Comparative Analysis of Effective Mathematics Curriculums in the State of Missouri

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A Comparative Analysis of Effective

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in the State of Missouri

by

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Declaration of Originality

I do hereby declare and attest to the fact that this is an original study based solely upon my own scholarly work here at Lindenwood University and that I have not submitted it for any other college or university course or degree here or elsewhere.

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Abstract

The purpose of this study was to examine the mathematics curriculums and implementation strategies of high-performing school districts in Missouri. The study was designed to determine any similarities or differences in the selection of mathematics curriculums or in implementation strategies among these high-performing school districts. Scores from the mathematics section of the ACT during the years all Missouri 11th-grade students were mandated to take the ACT were used to make determinations about the efficacy of mathematics curriculums and implementation strategies. The school districts with an average score in the top 10% of the state during the mandated years were asked to participate in the study. The school districts that agreed to participate in the study were then asked to complete a survey. The survey included questions about the specific curriculums and implementation strategies the school districts implemented in grades K–11 to determine if specific mathematics curriculums could increase the understanding of concepts and make a difference in student scores on the mathematics section of the ACT. The results indicated there was no significant difference between districts based on the choice of mathematics curriculum and success on the ACT; however, the data indicated some similarities in implementation strategies among the high-performing school districts.

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Chapter One: Introduction

With increased focus on science, technology, engineering, and mathematics (STEM), many school districts have attempted to improve their mathematics curriculums (Ather Khan et al., 2018; Dossey et al., 2016; Nowikowski, 2017; Potari et al., 2019; Shirani Bidabadi et al., 2019). Information comparing specific mathematics curriculums in the current literature is limited, as is research regarding strategies that contribute to peak student performance. While a multitude of articles has been written about mathematics curriculums (Codding et al., 2016; Davidson, 2019; Doabler et al., 2019), there is still "much to learn about teaching certain topics in STEM and about the characteristics of curriculum development and professional development that will let children realize their full potential in these critical subjects" (Clements & Sarama, 2016, p. 91).

Escalera-Chávez and Rojas-Kramer (2019) asserted, "Mathematics plays a fundamental role in any curricular plan of educational institutions because it promotes students' reasoning and analytical thinking" (p. 128). Disagreement exists in mathematics communities about whether a conventional or standards-based mathematics curriculum is superior (Ardeleanu, 2019). This study was conducted to add to the literature by comparing specific mathematics curriculums and implementation strategies of high-performing school districts in Missouri.

In 2015, 2016, and 2017, the Missouri Department of Elementary and Secondary Education (MODESE) mandated juniors in high school who were eligible for the ACT must take the ACT (Helwig, 2014; Sireno, 2017). This development allowed for school districts across the state to be measured against each other, with all students represented

(Cooper, 2015). This study was focused on examining the mathematics curriculums or series utilized by school districts identified as high achieving on the mathematics section of the ACT. The strategies these high-performing school districts use when implementing a chosen mathematics curriculum were also examined. Based upon this research, school districts will have current information to make informed decisions when choosing or updating a mathematics curriculum.

Background of the Study

In the past five years, two major developments have caused public school districts in Missouri to evaluate their mathematics curriculums. On January 14, 2014, the MODESE mandated all juniors who were not eligible for alternative assessment must take the ACT (Helwig, 2014). The mandate not only allowed students to receive "a valid ACT score that can be used when applying to an institution of higher education," it also "provided a valuable snapshot of college and career readiness among Missouri students" (Cooper, 2015, para. 1). This development allowed all students in the state who were eligible to take the ACT to be represented in their school district's Annual Performance Report (APR) (Cooper, 2015).

Furthermore, each school district's average composite score would be available on the school district's APR summary data page (Cooper, 2015). The ACT directive provided a unique opportunity for school districts across the state to be measured against each other in content-specific categories on a nationally recognized test (Cooper, 2015). Additionally, a renewed push for STEM education brought mathematics and science to the forefront of curriculum evaluation and development (Coxon et al., 2018; Dossey et al., 2016).

Even before the mandated ACT and the STEM push, there were movements to improve mathematics curriculums (Phillips, 2014a, 2014b). Mathematics curriculums have been a topic of much interest in educational circles for many years (Phillips, 2014a). Increased interest in understanding why some students struggle with mathematics concepts has become apparent (Høgheim & Reber, 2019; Kong & Orosco, 2016). Gillum (2014) determined, “Over the past ten years, there has been growing interest in the difficulties that children experience in mathematics” (p. 275). Because “mathematics is a discipline that develops students’ critical thinking skills” (Nool & Corpuz, 2018, p. 292), school districts have attempted to understand the struggles of students who have historically not been successful in mathematics (Clements & Sarama, 2016; Diemer et al., 2016; Young et al., 2017). Researchers have examined the struggles of rural students (Irvin et al., 2017) and students who have grown up in poverty (Diemer et al., 2016). Also, researchers have examined the impact on students who, through no fault of their own, have been transient and have moved from school district to school district (Folke, 2018; Giambona et al., 2017).

While many studies have been conducted to try and explain why students do poorly in mathematics (Harwell et al., 2014; Scammacca et al., 2020), numerous other studies have been focused on the topics of how to improve a student’s understanding of mathematics (Barbieri et al., 2020; Grégoire, 2016). Theories range from incorporating physical activity into the mathematics curriculum (Have et al., 2016; Mead et al., 2016) to attempting to control the composition of student enrollment in a classroom (Boonen et al., 2014).

There are also multiple theories on how mathematics curriculums should be introduced to students (Ardeleanu, 2019; Davidson, 2019). Some believe traditional methods of mathematics education, such as memorizing facts, focusing on core knowledge and skills, and testing, have more to do with student success than the current trend of focusing on student-centered learning (Joseph & Buckingham, 2018). Others believe using “modern, interactive methods” will lead to increased student understanding of mathematics concepts (Ardeleanu, 2019, p. 133). Mehmood et al. (2019) explained, “Mathematics is affected by teachers and the teaching methods adopted by the teachers” (p. 252).

While the method of mathematics instruction is up for debate, deciding on the best method of measuring mathematics achievement is also a struggle for school districts (Arens et al., 2017). Multiple states use standardized achievement tests to measure student achievement against other students within the state (Arens et al., 2017). If a researcher’s goal is to compare students from different countries, a different tool would be used, such as a study of international student performance (Jung Kang, 2014). In Missouri, tests such as the Missouri Assessment Program “test students’ progress toward mastery of the Missouri Show-Me Standards” (MODESE, 2019, para. 2), while national tests, such as the ACT, measure student growth compared to other students in the country (Dickinson & Adelson, 2016).

Theoretical Framework

This study was based on the principle of curriculum theory. Curriculum theory is a complicated educational topic (Beauchamp, 1961; Pinar, 2012, 2014) which involves political (Baker, 2015; Pinar, 2012), societal (Baker, 2015; Gravemeijer & Terwel, 2000;

Lundgren, 2015; Pinar, 2014), and educational (Beauchamp, 1982; Lundgren, 2015; Young, 2013) implications. The topic of curriculum theory can be contentious, and experts Morris and Hamm (1976) declared, “Much confusion exists as to what curriculum theory is” (p. 299). Experts in the field also have a difficult time agreeing on how to best define the term *curriculum theory*. Pinar (2012) stated curriculum theory is “the scholarly effort to understand the curriculum” (p. 1), while Beauchamp (1982) defined curriculum theory as “a set of related statements, or propositions, that gives meaning to the phenomena related to the concept of a curriculum, its development, its use, and its evaluation” (p. 24).

Even though curriculum theory is a continuous subject among scholars, the root of curriculum work is not only in helping the educational community; it is important to society as a whole (DeMatthews, 2014). As determined by DeMatthews (2014):

> All of the educative experiences learners have in an educational program, the purpose of which is to achieve broad goals and related specific objectives that have been developed within a framework of theory and research, past and present professional practice, and the changing needs of society. (p. 192)

While curriculum theory is focused on helping society as a whole, societal understanding of curriculum theory should lead to a more educated populous, whereby “knowledge of the powerful is powerful knowledge itself – and hence widespread access to education equals mass access to powerful knowledge” (Baker, 2015, p. 764).

While scholars such as Baker (2015), DeMatthews (2014), Pinar (2012, 2014), and Young (2013, 2015) debated the overall implications of curriculum theory, and others such as Yates and Millar (2016) called for continued growth in the field of curriculum, the focus of this study was on the implications of curriculum theory to mathematics. According to Gravemeijer and Terwel (2000), much of the theoretical work on mathematics curriculums can be attributed to the Dutch mathematician Hans Freudenthal. Freudenthal emphasized, “General education theories not only do not fit the situation of mathematics education but in many cases, are detrimental” (as cited in Gravemeijer & Terwel, 2000, p. 784). Gravemeijer and Terwel (2000) concluded, “Mathematics must be seen foremost as a process, a human activity. However, at the same time, this activity has to result in mathematics as a product” (p. 786).

While Freudenthal developed the theoretical framework for curriculum development in mathematics, today there are a multitude of curriculums available (Taylor & Brickhill, 2018). These curriculums have undergone many changes as the focus of mathematics has evolved from teacher-centered learning to a conceptual learning model (Eronen & Kärnä, 2018). As mathematics curriculums continue to evolve, the field of curriculum theory will work to keep up with and influence these changes (Greer, 2017).

Statement of the Problem

Bulut et al. (2020) clarified, “How learning takes place has always occupied our minds. In fact, this is because we have not been able to solve the entire working mechanism of brain yet” (p. 461). The mystery of how the brain works can be applied to how students best learn mathematical concepts. There is an abundance of research available on how to improve mathematics education in general (Foley, 2019), but there is a noticeable void in the available research when attempting to identify the specific strategies successful school districts use and even less research on which mathematics curriculums work in these school districts.

Due to those in mathematics education promoting "logical thinking ability among learners which is key for development in the modern era" (Shah, Majoka, et al., 2019, p. 198), many agree there needs to be an increased focus on integrating STEM education into the classroom (Farwati et al., 2018; Wu-Rorrer, 2017; Yıldırım & Sidekli, 2018). Chen et al. (2019) stated, "As a basic subject of higher education, higher mathematics is an important course for all kinds of majors in higher mathematics and engineering" (p. 414). Some researchers believe that to meet the needs of the U.S. workplace in the next decade, approximately one million more STEM graduates will be required (Wade et al., 2017).

With more employers relying on some type of technology in the workplace, "skilled workers with expertise in science, technology, engineering and mathematics (STEM) are deemed essential for the research and development activities that stimulate economic growth" (Boyd & Tian, 2017, p. 75). According to Hutton (2019), "The American workforce needs every capable STEM worker to keep America in a global leadership position" (p. 16). There is also agreement that there has been a "persistent decline in mathematics performance of students who transition into college" (Atuahene & Russell, 2016, p. 12). With the understanding students are not coming out of high school prepared to be successful in post-high school mathematics (Piercey & Aly, 2019), researchers have postulated that by examining the current mathematics curriculums, improvements can be made (Harwell et al., 2014). Rogovaya et al. (2019) not only believed students are not prepared from a basic mathematical skills standpoint, but many are not prepared to engage in critical thinking necessary to be successful in college and the workplace.

By examining the mathematics curriculums and strategies successful school districts implement, trends may be identified. Experts continue to "attempt to identify the core skills needed to work successfully with numbers" (Gillum, 2014, p. 277). Much of the research on effective mathematics teaching has focused on the effectiveness of mathematics lessons and the teacher's instructional practices (Kor & Lim, 2020; Rosário et al., 2019).

While a growing number of beginning college students are not prepared for college mathematics (Harrell & Lazari, 2020), some of this unpreparedness has been linked to ineffective mathematics curriculums at the high school level (Combs et al., 2010). This lack of preparation has led to an increase in the number of students who "are in need of remediation" when they begin college mathematics classes (Combs et al., 2010, p. 444). According to Froneman and Hitge (2019), "A survey done in the USA revealed that an increasing number of incoming students needed remedial courses in mathematics" (p. 81). Ngo (2020) has, at least in part, linked this remediation to students taking courses at the college level that are redundant to what they have already taken in high school.

To produce better prepared college students, high schools can begin by examining the mathematics curriculums they use (Harwell et al., 2014). Harwell et al. (2014) believed:

> There are many reasons to believe that the high school mathematics curriculum a student completes plays a key role in their preparation for college mathematics, but there is disagreement of the ability of different curricula to prepare students for college mathematics. (p. 6)

According to Willoughby (1986), “Textbooks dominate the curriculum in the United States” (p. 85). Some experts have argued, “Since textbooks play an important role in the process of teaching and learning and mostly determine what is to be taught and what students learn, the analysis of textbooks can provide insights into reasons for differences in student achievement” (Hong & Choi, 2014, p. 241).

Hong et al. (2019) suggested, “The textbook often forms an important launch point in determining what to include in lessons and how to do so” (p. 240). While examining the curriculum is important, examining the curriculum alone is insufficient (Dietiker, 2015). The search for answers has resulted in researchers calling “for an increased attention to how teachers make sense of the context of mathematical textbooks” (Dietiker, 2015, p. 285).

Based upon examination of mathematics curriculums, it may be possible for educators to take the time to ensure they are creating more than students who can only memorize facts and mathematical concepts. It is important for the advancement of STEM in society for high schools “to produce more STEM-proficient students” (Kennedy et al., 2018, p. 554). By helping students make these connections, educators can ensure students can apply knowledge gained in school to help society (Knipprath et al., 2018).

Purpose of the Study

The purpose of this study was to examine the mathematics curriculum choices and implementation strategies of school districts that scored in the upper 10% of all Missouri districts on the mathematics section of the ACT. The study consisted of two phases. Data available on the MODESE website were used to determine which schools were in the top 10% of Missouri school districts during the years 2015–2017. Then, data were obtained from the mathematics scores on the ACT during the years 2015, 2016, and 2017 for those school districts. The beginning year of 2015 was selected because this was the initial year the MODESE mandated juniors who were not MAP-A eligible to take the ACT (Cooper, 2015). The end date of 2017 was chosen because this was the year the MODESE eliminated the mandate for juniors to take the ACT (Sireno, 2017).

After the school districts that scored in the top 10% were identified, the second phase of the quantitative research began. A survey was used to determine whether trends existed among these high-performing school districts with regard to mathematics curriculum choice and school district implementation strategies. A survey instrument was also used to explore whether elevated mathematics scores on the ACT were related to mathematics curriculum choice and if there were trends in implementation strategies in high performing school districts. Mathematics curriculums or curriculum types were examined, along with determining if the same mathematics curriculum or curriculum type was used at all grade levels. Moreover, participants were asked at what grade levels the topic of mathematics was allotted specific instructional time and the amount of time scheduled for mathematics instruction.

Research Questions and Hypotheses

The following research questions guided this study:

1. What is the difference between scores on the mathematics section of the ACT of school districts that use a standards-based mathematics curriculum in grades K–5 and school districts that use a traditional mathematics curriculum in grades K–5?

$H1_0$: There is no statistical difference between school districts that use a standards-based mathematics curriculum in grades K–5 and school districts that use a traditional mathematics curriculum in grades K–5 on the mathematics section of the ACT.

$H1_a$: There is a statistical difference between school districts that use a standards-based mathematics curriculum in grades K–5 and school districts that use a traditional mathematics curriculum in grades K–5 on the mathematics section of the ACT.

2. What is the difference between scores on the mathematics section of the ACT of school districts that use a standards-based mathematics curriculum in grades 6–11 and school districts that use a traditional mathematics curriculum in grades 6–11?

$H2_0$: There is no statistical difference between school districts that use a standards-based mathematics curriculum in grades 6–11 and school districts that use a traditional mathematics curriculum in grades 6–11 on the mathematics section of the ACT.

$H2_a$: There is a statistical difference between school districts that use a standards-based mathematics curriculum in grades 6–11 and school districts that use a traditional mathematics curriculum in grades 6–11 on the mathematics section of the ACT.

3. What is the difference between school districts that use a consistent type of mathematics curriculum (either standards-based or traditional) in grades K–11

and school districts that use a combination of standards-based and traditional mathematics curriculums in grades K–11?

$H3_0$: There is no statistical difference between school districts that use a consistent (standards-based or traditional) mathematics curriculum in grades K–11 and school districts that use a mixture of standards-based and traditional mathematics curriculums on the mathematics section of the ACT.

$H3_a$: There is a statistical difference between school districts that use a consistent (standards-based or traditional) mathematics curriculum in grades K–11 and school districts that use a mixture of standards-based and traditional mathematics curriculums on the mathematics section of the ACT.

4. What are the implementation strategies applied by school districts that scored in the upper 10% in Missouri on the mathematics section of the ACT for the years 2015, 2016, and 2017 with regard to the following:

   a. Type of mathematics curriculum used.

   b. The grade level mathematics is introduced as a specific content area.

   c. The number of minutes per week allocated to mathematics in grades K–11.

   d. The length of time a school district uses a specific mathematics curriculum.

Significance of the Study

Due to increased reliance on technology, there is an increased demand for members of society proficient in the STEM fields (Han & Appelbaum, 2018; Mastrangeli, 2019; McMurtry 2019; Yıldırım & Sidekli, 2018). Advancements in technology require people in today's society to have more of a grasp on advanced mathematical concepts (Ather Khan et al., 2018; Demirci; 2019; Dossey et al., 2016). Because of this demand, there is a renewed push to focus on integrating STEM education into the classroom (Wu-Rorrer, 2017; Yıldırım & Sidekli, 2018).

This study will contribute to the field of curriculum theory by determining if the selection and implementation of specific mathematics curriculums can lead to an increase in the understanding of advanced mathematical concepts. This study was conducted due to the need for students in today's society to have an increased understanding of mathematical concepts (Ather Khan et al., 2018; Dossey et al., 2016). The determination of whether a specific prepared curriculum, curriculum type, or implementation strategy can lead to an increased understanding of mathematical concepts would be a significant finding in the field of curriculum theory.

Definition of Key Terms

ACT

The ACT is a four-section test developed by E. F. Lindquist consisting of reading, science, mathematics, and English sections (Welborn et al., 2015). The test plays an important role in college admission and is predominately taken by students in the southern and midwestern regions of the United States (Welborn et al., 2015).

Aligned Curriculum

An aligned curriculum refers to a mixed core syllabus consisting of mandated standards; a common reference for teaching, learning, and assessment; specific teaching resources and materials; and a qualified team of teachers for classroom implementation (Aguas, 2020). The focus on implementation requires consistency, specificity, stability, authority, and systematization to ensure success and prevent educational institutions from stagnation (Aguas, 2020).

Conventional or Traditional Mathematics Curriculum

A conventional or traditional mathematics curriculum focuses more on the learning of facts and less on the application of facts to different situations (Dossey et al., 2016).

Curriculum

Curriculum is the day-to-day outline of strategies teachers use to help students learn (MODESE, 2017). Curriculum involves textbooks, homework assignments, classroom activities, and assessments – the "how" of teaching (MODESE, 2017).

Standards-Based Mathematics Curriculum

A standards-based mathematics curriculum is focused on students demonstrating mastery of knowledge and is less focused on the memorization and repeating back of facts (Dossey et al., 2016).

Limitations and Assumptions

The following limitations were identified in this study:

Sample

The sample in this study included the top 10% of public schools in Missouri. This study would need to be repeated using a similar methodology with school districts from multiple states to help decrease the chance an error may have occurred.

Data

The data collected for this study were collected over a period of three years. These years were chosen because the entire student population of the state took the ACT during this time frame (Cooper, 2015). The mandate all juniors take the ACT was discontinued during the 2016–2017 school year (Sireno, 2017).

Instrument

There were two possible limitations with the instrumentation. The first was the ACT. The ACT is a nationally normed test, but the test's validity for minorities has been brought into question (Toldson & McGee, 2014). Toldson and McGee (2014) stated, "Throughout the history of the SAT and ACT, Black students' average scores have been the lowest among all racial group" (p. 1). The second limitation was that the survey was created by the researcher.

The following assumptions were accepted:

1. All participants' responses were given truthfully and without reservation.
2. Participants were not coerced into completing the survey.

Summary

The choice of curriculum by a school district can have implications on student success (Combs et al., 2010). Multiple curriculums are available for school districts to choose from (Codding et al., 2016; Doabler et al., 2015; Hong & Choi, 2014). The choice of a mathematics curriculum that will develop "mathematical proficiency is absolutely critical for success in school and in postsecondary experiences" (Doabler et al., 2015, p. 97). With the future success of students depending on the choice of curriculum, it is necessary for school districts to make informed decisions on which type of curriculum to adopt and which strategies the school district will implement.

With the MODESE mandating all juniors who were not MAP-A eligible must take the ACT in the years 2015, 2016, and 2017 (Helwig, 2014), it became possible for school districts across the state to be measured against each other with all students represented (Cooper, 2015). The topic of improving mathematics curriculums and helping students who struggle in mathematics has been addressed by experts such as Phillips (2014a, 2014b) and Gillum (2014). The historical and theoretical aspect of developing and changing curriculums has been studied and debated by authors such as Beauchamp (1982), Pinar (2014), and Young (2013). Employers are also beginning to look for employees with a stronger background in the STEM fields (Banerjee, 2017; Boyd & Tian, 2017). Unfortunately, many students enter college without the knowledge needed to be successful in post-high school mathematics (Atuahene & Russell, 2016). With an increased focus on STEM, the debate on how to improve mathematics curriculums may continue into the future (Dossey et al., 2016).

A comparative analysis of mathematics curriculums could be useful for any school district attempting to improve its mathematics curriculums. There are many curriculums available for school districts to choose (Harwell et al., 2014). The results of this study may assist school districts in making a decision about what type of mathematics curriculums might work best for their students. By no means is the information in this study meant to be an endorsement or condemnation of any specific mathematics curriculum series. The study is meant to be used as a guideline to see which mathematics curriculums were used by high-performing school districts.

In Chapter Two, the literature review includes the theoretical framework of curriculum theory and a discussion of historical events that have affected the development of mathematics curriculums in the United States. A review of international comparisons and the ACT is presented. A discussion of national legislation and its effect on mathematics curriculums is also presented. An analysis of different mathematics curriculums used in Missouri concludes the chapter.

Chapter Two: Review of Literature

Increasing academic performance is an area of focus in education today (Jones et al., 2017; Salas-Velasco, 2019). One of the ways educators have tried to increase academic performance is by developing and attempting to improve curriculums (Dossey et al., 2016). According to Klieger (2015), "There are many factors that influence the curriculum" (p. 418). The reasons the curriculum has changed over time are due to political (Neem, 2016; Phillips, 2014a, 2014b), societal (DeMatthews, 2014), and historical (Pinar, 2014) developments.

Due to the structure of the United States Constitution, public school districts in the U.S. take a different approach to curriculum development and implementation than other countries (Lundgren, 2015). Lundgren (2015) stated, "U.S. tradition has its roots in the local government of schooling and a freedom for local curricula. In other countries, national governments and their bureaucracies have been responsible for curriculum development and implementation" (p. 790). Instead of the federal government legislating educational decisions, the U.S. allows local governments to make many of the decisions with regard to education (Dossey et al., 2016). According to Dossey et al. (2016), "[The] United States does not claim education as a responsibility of the federal government; individual states have considerable leeway in structuring the education of their students" (p. 7).

Due to local control in the United States, "no school or school system is the same. Each is unique in its own way, with differences in demographics, resources, socioeconomic factors, challenges being faced, or needs to be addressed" (Wu-Rorrer, 2017, p. 9). While local governments have traditionally been in control of developing curricula, "the role of the federal government in education has increased markedly since the establishment of the No Child Left Behind Act (NCLB), passed by Congress in 2001" (Dossey et al., 2016, p. 7).

Theoretical Framework

The philosophy of curriculum theory has far-reaching impacts in the field of education (Beauchamp, 1961; Pinar, 2012) and on society as a whole (Baker, 2015; DeMatthews, 2014; Pinar, 2014). The term curriculum theory has appeared in publication since a 1947 conference at the University of Chicago (Beauchamp, 1961). While the term goes back over half a century, the exact definition of curriculum theory has undergone many iterations (Beauchamp, 1961; Morris & Hamm, 1976; Pinar, 2012). Depending on who is asked, the definition of curriculum theory can be as straightforward as "the scholarly effort to understand the curriculum" (Pinar, 2012, p. 1), or as complex as "a set of related statements, or propositions, that gives meaning to the phenomena related to the concept of a curriculum, its development, its use, and its evaluation" (Beauchamp, 1982, p. 24).

While the definition of curriculum theory seems to be ever-evolving and changing, many scholars, including DeMatthews (2014) and Pinar (2014), have suggested the study of curriculum theory affects the educational community and society as a whole. Popkewitz (2011) stated, "The principles that order and classify school curricula are assembled, connected, and disconnected through complex historical processes" (p. 2). One of the earliest and most influential figures in mathematics curriculums, Hans Freudenthal, had a deep interest in "the nature of mathematics and its embeddedness in historical, cultural, social, political, and above all, educational context"

(Greer, 2017, p. 116). Pinar (2014) proposed, "Curriculum is intensely historical, political, racial, gendered, phenomenological, autobiographical, aesthetic, theological, and international" (p. 847). In addition, Pinar (2014) asserted, "Curriculum is an extraordinarily complicated conversation" (p. 848).

Today, many curriculums are available for school districts to choose (Taylor & Brickhill, 2018), although the focus of these curriculums has changed over the years (Krupa & Confrey, 2017). Scholars such as Beauchamp (1982), DeMatthews (2014), and Eronen and Kärnä (2018) have questioned the most efficient way of presenting mathematics to society. For example, as far back as Freudenthal, the method of writing word problems for students has been questioned (Greer, 2017). According to Greer (2017), "Freudenthal did not understand artificial word problems as opposed to meaningful problems that made sense and are relevant to future members of society" (p. 115). As societal and technological needs continue to evolve and develop, the field of curriculum theory will evolve a framework of curriculum to meet the "changing needs of society" (DeMatthews, 2014, p. 192).

Historical Influences on Mathematics Curriculums

Mathematics has been a topic of importance to humans since the earliest recordings of civilized humans (Saracho & Spodek, 2009). Saracho and Spodek (2009) reviewed, "Ancient Greek philosophers had their influence (on mathematics education). Plato, Pythagoras, and Euclid are some of the early mathematics pioneers" (p. 297). Nelsen (2014) reiterated, "Humans have engaged in mathematics as far back in time as the earliest civilizations of Babylon and Egypt, where practical and educational interests necessitated arithmetic and geometry" (p. 104). According to experts Saracho and

Spodek (2009), “Over the years, mathematics education for young children has seen several reforms and the teaching of mathematics has changed with each reform” (p. 297).

Furthermore, Saracho and Spodek (2009) stated, “Early childhood education in the United States started in colonial times with the establishment of the common school in New England” (p. 298). The common schools were initially established to give young people in the community the ability to read the Bible (Saracho & Spodek, 2009). As the United States gained its independence from England, the Establishment Clause in the Constitution caused schools to become more secular (Neem, 2016). The government “sought to enforce strict laws separating church from state” (Neem, 2016, p. 50).

The first kindergarten in America was established in 1856 (Saracho & Spodek, 2009). Mathematics was taught by “allowing young children to become aware of numerical and geometric relationships with the use of geometric gifts and with such activities as simple counting, measuring, and adding” (Saracho & Spodek, 2009, p. 302). The teaching of mathematics in this way was very successful; the students “acquired a substantial amount of mathematical knowledge, although it was attained incidentally and instinctively through play” (Saracho & Spodek, 2009, p. 302).

In the time period between the American Revolution and the Civil War, publicly funded school systems were set up across the United States (Neem, 2016). During this transition in education, the focus shifted from students learning to read the Bible to teaching “individuals the essential basics needed to function as citizens in a democratic society and to master simple acts of commerce” (Saracho & Spodek, 2009, p. 298). The method of instruction during this time consisted mainly of “direct instruction and recitation” (Saracho & Spodek, 2009, p. 298). Saracho and Spodek (2009) explained, "Mathematics instruction gave exclusive attention to arithmetic, consisting of counting words and arithmetic operations such as addition and subtraction" (p. 298). Curriculum development continued to evolve until it became a new discipline in education. According to Wraga (2016), "During the early twentieth century, curriculum development emerged as a professional practice in the USA in response to several new educational realities" (p. 567).

The Cold War and its Influence on Mathematics Curriculums

The practice of employing "direct instruction and recitation" (Saracho & Spodek, 2009, p. 298) for instruction and curriculum development came under scrutiny during the time period known as the Cold War (Herrera & Owens, 2001; Lundgren, 2015; Phillips, 2014a). Due to a fear of the U.S. educational system falling behind the Soviet Union's educational system, the federal government took an active role in mathematics education and curriculum development (Herrera & Owens, 2001).

Much of the federal government's influence on the emphasis and development of the importance of mathematics curricula can be traced to the influence of the Cold War between the United States and Russia (Lundgren, 2015). Lundgren (2015) reported:

> Two consequences of the Cold War competition can be discerned in curriculum construction. One tendency was the focusing on cognitive processes in creating curriculum guidelines and, above all, instructional principles for improving teaching in mathematics and science. The Woods Hole conference at the end of the 1950s became the starting point for a period of curriculum development that had an international impact. A second tendency was the search for effective teaching technologies based on a behavioristic psychology. (p. 791)

One specific incident during the Cold War had a major influence on the increased emphasis on developing and improving mathematics curriculums—the launch of the Russian satellite Sputnik (Curry et al., 2018; Herrera & Owens, 2001; Lundgren, 2015; Phillips, 2014a). With the launch of the Russian satellite Sputnik, "many national curricula were influenced by the reforms in the USA, especially mathematics and science" (Lundgren, 2015, p. 791). According to Baker (2007), "The idea that America was being harmed because our schools were not keeping up with those in other advanced nations emerged after Sputnik in 1957" (p. 101).

The launch of the Soviet satellite Sputnik had both political and educational implications (Phillips, 2014a). According to Phillips (2014a), "The Soviet launch of Sputnik in October 1957 seemed to bolster the view of critics like Admiral H. G. Rickover, who had long claimed that the lack of intellectual discipline in schools was ultimately a matter of national security" (p. 541). To address the belief that the United States was falling behind other countries, the federal government took steps to influence curriculum decisions that had traditionally been made at the local level (Sepnafski, 2018). One example of this federal influence occurred when "President Dwight D. Eisenhower signed the National Defense Education Act (NDEA). [The] NDEA was introduced partly in response to the Soviet Union's Sputnik launch, which caused public fear U.S. schools were inferior to schools in the Soviet Union" (Wallender, 2014, p. 8). The NDEA was designed to promote knowledge in science, math, and foreign languages to help keep up with the Soviet Union (Wallender, 2014).

The launch of Sputnik had a profound effect on curriculum development in the United States (Phillips, 2014b). According to Phillips (2014b), "The Soviet Union's launch of Sputnik in October 1957 ensured that educational projects would be well funded through the next decade; NSF appropriations increased nearly threefold, with a disproportionate amount dedicated to curriculum work" (p. 458). The federal government's increased influence on local education resulted from the belief that "schools should become a central battle zone of the Cold War" (Phillips, 2014b, p. 459).

New Math

The launch of the Soviet satellite Sputnik also launched a new era in mathematics curriculum development (Herrera & Owens, 2001). According to Herrera and Owens (2001), the launch of Sputnik has "commonly been cited as the event that marked the beginning of the New Math revolution" (pp. 84–85). Saracho and Spodek (2009) determined:

> When the Soviet Union launched a satellite into space, the United States was unprepared to launch one. In order to deal successfully with this dilemma, it was felt that the United States needed to prepare more scientists and mathematicians. This would require a reform in the school curriculum at all grade levels, from the kindergarten through the high school levels. (p. 308)

When President Eisenhower signed the NDEA, one goal was to improve American schools (Wallender, 2014). Under the auspices of the NDEA, the National Science Foundation (NSF) was created; under the NSF, the School Mathematics Study Group (SMSG) was created (Herrera & Owens, 2001). The SMSG was the "largest curriculum project of the era" (Herrera & Owens, 2001, p. 86).

In the 1950s and 1960s, a curriculum was developed by the SMSG called the New Math curriculum (Herrera & Owens, 2001; Phillips, 2014a, 2014b). The New Math curriculum started in the late 1950s when "professional mathematicians and educators worked together to overhaul the nation's mathematics textbooks to include sets, symbolic logic, and new forms of arithmetic" (Phillips, 2014b, p. 454). The new curriculum was fully supported by the federal government and was designed to implement "rapid and fundamental change in how children learned math" (Phillips, 2014b, p. 454). According to Phillips (2014a), "The vast majority of mathematicians' formal curriculum efforts were concentrated in the NSF" (p. 543). The NSF was headed by Yale mathematician Edward Begle (Phillips, 2014a, 2014b).

The SMSG took the approach of combining mathematicians and educators to develop a new curriculum (Herrera & Owens, 2001; Phillips, 2014a, 2014b). The SMSG "held writing sessions each summer for nearly a decade in a massive effort to design model textbooks appropriate for every student in the country, regardless of grade level or ability" (Phillips, 2014a, p. 543). The summer writing sessions "involved hundreds of mathematics teachers and mathematicians" (Herrera & Owens, 2001, p. 86).

Herrera and Owens (2001) proclaimed, "Teachers responded enthusiastically by taking advantage of NSF funded summer-long institutes and trainings offered by the innovative programs" (p. 86). The SMSG was very prolific in their textbook production; they "produced over four million copies of nearly thirty different textbooks and inspired commercial publishers to produce many millions more" (Phillips, 2014a, p. 543). Along with the textbooks, "a variety of supplemental materials and reports" were produced by the SMSG (Herrera & Owens, 2001, p. 86). At its peak, "nearly 75 percent of the nation's high school students and 40 percent of elementary students were using New Math" (Phillips, 2014a, p. 543). The creators of the New Math curriculum "rejected rote memorization in favor of mathematics taught as structured reasoning" (Phillips, 2014a, p. 544).

While not all people were happy with the New Math movement at the time, the proponents of the curriculum pointed to the fact mathematicians, not educators, were in charge of curriculum design as a positive step in ensuring the New Math curriculum would put Americans ahead of the Soviet Union in the field of mathematics (Herrera & Owens, 2001; Phillips, 2014b). Begle, the head of the NSF, "reiterated the congressional mandate to reform the intellectual training of citizens" when he claimed "the SMSG would not just be producing students with facts and techniques for future careers but would be training them to be intelligent citizens" (Phillips, 2014b, p. 460).

The New Math initiative was met with mixed reviews (Phillips, 2014b). During the early days of the New Math initiative, "New Math had been transformed from a Cold War manpower initiative to a model program of the Great Society" (Phillips, 2014b, p. 470). The SMSG was disbanded in 1972, and a few years after the disbandment, "official perceptions of the New Math had decisively soured" (Phillips, 2014b, p. 471). While Begle and the SMSG were pleased with the curriculums they had produced, as the curriculums were implemented, critics began to speak out against New Math (Herrera & Owens, 2001). Parents were upset with the New Math curriculum because they believed they were no longer able to help their children with mathematics (Herrera & Owens, 2001). From the outset of the New Math curriculum design, Begle knew "that rote computational ability might decline among students learning the New Math, and he was willing to accept a minor decrease in exchange for greater conceptual understanding and facility with mathematical reasoning" (Phillips, 2014b, p. 464). While Begle and the

SMSG were willing to accept these decreases, many people in the United States were not as willing to accept a decline in rote mathematical skills (Phillips, 2014b).

Back-to-Basics

As the public became more disenchanted with the New Math movement, a new movement referred to as back-to-basics commenced (Phillips, 2014b). In the mid-to-late 1970s, the movement started to replace New Math with a “back-to-basics” model (Phillips, 2014b, p. 474). According to Herrera and Owens (2001), “The decade of the 1970s was characterized as a back-to-the-basics era” (p. 87). The back-to-basics model moved away from the logic, language sets, and algebraic structures of New Math and instead returned to an emphasis on computations and algebraic manipulations (Herrera & Owens, 2001).

The critics of the New Math movement claimed New Math was “an elite top-down approach to intellectual training that failed because it ignored the value of traditional, discipline-oriented mental habits” (Phillips, 2014b, p. 473). The back-to-basics proponents asserted, “Mathematics classes that disciplined students through rote exercises and memorization were inseparable from the broader desire for discipline and order” (Phillips, 2014b, p. 475). According to opponents of New Math, the SMSG, which had “originally been organized to win the Cold War of the classroom,” along with Project Apollo, the resignation of Richard Nixon, and the Vietnam War, had become one of the many political failures of the 1970s (Phillips, 2014b, p. 476).

The NCTM Standards

A recent reform in mathematics curriculum is what Herrera and Owens (2001) referred to as the “math wars” (p. 84). Due to growing concerns about the quality of mathematics education in the United States, the NCTM established the Commission on Standards for School Mathematics in 1986 (NCTM, 1989). The Commission developed "a set of standards for mathematics curricula in North America" (NCTM, 1989, p. v).

The standards were developed by four working groups, which included a cross-section of classroom teachers, supervisors, educational researchers, teacher educators, and university educators (NCTM, 1989). According to the NCTM (1989):

> The Standards is a document designed to establish a broad framework to guide reform in school mathematics in the next decade. In it, a vision is given of what the mathematics curriculum should include in terms of content priority and emphasis. (p. v)

The 1989 report by the NCTM opened the doors for a new era in mathematics curriculum development. Burrill (1997) stated:

> The NCTM standards are not intended to be a national curriculum; they are intended to provide guidelines and a vision for which mathematical concepts are important for all children to learn if they are to take their rightful places as workers and as citizens in a different world. (p. 336)

While the Standards were not specifically designed to influence mathematics curriculums outside of North America, Toumasis (1997) reported:

> The Standards constitutes a political document about what it means to do mathematics and how one learns to do mathematics, which will strongly influence the teaching of school mathematics in the 1990s, not only in North America, but all over the world. (p. 318)

According to Herrera and Owens (2001), “The reform has had an impact on school mathematics to the extent that most states have rewritten their frameworks to align with the [NCTM] standards in language, grade level demarcations, and goals” (p. 90).

The NCTM continues to develop and change the standards due to “the demand to educate students in a better way, which increases the need for more efficient and effective training programs” (Cumhur & Tezer, 2020, p. 2). While the initial response to the NCTM Standards was positive, “opponents of the standards proposed by NCTM in 1989, believe that it is the reincarnation of the New Math movement of the 1960’s” (Herrera and Owens, 200, p. 89). Opponents of the NCTM standards also “object to NCTM’s support for calculator use in the primary grades, argued that the [NCTM] standards are vague on the importance of basic computational skills and feel that mathematical applications are overemphasized throughout” (Herrera & Owens, 2001, p. 90).

While there were and are critics of standards-based curriculums, there were also many people in favor of the new curriculum who argued the NCTM standards-based curriculum was not the 1960s New Math curriculum repackaged (Herrera & Owens, 2001). Supporters of the standards-based curriculum pointed to multiple differences between standards-based curriculums and the New Math curriculum, namely, the standards-based curriculum was designed to address the needs of all students in society, while the New Math curriculum was arguably geared only toward college-bound students (Herrera & Owens, 2001). Since standards regarding mathematics education were initially released by the NCTM, the standards have continued to evolve and change due to “developments in technology and changing living conditions [that] require individuals to be more knowledgeable and equipped than in the past” (Cumhur & Tezer, 2020, p. 2).

Another difference between standards-based curriculums and the New Math curriculum was the emphasis on teachers (Herrera & Owens, 2001). Herrera and Owens (2001) suggested the standards produced by the NCTM not only addressed what students should be learning, but also "the changes in teaching" they felt were necessary for their standards-based curriculum to be successful (p. 89). There is a belief among some experts that for society to continue to be able to make technological advancements, the educational system needs to become more efficient (Bråting et al., 2019; Weinberg, 2019). The purpose of mathematics has evolved from citizens needing to perform basic mathematics computations for commerce to today's need for mathematicians to apply their knowledge to solve everyday problems (Cumhur & Tezer, 2020). This evolution has caused experts to look at how mathematics is taught in high school (Baker et al., 2018).

The NCTM has promoted increased professional development among today's mathematics teachers (Baker et al., 2018). Besides promoting professional development, the NCTM (2019) has updated its curriculum recommendations. The current NCTM guidelines are divided into principles and standards (Alshehri & Ali, 2016). The principles are divided into the following six sections: equality, curriculum, teaching, learning, assessment, and technology, and the standards are divided into two sections: content and process (Cumhur & Tezer, 2020). According to Cumhur and Tezer (2020), "[The] content standard consists of elements such as numbers and operations, algebra, geometry, measurement, data analysis and probability" (p. 2). On the other hand, the "process standard is formed by criteria such as problem solving, reasoning and proof, communication, representations and associations" (Cumhur & Tezer, 2020, p. 2).

International Comparisons

While the earliest civilizations were concerned with mathematics out of necessity, a current trend in mathematics education is using mathematics for political gain (Neem, 2016; Phillips, 2014b; Pinar, 2014). Smith and Morgan (2016) declared, “The function of mathematics within the curriculum has long been a source of difference and debate” (p. 25). According to Smith and Morgan (2016), “Mathematics occupies a privileged position with curricula around the world” (p. 25). With this debate and position of privilege, experts such as Phillips (2014b) clarified that mathematics curriculums have been used as a political tool. Phillips (2014b) determined:

> [The] politicization of the midcentury schoolroom was not particularly surprising. Schools have long been objects and mechanisms of reform, especially between World War II and the presidency of Ronald Reagan, when the nation’s public schools became prominent among American intuitions. (p. 454)

The importance of mathematics can be seen in the influence of “international testing regimes such as PISA and TIMSS” (Smith & Morgan, 2016, p. 24). Smith and Morgan (2016) continued, “The results of such tests, especially the ranking of countries by test outcomes, have been used in many countries to fuel policy debates and to focus attention and investment in mathematics education” (p. 25).

Low achievement on international surveys has led to curriculum reform in many countries (Clarke et al., 2019; Klieger, 2015; Schmidt, 2003; Schmidt et al., 2005). According to Klieger (2015), “International surveys have served as agents of change for the introduction of reforms in curricula worldwide” (p. 404). Klieger (2015) acknowledged international surveys "test proficiency and literacy in fields that produce knowledge: mathematics and science" (p. 405).

According to Vázquez-Cano et al. (2020), "The main challenge facing studies of an international nature that seek to make comparisons between countries is the different types of educational levels and systems" (p. 52). Saracho and Spodek (2009) stated, "During the last decade, mathematics education has undergone a major reform worldwide" (p. 297). Many of these changes have led to changes in how mathematics is taught not only in the United States but in other countries as well (Klieger, 2015; Schmidt, 2003; Schmidt et al., 2005). According to Klieger (2015), "The low achievements of American students in international tests in the 1980's caused great concern and led to the publication of the 'Nation at Risk' report in 1983, which highlighted the poor results of American schools" (p. 407).

First International Mathematics Study

Aside from the public's desire to stay ahead of the Russians, a second blow to American's belief that schools in the United States were superior to educational systems in other countries came in 1964 with the release of the First International Mathematics Study (FIMS) (Baker, 2007, p. 101). While international comparisons had been around since 1908, the release of the results from the FIMS caused concern in the field of mathematics education (Dossey et al., 2016). The FIMS "was conducted in 1964 with 12 countries participating" (Travers et al., 1989, p. 47). The FIMS did not put a positive light on mathematics education in the United States (Dossey et al., 2016). Dossey et al. (2016) explained, "The release of the FIMS achievement results in 1967 indicated U.S. K–12 students did not measure up in mathematics achievement with their peers in other countries" (p. 11).

Second International Mathematics Study

The FIMS was followed by the Second International Mathematics Study (SIMS), which took place over a two-year span from 1980 to 1982 (Dossey et al., 2016; Willoughby, 1986). The SIMS was a more comprehensive examination of the mathematical prowess of countries than the FIMS (Westbury & Travers, 1990). According to Westbury and Travers (1990), "[The] SIMS was intended to have a much stronger emphasis on mathematics education than had FIMS, where mathematics tended to be treated as a surrogate for school achievement in general" (p. 9).

Like its counterpart, the FIMS, the SIMS examined student achievement of 13-year-old students in their final year of secondary school (Dossey et al., 2016; Westbury & Travers, 1990). In the study, "data were obtained from approximately 3,900 schools, 6,200 teachers, and 124,000 students in more than 20 education systems around the world" (Westbury & Travers, 1990, p. 7). Besides being a more comprehensive longitudinal study of the mathematical prowess than the FIMS, the SIMS was also designed to be a "thorough analysis of the curricula of participating systems" (Westbury & Travers, 1990, p. 9). The results of the SIMS were similar to the results of the FIMS; U.S. students still did not measure up to their counterparts in other countries (Dossey et al., 2016).

Trends in International Mathematics and Science Study

The most current version of the International Mathematics Study is the Trends in International Mathematics and Science Study (TIMSS) (Yoon Fah, & Chandrasegaran, 2018). The TIMSS, produced by the International Association for the Evaluation of Equational Achievement (IEA), "was the most extensive and far-reaching cross-national comparative study ever attempted within education" (Schmidt et al., 2005, p. 532). This TIMSS's results allowed for international comparison, which "provides information about the effects of policy and practices in each participating country's educational system" (Depren et al., 2017, p. 1618).

According to Filiz and Öz (2020), the TIMSS is "one of the biggest projects of IEA that assesses the student success at the international level, and more than 60 countries have participated in this project" (p. 964). Students are tested at the fourth and eighth-grade levels (Elmazouni et al., 2019; Yamaguchi & Okada, 2018). The TIMSS "evaluates the mathematics achievement of 8th-grade students by using the achievement test which includes questions on numbers, algebra, geometry, data, and probability learning areas" (Çiftçi, & Yıldız, 2019, p. 619).

The data collected from the TIMSS are focused on an "emphasis on STEM education" (Wiseman et al., 2016, p. 371). Schmidt (2003) stated, "The TIMSS, the largest international study of science curriculum and student achievement ever undertaken, provides both a compelling impetus and an invaluable resource for reexamining, rethinking, and restructuring what we do in U.S. science education" (p. 571). The TIMSS considers three curricular levels including "the intended, the implemented, and the attained" (Klieger, 2015, p. 407).

The TIMSS was the first international study that specifically focused on math and science (Dossey et al., 2016; Wiseman et al., 2016). According to Klieger (2015), "The TIMSS tests students' mastery in mathematics and science and compares achievement between participating countries while examining correlations between achievements, the curriculum, and the educational context in which the curriculum is implemented" (p. 406). Trends in mathematics and science achievement may be identified from reviewing TIMSS data (Depren et al., 2017).

Once again, similar to results on the FIMS and SIMS, the United States lagged behind other countries (Schmidt, 2003; Yoon Fah & Chandrasegaran, 2018). According to Schmidt (2003), "Ample evidence exists that the performance of U.S. students is not strong in terms of the internal assessments such as the TIMSS" (p. 569). Schmidt et al. (2005) suggested the curriculums in the United States were at least partially to blame for poor performance on the TIMSS. According to Schmidt et al. (2005), "The TIMSS curriculum study showed the U.S. mathematics and science curricula to be unfocused, repetitive, and to be undemanding by international standards" (p. 532).

Yoon Fah and Chandrasegaran (2018) found certain countries have continually outperformed the United States and other countries. Schmidt (2003) determined:

> In terms of international standards of excellence as evidenced by the TIMSS, the relative standing of the U.S. declined from fourth to twelfth grade so that by the end of secondary school, the U.S. outperformed only two other countries on a basic literacy test. (p. 569)

Yoon Fah and Chandrasegaran (2018) determined, "Singapore schools have consistently been outperforming their counterparts in mathematics and science on each and every cycle of the TIMSS" (p. 576). Schmidt (2003) observed that as students in the United States progress through school, their relative standings in the international comparison actually decline.

Program for International Student Assessment

In addition to the FIMS, SIMS, and TIMSS, another international comparison is widely recognized: the Program for International Student Assessment (PISA) Hopfenbeck et al., 2018; Klieger, 2015; Park & Weng, 2020). The PISA test is given to 15-year-old students in developed democracies that are members of the Organization of Economic Cooperation and Development (OEDC) (Hopfenbeck et al., 2018; Klieger, 2015; Park & Weng, 2020). According to Klieger (2015), “[The] OEDC is an international organization of developed countries whose goal is to enable economic and social welfare for people worldwide” (p. 406). Schleicher (2017) stated, “International comparisons are never easy, and they are not perfect, but PISA shows what is possible in education and it helps countries to see themselves in the mirror of student performance and educational opportunities” (p. 124). Unlike the TIMSS, which “defines its scope according to mathematical content of the curricula, PISA is concerned with the extent to which educational systems prepare young people for participation in adult life, in particular equipping them with mathematical literacy” (Smith & Morgan, 2016, p. 25).

The PISA test began in 2000 and is still given every three years (Meng et al., 2019). The test is “supposed to measure the extent to which students, at the end of their compulsory schooling (at 15 years of age), have acquired the mathematical knowledge and skills that are essential for everyday-life situations” (Aydın, & Özgeldi, 2019, p. 105). Unlike the TIMSS, which “can be called a ‘school knowledge test’” (Rindermann & Baumeister, 2015, p. 16), the PISA is “recognized at international level as the producer of the major part of knowledge about educational systems in several part of the world”

(Villani & Andrade Oliveira, 2018, p. 1347). According to Rindermann and Baumeister (2015), “PISA tasks are testing general cognitive competence” (p. 16).

With the PISA test, the ODEC “has been able to greatly influence national educational systems” (Niemann et al., 2017, p. 175). This influence has not translated to success on the PISA assessment for students in the United States (Brow, 2019). According to Brow (2019), on the 2012 test, 15-year-old students in the United States performed no better than 26th. The performance of the United States on the PISA was “particularly disconcerting” (Brow, 2019, p. 727).

TIMSS and PISA Comparison

While the TIMSS and PISA comparisons were produced by two different entities, Klieger (2015) explained the tests are “two sides of the same coin” (p. 406). They can both be used to compare mathematics education systems in countries, although from different angles (Klieger, 2015). According to Klieger (2015), “The TIMSS survey evaluates the extent to which students learn the curriculum and the PISA test evaluates whether students can implement the knowledge to everyday problems” (p. 406). Rindermann and Baumeister (2015) stated:

> [The] PISA and TIMSS differ in how similar their tasks are to the curriculum taught at school. The PISA tries to measure distinct abilities of students for coping with cognitive challenges on modernity. PISA abandons the assessment of mere academic knowledge but focuses on assessing competencies. (p. 4)

Rindermann and Baumeister (2015) continued, “The PISA tasks comprise a lot of text. Each problem is followed by several open or closed questions assessing the indicated competence in different ways” (p. 4). Rindermann and Baumeister (2015) concluded:

> With regards to the TIMSS, the assessment of the competencies of mathematics and science is more closely related to the subjects taught at school. Generally, tasks of TIMSS are shorter than those of the PISA. They include little or no text. Similarly, to PISA there are two answering modes: open and multiple choice. Solving TIMSS tasks appears to depend more on knowledge retrieval. (p. 4)

As the results of international comparisons continue to be investigated, "it is expected that the results of these surveys will help policy-makers set expectations from students and consider ways for improving learning in their countries" (Klieger, 2015, p. 405).

While international comparisons are a key component of some countries' plans to overhaul or adjust their curriculums, Ayorinde et al. (2020) advised delays in the publication of materials can lead to a time lag bias. Ayorinde et al. (2020) defined *time lag bias* as a "delay in publication arising from the direction or strength of the study findings" (p. 8). This time lag bias can cause data that would help develop new curriculums not be available to researchers (Ayorinde et al., 2020).

Klieger (2015) stated, "Some scholars have argued that the international surveys influence the curricula in many countries" (p. 406). According to Klieger (2015), "The poor student outcomes in international surveys were a major incentive for reforms in many countries" (p. 407). No matter which type of comparison is used, "American students' math and science achievement remains far below that of most countries" (Kulm, 2007, p. 368).

Klieger (2015) concluded, "International surveys have become central in curriculum planning as well as in educational policy" (p. 408). According to Klieger (2015), "International surveys such as PISA and TIMSS enable countries to compare their students to a common standard. In the global world, it is important to be part of the family of nations" (p. 419). Regardless of whether curriculum selection remains in the hands of local policymakers or if the federal government continues to take a larger role in curriculum selection and implementation, "Americans have come to rely on testing as the primary tool for making instructional and policy decisions" (Kulm, 2007, p. 638).

No Child Left Behind Legislation

As the public's perception of the efficacy of the United States educational system eroded, the federal government attempted to develop and change curriculum implementation and development in local school systems (Phillips, 2014b). The most current curricular overhaul began with the passage of the No Child Left Behind (NCLB) Act of 2001. According to Heise (2017), "When passed in 2001, the No Child Left Behind Act represented the federal government's most dramatic foray into the elementary and secondary public school policymaking terrain" (p. 1859).

Adler-Greene (2019) stated, "NCLB was enacted following a report released in 1983 claiming that the nation's future was at risk. Students in the United States were falling behind in both math and reading as compared to their European and Asian counterparts" (p. 2). Shah, Jannuzzo, et al. (2019) reported the following:

> The U.S. government has acknowledged the critical role that teachers play in the production of Science, Technology, Engineering, and Mathematics (STEM) professionals who will drive our nation's economy. The No Child Left Behind Act of 2001 (NCLB) was passed to improve the quality of education nationwide. (p. 1)

A 2008 report from the U.S. Department of Education stated that NCLB "provided financial incentives for schools with good performance profiles and penalties for schools with poor performance records. The program was unprecedented in the nation's history" (Dossey et al., 2016, p. 7). When writing about NCLB, Li et al. (2017) stated, "With the enactment of the No Child Left Behind Act of 2001 in the United States, test scores have increasingly been used as a basis for evaluating teachers' performance" (p. 1). According to Schmidt et al. (2005), "State departments of education have been and continue to be the major players in the settings of standards, especially in the light of the NCLB" (p. 531).

From a mathematics curriculum standpoint, NCLB was also important because it directly addressed the belief all students should receive a high-quality mathematics education (Dossey et al., 2016). In their 2016 report to the Thirteenth International Congress of Mathematical Education, Dossey et al. (2016) wrote, "The disaggregation of state and local data required by NCLB mandated all students, and in particular, special education students of various types, receive a high-quality mathematics education" (p. 8). The passage of the mathematics section of the No Child Left Behind Act required states to critically examine their mathematics standards (Hebert et al., 2019). As a result of this analysis, many states adopted the Common Core State Standards (CCSS), which not only "forced changes to the mathematics content taught in classrooms," but also challenged local control of the curriculums (Hebert et al., 2019, p. 144).

Wallender (2014) reported, "It is unconstitutional for the federal government to mandate CCSS adoption; therefore, individual states voluntarily adopted either ELA, Mathematics, or both sets of standards" (p. 10). While unconstitutional for the federal government to mandate the adoption of the CCSS through the linking of federal funding to the adoption of standards, the federal government has caused states to critically examine their curriculums, and in many cases, adopt new state standards (Wallender, 2014).

Every Student Succeeds Act

The most recent reauthorization of the Elementary and Secondary Education Act of 1965 is commonly referred to as the Every Student Succeeds Act (ESSA) (Darrow, 2016; Pasachoff, 2017). The ESSA was signed into law by President Barack Obama on December 10, 2015 (Adler-Greene, 2019). The ESSA "reauthorized and revised the No Child Left Behind Act" (Villagrana, 2020, p. 88). Areas revised included protocols concerning standardized testing and the requirements for highly qualified teachers (Adler-Greene, 2019). According to Adler-Greene (2019), the reauthorization led to a "hands off approach towards regulating education" (p. 11) and "has deferred educational decision making to the states" (p. 12).

Swain (2019) determined, "[The] ESSA required states to reflect on their overall vision and goals for education and determine how to best achieve their goals" (p. 21). Educational analysts Petrilli et al. (2016) explained the passage of the ESSA has afforded states the opportunity to narrow excellence gaps. The ESSA also encourages school districts to focus on "access to and completion of advanced course work" (U.S. Department of Education, 2015, Section 1111). Gamoran (2016) expressed cautious optimism about the ESSA's effect on STEM education. While the federal government has returned local control to the state level (Robinson, 2018), they still continue to support STEM education financially (Fisher, 2019). According to Fisher (2019), "On

March 23, 2018, Congress signed into law the federal spending bill for ESSA. Many provisions within the bill provide funding for STEM initiatives" (p. 28).

The ESSA also recognizes the teacher's role in STEM education (Wolfmeyer, 2017). Wolfmeyer (2017) determined, "Included in the act are specific and multiple opportunities to develop STEM education, including the fiscal recruitment and retention of STEM teachers and the development of STEM specific schools" (p. 13). While some experts believe the ESSA may lead to gains in areas of educational growth (Dennis, 2017; Gamoran, 2016), others believe it is too early to tell what impact the ESSA will have on education and curriculum development. Heise (2017) concluded, "[The] ESSA's relative infancy makes it difficult to assess with accuracy how it will mature and evolve over time" (p. 1861).

ACT

The ACT was developed by E. F. Lindquist and "assesses high school students' general subject-matter knowledge and college or workforce readiness in four skill areas: English, mathematics, reading, and science" (Dossey et al., 2016, p. 62). While the ACT is available nationwide, it "is predominantly taken by high school juniors and/or seniors in the southern and mid-western regions of the United States" (Welborn et al., 2015, p. 329).

According to Dickinson and Adelson (2016), "ACT scores have historically been used to identify higher-performing students for selection into post-secondary education" (p. 8). The test is comprised of multiple-choice questions to measure prior learning in the areas of reading, science, English, and mathematics (Welborn et al., 2015). The test is designed so "the four sections of the test yield subscores, and an overall composite score is computed by averaging the subscores and rounding to the nearest whole number between 1 and 36" (Welborn et al., 2015, p. 329). The mathematics section of the ACT is a 60-question, 60-minute test (Welborn et al., 2015). Welborn et al. (2015) reported the mathematics section of the test covers basic mathematics concepts up to 11th grade.

Toldson and McGee (2014) declared, "There are tangible benefits to achieving a high score on the ACT" (p. 2). Combs et al. (2010) added, "Results for ACT examinations are another indicator used in reporting college-readiness" (p. 447). The ACT is used to influence admissions and placement at colleges and universities in the United States (Toldson & McGee, 2014; Welborn et al., 2015). Dossey et al. (2016) spoke to the importance colleges put on the ACT when they wrote the following: "Because college entrance examination scores provide the only easily quantifiable and comparable measure for students coming from different high schools and different areas of the country, they are often given great importance by colleges" (p. 61). According to Welborn et al. (2015), "With the ACT playing an important role in college admissions, the predictive ability of the tests has been scrutinized across the academic realm" (p. 328). In recent years, the percentage of students taking the ACT has increased since some states have mandated all students take the ACT at least once during their 11th or 12th-grade year (Dickinson & Adelson, 2016; Dossey et al., 2016).

In a report for the Thirteenth International Congress on Mathematical Education prepared by Dossey et al. (2016), conflicting trends in the mathematics section of the ACT were revealed. Dossey et al. (2016) stated, "[The] graduating seniors' mean mathematics performance on both the SAT and ACT has shown substantial improvement since 1995" (p. 62). In addition, there has "been a decline in the overall scores on the mathematics section of ACT" (Dossey et al., 2016, p. 66). According to Dossey et al. (2016), "The most prevalent explanation is the numbers of students who are now attending college have increased, and they include many who would not have been traditional college attendees but are now taking the test and hoping to attend" (p. 66).

Curriculums

Experts such as Kulm (2007) have determined "reforms, controversy, and public opinion" affect curriculum implementation and selection (p. 368). As previously discussed, education in the United States is a local responsibility, not a national responsibility, making the United States unique from many of its counterparts that implement national curriculums (Dossey et al., 2016; Lundgren, 2015). Smith and Morgan (2016) stated:

> Educational systems around the world tend to value mathematics as a school subject that is not only studied by a large majority of students throughout the years of compulsory schooling but is also widely used as a key indicator of the success of individual students and of educational systems themselves. (p. 24)

Lundgren (2015) concluded, "U.S. tradition has its roots in the local government of schooling and a freedom for local curricula. In other countries, national governments and their bureaucracies have been responsible for curriculum development and implementation" (p. 790). This local control also leads to a variety of different textbooks and curriculums being implemented (Lundgren, 2015).

In 2016, Dossey et al. stated, "The variety of education programs available in the United States is very great" (p. vi). Specifically, Dossey et al. (2016) clarified, "In 2013–14, 98,271 public schools or agencies were in operation in the 50 states and the District of

Columbia" (p. 4). Because of the way the educational system is set up in the United States, theoretically there could be 98,271 different textbooks and curriculums used in the United States (Dossey et al., 2016).

Instead of each school district developing their curriculums and corresponding textbooks, many school districts use textbooks and curriculums developed by companies (Dossey et al., 2016). According to experts, there are two main classifications of mathematics textbooks (Stein et al., 2007). Mathematics textbooks can be classified as either traditional or standards-based. Jung Kang (2014) determined, "The primary features of traditional textbooks are focused on algorithm procedures, with a superficial presentation of important topics and little application to real life" (p. 95).

Stein et al. (2007) examined the organization of traditional textbooks and concluded these textbooks rely on direct explanation from a teacher, while students are expected to master the procedural aspect of the problems before they attempt to solve conceptual problems. Jung Kang (2014) described the curricula in traditional textbooks as having a "spiral organization" (p. 95). A spiral organization occurs when "the textbooks introduce and reintroduce the specific topic with an increasing level of sophistication for each successive grade" (Jung Kang, 2014, p. 95). Jung Kang (2014) concluded, "Spiral organization does not enable students to master the topic the first time they see it, but it does help students to attain eventual mastery over time when they revisit the topics" (p. 95).

Traditional curriculums and textbooks have been criticized by multiple researchers, including Trafton et al. (2001), who determined traditional curriculums do not encourage students to see the practical relevance or usefulness of the mathematics they learn for use in their everyday lives. According to Berger (2019), “Many learners do not read or use their mathematics textbooks productively” (p. 46).

Since the release of the U.S. National Council of Teachers of Mathematics (NCTM) *Curriculum and Evaluation Standards for School Mathematics*, the idea of standards-based reform has been “crystallized” (Schmidt et al., 2005, p. 531). In contrast to traditional textbooks and curricula, standards-based textbooks and curriculums are characterized as being adept at developing in-depth ideas and motivating learning (Trafton et al., 2001). Schmidt et al. (2005) stated, “Over the past two decades, an increased demand for ‘higher quality’ public education has emerged from many interest groups in the U.S. . . . This demand has fostered the standards-based education movement” (p. 526). Trafton et al. (2001) also concluded standards-based curriculums give students the opportunity to make sense of mathematical ideas and motivate students by linking mathematics with its application in everyday situations.

Schmidt et al. (2005) reported, “In recent years, U.S. curriculum policy has emphasized standards-based conceptions of curricula in mathematics and science” (p. 525). In Stein et al.’s (2007) analysis of the organization of textbooks, they concluded standards-based materials lean on student engagement instead of direct instruction, and students are encouraged to interact with a concept before mastery has occurred to aid in the overall mastery of a concept. Jung Kang (2014) also described the organization of the standards-based curriculums as a “modular approach,” as opposed to the spiral approach of traditional curriculums (p. 96). According to Dossey et al. (2016), “In 2013–14, 98,271 public schools or agencies were in operation in the 50 states and the District of Columbia” (p. 4). Dossey et al. (2016) pointed out that “these schools were providing a variety of educational services to the estimated 50 million K–12 students enrolled in them. Most of the schools (89,183) were focused on delivering the broad standard curriculum to their students" (p. 4).

No matter if a school district chooses to use a traditional or standards-based textbook and curriculum, this choice is a decision that cannot be taken lightly (Özer & Sezer, 2014). Reyhani and Izadi (2018) found, "Textbooks are considered as a bridge between the intended curriculum and the implemented curriculum" (p. 295). Experts such as Özer and Sezer (2014) determined, "Textbooks are considered the most important component of a reformed curriculum because they are a reflection of the curriculum for the teachers, students, and parents" (p. 411).

Not only choosing the textbook but evaluating its usage is of the utmost importance for a school district (Özer & Sezer, 2014). Özer and Sezer (2014) advised, "Which textbooks are used is a good indicator of a curriculum, and analysis of the textbooks explores how well the intended curriculum is implemented" (p. 412). According to Schmidt et al. (2005), "Simple, coherent, intellectually profound and systemically powerful visions guide U.S. mathematics and science education" (p. 530). The decision of which curriculum and textbook to use should be constantly evaluated to keep up with the changing needs of students, because "of all learning materials, textbooks offer the most learning opportunities" (Özer & Sezer, 2014, p. 412).

Summary

Mathematics education has evolved from teaching basic mathematics principles for everyday commerce (Saracho & Spodek, 2009) to today's mathematics curriculums designed to allow students to be competitive in a society with an ever-increasing reliance on STEM (Boyd & Tian, 2017). These advancements have taken place due to societal (Lundgren, 2015) and political influences (Demirci, 2019; Herrera & Owens, 2001). In the United States, substandard performance on international comparisons have led to continued changes in how mathematics is taught in public high schools (Klieger, 2015; Schmidt, 2003; Schmidt et al., 2005). A multitude of prepared mathematics curriculums are available for student use, and multiple ways of implementing these curriculums exist (Dossey et al., 2016).

Chapter Two included a review of literature on curriculum theory, historical influences on mathematics curriculum development, multiple movements that influenced mathematics curriculum development, and how international comparisons have driven mathematics curriculum development. A melding of published findings regarding mathematics curriculums and topics which have influenced their development allowed for an examination of the development of mathematics curriculums.

In Chapter Three, information regarding the problem and purpose is restated, and the research questions and hypotheses are presented. The research design is detailed. Information concerning the population and sample is described. The methods of data collection and analysis are offered.

Chapter Three: Methodology

The purpose of this study was to evaluate the impact of mathematics curriculums on student performance in Missouri. This evaluation was designed to determine if a specific curriculum or curriculum type yields better results for students on the ACT. The findings of this study may help school district leaders when evaluating mathematics curriculum adoption.

Research Design

In the two-part quantitative study, the data for the initial phase consisted of archival data in the form of ACT scores from the 2014–2015, 2015–2016, and 2016–2017 school years. According to an administrative memo dated May 29, 2014, from the Assistant Commissioner of the MODESE:

> On January 14, 2014, the State Board of Education approved the administration of the ACT® to all grade 11 students in Missouri public schools, beginning in 2014–15, with the exception of students who are eligible for the Missouri Assessment Program-Alternate (MAP-A). (Helwig, 2014, para. 1)

Although the mandate was short-lived due to financial constraints, the timeframe allowed for the state board to collect data from all Missouri juniors for three years (Cooper, 2015). This development allowed for the collection of valid data, which were equally measured for junior-level student progress in Missouri public school districts. In this study, the scores from the mathematics section of the ACT were collected from the college and career readiness section of the MODESE website. Once the ACT data were collected, the data were averaged and sorted for each school district for the three years of mandatory ACT administration in Missouri. After the scores were averaged and sorted, the scores were analyzed to determine which school districts scored in the upper 10% of reported scores during this time frame. These school districts were identified as high-performing for the purpose of this study. After the high-performing school districts were identified, the initial quantitative section of the study was considered completed.

After the top 10% of school districts were identified, the second quantitative section of the study commenced. A survey was distributed to the curriculum directors of the school districts identified as top performers in the initial section of the study. The survey was designed to collect data regarding each participating district's specific mathematics curriculum and implementation strategies. The first questions of the survey were posed to determine if school district leaders implemented a traditional or standards-based mathematics curriculum. Next, the curriculum directors were asked a series of questions to determine the specific curriculum(s) the school district implemented. The participants were also asked if a single curriculum was used at all levels of the school district, how long school district leaders have used the specific mathematics curriculum, and how many minutes per week were allocated for mathematics instruction at grades K–11. After the curriculum directors completed and returned the survey, data were evaluated to determine whether a specific curriculum encompassed elements for increased proficiency of the mathematics section of the ACT.

Problem and Purpose Overview

The purpose of this study was to evaluate whether there exists a specific mathematics curriculum or a specific type of curriculum most often used in school districts ranked at the top 10% of ACT proficiency among school districts in Missouri for the 2014–2015, 2015–2016, and 2016–2017 school years. The Missouri State Board of

Education is committed to ensuring students are college and career-ready, and as part of this commitment, curriculums in all areas have come under scrutiny (MODESE, 2017). According to Combs et al. (2010), "High Schools have come under recent scrutiny in the quality of their programs and curriculum related to college preparedness" (p. 444). Some experts believe high school mathematics curriculums play a key role in student success (Combs et al., 2010).

Research Questions and Hypotheses

The following research questions guided this study:

1. What is the difference between scores on the mathematics section of the ACT of school districts that use a standards-based mathematics curriculum in grades K–5 and school districts that use a traditional mathematics curriculum in grades K–5?

$H1_0$: There is no statistical difference between school districts that use a standards-based mathematics curriculum in grades K–5 and school districts that use a traditional mathematics curriculum in grades K–5 on the mathematics section of the ACT.

$H1_a$: There is a statistical difference between school districts that use a standards-based mathematics curriculum in grades K–5 and school districts that use a traditional mathematics curriculum in grades K–5 on the mathematics section of the ACT.

2. What is the difference between scores on the mathematics section of the ACT of school districts that use a standards-based mathematics curriculum in grades 6–

11 and school districts that use a traditional mathematics curriculum in grades 6–11?

$H2_0$: There is no statistical difference between school districts that use a standards-based mathematics curriculum in grades 6–11 and school districts that use a traditional mathematics curriculum in grades 6–11 on the mathematics section of the ACT.

$H2_a$: There is a statistical difference between school districts that use a standards-based mathematics curriculum in grades 6–11 and school districts that use a traditional mathematics curriculum in grades 6–11 on the mathematics section of the ACT.

3. What is the difference between school districts that use a consistent type of mathematics curriculum (either standards-based or traditional) in grades K–11 and school districts that use a combination of standards-based and traditional mathematics curriculums in grades K–11?

$H3_0$: There is no statistical difference between school districts that use a consistent (standards-based or traditional) mathematics curriculum in grades K–11 and school districts that use a mixture of standards-based and traditional mathematics curriculums on the mathematics section of the ACT.

$H3_a$: There is a statistical difference between school districts that use a consistent (standards-based or traditional) mathematics curriculum in grades K–11 and school districts that use a mixture of standards-based and traditional mathematics curriculums on the mathematics section of the ACT.

4. What are the implementation strategies applied by school districts that scored in the upper 10% in Missouri on the mathematics section of the ACT for the years 2015, 2016, and 2017 with regard to the following:

    a. Type of mathematics curriculum used.
    b. The grade level mathematics is introduced as a specific content area.
    c. The number of minutes per week allocated to mathematics in grades K–11.
    d. The length of time a school district uses a specific mathematics curriculum.

Population and Sample

A population is “the group to which the researcher would like the results of a study to be generalizable; it includes all individuals with certain specified criteria” (Fraenkel et al., 2018, p. G-6). For the first quantitative section of this research project, the population consisted of all school districts in Missouri whose ACT scores were available on the 2016, 2017, and 2018 APR summary pages. A total of 437 school districts reported mathematics ACT scores for the 2016 APR; these scores represented the students who took the mandated ACT in the school year 2014–2015. A total of 437 school districts reported math ACT scores for the 2017 APR; these scores represented the students who took the mandated ACT in the school year 2015–2016. A total of 436 school districts reported math ACT scores for the 2018 APR; these scores represented the students who took the mandated ACT in the school year 2016–2017. All available school district ACT scores for the 2014–2015, 2015–2016, and 2016–2017 school years were analyzed.

According to N. Bowles (personal communication, January 14, 2019), only school districts with 10 or more reported scores were available through the MODESE website. While school districts with fewer than 10 students reported scores to the MODESE, their results were not included on their APR reports or in the summative reports of all school districts available on the MODESE's website. This stipulation eliminated some school districts from the population. Only schools with three years of reported data were included in the population. During the three-year sample of data, there were 421 school districts that reported scores for all three years. These school districts comprised the population for this study.

Once the population was determined, a sample consisting of school districts that scored in the upper 10% of the population was identified to obtain an appropriate sample size to gather the data needed to conduct a statistical analysis (Fraenkel et al., 2018). School districts that had mathematics scores reported by the MODESE and that scored in the upper 10% of all districts were used for the purposive sample of this study. A purposive sample occurs when "researchers do not simply study whoever is available, but rather use their judgment to select a sample that they believe, based on prior information, will provide the data needed" (Fraenkel et al., 2018, p. 101). According to the data from the MODESE, there were 43 school districts included in the sample for this study.

For the second section of the quantitative study, a survey was sent to 43 curriculum directors of school districts identified in the upper 10% of the state based upon ACT mathematics subscores. The questions on the survey were used to identify the specific mathematics curriculums used in grades K–5 and grades 6–11, if the type of curriculum (standards-based or traditional) was consistent at all grade levels, when the curriculums were introduced, and how long the curriculums had been used.

Instrumentation

Two different instruments were used for the collection of data in this study. The ACT results and a survey created by the researcher served as the instruments for data collection. By using a quantitative survey instrument, numerical data were extracted to use for *t*-test statistical analyses for differences (Fraenkel et al., 2018).

ACT

During the initial phase of this study, the researcher analyzed archival ACT data from the MODESE. The ACT is a nationally recognized test many colleges use as a tool to compare students from different school districts (Welborn et al., 2015). The test is composed of reading, science, mathematics, and English subtests (Welborn et al., 2015). The mathematics section consists of a 60-question, 60-minute test, which covers basic mathematics concepts up to 11th grade (Welborn et al., 2015). Students who take the ACT can select up to four colleges to receive their ACT scores for free (Stegmeir, 2018).

Survey

The researcher created a survey based on the theoretical framework and review of relevant literature (see Appendix A). Then, the survey was presented to educators not included in the sample to field test the instrument. Feedback from individuals who piloted the survey questions was considered and incorporated into the final surveys. According to van Teijlingen and Hundley (2001), the purpose of piloting a survey is to find whether the wording, the order of the questions, the range of answers, or other factors produce purposeful data. This process may help to identify practical problems and ensure the validity and reliability of the instrument (van Teijlingen & Hundley, 2001).

Data Collection

There were multiple ethical issues to address before data collection began (Creswell, 2018). To ensure all data had been collected in an appropriate manner, "all research instructions receiving federal funds establish what are known as institutional review boards (IRBs) to review and approve research projects" (Fraenkel et al., 2018, p. 69). To ensure all ethical issues had been identified and addressed for this study, no data were collected until approval was given by the IRB from Lindenwood University (see Appendix B). Once approval was given by the IRB, data collection began.

For the initial collection, archival data from the MODESE were used to collect ACT scores from all public school districts in Missouri. These quantitative data were analyzed comparatively to determine the sample for this study based on which school districts' ACT composite scores averaged in the top 10% of Missouri school districts for the years 2014–2015, 2015–2016, and 2016–2017. The ACT scores analyzed were from the APR for the years 2016, 2017, and 2018.

Curriculum directors were contacted via email and invited to complete a survey via Qualtrics. Before the survey was completed, a consent form (see Appendix C) and a letter of participation (see Appendix D) were sent to the participating curriculum directors via email. A link was provided in the email for the Qualtrics survey. By clicking on the link to participate in the survey, the curriculum directors gave informed consent. Finally, the curriculum directors completed the survey via Qualtrics, from which results were extracted.

Data Analysis

Survey data were gathered from each of the high-performing school districts, and *t*-tests were conducted for research questions one, two, and three. Findings for these questions are presented in tables. Descriptive statistics were applied for research question four to describe implementation strategies for high-performing school districts in the areas of curriculum choice, mathematics instructional minutes per week, the length of time associated with curriculum implementation, and the grade level at which mathematics instruction is introduced. Percentages of responses were calculated by dividing the number of responses in each category by the total number of respondents. The findings for research question four are presented through frequency tables and graphical representations (Fraenkel et al., 2018).

Ethical Considerations

When conducting research, it is of the utmost importance to take all ethical concerns into consideration (Creswell, 2018). According to Fraenkel et al. (2018):

> It is a fundamental responsibility of every researcher to do all in his or her power to ensure that participants in a research study are protected from physical or psychological harm, discomfort, or danger that may arise due to research procedures. (p. 63)

The MODESE (2020) has multiple safeguards to ensure they do not violate the Family Educational Rights and Privacy Act (FERPA). According to the MODESE (2020), “FERPA prohibits disclosure of identifiable student information without parental consent” (para. 1). The MODESE (2020) has multiple procedures to ensure the FERPA is not violated, and “procedures are used to ensure the confidentiality of student records maintained” (para. 3).

All identifiable information was removed from the data. Individual curriculum director data were not exploited throughout the course of this study. There was no possibility of harm to the participants, as there was no experimental group, and no rewards were attached to participation in the study. During this study and data gathering stage, all data were secured on a password-protected desktop computer for the extent of the study. A removable backup of data was created and secured in a locked file under the supervision of the researcher. All information was kept locked and secure throughout the course of this study and will be destroyed three years after completion.

Summary

Chapter Three included the problem and purpose of the study with regard to whether there exists a specific mathematics curriculum or a curriculum type that is most often used in school districts at the top 10% of ACT proficiency in Missouri for the 2014–2015, 2015–2016, and 2016–2017 school years. The research questions, population, and sampling procedures were discussed. A description of how data were analyzed, including ethical considerations for this study, was presented. An analysis of the data is provided in Chapter Four.

Chapter Four: Analysis of Data

The impact of a school district's choice of curriculum on student achievement is a topic of discussion for many scholars (Mkandawire et al., 2018; Priestley, 2019; Sullivan et al., 2018). While many states, including Missouri, use standardized tests to quantify student progress, during a three-year time frame the MODESE used the ACT to measure student progress and compare scores across the state (Cooper, 2015; Helwig, 2014; Sireno, 2017). The ACT allowed for students from across the state to be measured on a nationally normed test (Cooper, 2015).

Recently, there has been a multitude of research conducted and published regarding how to improve students' understanding of mathematics concepts (Pepin et al., 2017). There have been studies on the benefits of making connections between new ideas and students' prior knowledge so they may begin to recognize connections in mathematics to increase their understanding (Klosterman, 2018), the use of scaffolding in mathematics education (Quinnell, 2017), mathematics as an art form (Gordon, 2019), and the importance of closely reading word problems (Ediger, 2018). As an increased focus has been placed on ensuring students have the STEM skills necessary to succeed in a workplace that continues to become more reliant on technology, the importance of mathematics education in public schools will continue to be critically examined and researched (Boyd & Tian, 2017; Wu-Rorrer, 2017; Yıldırım & Sidekli, 2018).

The purpose of this two-part quantitative study was to examine the data for similarities among specific mathematics curriculums, specific types of mathematics curriculums, or differences in specific strategies implemented by school districts in the top 10% during the years the ACT was mandated by the MODESE. Data were collected from a survey of the researcher's design. The survey was distributed to curriculum directors in school districts that scored in the top 10% on the mathematics section of the ACT during the targeted school years.

For the purpose of this study, data from the mathematics section of the ACT were used to determine which school districts were high performing. The decision to use the ACT was made primarily because the ACT is used by colleges and universities as a predictor for future success (Dossey et al., 2016; Toldson & McGee, 2014; Welborn et al., 2015). Data from three academic years (2014–2015, 2015–2016, 2016–2017) were examined. These data were chosen because during this time frame, the ACT was mandated for all 11th-grade students who were not MAP-A eligible (Cooper, 2015; Helwig, 2014; Sireno, 2017).

These data were made available through the MODESE public website and were provided on each school district's APR (Cooper, 2015). According to N. Bowels (personal communication, January 14, 2019), the ACT scores were made available on the APR from 2016, 2017, and 2018. The results on the 2016 APR correlated with the ACT taken by students during the school year 2014–2015, and results from 2017 represented students who took the mandated ACT during the 2015–2016 school year. The results from the 2016–2017 test were reflected on the 2018 APR. The lag between the school year the ACT was taken and when the scores were reported by the MODESE occurred because the students were in the 11th grade when the ACT was taken, and the APR was not released until after the students' anticipated graduation date (N. Bowels, personal communication, January 14, 2019). N. Bowels (personal communication, January 14, 2019) stated only school districts with 10 or more reported scores were available through the MODESE. While schools with fewer than 10 students reported scores to the MODESE, the results were not included on their APR or in the summative report of all school districts available on the MODESE's website (N. Bowels, personal communication, January 14, 2019).

Included in this chapter are results from the data collected from the survey. For research question one, a *t*-test was used to determine if there was a statistical difference in scores on the mathematics section of the ACT between school districts that implemented a standards-based mathematics curriculum and school districts that implemented a traditional mathematics curriculum in kindergarten through fifth grade. For research question two, a *t*-test was applied to determine if there was a statistical difference in scores on the mathematics section of the ACT between school districts that implemented a standards-based mathematics curriculum and a traditional mathematics curriculum in grades six through 11.

For research question three, a *t*-test was used to determine if there was a statistical difference between school districts that aligned their mathematics curriculums in kindergarten through 11th grade by either using standards-based or traditional mathematics curriculums at all grade levels and school districts that mixed standards-based and traditional mathematics curriculums in kindergarten through 11th grade. Descriptive statistics were applied to answer research question four with implementation strategies of the high-performing school districts in the areas of mathematics curriculum choice, mathematics instructional minutes per week, the length of time associated with mathematics curriculum implementation, and the grade level at which mathematics instruction was introduced.

Population and Sample

The targeted population for this study included all public school districts in Missouri that administered the mandated ACT. Since only school districts with more than 10 students were included in the APR, this targeted population was not available; therefore, the accessible population was considered. Fraenkel et al. (2018) defined the accessible population as “the population to which a researcher is able to generalize” (p. 93). The accessible population for this study consisted of school districts that had more than 10 students take the ACT during the 2014–2015, 2015–2016, and 2016–2017 school years.

After eliminating schools that did not have three years of reportable data, the accessible population was determined to be 423 school districts. After this determination was made, school districts scoring in the top 10% on the mathematics section of the ACT were identified. This created a sample of 43 school districts. Two attempts were made to determine which staff members within the school districts would be able to best answer questions about the mathematics curriculums and implementation strategies in kindergarten through 11th grade. The initial attempt was in the form of an email to the school district superintendents. There were responses from 18 superintendents. The superintendents indicated the best contact persons in the school districts and also gave consent to contact the staff members to ask them to respond to the survey.

The initial email to superintendents did not elicit the number of responses anticipated. To get a larger sample, a second email was sent to the person in charge of curriculum and instruction in each school district who had not responded to the original email. From this second attempt, 12 responses were received, which increased the sample to 30 participants.

The survey was distributed to the staff members indicated to be the best contact to answer questions about each school district's current mathematics curriculum and implementation strategies. After the survey was emailed to the participants, 14 responses were received. Since some of the 14 participants did not respond to all the prompts, the available data from the incomplete surveys were still used.

Validity

One area that may come into question was the low number of responses to the survey. Initially, there were responses from 30 district leaders indicating they would be willing to participate in the study; however, after the surveys were distributed, only 14 school districts actually responded to the survey. Of the 14 school districts that responded, there were multiple surveys only partially completed. There were between 10 and 12 school districts represented for each question of the survey.

After discussing the issue of validity with the dissertation committee members, adjustments were made to the methods of statistical analysis, and the research moved forward. According to Fraenkel et al. (2018), validity "revolves around the defensibility of the inferences researchers make from the data collected through the use of an instrument" (p. 113). The data from this survey are valid, although the number of participants could have been greater.

Data Collection

For the initial section of this two-part quantitative study, data on the mathematics section of the ACT were collected from each school district's APR for the years the ACT was mandated for 11th-grade students in Missouri. The school districts scoring in the top 10% on the mathematics section on the ACT were selected as the sample. The ACT scores were available through the MODESE website without any login information needed. All data used to collect ACT scores were and are available to any member of the public.

For the second part of the quantitative study, a seven-part survey of the researcher's design was distributed to school districts included in the sample. The information from the survey was used to answer questions about each school district's implemented mathematics curriculums and implementation strategies. Questions two through four of the survey were designed to answer research question one. Statement five was designed to answer research question two, while the data obtained from survey questions six and seven were used to answer research question three.

Findings

Research Question One

What is the difference between scores on the mathematics section of the ACT of school districts that use a standards-based mathematics curriculum in grades K–5 and school districts that use a traditional mathematics curriculum in grades K–5?

For survey question number two, the participants classified the mathematics curriculum they used in each grade from K–5 as standards-based or traditional. Twelve of 30 school districts responded to this prompt on the survey. Out of these 12 school districts, the majority indicated they used a standards-based mathematics curriculum at all grade levels. In grades K–2, a high-performing school district was five times as likely to self-identify their mathematics curriculum as standards-based rather than a traditional mathematics curriculum. In grades 3–5, the school districts were three times as likely to self-identify the mathematics curriculum they implemented as standards-based rather than a traditional mathematics curriculum. The results are displayed in Table 1.

Table 1

Type of Mathematics Curriculum Implemented in Grades K–5

Grade	Standards-Based	Traditional
Kindergarten	10	2
First Grade	10	2
Second Grade	10	2
Third Grade	9	3
Fourth Grade	9	3
Fifth Grade	9	3

Note. $n = 12$.

As shown in Table 2, each school district's three-year average scores on the mathematics section of the ACT are compared to the type of mathematics curriculum the school district reported using. School District G reported using a combination of standards-based and traditional mathematics curriculums at different grade levels; therefore, District G was not included in the data analysis.

Table 2

District ACT Mathematics Average and Type of Curriculum Implemented in Grades K–5

District	Three-Year ACT Math Average	Type of Curriculum K–5
A	20.63	Standards-Based
B	20.76	Standards-Based
C	20.96	Traditional
D	25.06	Standards-Based
E	20.73	Traditional
F	22.70	Standards-Based
G	20.86	Mixed (not included in analysis)
H	21.50	Standards-Based
I	22.30	Standards-Based
J	21.33	Standards-Based
K	23.13	Standards-Based

Note. n = 11.

To answer research question one, a *t*-test was used to determine if there was a significance difference in the type of mathematics curriculums used by high-performing school districts in grades K–5. According to Bluman (2017), a *t*-test can be used when the sample size is below 30 or “a standard deviation is not known” (p. 489). Bluman (2017) specified, “In these cases a *t*-test is used to test the difference between two means when the two samples are independent and when the samples are taken from two normally or approximately normal distributed populations” (p. 489).

An independent *t*-test was conducted to compare the mean scores on the mathematics section of the ACT of the two classifications: standards-based or traditional. According to Bluman (2017), “The degrees of freedom are the number of values that are free to vary after a sample statistic has been computed” (p. 375). For this set of data, there were 12 reported values. Assuming that the degrees of freedom (*df*) are equal to the number of reported values minus 1 ($df = n - 1$), the degrees of freedom would be $df = 12 - 1$. In this case, the degrees of freedom was equal to 11. Using 11 as the value for degrees of freedom and a confidence level of a minimum of 80%, the *t*-value needed to support the hypothesis of a statistically significant difference between school districts with a standards-based mathematics curriculum in grades K–5 and school districts with a traditional mathematics curriculum in grades K–5 would be 1.363 or higher. The calculated value for the *t*-test was 0.1277. According to the results of the *t*-test, no significant difference was found between the two groups. The mean of the school districts that implement a standards-based mathematics curriculum ($m = 22.17$, $sd = 1.468$) was not significantly different from the mean of the school districts that implemented a traditional mathematics curriculum ($m = 20.85$, $sd = 0.163$).

Research Question Two

What is the difference between scores on the mathematics section of the ACT of school districts that use a standards-based mathematics curriculum in grades 6–11 and school districts that use a traditional mathematics curriculum in grades 6–11?

For survey question number four, the participants classified the mathematics curriculums used in grades 6–11 as standards-based or traditional (see Table 3). Twelve of the 30 school districts responded to the survey question. Upon initial examination of the data, there seemed to be a shift in the type of self-identified mathematics curriculums as compared to the previous survey question. In grades K–5, school districts were three to five times as likely to identify their mathematics curriculums as standards-based rather than traditional. When examining the data in 6th grade, the type of mathematics curriculums identified was equal, with six school districts identifying as standards-based and six identifying as traditional. After 6th grade, school districts were three to five times as likely to use a traditional mathematics curriculum as they were to identify using a standards-based mathematics curriculum. This is the opposite trend as was observed in grades K–5.

Table 3

Type of Mathematics Curriculum Implemented in Grades 6–11

Grade	Standards-Based	Traditional
Sixth Grade	6	6
Seventh Grade	3	9
Eighth Grade	3	9
Ninth Grade	3	9
10th Grade	2	10
11th Grade	3	9

Note. $n = 12$.

As displayed in Table 4, the school district three-year ACT mathematics average score is compared to the type of mathematics curriculum each school district reported using. School Districts A, B, J, and K reported a combination of standards-based and traditional mathematics curriculums at different grade levels, so these school districts were not included in the data analysis. Upon examination, there were not sufficient data to perform a *t*-test. The majority of the mathematics curriculums in grades 6–11 were either mixed through the grade levels or traditional. Only a single school district reported using a standards-based mathematics curriculum for grades 6–11. To perform a *t*-test, a standard error must be calculated, and to calculate the standard error, there need to be two points of data available (Bluman, 2017). With only one school district using a standards-based mathematics curriculum at all grade levels between 6th and 11th grade, it was not possible to calculate a standard error for this set of data; therefore, the null hypothesis was neither rejected nor not rejected for research question two.

Table 4

District ACT Mathematics Average and Type of Curriculum Implemented in Grades 6–11

District	Three-Year ACT Math Average	Type of Curriculum 6–11
A	20.63	Mixed
B	20.76	Mixed
C	20.96	Traditional
D	25.06	Traditional
E	20.73	Traditional
F	22.70	Standards-Based
G	20.86	Traditional
H	21.50	Traditional
I	22.30	Traditional
J	21.33	Mixed
K	23.13	Mixed

Research Question Three

What is the difference between school districts that use a consistent type of mathematics curriculum (either standards-based or traditional) in grades K–11 and school districts that use a combination of standards-based and traditional mathematics curriculums in grades K–11?

To determine the response to the third research question, data from questions two and four on the survey were first considered. Participants classified the mathematics curriculums they used in grades K–5 and 6–11 as standards-based or traditional. If a school district self-identified their mathematics curriculum as either standards-based or traditional at all grade levels, they were classified as aligned. If they self-identified as using a combination of standards-based and traditional mathematics curriculums at different grade levels, they were classified as using a mixed mathematics curriculum. A total of 11 school districts responded to this question, with eight school districts professing to using a mixture of standards-based and traditional mathematics curriculums and three school districts aligning their mathematics curriculum types at all grade levels for grades K–11 (see Table 5).

Next, an independent *t*-test was conducted to compare the mean scores on the mathematics section of the ACT for two types of mathematics curriculum classifications: mixed and aligned. For this data set, there were 11 reported values. Assuming the degrees of freedom (*df*) are equal to the number of reported values minus 1 ($df = n - 1$), the degrees of freedom would be $df = 11 - 1$. In this case, the degrees of freedom equal to 10; therefore, the *t*-value needed to not support the hypothesis that an aligning mathematics curriculum has a positive effect on learning at a confidence level of a minimum of 80% would be 1.372 or higher. The calculated value for the *t*-test was 0.1277. According to the results of the *t*-test, no significant difference was found between the two groups. The mean of the school districts that align their mathematics curriculum ($m = 21.76$, $sd = 1.078$) was not significantly different from the mean of the second group ($m = 21.95$, $sd = 1.517$).

Table 5

District ACT Average and Alignment in Grades K–11

District	Three-Year ACT Average	Mixed or Aligned Curriculum
A	20.63	Mixed
B	20.76	Mixed
C	20.96	Aligned
D	25.06	Mixed
E	20.73	Aligned
F	22.70	Aligned
G	20.86	Mixed
H	21.50	Mixed
I	22.30	Mixed
J	21.33	Mixed
K	23.13	Mixed

Note. $n = 11$.

Research Question Four

What are the implementation strategies applied by school districts that scored in the upper 10% in Missouri on the mathematics section of the ACT for the years 2015, 2016, and 2017 with regard to the following:

a. Type of mathematics curriculum used.

b. The grade level mathematics is introduced as a specific content area.

c. The number of minutes per week allocated to mathematics in grades K–11.

d. The length of time a school district uses a specific mathematics curriculum.

For this phase of the research, the data were examined using frequency analysis to determine the trends in mathematics curriculum choice or mathematics curriculum implementation among high-performing school districts. Frequency tables and graphical representations are provided.

Specific Mathematics Curriculum Implemented. Participants were asked to provide the names of the specific mathematics curriculums used for grades K–5 and grades 6–11**.** The raw data are displayed in Appendix E. The frequency of the responses as well as a percentage breakdown of these data are presented. Each data table represents one grade level for grades K–11. Shown in Figure 1 are the ACT mathematics average and the mathematics curriculums the school districts indicated they used at the specific grade levels.

When analyzing these data, 10 of 30 school districts responded to the survey question for grades spanning K–8, and 11 of 30 school districts responded to the question for grades spanning 9–11. Many of the mathematics curriculums identified were only used by a single school district at the grade level, with at most three school districts using one type of mathematics curriculum. In the instances where three school districts indicated they only used a single mathematics curriculum in grades 9–11, the mathematics curriculum was identified not as a mathematics curriculum prepared by a publisher but as a mathematics curriculum the school district created by and implemented by their staff. While an attempt was made to identify a specific mathematics curriculum used by the high-performing school districts, after examining and analyzing the results, not one emerged. Therefore, the data regarding the implementation of a specific mathematics curriculum are not deciding factors for future success on the mathematics section of the ACT.

Figure 1

District ACT Mathematics Average and Curriculum Implemented by the District

District	Three-Year ACT Math Average	Grade	Curriculum
A	20.63	K–5	My Math
		6–7	Glencoe
		9–11	Various
B	20.76	K–6	Eureka
		7 & 8	Larson Big Idea
		9	Glencoe Algebra I
		10	Glencoe Geometry
		11	Larson Algebra II
C	20.96	K–6	My Math
		7 & 8	Houghton Mifflin
		9–11	McGraw Hill
D	25.06	K–5	Math in Focus-Common Core
		6–11	Big Ideas-Common Core
E	20.73	K–5	McGraw Hill
		6–11	Different Throughout
F	22.70	K–5	Everyday Math 4th Edition
		6–8	Connected Math Program
		9–11	Center for Mathematics Education
G	20.86	K–5	Math in Focus-Learning Standards
		6–11	Glencoe Math-Learning Standards
H	21.50	K–11	District Written Curriculum
I	22.30	K–5	Go Math
		6–7	Holt McDougal
		8	Holt McDougal/Pearson
		9–11	Pearson
J	21.33	K–6	Unknown
		7–11	Teacher Driven
K	23.13	K–5	Investigations 3rd Edition
		6	Illustrative Math from OUR
		7 & 8	Teacher Created
		9–11	Various

The Grade Level Math Was Introduced As a Specific Content Area. This topic was examined to determine if there was an advantage to introducing mathematics at an early grade level, such as kindergarten, or if there was an advantage in focusing on other areas and introducing mathematics at a later grade level, such as first or second grade. Eleven school districts responded to the survey, and all of the school districts indicated they introduce mathematics as a specific content area at kindergarten.

The Number of Minutes Per Week Allocated to Mathematics until 11th Grade. In response to survey question number five, participants indicated how many minutes per week were dedicated to mathematics instruction at all grade levels. There was a separate entry for each grade level spanning K–8 and one entry for high school. The decision was made to separate the grade levels, working under the assumption that most high schools follow a schedule with all periods receiving the same number of minutes per week of instruction, and there is more flexibility in the allocation of time for instruction at lower grade levels. The choices were 0–99 minutes per week, 100–399 minutes per week, 400–699 minutes per week, 700–999 minutes per week, or greater than 1,000 minutes per week (see Table 6).

Ten of 30 school districts responded to the survey question for grades spanning K–8, and 11 school districts responded for grades 9–11. In grades K–6, nine of the responding school districts reported dedicating 100–399 minutes per week to mathematics instruction, while one school district reported dedicating 400–699 minutes per week to mathematics instruction. Ten school districts responded they allocated 100–399 minutes per week to mathematics instruction in grades 7–8. Eleven school districts indicated they dedicated 100–399 minutes per week for mathematics instruction in the high school grades. Most school districts performing at a high level on the mathematics section of the ACT dedicated between 99 and 399 minutes per week to mathematics instruction.

Table 6

Number of School Districts and the Amount of Time Per Week

Grade	100–399 Minutes Per Week	400–699 Minutes Per Week
Kindergarten	9	1
First Grade	9	1
Second Grade	9	1
Third Grade	9	1
Fourth Grade	9	1
Fifth Grade	9	1
Sixth Grade	9	1
Seventh Grade	10	0
Eighth Grade	10	0
Grades 9–11	11	0

Length of Time the Current Mathematics Curriculum Has Been Implemented by the School District. Participants indicated how many years they have used their current mathematics curriculums in grades spanning K–5 and 6–11. The choices were 0–5 years, 6–11 years, and 11–15 years (see Table 7). Ten of 30 school districts responded with regard to grades K–6, and 11 school districts provided information for grades 7–11. For kindergarten, first, second, and fifth grades, eight of the 10 school districts (80%) indicated the mathematics curriculums had been in use for less than five years, one school district (10%) reported using the current mathematics curriculums for 6–10 years, and one school district (10%) reported using the same mathematics curriculums for more than 11 years.

In third and fourth grades, seven of the school districts (70%) indicated their current mathematics curriculums had been in use for fewer than five years. In these same grade levels, two (20%) of the school districts indicated the current mathematics curriculums had been in use for 6–10 years, while one (10%) school district indicated the current mathematics curriculums had been in use for more than 11 years. In 7th and 8th grades, six of the school districts (55%) had used the current mathematics curriculums for fewer than five years, and five (45%) of the school districts indicated they had used the current mathematics curriculums for 6–10 years. None of the school districts indicated they had used the current mathematics curriculums for more than 10 years.

For grades nine, 10, and 11, the same pattern emerged regarding the amount of time the current mathematics curriculums had been used. Of the 11 school districts, four of the school districts (37%) indicated the mathematics curriculums had been in use for fewer than five years, while seven school districts (36%) indicated they had used their current mathematics curriculums for more than five years but fewer than 11 years.

When examining the results from these data, the majority of school districts have used their current mathematics curriculums for fewer than 11 years. The split between 0–5 years and 6–10 years becomes inversed at the upper grades. The lower grades implemented new mathematics curriculums more often than the upper grade levels.

Table 7

Number of Years a District Used the Current Mathematics Curriculum by Grade Level

Grade	0–5 years	5–10 years	11+ years
Kindergarten	8	1	1
First Grade	8	1	1
Second Grade	8	1	1
Third Grade	7	2	1
Fourth Grade	7	2	1
Fifth Grade	8	1	1
Sixth Grade	5	5	0
Seventh Grade	6	5	0
Eighth Grade	6	5	0
Ninth Grade	4	7	0
10th Grade	4	7	0
11th Grade	4	7	0

Summary

In this chapter, data collected from a survey and secondary data from the ACT mathematics section were analyzed. Each research question was restated, and the findings related to the questions were presented. Findings regarding the standards-based and traditional mathematics curriculums and mean ACT mathematics scores for school years 2014–2015, 2015–2016, and 2016–2017 were included. Data were also collected regarding each school district’s type of mathematics curriculum, grade levels math was introduced as a specific content area, number of minutes per week allocated to mathematics, and length of time a specific mathematics curriculum was implemented. This data are summarized in Appendix E.

Chapter Five includes a summary of the study elements, findings, and conclusions. The chapter begins with a review of the findings of the study. A response to each research question is provided, followed by presentation of the conclusions. Implications for practice and recommendations for future research are discussed.

Chapter Five: Summary and Conclusions

Research conducted in the area of mathematics has progressed from Dutch mathematician Hans Freudenthal and his studies to the most current research used to design and develop mathematics curriculums (Greer, 2017). The purpose of mathematics education in the United States has evolved (Ather Khan et al., 2019). The inception of mathematics education in the United States arose from a need for the general populace to obtain the knowledge necessary to perform simple mathematic computations for business transactions (Boyd & Tian, 2017; Dossey et al., 2016; Saracho & Spodek, 2009).

According to Shah, Jannuzzo, et al. (2019), "Well-educated STEM workforce is a fundamental pillar of our economy" (p. 1). Because of society's increased reliance on STEM, there is a growing need for the general public to have more than a rudimentary understanding of mathematical concepts (Boyd & Tian, 2017; Chacko & Chacko, 2019; Dossey et al., 2016). Due to the anticipated increase in technological advancements, future generations' understanding of mathematics concepts must continue to evolve and advance (Boyd & Tian, 2017; Doğan et al., 2019; Görlitz & Gravert, 2018; Smith et al., 2019).

This study was focused on examining the mathematics curriculums or series utilized by school districts whose students were classified as high performing on the mathematics section of the ACT during the years the test was mandated by the MODESE. The strategies these high-performing school districts used in implementing chosen mathematics curriculums were also examined. This two-part quantitative study was designed to identify differences in these high-performing school districts with regard to a mathematics curriculum choice and implementation strategies at specific grade levels and district-wide.

Findings

In this section, the findings regarding mathematics curriculum choice and implementation strategies from the analysis of the data are presented. When examining curriculum choice, the topics included curriculum type, curriculum alignment, and the specific curriculum implemented by each school district. The areas examined when comparing implementation strategies included the grade level mathematics were introduced, how much time was devoted to mathematics instruction, and the length of time a mathematics curriculum was implemented by a school district.

Research Question One

What is the difference between scores on the mathematics section of the ACT of school districts that use a standards-based mathematics curriculum in grades K–5 and school districts that use a traditional mathematics curriculum in grades K–5?

When examining the data regarding curriculum type for grades K–5, an independent *t*-test was used to determine if the use of a standards-based or traditional mathematics curriculum in grades K–5 could lead to an increase in scores on the mathematics section of the ACT. The majority of the school district leaders in grades K–5 indicated the school districts they represented implemented a standards-based mathematics curriculum. Further analysis of the data showed that while standards-based mathematics curriculums were by far the most common type of mathematics curriculum implemented in grades K–5, as the grade levels increased, the number of school districts implementing standards-based mathematics curriculums decreased.

In grades K–2, the respondents indicated the school districts they represented were five times as likely to implement a standards-based mathematics curriculum as opposed to a traditional mathematics curriculum. Respondents from grade levels 3–5 indicated that while standards-based mathematics curriculums were still the most prevalent, school districts were only three times as likely to implement a standards-based mathematics curriculum over a traditional mathematics curriculum. Once the number of school districts implementing each type of curriculum was determined, an independent *t*-test was conducted to compare the mean scores on the mathematics section of the ACT of school districts with the two classifications of mathematics curriculums.

It was determined there was not a significant difference between the two types of curriculums and the scores on the mathematics section of the ACT for grades K–5. In this study, the use of a standards-based or traditional mathematics curriculum in grades K–5 did not lead to a significant difference in aggregate scores on the mathematics section of the ACT. Therefore, the null hypothesis was not rejected.

Research Question Two

What is the difference between scores on the mathematics section of the ACT of school districts that use a standards-based mathematics curriculum in grades 6–11 and school districts that use a traditional mathematics curriculum in grades 6–11?

When examining the data regarding curriculum type for grades 6–11, the results were found to be inconclusive. This was due to the lack of respondents indicating the implementation of standards-based mathematics curriculums at all grade levels in grades 6–11. For grades 6–11, over half of the respondents reported the use of a traditional mathematics curriculum. Only one respondent reported using a standards-based mathematic curriculum at all grade levels in grades 6–11.

The remaining respondents indicated a combination of standards-based and traditional mathematics curriculums in grades 6–11. Because there were fewer than two school districts implementing standards-based mathematics curriculums in grades 6–11, it was not possible to calculate a standard deviation. Since a standard deviation is necessary to perform an independent *t*-test, it was not possible to perform the independent *t*-test as planned. After a cursory examination of the average scores from the mathematics section of the ACT, there did not seem to be a difference in the range of scores in any of the school districts to indicate there would have been a statistically significant difference between standards-based and traditional mathematics curriculums. However, this inference was not based on statistical analysis; it was based solely on preliminary observations of the raw data. Because an independent *t*-test could not be conducted, it was not possible to reject or not reject the null hypothesis.

Research Question Three

What is the difference between school districts that use a consistent type of mathematics curriculum (either standards-based or traditional) in grades K–11 and school districts that use a combination of standards-based and traditional mathematics curriculums in grades K–11?

When examining the data regarding the importance of vertical alignment of curriculums in grades K–11, an independent *t*-test was used to determine if the exclusive use of either standards-based or traditional mathematics curriculums in grades K–11 could lead to an increase in scores on the mathematics section of the ACT. The majority of the respondents indicated the school districts they represented implemented a mixed curriculum in grades K–11. Further analysis of the data showed that combining the use of standards-based and traditional mathematics was by far the most common implementation method used by school districts. Of the 11 school districts included in the study, eight of the respondents indicated the implementation of a mix of standards-based and traditional mathematics curriculums at different grade levels.

Once the number of school districts implementing mixed and aligned mathematics curriculums was determined, an independent *t*-test was conducted to compare the mean scores on the mathematics section of the ACT for districts implementing aligned or mixed mathematics curriculums in grades K–11. It was determined there was not a significant difference between the alignment or nonalignment of mathematics curriculums and scores on the mathematics section of the ACT. The alignment or nonalignment of mathematics curriculums in grades K–11 did not lead to a significant difference in the aggregate scores on the mathematics section of the ACT; therefore, the null hypothesis was not rejected.

Research Question Four

What are the implementation strategies applied by school districts that scored in the upper 10% in Missouri on the mathematics section of the ACT for the years 2015, 2016, and 2017 with regard to the following:

a. Type of mathematics curriculum used.

b. The grade level mathematics is introduced as a specific content area.

c. The number of minutes per week allocated to mathematics in grades K–11.

d. The length of time a school district uses a specific mathematics curriculum.

Specific Mathematics Curriculums Implemented. When examining the data regarding the specific mathematics curriculums implemented by high-performing school districts, data were collected via a Qualtrics survey. Once the survey results were collected and categorized, a frequency analysis was conducted to look for differences regarding specific mathematics curriculums implemented by high-performing school districts. After examining the data provided by the respondents, it was determined there was not a single prepared mathematics curriculum that occurred at a higher rate. Many of the mathematics curriculums implemented by high-performing school districts were only implemented by a single school district in the study.

After examining the frequency analysis, it was determined multiple high-performing school districts did not implement a specific prepared mathematics curriculum. Instead, they implemented mathematics curriculums designed by the staff members in each school district. Because there was not a specific mathematics curriculum implemented by high-performing school districts, the implementation of a specific prepared mathematics curriculum was not a deciding factor for student success on the mathematics section of the ACT.

Introduction of Mathematics. To examine the data regarding when mathematics was introduced as a specific subject, data were collected via a survey. A frequency analysis was conducted to determine the differences regarding the grade at which high-performing school districts introduced mathematics as a specific subject area. All school district leaders responded their school districts introduced mathematics as a specific content area in kindergarten.

This finding would support the work of Cueli et al. (2020), who stated, “Early mathematical skills may be important indicators of school success” (p. 237). Because all respondents responded in the same manner, the frequency analysis could not reveal differences between the high-performing school districts. The unanimous responses from the school district leaders indicate that introducing mathematics as early as possible may be advantageous to future performance on the mathematics section of the ACT.

Time Allocated to Mathematics Instruction. When examining the data regarding the amount of time allocated to mathematics instruction per week by high-performing school districts, data were collected via a survey. The primary purpose was to determine if there were differences in the amount of time high-performing school districts allocated to mathematics instruction. The secondary purpose was to examine if school districts allocated an inordinate amount of time to mathematics instruction. While the allocation of an inordinate amount of time for mathematics instruction could lead to increased mathematics scores, it could also be detrimental to other subject areas.

After using frequency analysis to examine the data from the survey, the most common answer was that school districts allocated between 99 and 399 minutes per week to mathematics instruction. There were school districts that indicated they allocated more than 399 minutes per week to mathematics instruction, but no school districts indicated they allocated fewer than 99 minutes per week to mathematics instruction. The frequency analysis performed indicated 99 to 399 minutes per week for mathematics instruction could result in increased scores on the mathematics section of the ACT.

Amount of Time the Current Mathematics Curriculum Has Been Implemented. When examining the data regarding how long high-performing school districts had implemented their current mathematics curriculum, data were collected via a survey. Once the survey results were gathered, a frequency analysis was conducted to determine the difference in how long school districts had implemented their current mathematics curriculums. After analyzing the data, there were trends at different grade levels. One trend identified by the frequency analysis was that high-performing school districts did not implement mathematics curriculums for more than 10 years.

Only one respondent indicated their district had implemented a mathematics curriculum for more than 10 years. That specific school district had only implemented that mathematics curriculum for that period of time in grades K–5. At the secondary level, grades 6–11, school districts implemented their current curriculums between five and 10 years. In grades K–5, school districts implemented new mathematics curriculums more often. The majority of the school district leaders indicated the curriculums they currently implemented had been in use for fewer than five years.

Conclusions

The conclusions emerged based on responses to a survey of the researcher's design. The responses were collected and examined using statistical analyses. The results of data analyses were applied to the research questions with conclusions resulting from the outcome of these analyses.

The design of the study allowed for a determination of whether the ACT mathematics scores of students from high-performing school districts in Missouri were affected by either (1) the choice of mathematics curriculums or (2) curriculum implementation. Examined in this study were the differences in how the high-performing school districts chose to implement their mathematics curriculums. All school districts in the study scored in the top 10% on the mathematics section of the ACT during the three years the MODESE mandated all 11th-grade students take the ACT.

The theoretical framework for this research was curriculum theory. While scholars such as Beauchamp (1961, 1982), DeMatthews (2014), and Pinar (2012, 2014) contributed to curriculum theory, this study was based on the work of Dutch mathematician Hans Freudenthal. Freudenthal believed instructional conjectures of the mid-1900s were inappropriate and detrimental for mathematics education (Gravemeijer & Terwel, 2000). The development of mathematics curriculums continues to evolve since the time of Freudenthal. Experts such as Eronen and Kärnä (2018) explained mathematics curriculums have advanced from teacher-centered learning to a conceptual learning model.

The goal of this research was to determine if this evolution in mathematics curriculums and implementation strategies has taken place not only in the theoretical design of mathematics curriculums but in their practical implementation. The study was designed to determine if high-performing school districts in Missouri embraced these theories and changes. Quantitative data, curriculum theories, and implementation strategies were examined in response to the four research questions for this research project.

For research question one, data regarding the use of a traditional or standards-based mathematics curriculum in grades K–5 were gathered and analyzed to determine if using either type of mathematics curriculum made a difference in the outcome of the mathematics section of the ACT. After gathering data and performing statistical analysis via an independent *t*-test, the findings indicated the use of a standards-based or traditional mathematics curriculum in grades K–5 made no statistical difference in outcomes on the mathematics section of the ACT.

Researchers such as Goldenberg (2019) asserted mathematics education at early grade levels should encourage creativity, but in actuality, current mathematics curriculums are "more rigidly constrained than they used to be" (p. 319). This current study indicated a shift from traditional or teacher-centered mathematics education toward a standards-based or student-centered mathematics education is occurring and will benefit students' understanding of mathematical concepts. While Goldenberg's (2019) belief may be the trend in mathematics education, this study did not support the assumption that using one type of mathematics curriculum over another type leads to increased performance on the ACT. The type of mathematics curriculum used in grades K–5 is not a deciding factor for the future understanding of mathematical concepts; therefore, more research should be conducted at the lower grade levels to examine other factors that may influence the interpretation of mathematical concepts.

To answer research question two, data regarding the use of a traditional or standards-based mathematics curriculum in grades 6–11 were gathered and analyzed to determine if using either type of mathematics curriculum made a difference in the outcome of results of the mathematics section of the ACT. Unlike research question one, data from grades 6–11 were examined for research question two.

As the grade level increases, the complexity of mathematical concepts will also increase (Jordan et al., 2009); therefore, the type of curriculum implemented may also need to be adjusted. After gathering data from all participants, there were insufficient survey results to perform statistical analysis. Too few school districts indicated they implemented a standards-based mathematics curriculum to perform a *t*-test. Although the data were inconclusive, the number of school districts indicating implementation of traditional mathematics curriculums was unexpected.

Researchers Karakoç and Alacacı (2015) stated, “Making real-world connection in mathematics curricula and in teaching mathematics is generally viewed favorably within the educational community” (p. 31). This belief about making real-world connections in mathematics education would seem to favor school districts implementing standards-based curriculums (Dossey et al., 2016). This type of curriculum is focused on students demonstrating mastery of knowledge and is less focused on the memorization, drill, and repetition of facts (Dossey et al., 2016).

In contrast, a traditional mathematics curriculum focuses more on the learning of facts and less on applying facts to different situations (Dossey et al., 2016). As stated by Schmidt et al. (2005):

> Over the past two decades, an increased demand for ‘higher quality’ public education has emerged from many interest groups in the U.S. – from parents, the business community, governors, academics, economists, and politicians, to name some of the more vocal. This demand has fostered the standards-based education movement. (p. 526)

Most research suggests school districts should choose to implement a standards-based mathematics curriculum; however, the data from this study indicated the opposite trend in high-performing school districts. The high-performing school districts in the study reported they implemented traditional mathematics curriculums at a higher rate than standards-based curriculums, contradictory to the research of Dossey et al. (2016) and

Schmidt et al. (2005). No conclusion could be drawn regarding whether a specific type of mathematics curriculum at grade levels 6–12 increases scores on the ACT.

Research question three was posed to examine the importance of aligning mathematics curriculums at all levels in grades K–11 and determine if there was an advantage to using the same curriculum or curriculum type at all grade levels. Roach et al. (2008) stated, “Overload and fragmentation are major barriers to the successful implementation of accountability and standards-based educational reform” (p. 158). By using different curriculum types, students could be overloaded, as students not only have to learn new mathematics concepts, they also have to adapt to a new way of learning mathematics based on how the material is presented.

Using varied types of curriculums at different grade levels could be a factor that contributes to fragmentation (Roach et al., 2008). After collecting the data and performing a *t*-test, it was determined there were no advantages to aligning curriculums at all grade levels. If fragmentation and overload occur, they are not related to the alignment or non-alignment of mathematics curriculums, according to the data collected in this study.

Further inspection of the data revealed an interesting trend. Respondents were asked to identify the specific curriculums they used at all grade levels in grades K–11 and also to classify the curriculums as either traditional or standards-based. Many of the school districts indicated using a mix of curriculums. School districts apply different types and curriculums at different grade levels, sometimes switching back and forth multiple times between grades K–11. The lack of continuity between grade levels was surprising. After researching this topic, the initial belief was that it would be advantageous to use the same curriculum or curriculum type at all grade levels to reduce or limit the fragmentation or overlap that could occur when switching curriculums or curriculum types. Still, after analyzing the data, this did not seem to be the case.

The fourth research question addressed the implementation strategies high-performing school districts use in their mathematics curriculums. The strategies examined included the specific mathematics curriculums implemented, the grade level in which mathematical principles are introduced as a particular subject, the number of minutes allocated to mathematics teaching per week, and the length of time a district implements a mathematics curriculum before switching to a different mathematics curriculum.

The first topic examined was the specific mathematics curriculums implemented at each grade level. Many mathematics curriculums have been developed over the years (Herrera & Owens, 2001; Phillips, 2014b). The creation of mathematics curriculums is in response to multiple external factors, including historical events (Lundgren, 2015), political events (NCTM, 1989), and international testing (Klieger, 2015; Schmidt, 2003; Schmidt et al., 2005).

Respondents identified which mathematics curriculums their district implemented at each grade level. A frequency analysis allowed for an examination of the differences among the responses. While responses varied, there was no specific mathematics curriculum implemented by high-performing school districts at a significantly higher rate than any other mathematics curriculum. Upon further examination of the data, there was one trend to note. Three of the respondents from high-performing school districts indicated their districts did not implement specific curriculums from publishing companies. Instead, they used district personnel to develop mathematics curriculums unique to their school district needs. After examining the data of high-performing school districts, the conclusion could be drawn that school districts should investigate the possibility of implementing mathematics curriculums the school districts create utilizing district employees.

The second implementation strategy examined was the introductory grade level for mathematics as a standalone subject. Robb (2002) asserted, “Learning to read and reading to learn should be happening simultaneously and continuously from preschool through middle school-and perhaps beyond” (p. 24). Other authors such as McKee and Carr (2016) took the idea of learning to read, then reading to learn further, to develop ways to support beginning readers with their reading comprehension.

According to Bower et al. (2020), “Early spatial skills predict the development of later spatial and mathematical skills” (p. 1894). However, students must first be able to grasp the meaning of words associated with spatial orientation before they can understand the concept of spatial skills (Bower et al., 2020). Many of today’s mathematics curriculums emphasize students should closely read word problems (Ediger, 2018). Chen et al. (2019) stated, “The advancements in our understanding of mathematics interventions for young students have increased remarkably in the last decade” (p. 141).

Frequency analysis was applied to the data to identify the differences among high-performing school districts regarding when mathematics was introduced as a specific content area. Based on the research regarding the importance of reading, was there an advantage to delaying the introduction of mathematics as a specific content area to allow students to focus on literacy? While it may seem counterintuitive that high-performing school districts introduce math later, after studying the importance of reading in today's mathematics curriculums, the topic was reviewed.

After examining the frequency analysis, it was abundantly clear the high-performing school districts all introduced mathematics as early as possible. While the school districts differed in implementing the same type of mathematics curriculums or alignment of mathematics curriculums, all the school districts surveyed indicated the introduction of mathematics in kindergarten. Therefore, school districts should present mathematics as a specific subject area as early as possible.

The third implementation strategy examined was the time per week high-performing school districts allocated to mathematics instruction at all grade levels. Mandel et al. (2019) studied the impact of instructional time allocation on student understanding. A frequency analysis of the amount of time allocated to mathematics instruction per week in high-performing districts at all grade levels was conducted. An examination of the data showed high-performing school districts had very few differences in their responses. The school districts specified the allocation of between 99 and 399 minutes per week to mathematics instruction.

The results indicated these school districts allocated approximately an hour per day for mathematics instruction. Some upper-level classes apportioned more time to mathematics instruction. The increase in daily minutes resulted from some students taking more than one mathematics class per day at the high school level. Based on the data from this study, school districts should allocate between 99 and 399 minutes per week to mathematics instruction, increased by the factor of how many math classes in which a student enrolls.

The fourth and final implementation strategy examined was the length of the mathematics curriculum adoption cycle among the higher-performing school districts. Krupa and Confrey (2017) studied the impact of switching high school mathematics curriculums. In this study, frequency analysis data indicated high-performing school districts adopt and implement new curriculums as necessary, although results varied from district to district. After examining the data of high-performing school districts, school districts should explore the possibility of a regular mathematics adoption cycle less often than every 10 years.

Implications for Practice

The results obtained through examining the mathematics curriculums and implementation strategies of high-performing school districts provided multiple suggestions related to practice. Inferences may be made by struggling and high-performing school districts when district leaders critically examine mathematics curriculums and implementation strategies. Examining the results from this study may benefit school districts undertaking the process of examining their mathematics curriculums and implementation strategies.

There were findings from the data deemed nonsignificant. However, according to Connelly (2017), "[Nonsignificant findings] need to be available for future researchers and clinicians" (p. 214). Connelly (2017) continued, "Researchers should be honest in reporting their findings, including any that are nonsignificant" (p. 214). The lack of evidence to reject a null hypothesis in this study should not be ignored. A discussion of the nonsignificant and significant findings and their implications on mathematics curriculums and instruction is contained in this chapter.

Because of the increased emphasis placed on STEM education by employers (Edwin et al., 2019; Stein, 2018), school districts need to critically examine the mathematics curriculums they implement (Prendergast & Treacy, 2018) and the strategies used to teach mathematics (Patterson et al., 2020). School districts should regularly examine the latest mathematics teaching methodologies for the benefit of their current student population. It can be difficult for a school district to chase the newest mathematics curriculum trends for instruction. Still, any tendency to increase student learning in mathematics and other subject areas should be investigated.

The data gathered for this study provided evidence that successful school districts implement a variety of different mathematics curriculums. Implementing a specific mathematics curriculum does not affect future success on the mathematics section of the ACT, according to the data from this study. While this finding was statistically nonsignificant, school districts should choose a mathematics curriculum after careful research and an account of the current student population. Since no single mathematics curriculum was more prevalent among high-performing school districts in the study, a district leader has the freedom to choose the mathematics curriculum that best fits the school district.

The finding that the alignment or non-alignment of mathematics curriculums at different grade levels does not affect future student success, as measured by the ACT, was considered statistically insignificant. Leaders can switch between traditional and standards-based mathematics curriculums at different grade levels. District leaders may mix and match curriculums and curriculum types based on what is best for their student population or grade level.

While curriculum choice may not affect future student success, there were some indications that high-performing school districts' implementation strategies may affect future success. Özer and Sezer (2014) specified that while choosing a curriculum is essential, implementing the curriculum is of utmost importance. After reviewing the data, the mathematics curriculums implemented were more important than the specific type of curriculum. While the data on particular mathematics curriculums and mathematics curriculum types were inconclusive, there were commonalities in mathematics curriculum implementation strategies.

Data were collected to determine the differences in high-performing school districts; the data revealed multiple commonalities in mathematics curriculum implementation among high-performing school districts. The question of a possible advantage to focusing on reading alone at early grade levels and only incorporating mathematics into other subject areas was posed. The mantra *learning to read* is *reading to learn* is popular (Kerr & Frese, 2017; McKee & Carr, 2016), but the research in this study indicated students should also be introduced to mathematics concepts as early as possible. District leaders agreed to the importance of implementing mathematics as a standalone subject in kindergarten; therefore, mathematics should be implemented as a standalone subject as early as possible.

The second common strategy among high-performing school districts was the amount of time dedicated to mathematics instruction. There was an initial concern that the successful school districts in the study may have been focusing so much on mathematics that they ignored other subject areas. After reviewing the results, this did not seem to be the case. On average, high-performing school districts spent 100–399 minutes per week (20–79.8 minutes per day) on mathematics instruction. The data indicated the amount of time dedicated to mathematics instruction is an essential factor for district leaders to consider when designing student schedules.

Due to the plethora of mathematics curriculums available for district use, it would be easy for districts to change mathematics curriculums regularly. This study's findings indicated high-performing school districts do switch curriculums on a semi-regular basis. The district leaders seemed willing to make changes and implement new mathematics curriculums when better curriculums were available. School districts with the most success in mathematics used mathematics curriculums fewer than 11 years old. School districts that performed well on the ACT mathematics section changed mathematics curriculums at lower grade levels more often than at the higher-grade levels. These school districts indicated the mathematics curriculum used at lower grade levels tended to be less than five years old in grades K–5 and between five and 10 years old in grades 6–11. The research also indicated districts should not use mathematics curriculums for more than a decade without making changes. These findings would suggest school districts should continually study and critically examine new curriculums as they become available. Still, they should only adopt new curriculums if they are significantly better than the current mathematics curriculums.

Recommendations for Future Research

While research suggests students are ill-prepared for college-level mathematics (Atuahene & Russell, 2016; Combs et al., 2010), school districts have increased their focus on technology-reliant, workforce-ready STEM skills necessary to succeed in a workplace (Boyd & Tian, 2017; Combs et al., 2010; Wu-Rorrer, 2017; Yıldırım &

Sidekli, 2018). Creswell and Speelman (2020) noted, “Mathematical thinking appears associated with certain thinking skills” (p. 18). These thinking skills may lead to a more prepared workforce in today’s workplace (Creswell & Speelman, 2020). Mathematics education in public schools will continue to be critically examined and researched. By reviewing the choices made by high-performing school districts, struggling school districts may be better able to find ways to improve their students’ understanding of mathematical concepts.

This current study was focused on high-performing school districts with regard to their mathematics curriculums and implementation strategies. Mathematics curriculums and implementation strategies of low-performing school districts were not examined. If the same information from school districts in the lowest 10% were gathered and then compared to high-performing school districts, a determination could be made of how these two classifications of school districts differ. Determining where differences and similarities in mathematics curriculum choice and implementation strategies occur could inform school district leaders to choose curriculums and strategies which are most effective.

This study included an analysis of ACT results to determine the efficacy of curriculums and curriculum alignment. The validity of the results from the ACT has been questioned by scholars (Toldson & McGee, 2014). Because of this controversy, it could be worthwhile to use a different standardized test to determine if mathematics curriculum choice and implementation strategies affect student outcomes. If a state mandated that all students take another nationally normed standardized test, such as the SAT, comparing the results to the mandated ACT would prove statistically valuable. Comparing the results from two nationally normed standardized tests could determine if the mathematics curriculums or implementation strategies made a difference in student learning or if the results from this study could be related to test bias in the ACT.

For this study, the ratio of standards-based mathematics curriculums to traditional mathematics curriculums was examined. Future research could be conducted to determine the proportion of standards-based to traditional mathematics curriculums from all schools in Missouri, which may shine a light on the type of mathematics curriculum that produces the most student success on standardized tests. Another area where future research could occur is the impact of college-level classes in high school on the ACT's mathematics section results. One of the issues in this current study was the increased rate at which students take college-level mathematics classes in dual credit, dual enrollment, or campus environments. The result of omitting college-enrolled students was leaving the 12th grade out of the research altogether. The sample of students who took college-level classes while still in high school compared to their classmates who took classes based on the mathematics curriculums their school districts implemented would be another area of research to explore.

The final area for future research is to examine high-performing school districts that implemented district-created mathematics curriculums instead of curriculums developed by publishing companies. One of the study goals was to determine if a specific prepared mathematics curriculum occurred more often than other prepared mathematics curriculums. The results were inconclusive, but multiple high-performing school districts created and implemented their own district-created mathematics curriculums. This finding supported the belief of Gordon (2019), who stated, "Research suggests that textbooks are not as helpful as one would hope" (p. 193). Future research of these district-developed mathematics curriculums may inform others of the methodology for successfully designing and implementing in-house programs.

Summary

The purpose of the study was to examine mathematics curriculums implemented in high-performing school districts with regard to student success on the ACT mathematics section. Additionally, data were collected to determine if implementing either a standards-based mathematics curriculum or a traditional mathematics curriculum in grades K–5 and 6–11 affected student scores on the ACT mathematics section. Implementation strategies used in the school districts were identified, which included when mathematics was introduced as a standalone subject, the amount of time dedicated to mathematics instruction, and the curriculum adoption-cycle length.

This two-part quantitative study was designed to examine school districts that performed well on the mathematics section of the ACT during the years Missouri mandated all juniors in the state who were not MAP-A eligible to take the ACT. The first part of the study consisted of two stages. The initial stage involved analyzing scores from the mathematics section of the ACT to determine which school districts were in the top 10% during the three-year span the ACT was mandated.

In the second stage of part one, surveys were distributed to school districts that averaged in the top 10% for three years. The persons identified as most knowledgeable about the mathematics curriculums in each participating school district completed and returned the survey. The survey included questions about each school district's current mathematics curriculums and implementation strategies. Then, the data from the survey were analyzed. Multiple areas were examined to determine if curriculum selection affected ACT mathematics results. Along with curriculum selection, the high-performing school districts' implementation strategies were examined to determine if there were differences in specific areas regarding implementation strategies.

Data collected regarding the type of mathematics curriculum implemented by high-performing school districts indicated the curriculums implemented did not affect future success on the mathematics section of the ACT. It was determined the results on the mathematics section of the ACT were not affected by the use of a standards-based or traditional mathematics curriculum in grades K–6. There was not a significant difference in average ACT scores between high-performing school districts to show statistical significance on the ACT outcome.

When attempting to determine if using a standards-based or traditional mathematics curriculum in grades 7–11 makes a difference in ACT scores, the results were inconclusive. There were not enough school districts indicating they implemented traditional mathematics curriculums to have a large enough sample to perform an independent *t*-test. An independent *t*-test was used to examine the data for using various types of curriculums at different grade levels versus using the same curriculum (alignment) for grades K–11. The data indicated using various mathematics curriculums was not a contributing factor to the results of the mathematics section of the ACT.

These results indicated that while curriculum choice is an important decision for a school district, there is not a single type of curriculum that could ensure future success on the mathematics section of the ACT. After the data regarding curriculum type were statistically analyzed, the implementation strategies of high-performing school districts were examined. The implementation strategies were analyzed using frequency analyses. The frequency analyses were used to determine how high-performing school districts implemented their mathematics curriculums. District curriculum implementation strategies were examined to determine when mathematics was introduced as a standalone subject, the amount of time high-performing school districts dedicated to mathematics instruction, and the curriculum adoption-cycle length.

The first implementation strategy examined was the specific mathematics curriculums implemented. After reviewing the data submitted by district leaders, it was found there were multiple mathematics curriculums implemented by school districts. No single prepared mathematics curriculum was implemented more significantly than any other prepared curriculum. There was a trend among high-performing school districts to develop their own curriculums using district personnel. Future research about teacher-created versus purchased mathematics curriculums may lead to an increased understanding of which strategy best benefits school districts.

The second implementation strategy studied was the age at which mathematics is introduced to students. While the study was designed to identify differences among high-performing school districts, all of the high-performing school districts in the study indicated mathematics was introduced as a standalone subject in kindergarten. School districts that present mathematics after kindergarten in order to focus on other areas, such as reading, may want to reexamine that strategy and introduce mathematics as early as possible.

The data collected regarding differences in the amount of time high-performing school districts allocated to mathematics instruction per week also revealed very few differences. High-performing school districts appropriated a similar amount of time to mathematics instruction per week. These high-performing school districts dedicated between 100 and 399 minutes per week (20–79.8 minutes per day) for mathematics instruction.

The final implementation strategy surveyed in the study examined the length of the adoption cycle for mathematics curriculums. While there were differences in the amount of time high-performing school districts used the current mathematics curriculums, the data indicated that most successful school districts used the existing mathematics curriculums for 10 or fewer years. Because of these findings, or lack of significant differences in the data analyzed, further research into high-performing school districts' traits is warranted. Future research may clarify factors that make these school districts successful. In conclusion, the areas studied in this research did not point to a specific strategy or curriculum a struggling district could quickly implement to improve student understanding of mathematical concepts or assure improved scores on the ACT.

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Appendix A

Survey

Q1 What mathematics curriculum is implemented in grades K–5 in your district?

Kindergarten ____

Grade 1 ____

Grade 2 ____

Grade 3 ____

Grade 4 ____

Grade 5 ____

Q2 Would you consider the mathematics curriculum you implement in grades K–5 to be Standards-Based or Traditional?

	Standards-Based	Traditional
Kindergarten	○	○
Grade 1	○	○
Grade 2	○	○
Grade 3	○	○
Grade 4	○	○
Grade 5	○	○

Q3 What mathematics curriculum is implemented in grades 6–11 in your district?

Grade 6 ____

Grade 7 ____

Grade 8 ____

Grade 9 ____

Grade 10 ____

Grade 11 ____

Q4 Would you consider the mathematics curriculum you implement in grades 6–11 to be Standards-Based or Traditional?

	Standards-Based	Traditional
Grade 6	○	○
Grade 7	○	○
Grade 8	○	○
Grade 9	○	○
Grade 10	○	○
Grade 11	○	○

Q5 Please indicate how many minutes per week are dedicated to mathematics in each grade-level.

	0–99	100–399	400–699	700–999	≥1000
Kindergarten	○	○	○	○	○
Grade 1	○	○	○	○	○
Grade 2	○	○	○	○	○
Grade 3	○	○	○	○	○
Grade 4	○	○	○	○	○
Grade 5	○	○	○	○	○
Grade 6	○	○	○	○	○
Grade 7	○	○	○	○	○
Grade 8	○	○	○	○	○
High School Algebra, Algebra II, Geometry, Trigonometry, Etc.	○	○	○	○	○

Q6 How many years has your district used the current K–5 mathematics curriculum?

	0–5 years	6–10 years	11–15 years
Kindergarten	○	○	○
Grade 1	○	○	○
Grade 2	○	○	○
Grade 3	○	○	○
Grade 4	○	○	○
Grade 5	○	○	○

Q7 How many years has your district used the current 6–11 mathematics curriculum?

	0–5 years	6–10 years	11–15 years
Grade 6	○	○	○
Grade 7	○	○	○
Grade 8	○	○	○
Grade 9	○	○	○
Grade 10	○	○	○
Grade 11	○	○	○

Appendix B

IRB Approval

From: irb@lindenwood.edu <irb@lindenwood.edu>
Sent: Tuesday, April 2, 2019 10:27 AM
To: Williams, Julie R.; Grover, Kathy; MRB265@lindenwood.edu
Subject: IRB-19-180 - Initial: Initial - Exempt - Approved

Apr 2, 2019 10:27 AM CDT

RE:
IRB-19-180: Initial - A Comparative Analysis of Effective Mathematics Curriculum in Grades K-11 in the State of Missouri

Dear Matthew Britt,

The study, A Comparative Analysis of Effective Mathematics Curriculum in Grades K-11 in the State of Missouri, has been Exempt.

Category: Category 1. Research, conducted in established or commonly accepted educational settings, that specifically involves normal educational practices that are not likely to adversely impact students' opportunity to learn required educational content or the assessment of educators who provide instruction. This includes most research on regular and special education instructional strategies, and research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

The submission was approved on April 2, 2019.

Here are the findings:

- This study has been determined to be minimal risk because the research is not obtaining data considered sensitive information or performing interventions posing harm greater than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests.
- The component of this application involving collection of secondary data from MODESE has been determined to be non-human subjects research as these data are anonymized from the perspective of the investigator.

Sincerely,
Lindenwood University (lindenwood) Institutional Review Board

Appendix C

Consent Form

LINDENWOOD

Survey Research Consent Form

A Comparative Analysis of Effective Mathematics Curriculum in Grades K–12 in Missouri

You are asked to participate in a survey being conducted by Matthew Britt under the guidance of Dr. Julie Williams at Lindenwood University. We are conducting this study to examine the curricula and strategies successful districts implement, so districts experiencing lower achievement may use the findings as an element to explore student performance issues within their own systems. It will take about 10 minutes to complete this survey.

Answering this survey is voluntary. We will be asking about 54 other people to answer these questions.

What are the risks of this study?

We do not anticipate any risks related to your participation other than those encountered in daily life. You do not need to answer any questions that make you uncomfortable, or you can stop taking the survey at any time.

We are collecting data that could identify you, such as your district name and mathematics curriculum implemented. Every effort will be made to keep your information secure and confidential. Only members of the research team will be able to see your data. We do not intend to include any information that could identify you in any publication or presentation.

Will anyone know my identity?

We will do everything we can to protect your privacy. We do not intend to include information that could identify you in any publication or presentation. Any information we collect will be stored by the researcher in a secure location. The only people who will be able to see your data include members of the research team, qualified staff of Lindenwood University, and representatives of state or federal agencies.

What are the benefits of this study?
You will receive no direct benefits for completing this survey. We hope what we learn may benefit other people in the future.

If you have any questions about your rights as a participant in this research or concerns about the study, or if you feel under any pressure to enroll or to continue to participate in this study, you may contact the Lindenwood University Institutional Review Board Director, Michael Leary, at (636) 949-4730 or mleary@lindenwood.edu. You can contact the researcher, Matthew Britt directly at XXX or mrb265@lindenwood.edu. You may also contact Dr. Julie Williams at XXX**.**

By clicking the link below, I confirm that I have read this form and decided that I will participate in the project described above. I understand the purpose of the study, what I will be required to do, and the risks involved. I understand that I can discontinue participation at any time by closing the survey browser. My consent also indicates that I am at least 18 years of age.

You can withdraw from this study at any time by simply closing the browser window. Please feel free to print a copy of this consent form.

Appendix D

Letter of Participation

Date:

My name is Matthew Britt, and I am a doctoral student at Lindenwood University. For my dissertation, I am attempting to identify common characteristics of mathematics curriculums used in high-performing schools in Missouri. I am using the scores from the mathematics section of the ACT for the years during which the ACT was mandated by the state (2015, 2016, and 2017).

Your district has been identified as scoring in the upper 10% of all districts that reported scores during the years in which the ACT was mandated. I am asking for your help in identifying the staff member in your district who is most knowledgeable about the mathematics curriculum and strategies implemented by your district.

Once you have identified this person for me, I will send them a six-question survey that will take approximately 10 minutes to complete. If you can provide me with the name and email address of the staff member who can answer my questions, I would greatly appreciate it.

Appendix E

Summary of Data Survey Collected

District	3-Year ACT Average	Grade	Curriculum	Alignment	Grade	Minutes	Grade	Length
A	20.63	K-5	Standards-Based	Mixed	K-11	100-399	K-11	0-5
		6-11	Mixed					
B	20.76	K-5	Standards-Based	Mixed	K-6	400-699	K-11	0-5
		6-11	Mixed		7-11	100-399		
C	20.96	K-5	Traditional	Aligned	K-11	100-399	K-8	0-5
		6-11	Traditional				9-11	6-10
D	25.06	K-5	Standards-Based	Mixed	K-11	100-399	K-5	0-5
		6-11	Traditional				6-11	6-10
E	20.73	K-5	Traditional	Aligned	K-11	100-399	K-11	6-10
		6-11	Traditional					
F	22.70	K-5	Standards-Based	Aligned	K-11	100-399	K-5	11-15
		6-11	Standards-Based				6-11	6-10
G	20.86	K-5	Mixed	Mixed	K-11	100-399	K-5	0-5
		6-11	Traditional				6-11	6-10
H	21.50	K-5	Standards-Based	Mixed	K-11	100-399	K-5	0-5
		6-11	Traditional				6-11	6-10
I	22.30	K-5	Standards-Based	Mixed	K-11	100-399	K-11	0-5
		6-11	Traditional					
J	21.33	K-5	Standards-Based	Mixed	K-10	No Response	K-6	No Answe r
		6-11	Mixed		11	100-399	7-11	0-5
K	23.13	K-5	Standards-Based	Mixed	K-11	100-399	K,1,2, 5,6,7, & 8	0-5
		6-11	Mixed				3,4,9, 10,11	6-10

Vita

Matthew Britt was born in Greenville, Illinois. He attended Mulberry Grove Community Unit School District Number 1 in Mulberry Grove, Illinois, for grades K–12. After graduating from high school, Matthew attended Greenville College for two years. While at Greenville College, Matthew began dating Crystal Dothager, who later became Crystal Britt. After two years at Greenville, Matthew decided to transfer to the University of Illinois at Urbana-Champaign. Matthew graduated from UIUC in December of 1999.

After graduation, Matthew began his teaching career in Athens, Illinois, where he taught science for one year. During that year, Matthew married Crystal. After that year they moved to Waterloo, Iowa, and Matthew continued his teaching career at Waterloo East High. After four years in Waterloo, Matthew, Crystal, and their baby Sydney moved to Southeast Missouri. Matthew accepted a teaching position at Leopold R-III and stayed there for two years. After two years, Matthew accepted a position to teach science at Cape Girardeau Junior High. During his time at CJHS, the final member of the family, Makenzie, arrived. Matthew also began working on his administrative degree from Southeast Missouri State University. In 2011, Matthew returned to Leopold as the principal of the K–12 school district. Matthew spent seven years as principal at Leopold. During this time, Matthew earned his specialist degree in education administration from SEMO. In 2019, Matthew became the superintendent at Leopold.

Matthew still lives in Cape Girardeau with Crystal, Sydney, and Makenzie. He enjoys spending any free time he has with his family doing whatever his girls talk him into. They especially enjoy watching Cardinal games, and he has even gotten lucky enough to have three ladies in his life who love fishing.