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The impact of Singapore Math on student knowledge and enjoyment in mathematics

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THE IMPACT OF SINGAPORE MATH ON STUDENT KNOWLEDGE AND ENJOYMENT IN MATHEMATICS

by

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ABSTRACT

The purpose of this study was to investigate the effect of the Singapore Math curriculum and approach to teaching on enjoyment and knowledge in mathematics in one rural school district in north Louisiana. The quantitative data used were collected from a Math Enjoyment Inventory and a mixed skills pre and posttest. Additional supplemental data were collected from a Teacher Response Form. All data were gathered in the 2010-2011 school year, and an intact population was utilized. Participants were categorized into two groups, the Singapore Math group and the traditional math group. The participating district implemented Singapore Math in the fall of 2010 in three of the seven public elementary schools. The Singapore Math group was comprised of first-grade students in the three schools that implemented Singapore Math. The traditional math group was comprised of first-grade students in the remaining four schools. Two separate independent *t*-tests were calculated, comparing the inventory scores the pretest scores of the two groups. To control for any differences at the time of the pretest, an Analysis of Covariance (ANCOVA) was used on posttest data. Results indicated a significant main effect for group $F(1,259) = 15.39$, $p < .05$. Students taught Singapore Math demonstrated more knowledge of mathematics skills than students taught traditional approaches. No significant difference was found for enjoyment of mathematics $t(279) = .300$, $p > .05$. Findings will provide information to the district in the study on its decision of a possible full implementation of Singapore Math. In addition, the findings will be valuable to other schools and districts considering implementation.

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DEDICATION

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CHAPTER 1

INTRODUCTION

Purpose of the Study

"If we want kids to start liking, learning, and understanding math, we have to change how we teach" writes Walker (2010, p. 4). According to the U.S. Department of Education (n.d.), schools in America share the role of preparing students to become productive citizens of a global society in the 21^{st} century. Although the United States is a leader in the international community, efforts should be made to advance students as other countries strive toward the same goal. Kadlec, Friedman, and Public Agenda Foundation (2007) explain the important quest of schools to nurture the next generation of Americans by equipping them with strong skills in mathematics, science, and technology. Such skills are important in the current technological age.

The future success of the United States of America may be predicted by the achievement of its students. In order to assess educational excellence of American students in relation to international peers, organizations such as the International Association for the Evaluation of Educational Achievement (IEA) have conducted large-scale international assessments in various academic subjects (International Association for the Evaluation of Education Assessment, 2007). The largest, most comprehensive study of the IEA is the Trends in International Mathematics and Science Study (TIMSS), conducted in four-year cycles to assess student achievement in mathematics and science.

Results from the TIMSS indicate that American students fall behind many other developed countries around the world. In contrast, Asian countries earn their place at the top of international rankings (Ginsburg, Leinwand, Anstrom, & Pollock, 2005; Mullis et al., 1997; Mullis et al., 1998; Mullis et al., 2000; U.S. Department of Education, 2007a).

Results from the TIMSS have captured the attention of American educators especially in the subject of mathematics. The tiny Asian country of Singapore has consistently ranked first in mathematics achievement (Ginsburg et al., 2005; Mullis et al., 1998; Mullis et al., 2000). In recent years, numerous American school districts have looked toward Singapore as a model of success. In an effort to increase student achievement in mathematics, many schools and districts have implemented various teaching strategies from the Singapore Math approach or adopted the Singapore Math curriculum in its entirety (Begley, 2010; Buzzard, 2010; Fox News Arizona, 2010; Gabriella and Paul Rosenbaum Foundation, 2009; Jordan, 2009; Ramsey, 2010; Stewart, 2009; Waight, 2006).

The Singapore Math curriculum and approach to teaching, most commonly known as Singapore Math, was created by the Singapore Ministry of Education. The curriculum framework emphasizes five components: (a) concepts, (b) processes, (c) metacognition, (d) attitudes, and (e) skills (Singapore Ministry of Education, 2006a). The purpose of this study was to investigate the effect of the Singapore Math curriculum and approach to teaching on student enjoyment and knowledge in mathematics in one rural school district in north Louisiana. For the purposes of this study, the term Singapore Math was used since this is the term most widely used in the United States of America to describe the combined use of the curriculum and approach to teaching. These are not separate entities, but two elements of Singapore Math that are intertwined. Scores from the Math Enjoyment Inventories and mixed skills pre and posttests were used to measure student enjoyment and knowledge in mathematics.

Justification for the Study

Educators in America and throughout the world have the same responsibility: prepare each generation to be contributing citizens. The Singapore Ministry of Education strives to create confident, self-directed learners who are reflective and innovative and who demonstrate perseverance in their learning, work well in a team, and communicate effectively. It is the assumption that learners with these qualities will enter society as concerned citizens who contribute to the greater good of the country (Singapore Ministry of Education, n.d.a). These outcomes are also desired by American educators.

Singapore educational outcomes, as aforementioned, can be attributed to the Singapore Ministry of Education that makes all major educational decisions that country (Ginsburg et al., 2005). In America, educational focus is often not as concise as overarching decisions are made by the national and state governments. For example, in the state of Louisiana, decisions regarding state curricula are the responsibility of the Louisiana Department of Education. Educators teach to accomplish the state adopted standards and Grade Level Expectations (GLEs) outlined in the Louisiana Comprehensive Curriculum for each academic subject. Decisions regarding the instructional manner by which standards and GLEs are addressed, however, initiate with each school district (Louisiana Department of Education, n.d.a). These decisions support the missions that differ from district to district. With diverse interpretations, decisions regarding student achievement are the responsibility of district leaders, yet within the framework established by the state.

The north Louisiana school district participating in this study defines its mission as follows: "to ensure higher academic achievement for all students and prepare them to be effective citizens" (Lincoln District Schools, n.d.). Although the mission is briefly stated, it is comparable to the desired outcomes of the Singapore Ministry of Education. In 2009, a combined 69% of the district's third and fourth-graders scored at a basic level or above on the Integrated Louisiana Educational Assessment Program (*i*LEAP) and the Louisiana Educational Assessment Program for the 21st Century (LEAP 21), respectively, in the content area of mathematics. Scores placed the district slightly above the state percentage in each category, yet district leaders continuously seek new methods for increasing student learning that will elevate test scores (Louisiana Department of Education, n.d.b). In an effort to continue to increase student achievement in mathematics, Singapore Math was implemented at the onset of the 2010 school year. Three elementary schools in the district were chosen by the superintendent as pilot schools.

After a one-year pilot period, district leaders will decide the effectiveness of Singapore Math in meeting the needs of its student population before a possible full implementation in all elementary schools. Determining its effectiveness in increasing student enjoyment and knowledge in mathematics will provide the district leaders with useful information in the critical pilot year of implementation. The participating district aspires to produce effective citizens; the Singapore Ministry of Education believes that fostering positive affective characteristics such as a positive attitude or enjoyment for academics can mold citizens. This belief is evidenced by the emphasis on attitudes in the curriculum framework discussed in detail in the next chapter. Research has shown to connect positive attitudes with student achievement (Ma & Kishor, 1997; Multon, Brown, & Lent, 1991; Parjares & Kranzler, 1995). Student achievement is ultimately the goal of all educational systems including the district to be studied. For these reasons, attitudes and student knowledge were chosen to be studied in addition to providing information to leaders from other school districts (with similar student populations) considering the adoption of Singapore Math. Results add to the limited body of knowledge available on Singapore Math since its recent introduction to the United States at the turn of the millennium.

Theoretical Connections

Constructivism is reflected in Singapore Math. It is the idea that students should be given opportunities to take ownership of their learning and actively construct knowledge through enjoyable learning experiences. Through such experiences, students develop positive affective attributes such as appreciation, interest, confidence, and perseverance; key elements in the attitude component of the curriculum framework of Singapore Math. Parkay and Hass (2000) explain that curricula and instructional approaches based in constructivism guide students to think about material learned, make connections to their learning, and acquire a deep understanding of new material. Likewise, a true understanding of mathematical concepts, not memorization of rules or gimmicks, is a desired outcome of Singapore Math as it focuses on producing effective problem solvers who possess an appreciation for mathematics.

Skemp (1976) was a psychologist and the first professor of mathematics education at the University of Warwick. He identified the notion of relational understanding, or understanding of the reason behind mathematics. Skemp further noted its effectiveness over a simple instrumental understanding of mathematics. Many traditional American approaches to teaching mathematics emphasize only procedures (Ginsburg et al., 2005). When students truly understand "why," they unlock the power of mathematics.

Another important aspect of the constructivist approach to teaching is the belief that educators should scaffold learning. Scaffolding refers to the structural support system, or guidance, a teacher provides for students. When supported, students are given opportunities to experience success which fosters confidence and enjoyment. When a teacher scaffolds instruction, much support is provided in the early stages of learning new skills. Prior knowledge of a subject is elicited as students learn and develop. As students demonstrate understanding of the new skill, support is gradually reduced, allowing students to assume more responsibility (Parkay & Hass, 2000). Effective teachers using Singapore Math or more traditional math approaches scaffold instruction for their learners. An example of scaffolding that is reflective of the work of educational theorist Bruner (1960), is the concrete-pictorial-abstract approach to teaching in Singapore Math. This sequence that moves students through the use of manipulatives, visual models, and symbols is discussed in more detail in the following chapter.

Common characteristics exist in constructivist approaches to curriculum as well as teaching and learning methods. Curricular concepts are presented to students in a manner that communicates the usefulness of material learned in a school setting and in the world. Learning should be meaningful to students and connect to prior learning in order for it to be internalized (Parkay & Hass, 2000). Limited content is addressed, but content is addressed thoroughly in order for a genuine conceptual understanding to manifest. In addition, content is organized into powerful key principles. This is evidenced in Singapore Math but not evidenced in many traditional American approaches that teach many concepts in one year to only surface level knowledge. Americans are critically known for teaching "a mile wide, but only an inch deep" (Ginsburg et al., 2005, p. 41).

Research Questions and Null Hypotheses

It is important to note in the following research questions and null hypotheses that Singapore Math refers to the combined Singapore Math curriculum and approach to teaching. Traditional math simply refers to common American approaches to teaching math. It does not indicate a specific program or curriculum. Knowledge refers to the skills students demonstrate. In examining the scores from the Math Enjoyment Inventories and the mixed skills pre and posttests the following research questions were posed:

1. Is there a significant difference in student enjoyment in mathematics between students taught Singapore Math and students taught traditional math?
2. Is there a significant difference in student knowledge in mathematics between students taught Singapore Math and students taught traditional math?

For the purpose of this study, the following null hypotheses were tested:

H1. There is no significant difference between the scores on the Math

Enjoyment Inventory of students taught Singapore Math and students taught traditional math.

H2. There is no significant difference between the scores on the math skills test of students taught Singapore Math and students taught traditional math.

Definitions of Terms

1. Algorithm - A procedure for solving a mathematical problem in a finite number of steps that frequently involves repetition of an operation (Algorithm, n.d.).
2. Heuristics - Exploratory problem solving techniques (Heuristics, n.d.).
3. Metacognition - The awareness of, and the ability to control one's thinking processes, in particular, the selection and use of problem-solving strategies (Singapore Ministry of Education, 2006a).
4. Processes - The knowledge skills (or process skills) involved in the process of acquiring and applying mathematical knowledge (Singapore Ministry of Education, 2006a).
5. Scaffolding - The structural support system a teacher provides for students (Parkay & Hass, 2000).
6. Singapore Math - The mathematics curriculum and approach to teaching used in the country of Singapore (Singapore Math Story, n.d.).
7. TIMSS - Trends in International Mathematics and Science Study (International Association for the Evaluation of Education Assessment, 2007).

CHAPTER 2

LITERATURE REVIEW

Introduction

This study focused on the impact of Singapore Math on student enjoyment and knowledge in mathematics. Literature reviewed provides a historical overview of the Trends in International Mathematics and Science Study (TIMSS) that brought international attention to the Singapore as well as provided comparisons of mathematics achievement scores from the United States of America and Singapore. Education in Singapore was examined through a synopsis of the educational system and the mathematics curriculum and approach to teaching known as Singapore Math. The Singapore Math curriculum framework was reviewed by describing each of the five components of the framework: (a) concepts, (b) processes, (c) metacognition, (d) attitudes, and (e) skills. Literature was summarized separately on each component as well as its relation to Singapore Math with emphasis placed on attitudes and skills. This literature review is divided into the following sections: (a) Trends in International Mathematics and Science Study; (b) Education in Singapore with subsections that include Singapore Math and Effectiveness of Singapore Math, and (c) Singapore Math Framework with subsections that include concepts, processes, metacognition, attitudes, and skills.

Trends in International Mathematics and Science Study (TIMSS)

The Trends in International Mathematics and Science Study (TIMSS) focused attention in the United States on the achievement of foreign countries in mathematics. One such country, Singapore, gained recognition because of the stellar performance of its students in mathematics. TIMSS, as it is known today, is one part of the continuing assessment of student achievement conducted by the International Association for the Evaluation of Educational Achievement (IEA) in various subjects (Mullis et al., 1998).

The landmark TIMSS study referenced in much current mathematics literature has evolved over five decades (see Table 1). The IEA conducted the First International Mathematics Study (FIMS) in 1964 and the Second International Mathematics Study (SIMS) in 1980-1982. Singapore ranked first in the world in the area of mathematics on the Third International Mathematics Study (TIMSS), conducted in 1995, and was launched into the international spotlight. TIMSS studies have been administered in a four-year cycle from 1995 to present day. The study conducted in 1999 was named the Third International Mathematics Study Repeat (TIMSS-R). Studies conducted in 2003 and 2007 were renamed Trends in International Mathematics and Science Study (TIMSS) (Mullis et al., 1998).

The IEA reports that the TIMSS is becoming one of its largest studies. Traditionally, the focus of TIMSS has been on student achievement in mathematics and science. In recent years, TIMSS has expanded to include a study of curriculum and implementation (International Association for the Evaluation of Educational Assessments, 2007). According to the National Center for Education Statistics (n.d.), the

United States participates in universal studies to discover how American students compare to international students in a competitive environment.

Table 1

Timeline of the TIMSS

Year	Name
1964	First International Mathematics Study (FIMS)
1980-1982	Second International Mathematics Study (SIMS)
1995	Third International Mathematics Study (TIMSS)
1999	Third International Mathematics Study Repeat (TIMSS-R)
2003-current	Trends in International Mathematics and Science Study (TIMSS)

The IEA reported key findings on the TIMSS in 1995 that positioned the students of Singapore first in the international ranking of 25 countries in reference to student achievement in mathematics in the primary and middle school grades. The mean score of each country was calculated, and scale scores were derived to provide data on student achievement. Singapore scored notably higher than the international average score of 529 with a score of 625 (International Association for the Evaluation of Educational Assessments, 2007).

In 1999, the TIMSS-R, a follow-up study conducted with the participating countries from TIMSS 1995, provided trend data on students that participated in TIMSS 1995 as fourth-graders and once again in TIMSS-R as eighth-graders (International Association for the Evaluation of Educational Assessments, 2007). The TIMSS-R identified Singapore, once again, as the top performing country in mathematics in the primary grades. The international average was a score of 487 out of a possible 1,000; Singapore students scored 604. The students of the United States of America scored slightly above the international average of 487 with a score of 502. The IEA pointed out that students in the lower scoring countries who were considered proficient were performing on approximately the same level as below average students in Singapore. In 1999, four international benchmarks were named: (a) Top 10% Benchmark, (b) Upper Quarter Benchmark, (c) Median Benchmark, and (d) Lower Quarter Benchmark. Singapore had 46% of the students obtain a score which placed them in the Top 10% Benchmark. In the United States of America, 9% of students earned this position (Mullis et al., 2000).

In the 2003 assessment, the name behind the acronym TIMSS was changed to Trends in International Mathematics and Science Study. Using the same scaled scoring system as in previous years, a comparison of student achievement in 25 participating countries was conducted. The international average score in the year 2003 was 495. For the third consecutive testing cycle, Singapore was the top performing country with an average score of 594 while the United States ranked twelfth with an average score of 518, 16 points higher than on the previous test administration yet still significantly lower than Singapore (Mullis, Martin, Gonzales, & Chrostowski, 2004).

TIMSS 2007, conducted in a manner similar to TIMSS 2003, was the fourth study in a four-year cycle. Fourth and eighth-graders were once again assessed on skills in mathematics and science. Results from the study were similar to findings in previous years, however, an international average was not reported. Instead, a scale average of 500 (the median score between a possible 0 to 1000 points) was set in order for more accurate comparisons to be made across future assessment cycles (Mullis, Martin, & Foy, 2008). In mathematics, numerous Asian countries were positioned at the top of international rankings. Singapore ranked second with a score of 599, and the United States was eleventh with a score of 529, once again demonstrating improvement. According to the IEA, a remarkable 41% of Singaporean students reached the international benchmark (see Figure 1).

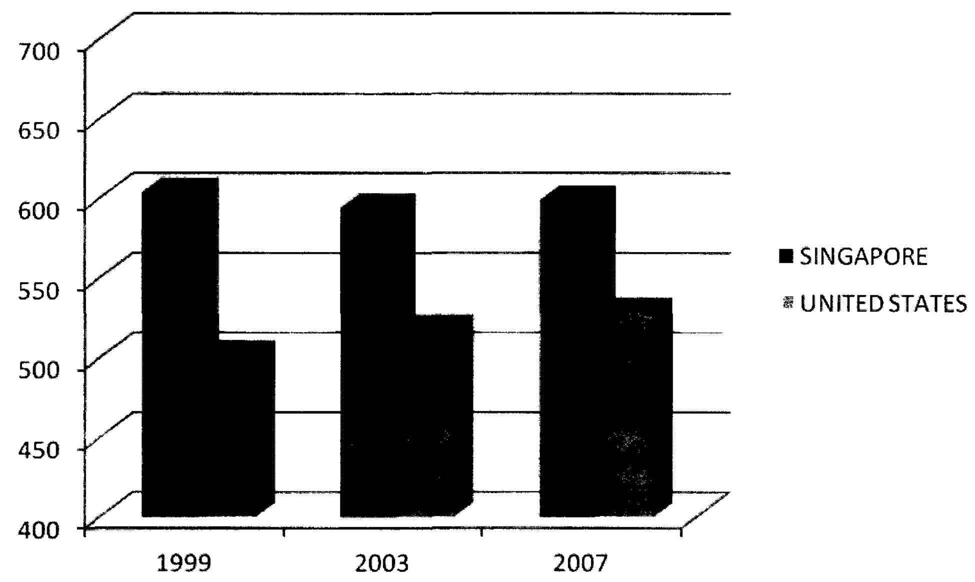


Figure 1. TIMSS mathematics scores/fourth-grade students.

In summary, the IEA has a history of assessing and reporting the achievement of students from countries around the world in an effort to provide international comparisons. These comparisons allow countries to learn from one another as they strive to improve schools. In 1995, Singapore ranked at the top of international TIMSS standings for the first time. From 1995 to the present, Singaporean students have consistently positioned themselves at or near the top while the American students are far behind. However, American students have improved with each testing cycle. The results from the TIMSS have sparked an international focus on Singapore and their methods for teaching mathematics.

Education in Singapore

Singapore is a small urban island (697 square kilometers) in southeast Asia. It is located between Malaysia and Indonesia. This prosperous nation is an international trading link with a population of approximately 4.5 million citizens (U.S. Central Intelligence Agency, n.d.). Education is a top priority in Singapore (Ministry of Education, n.d.a).

To understand Singapore Math, it is important to have knowledge of the educational philosophy of the country because it is engrained in the curriculum and teaching approach. One could not simply view curricular documents and understand Singapore Math. Furthermore, one could not successfully teach from such documents without understanding the philosophy. The Singapore Ministry of Education (n.d.a) states:

> The person who is schooled in the Singapore Education system embodies the Desired Outcomes of Education. He [*sic*] has a good sense of self-awareness, a sound moral compass, and the necessary skills and knowledge to take on challenges of the future. He is responsible to his family, community and nation. He appreciates the beauty of the world around him, possesses a healthy mind and body, and has a zest for life. (paragraph 2)

The Singapore Ministry of Education encourages educators to aspire to create model citizens who will become productive members of society. The Desired Outcomes of Education are as follows:

1. A confident person who has a strong sense of right and wrong, is adaptable and resilient, knows himself [*sic*], is discerning in judgment, thinks independently and critically, and communicates effectively;
2. A self-directed learner who takes responsibility for his own learning, who questions, reflects and perseveres in the pursuit of learning;
3. An active contributor who is able to work effectively in teams, exercises initiative, takes calculated risks, is innovative and strives for excellence, and;
4. A concerned citizen who is rooted to Singapore, has a strong civic consciousness, is informed, and takes an active role in bettering the lives of others around him. (Singapore Ministry of Education, n.d.a)

To further understand Singapore Math, it is important to know the context of the educational system in which it is taught. The Singaporean education system is different from the American education system. Singapore has a centralized curriculum that was developed by the Ministry of Education to prepare students for the ever changing world in which they live. In primary school, emphasis is placed on character development and building a firm foundation of basic skills in subject areas such as mathematics, languages, and the humanities. Students are given the opportunity to discover areas of enjoyment and are also encouraged to participate in cocurricular activities (known as extracurricular activities in the U.S.) such as sports or the arts. Schools are well resourced and have access to technology as well as learning support programs for students needing extra academic assistance (Mullis et al., 2008).

Singaporean students attend primary school for six years, secondary school for approximately five years, and postsecondary school for a minimum of two years.

Streaming (grouping students according to strengths, interests, and talents) is utilized in Singapore. At the end of primary school, students take the Primary School Leaving Examination (PSLE), which directs the next phase of the educational path of the students. This streaming provides opportunities to meet individual needs of students. In the first four years of primary school, student retention does not occur, but remediation is provided. After the first four years, a principal holds the responsibility of determining students in need of retention. Throughout the secondary years of Singaporean education, students are provided various opportunities to take paths that will ultimately lead to junior college, polytechical schools, universities, or alternative qualifications (Mullis et al., 2008; Singapore Ministry of Education, n.d.c; Singapore Ministry of Education, n.d.d).

According to Mullis et al. (2008), teachers undergo a stringent selection process. Hired teachers are thoroughly trained before entering the classroom. In addition to preservice training, teachers are entitled to 100 hours of professional development a year. Teachers are trained to foster relationships with students and create a positive, caring, and supportive learning environment with the partnership of parents (Singapore Ministry of Education, n.d.b).

Liu, Wu, and Zumbo (2006), examined the importance of considering outside of school and inside of school factors that exist when making international comparisons. Participants in the study included eighth-grade students, teachers, and principals from the following six countries: (a) United States, (b) Korea, (c) Japan, (d) Taiwan, (e) Singapore, and (f) Hong Kong. Results indicated outside of school factors such as availability of private tutoring, parent education levels, and parent values are highly related to student achievement in the United States. However, in Hong Kong and Singapore, inside of school factors have more important roles on student achievement. Inside of school examples include ability-level grouping, professional development opportunities for teachers, and teacher collaboration with colleagues. Both inside of school and outside of school factors affected student achievement in all countries. Liu et al. concluded by stating:

> Our central message to the readers is to remind them that a country's educational system is not an isolated component from the society, but is deeply embedded in the culture, family and personal characteristics, as well as the politics and economy of a country. (p. 27)

In brief, the small island nation of Singapore prioritizes education and has a direct focus on producing well-rounded citizens with strong character. Their educational outcomes are attained through a strong, centralized curriculum and opportunities for students to flourish in environments that meet academic needs and peak student interests. In addition, students are under the instruction of highly effective teachers. Cultural differences should be considered when implementing Singapore Math elsewhere because they contribute to the success of Singaporean students.

Singapore Math. Singapore Math refers to the mathematics curriculum and approach to teaching mathematics used in Singapore. This term was used in the United States approximately around the year 2000 when news of mathematical success in Singapore spread to countries in the western hemisphere (Singapore Math Story, n.d.). Currently, an estimated 1,500 schools are using Singapore Math in the United States, and its popularity is spreading (Fox News Arizona, 2010).

The textbooks commonly known as Singapore Math books refer to the Primary Mathematics series. Some mistakenly consider the Primary Mathematics series the Singapore Math program. The textbooks are merely resources used as part of Singapore Math. Between 1965 and 1979, mathematics textbooks utilized in Singapore were imported from other countries; during these years, the country was not the focus of international attention. In 1981, however, the first Primary Mathematics curriculum was developed by the Singapore Ministry of Education. It was not revised until 1992 when an emphasis on problem solving was included in the second edition. Two years later, the content of the curriculum was reduced to provide flexibility for teachers and to include other important activities such as thinking skills and information technology. In the third edition, published in 1999, further reductions occurred to provide time for other initiatives. In 2001, privately produced textbooks created opportunities for affordable textbooks with a wider range of choices. However, publishers were still required to follow the guidelines set in 1999. The most recent change in the Primary Mathematics series occurred with the development of the U.S. edition in 2003. This edition included measurement systems and currencies used in the United States of America (Singapore Ministry of Education, Singapore, 2006b). Although the textbooks are of great importance, Singapore Math is not a typical, packaged mathematics program consisting of only texts and teachers guides; it is a philosophy, curriculum, and approach to teaching intertwined.

Effectiveness of Singapore Math. Research on the effectiveness of Singapore Math is a new area of inquiry in the United States. It is an important area of study for educators who are considering implementing Singapore Math. Despite the differences between the Singaporean and American educational settings, many reports of schools achieving success with Singapore Math in the United States are available. The North Middlesex Regional School District (NMRSD), located in Massachusetts, is the school district that has used the Singapore Math curriculum and approach to teaching for the longest duration. A longitudinal statistical study was conducted from the years of 2003 to 2008 to determine the effects of the curriculum and approach to teaching by comparing the mathematical achievement of students in the NMRSD with the students in Massachusetts. Researchers also compared Singapore Math students with non-Singapore Math students within NMRSD (Gabriella and Paul Rosenbaum Foundation, 2009).

Results indicated that Singapore Math classes had a positive impact on test scores according to the Massachusetts Comprehensive Assessment System (MCAS). Waight (2006), Associate Superintendent of Schools in NMRSD, described the following indicators of success: (a) all eighth-grade students enrolled in Algebra I after implementation (only 25% enrolled in 1999), (b) there was a significant increase in the percentage of ninth-grade students enrolled in Algebra II, and (c) for the first time, in 2005-2006, students enrolled in AP Calculus.

The NMRSD was also included in an exploratory analysis of Singapore pilot sites in the United States conducted for the U.S. Department of Education. This was the first empirical study on the result of using Singapore Math textbooks in American classrooms (Ginsburg et al., 2005). Many schools were reported to use Singapore Math, however, only four matched the criteria for the selection process: (a) Baltimore City Public School System, (b) Montgomery County Public Schools, in the suburbs of Washington, D.C., (c)

North Middlesex Regional School District, in Maryland, and (d) Paterson Public School No. 2 in Paterson, New Jersey. The following criteria were reported to be met:

1. Had Singapore Math in place for at least two full school years;
2. Measured gain scores for at least a two-year period on either the same students or a repeated cross-section of students at a particular grade;
3. Could compare treatment gains with gains made by a comparison group of nontreatment schools or test publishers' norms. (p. 122)

Approximately 2,000 students participated in the Ginsburg et al. study. Student achievement data were collected at the individual school sites from either annual end-of-the-year assessments, or standardized assessments. The achievement of students in participating schools was compared with achievement of students in comparison groups. In sites where comparison groups were unavailable, district or state averages were compared. In addition, the researchers also visited each participating site (Ginsburg et al., 2005). Overall, results were favorable. Encouraging examples of gains demonstrated were found in two pilot sites where two year gains occurred, and many students reached advanced levels of achievement through the use of Singapore Math. It was determined that schools that did not demonstrate success did not receive sufficient professional development (Ginsburg et al.).

Numerous schools spanning the United States have also demonstrated success by using Singapore Math (Begley, 2010; Stewart, 2009). For instance, Imagine Bell Canyon, a charter school in Arizona, was recognized at the Imagine Schools National Conference as the Most Improved School. Over 85% of students at Bell Canyon demonstrated a year's growth in mathematics after the implementation of Singapore Math (Buzzard, 2010). Schmitz Park Elementary in Seattle, Washington, which implemented Singapore Math in 2007, reported 86% of its fifth-grade students passed the Washington Assessment of Student Learning (WASL) in mathematics. Previously, the district-wide passing rate was only 68% (Ramsey, 2010). Additionally, twelve schools in Hall County, Georgia use the Singapore Math curriculum. Schofield, Hall County Schools Superintendent, reported students gained 30 percentage points on the mathematics computation portion of the Iowa Test of Basic Skills since administration began in 2006 (Jordan, 2009).

Singapore Math has sparked success in diverse populations. One of these is an inner-city school in Hollywood, California, Romona Elementary School, which has demonstrated significant accomplishments using the curriculum and approach to teaching. At Romona Elementary School, 90% of students are eligible for free or reduced lunch and approximately 60% of the student body speak English as a second language. Landsberg, *Los Angeles Times* staff writer, reports that in 2006, 76% of students at Romana Elementary School scored on grade level on the standardized state test; this was higher than the 45% that scored on grade level the previous year. The difference was credited to the adoption of Singapore Math (Landsberg, 2008).

Decisions regarding Singapore Math must not be made without first considering the factors contributing to the success of Singapore Math in American schools. Ginsburg, Leinwand, Anstrom, and Pollock (2005) and McClain (2011) indicated that implementation of Singapore Math has the potential to result in increased student achievement if quality professional development is provided for teachers and favorable conditions exist. For instance, populations where students often move between schools would not be favorable. Waight (2006) notes that on-going professional development and administrative support are critical to the effectiveness of Singapore Math in American schools. Each school or district must determine if resources are available for such training and support. Continuous professional development is ideal in any type of implementation situation. It is critical, however, with a Singapore Math implementation because much of the philosophy and approach to teaching is not explained in teaching materials. Rather, teachers must be trained by one who has knowledge of the underlying philosophy and activities of Singapore classrooms. If quality professional development is not provided, much will be lost in translation.

In addition to the provision of continuous, quality professional development, curriculum decision makers must consider the qualifications of teachers. Quality teachers with strong mathematics backgrounds are best equipped for such a challenging implementation. Other suggestions include implementation beginning with only kindergarten and first-grades. When students in higher grade levels are introduced to Singapore Math without having the foundation from first-grade, the students struggle because their number sense is often not strong enough to grasp the advanced thinking that Singapore Math requires. Ginsburg et al. (2005) also recommend extra time and assistance be given to students not demonstrating high achievement in mathematics. The authors recommend that states align their standards with the Singapore Math curriculum before implementation in order to prevent gaps in student learning. In addition, they advise using the U.S. edition of the Singapore Math textbooks.

Singapore Math Framework

Fostering mathematical problem solving abilities is the primary goal of Singapore Math. The Singapore Primary Mathematics Syllabus (2006a) states that emphasis is placed on conceptual understanding, skills proficiencies, thinking skills, reasoning, applications, and the use of technology. In addition, the Singapore Math curriculum is designed to foster appreciation for mathematics by moving at a slower pace and providing more student support than many mathematics curricula. This enables teachers to teach in-depth and allows students to master skills in a variety of situations through the exploration of nonroutine and real-world problems (Singapore Private Limited, 2008).

The Singapore Primary Mathematics Syllabus states the aims of the mathematics education. Students should be enabled to accomplish the following:

1. Acquire the necessary mathematical concepts and skills for everyday life, and for continuous learning in mathematics and related disciplines;
2. Develop the necessary process skills for the acquisition and application of mathematical concepts and skills;
3. Develop the mathematical thinking and problem solving skills and apply these skills to formulate and solve problems;
4. Recognize and use connections among mathematical ideas, and between mathematics and other disciplines;
5. Develop positive attitudes towards mathematics;
6. Make effective use of a variety of mathematical tools (including information and communication technology tools) in the learning and application of mathematics;

7. Produce imaginative and creative work arising from mathematical ideas;
8. Develop the abilities to reason logically, communicate mathematically, and learn cooperatively and independently. (Singapore Ministry of Education, 2006a, p. 5)

A visual representation of the Singapore Math framework includes a pentagon with mathematical problem solving in the center. Five interrelated components, creating the five sides of the pentagon, are designed to foster problem solving and the goals aforementioned. The five components are as follows: (a) concepts, (b) processes, (c) metacognition, (d) attitudes, and (e) skills. Although each side of the pentagon is independently labeled, all components are overlapping and, together, foster success in mathematical problem solving. For the remainder of this literature review, each component will be reviewed separately, however, it is important to note that each one is intertwined with the others. For example, the two components of this study (attitudes and skills) are fostered through the development of the other three components.

Concepts. The Singapore Math curriculum focuses on a few concepts each year and is structurally different than curricula in the United States. Ginsburg et al. (2005) conducted an exploratory study that compared key components of the mathematics curriculum in Singapore with various curricula in the United States of America. The Singapore Math curriculum was found to emphasize a deep student understanding of mathematics. The curriculum is grouped into four key concepts: (a) numbers, (b) geometry, (c) algebra, and (d) statistics. Each concept is divided into subgroups. For example, the concept of numbers is divided into whole numbers, fractions, decimals, rates of speed, proportion, and percentages. Each subgroup is addressed in a logical order and builds on content addressed in previous grade levels (Singapore Ministry of Education, 2006a). Due to the likeness of the number concepts taught in Singapore Math and traditional math approaches, focus for this subsection will not be on the numerical, geometrical, algebraic, and statistical concepts themselves. Rather, focus will remain on the way in which the concepts are addressed in Singapore Math and how this differs from more traditional American approaches.

In Singapore, emphasis of specific content varies according to the appropriateness for students in each grade. The Singapore curriculum contains fewer key concepts than those outlined for American schools by the National Council of Teachers of Mathematics (NCTM) (2006). One distinguishing feature of the Singapore curriculum is the philosophy of teaching to mastery. By teaching fewer concepts, skills are covered in greater depth - allowing students to develop a relational understanding of mathematics. When a relational understanding is developed, so is confidence.

Mastery learning, classically formulated by Bloom (1968), is a model of teaching that helps many students achieve success in a given subject area. Certain key concepts should be present in the mastery learning approach: clear objectives, small learning units (sequenced effectively), appropriate instruction for the individual student, and formative assessments to guide instruction. Formative assessments are used to indicate student needs and drive instruction (Pearson Education, 2008). Another important aspect of mastery learning is time. According to Carroll, the learner should be given the appropriate time needed to master a skill or subject (as cited in Bloom, 1968). The role of the teacher is to be an encouraging assistant who appropriately scaffolds instruction for each student. The role of the learner is to be a good listener and hard worker in order to take control of one's learning. In turn, the student should acquire academic skills outlined in specific learning objectives as well as acquire self-initiation, self-direction, and motivation. Self-reflective learners are also a desired outcome from mastery learning (Joyce, Weil, & Calhoun, 2009).

According to Guskey and Gates (1986), the theory of mastery learning is based on the simple belief that all children can learn. Teachers must provide students with supportive conditions. Oftentimes, reteaching is necessary for students. Ratey (2001), clinical professor of psychiatry at Harvard Medical School, described the importance of repetition of a task for it to become permanently encoded in one's memory. When teaching to mastery, individualized instruction is designed to meet the needs of students since most students learn differently and at different rates.

The U.S. Department of Education (2006) conducted a descriptive study of eight secondary charter schools across the nation that demonstrated academic excellence. This study identified characteristics that contributed to success in these schools. They taught for an in-depth understanding, and they provided more time for students to acquire a skill if needed. In addition, the schools provided opportunity and support for students in need of such remediation or challenge.

The U.S. Department of Education (2007b) also conducted a descriptive study on seven elementary charter schools to build on the 2006 work. Seven themes emerged from descriptive data collection. Again, one theme was teaching to mastery. In these elementary charter schools, teachers used assessments to guide their instruction and worked long hours, if necessary, to optimize the success of students.

Guskey and Gates (1986), synthesized research available on group-based mastery learning in order to determine the effect on student achievement. From the pool of hundreds of studies collected, the researchers selected 27 studies considered to be well-designed studies. All studies reported that mastery learning had a positive effect on student achievement. Results also indicated that mastery learning had a positive effect on retention, student engagement in learning, and student attitudes.

Mastery learning is reflected in Singapore textbooks. According to Ginsburg et al. (2005), Singapore textbooks have a strong design that provides quality opportunities to practice and apply concepts learned. Textbooks in the Primary Mathematics series are smaller in size than widely used textbooks in the United States, cover fewer lessons, and contain many illustrations. However, the lessons are covered in more depth and span more pages than lessons in American textbooks. Textbooks and workbooks provide numerous opportunities for routine and nonroutine problem solving. In addition, Singapore textbooks are more rigorous than those used in American schools (Adams et al., 2002; Ginsburg et al., 2005). In contrast, American textbooks cover many concepts and have difficult vocabulary that often holds a different meaning in mathematics. In addition, each sentence is full of information with little repetition. The technical nature of the texts are difficult for even the most proficient readers (Phillips, Bardsley, Bach, & Gibb-Brown, 2009).

Another distinguishing feature of Singapore previously noted is the centralized educational system credited for the educational success of the country. The Ministry of Education determines concepts to be mastered. In contrast, many educational decisions, including curricula in America, are made by state governments (Louisiana Department of

Education, n.d.a). Members of the Center for the Study of Mathematics Curriculum (2006) analyzed state-level curricula in the United States. The purpose of the study was to describe emphasis of expectations and variations that exist in state curricula documents in relation to the concepts of numbers and operations, algebra, and reasoning. The researchers found that states give attention to all areas studied, but inconsistencies exist. Expectations across states differ regarding the skills required to be taught and mastered at each grade level. In addition, standards and grade level expectations are worded in a manner that often places the responsibility of interpretation on the reader. The researchers recommended an increased effort to align expectations across states (Center for the Study of Mathematics Curriculum, 2006).

Research such as those previously cited prompted the National Council of Teachers of Mathematics (NCTM) to form a writing team to study curricula from many states and countries in preparation to create focal points to guide concepts taught at each grade level from pre-kindergarten to eighth-grade in the United States. Although the U.S. is not currently adopting the model of mastery teaching, the focal points are described as a starting point for a more coherent, focused curriculum in the United States. The researched acknowledged the challenge of striving to teach many concepts in one year. In contrast, when students are exposed to few concepts, understanding, mathematical fluency, and the ability to generalize are fostered. Jensen (2005), a former educator and member of the Society for Neuroscience and New York Academy for Sciences, supported this notion by explaining that a student who is overloaded with information will not remember more information, but forget information that was not fully encoded in the brain's memory.

To summarize, the Singapore Math curriculum is grouped into four key concepts that are similar to concepts taught in traditional American mathematics programs. However, Singapore Math places emphasis on mastery teaching of these concepts which has proven to increase student mathematical skills and foster positive attitudes towards mathematics. When students internalize material, they acquire a firm foundation upon which to build. Singapore capitalizes upon this approach and many states within the United States are taking notice and increasing efforts to do the same.

Processes. Effective mathematics teachers are not solely interested in students arriving at mathematical solutions; they are also interested in the problem solving process. Process skills include: (a) reasoning, communication, and connections, (b) thinking skills and heuristics, and (c) application and modeling (Singapore Ministry of Education, 2006a). Such process skills are not only reflected in Singapore Math, but also in the process standards outlined by the National Council of Teachers of Mathematics (NCTM) in the United States (n.d.).

Reasoning requires students to be flexible in their thinking and to analyze mathematical situations and problems. Communication is the ability of a student to discuss mathematics precisely, concisely, and logically through daily mathematical discussions, allowing students to share their thinking processes and learn from peers. Connections refer to the ability of the students to recognize and be reminded of mathematics in other academic subjects as well as daily living. This ability naturally develops as students become mathematical thinkers (Singapore Ministry of Education, 2006a).

Eight thinking skills, similar to skills taught in American schools, are described in the Singapore Primary Mathematics Syllabus: (a) classifying, (b) comparing, (c) sequencing, (d) analysis of parts and wholes, (e) identifying patterns and relationships, (f) induction, (g) deduction, and (h) special visualization. Examples of heuristics, or exploratory problem solving techniques, are as follows: (a) giving a representation by drawing a diagram, (b) making a list, (c) using equations, (d) making a calculated guess by guessing and checking, (e) looking for patterns, (f) making suppositions, (g) going through the process by acting out, (h) working backwards, (i) changing a problem by restating, (j) simplifying, and (k) solving (Singapore Ministry of Education, 2006a).

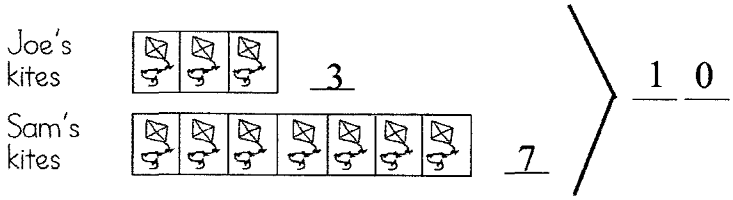
Application and modeling require students to apply mathematical skills in a variety of problems and situations, including problems that reflect real life. The key heuristic skill, unique to the Singapore Math approach that allows such application, is bar model drawing. Bar model drawing is an enjoyable strategy students use to visually solve word problems by capitalizing on their interest of drawing, thus making learning fun. This regularly used strategy develops students' visual thinking capabilities, algebraic thinking, and reflective reading skills in addition to providing a context for students to practice mental math strategies, computational skills, and deep thinking (Staff Development for Educators, 2009). Bar model drawing is often one piece of Singapore Math that is utilized by schools that are not trying a full implementation. Furthermore, bar model drawing is often mistakenly used synonymously for Singapore Math. It is important to realize it is only one piece of Singapore Math. Due to the distinctiveness and effectiveness in elevating student skill abilities in mathematics, bar model drawing will be discussed in more depth for the remainder of this subsection.

Hogan and Forsten (2007) define bar model drawing as drawing simple visual models to represent word problems. Garelick (2006) commented that word problems are considered one of the most challenging aspects of mathematics. Bar model drawing is as an incredibly powerful strategy that allows students to successfully solve such problems (Kuhns, 2009). Teachers exposed to bar modeling often have a common response: amazement. They often ask, "Why wasn't I taught this way?" (Salerno, 2009).

Bar modeling instruction, which can begin as early as first-grade, is a visual tool utilized by students of all ages. Lessons should begin at a slow pace, using step-by-step instruction, and problems should gradually increase in complexity in order to build student confidence, deepen understanding of modeling, and create effective problem solvers (Hoven & Garelick, 2007; Kuhns, 2009). Through model drawing, students build a solid foundation of number sense and problem solving skills before moving on to abstract problems (Hogan & Forsten, 2007). Hoven and Garelick (2007) agree that bar modeling provides students with a solid mathematical foundation and further explain this allows students to easily begin algebra as they are comfortable visually solving for missing pieces of information. Moreover, students are given opportunities to realize that there are multiple ways to solve a problem.

Finally, students utilizing bar model drawing are able to solve problems in middle school grades that students in most United States algebra classes would find challenging. Garelick (2006), an analyst for the United States Federal Government and advisor to an education advocacy organization that addresses mathematics, describes the Singapore approach to bar modeling as "Miracle Math" (see Figure 2).

Joe flew 3 kites.
Sam flew 7 kites.
How many kites did the boys fly?



3 + 7 = 10

The boys flew 10 kites.

Figure 2. Introductory bar model example. Adapted from *Word Problems for Model Drawing Practice* by C. J. Kuhns, 2009, Peterborough, NH: Crystal Springs Books Copyright (2009) by Crystal Springs Books. Reprinted with permission from SDE/Crystal Springs Books. Ten Sharon Road. PO Box 577. Peterborough, NH. 1-800-924-9621. All rights reserved.

Metacognition. Metacognitive thinking allows students to permeate surface level knowledge of mathematics and arrive at a deeper understanding. Metacognitive activities are encouraged in classrooms in the United States, however, metacognition is built into the framework of Singapore Math. Metacognition is described as "thinking about one's own thoughts" (Hacker, 1998, p. 3). Hacker further notes, this thinking "can be of what one knows (i.e., metacognitive knowledge), what one is currently doing (i.e., metacognitive skill), or what one's current cognitive or affective state is (i.e., metacognitive experience)" (p. 3). Students possessing metacognitive knowledge are often reflective and discern how they learn best, grasp the demands that specific tasks have upon them, and have the ability to determine the appropriateness of specific strategies to use in any given situation (Davidson & Sternberg, 1998; Kluwe, 1987).

According to Kluwe (1987), younger children are often unaware of cognition and therefore do not monitor their own thinking processes. However, Desoete and Ozsoy (2009) believe that metacognition can be trained through explicit teaching. Dominowski

(1998) points out that explicit teaching of oral communication has the potential to increase metacognition. People often talk aloud when solving problems. This is a self-regulating function that aids in problem solving by providing clarification for the learner. Furthermore, if students are asked to explain their reason for choosing certain strategies for solving a problem, profound thought is required. This technique for questioning can elicit more effective problem solving strategies and improved task performance in the future because student awareness is elevated by the questioning technique. Teachers can use verbalizing techniques to informally assess the problem solving approach of students and to identify areas of difficulty (Dominowski, 1998). Such social interactions as those described above can enhance understanding (Carr & Biddlecomb, 1998).

Kluwe (1987) describes four additional activities that encourage monitoring of cognition: (a) classification, (b) checking, (c) evaluation, and (d) prediction. Classification refers to the categorizing of cognitive activities in the mind of a student. Students able to classify can more readily recognize types of problems. These students are also familiar with the nature of thinking involved in reaching a solution to a problem. Checking occurs throughout the problem solving process when students pause to consider the progress they are making. Evaluation occurs when students judge the quality of their work or progress against criteria in their mind. Prediction refers to the awareness of the range of possibilities that exist in the problem solving process; some examples are predictions about possible solutions or predictions about the course of problem solving. These four activities are not separate, but often occur simultaneously in the problem solving process.

Livingston (2003), states metacognition is critical to ensure successful learning. This researcher provides the following examples of metacognitive activities in the subject of mathematics: (a) planning how to approach a given learning task, (b) monitoring comprehension, and (c) evaluating progress toward the completion of a task. Dominowski (1998) further notes that teachers are molding more effective problem solvers by nourishing their metacognitive processes. Learners that monitor their metacognitive activities often demonstrate more academic success than learners who do not (Carr & Biddlecomb, 1998; Livingston).

In conclusion, the Singapore Primary Mathematics Syllabus (Singapore Ministry of Education, 2006a) provides additional, similar examples to those previously outlined: (a) exposure to general problem solving and thinking skills, (b) encouraging students to seek multiple ways to solve problems, and (c) oral communication of the strategies they use to solve challenging problems that require planning. Ban Har (2007), the director of curriculum and professional development at an autism-oriented school in Singapore, stresses the need for students not only to read and comprehend problems, but also to explain their thought processes in solving a problem. The Singapore Primary Mathematics Syllabus encourages teachers to provide students with such opportunities as monitoring their own thinking and developing awareness of their cognitive activities. The Singapore Math approach employs metacognitive activities in primary grades to encourage this metacognitive thinking from a young age in order for it to become second nature (Singapore Private Limited, 2008).

Attitudes. Learning mathematics does not require intelligence alone, but also "perseverance, tenacity, and fearlessness," as stated by Schwartz (2005), recipient of the

2004 Distinguished College/University Teaching of Mathematics Award for New Jersey. Such affective characteristics are important to educators in Singapore and America alike, but again, attitudes are built into the framework of Singapore Math. Furthermore, despite the value American educators may place on positive attitudes, it is acceptable for students to say they are "not good at math." Students are not embarrassed by such struggles in the same manner they would be embarrassed if struggling to read. Student attitudes have been the topic of much research in recent years (Jensen, 2005; Kadlec, Friedman et al., 2007; Ma & Kishor, 1997; Multon, et al., 1991; Parjares & Kranzler, 1995). Researchers have focused on the process of fostering positive attitudes toward mathematics (Gilpin, 2010; Schoenfeld, 1992; Su, 1990; U.S. Department of Education, National Center for Education Research 2007; Wolk, 2008).

Approximately 2,800 students and parents in Kansas and Missouri were randomly surveyed to determine their attitudes concerning the subjects of mathematics, science, and technology. According to Kadlec et al. (2007), many parents surveyed believed that schools are successful in preparing students in mathematics. On the contrary, business leaders and education leaders who participated in focus groups indicated the inadequacy of American schools in preparing students for future careers in the fields of mathematics and science. In addition, students did not indicate a strong sense of motivation or interest towards mathematics or science.

Student attitudes toward mathematics are important and worthy of educators' attention. Jensen (2005) confirmed that learning and feelings are not separate entities, but are connected. The author further explained that brain research suggests the process of acquisition of new information and skills must be enjoyable and relevant to students because emotions are directly related to their learning. Positive student emotions aid in student attention, persistence, and retention of learned information.

Researchers in the field of mathematics have explored this connection between attitude and achievement. Pajares and Kranzler (1995), studied the influence of math self-efficacy and general mental ability on student performance in the area of mathematical problem solving. Research conducted on 329 high school students, in two southern public schools, indicated that self-efficacy and mental ability have a direct effect on student performance in mathematics. Self-efficacy was found to be more important than gender or background in relation to academic achievement.

Multon et al. (1991) conducted a meta-analysis on the self-efficacy beliefs of students and the relationship to behaviors, effort, task performance and persistence, vocational choice, and achievement. The researchers found self-efficacy does affect such academic outcomes. Ma and Kishor (1997) also conducted a meta-analysis of 113 primary studies on the relationship between attitude towards mathematics and achievement in mathematics at the elementary and secondary level. Results indicated there is a positive relationship between attitudes towards mathematics and achievement in mathematics.

As research suggests, attitudes toward mathematics affects educational outcomes, and educators must help cultivate positive attitudes (Gilpin, 2010; Schoenfeld, 1992; Su, 1990; U.S. Department of Education, National Center for Education Research 2007; Wolk, 2008). Of particular interest is Schoenfeld (1992), who discussed five common misconceptions about mathematics that can affect the attitudes of students towards the subject: (a) mathematics problems have only one correct answer, (b) there is only one correct method to solving a problem, (c) average students cannot be expected to understand mathematics, (d) mathematics is a solitary activity, and (e) students who understand the mathematics studied should be able to solve problems quickly. These misconceptions directly oppose the philosphophy of Singapore Math. Schoenfeld states that teachers have a responsibility to provide a different perspective in order to clarify misconceptions and help foster a more positive outlook towards mathematics. Schwartz (2005) depicts the learning process as a two-sided equation. On one side, learning mathematics involves the skills and attitudes the students bring to class; on the other, the skills and attitudes of the teacher.

Teachers must demonstrate to students that the trial-and-error method is an integral part of learning mathematics. Attitudinal patterns begin in elementary school; consequently, elementary teachers have a large responsibility in shaping student attitudes for their future encounters with mathematics (Clarke & Clarke, 2003). Clark and Clark encourage teachers to choose rich, challenging problems to work together with students while modeling the persistence needed to solve mathematical problems. Teachers should also support discussions of the mathematical process. Wolk (2008) describes the lasting impressions school experiences can have on student attitudes towards lifelong learning and encourages teachers to assist students in finding pleasure in learning. Wolk urges educators to provide students with choices in their learning.

Schwartz (2005) notes that many students likely fear mathematics because of past learning experiences. Two difficult, yet important, jobs of a mathematics teacher are to convince students they can experience success and to provide them with the tools needed. Su (1990) conducted a study in an inner-city school with a majority of underachieving elementary students who reported a dislike for mathematics. Su focused on creating a joyful learning environment and building student confidence in order to increase student achievement. Results of the study indicated significant gains in student achievement on mathematics time-tables and scores on an achievement test. Significant gains were also noted in the number of students who reported liking mathematics. Su explained that with increased teacher effort, student attitudes and achievement in mathematics can improve.

Gilpin (2010) founded a Math Matters club in response to students' negative attitudes about mathematics. Gilpin noted that American students and adults often avoid situations where failure is predicted. Many students do not feel successful in mathematics; therefore, they tend to avoid expending extra effort in the subject. The Math Matters club was founded on the idea that self-efficacy is critical to young adolescents because middle school is a time of change. In addition, self-efficacy is connected to mathematics achievement, and belief in one's self has shown to predict learning. It is important to note that avoidance of situations where failure is predicted is more commonly seen in American students. Asian students persist in such situations and demonstrate perseverance because it is viewed as an opportunity to improve themselves (Heine et al., 2001).

The U.S. Department of Education and the National Center for Education Research (2007) formulated research-based recommendations for educators to encourage girls in mathematics and science. Educators must first change negative beliefs in girls about their abilities in the subjects. It is important that students realize their ability or intelligence for mathematics and science is not fixed but can improve with practice and effort. The authors also recommended that educators plan activities to spark the interest of students and to focus on building mathematical skills.

A positive attitude in respect to mathematics is of extreme importance in Singapore because it is considered a key component in producing effective problem solvers. According to the Singapore Primary Mathematics Syllabus (Singapore Ministry of Education, 2006a), teachers are encouraged to infuse their own ideas into lessons in order to make learning enjoyable. The syllabus indicates attitudes refer to the following aspects:

1. Beliefs about mathematics and its usefulness;
2. Interest and enjoyment in learning mathematics;
3. Appreciation of the beauty and power of mathematics;
4. Confidence in using mathematics; and
5. Perseverance in solving a problem. (p. 9)

Lastly, studies have been conducted that report on student attitudes in Singapore and the United States of America. Mullis, Martin, and Foy (2008) provided information on student attitudes from countries participating in the Trends in International Mathematics and Science Study (TIMSS) 2007. Participating fourth-grade students were asked to respond to the three following statements: (a) I enjoy learning mathematics, (b) Mathematics is boring, and (c) I like mathematics. Participants identified the degree to which they agreed with the statements. Students were assigned to three categories depending on their responses, and student categories included high, average, and low levels of the index of positive affect toward mathematics.

Percentages of students in each of the three categories were calculated for each participating country. Seventy-one percent of Singaporean students reported a high level of positive affect toward mathematics. Fewer American students, 66%, were placed in the same category. Internationally, countries reporting high levels of positive affect toward mathematics scored higher in overall student achievement than countries reporting low levels of positive affect toward mathematics (Mullis et al., 2008).

Skills. Skills taught in American schools do not greatly differ from skills taught in Singapore schools. The Singapore Primary Mathematic Syllabus (Singapore Ministry of Education, 2006a) lists seven procedural skills primary students are expected to learn: (a) estimation/approximation, (b) mental calculation, (c) communication skills, (d) using mathematical tools, (e) arithmetic manipulation, (f) algebraic manipulation, and (g) handling data. Despite similar skills taught in Singapore and America, the methods of teaching and emphasis on skills in each country are different. The actual approach to teaching in Singapore and specific emphasis on certain skills contribute to the success of Singaporean students in mathematics.

When using Singaporean methods of instruction, skills are taught through a concrete-pictorial-abstract approach at each grade level. In this approach, students are first introduced to concepts and skills through the use of numerous manipulatives and other hands-on activities much like in the United States. Hartshorn and Boren (1990) note the importance of manipulatives because they can enhance learning when students are actively engaged in mathematics. Students are allowed to use manipulatives until they are ready to move to the pictorial stage. As students progress, the same skills are taught using picture representations of real-world problems. Picture representations may include, but are not limited to, photographs, drawings, diagrams, and bar model representations. Hogan and Forsten (2007) explain the frequently used pictorial stage, often skipped by American teachers, provides a bridge between the concrete and abstract stages. The final stage provides students with opportunities to work with abstract problems and mathematical algorithms. Proceeding through such stages is necessary before students can think abstractly (Hartshorn & Boren, 1990).

In Singapore, mathematical procedures and the application of many skills are required to be automatic (Salerno, 2009). Educational theorist, Benjamin Bloom describes the idea of automaticity by explaining that many skills carried out in daily life, either ordinary or extraordinary, are often executed as the result of one's ability to complete a task unconsciously with accuracy and speed. This notion of automaticity can also be described as over-learning. Bloom states a large amount of time must be devoted to develop automaticity in a skill, and practice is required to maintain automaticity. Bloom uses the example of learning to walk. When first learning to a walk, the skill requires much thought and effort. After much practice, the activity becomes natural, requiring minimal conscious thought (Bloom, 1986).

According to Bloom (1986), automaticity involves a "minimum of wasted motion or effort," and other conscious brain functions may occur at the same time as automatic functions (p.74). The author further describes the three types of learning required to develop automaticity: (a) learning isolated details, (b) learning larger units that are composed of details, and (c) use of mastered processes when a situation occurs. Bloom explains schools must take some responsibility for such learning, especially in basic skills such as arithmetic. This expectation holds true for students taught Singapore Math.

Basic addition, subtraction, multiplication, and division facts are expected to be learned to automaticity. One must be cautious to differentiate between mastery learning and automaticity. Oftentimes, the terms are used interchangeably. Students are expected to learn beyond mastery to achieve a state of automaticity.

Wittman, Marcinkiewicz, and Hamodey-Douglas (1998) studied the relationship between mathematics anxiety and automaticity of multiplication facts in fourth-graders. Sixty-three fourth-graders in the Pacific Northwest completed the Mathematics Anxiety Rating Scale-Elementary Version (MARS-E) before and after the treatment of computer-assisted instruction that aided in mastery and automaticity of multiplication facts. Based on pretest results, students were divided into three categories (a) high anxiety, (b) low anxiety, and (c) control group in order to determine results in various subgroups. Automaticity was defined as correctly answering a problem in one to three seconds. Results indicated all students achieved automaticity due to their computer-assisted instruction. In addition, significant reductions in math anxiety were reported in the high anxiety group after achieving automaticity, specifically for girls.

In addition to learning skills to automaticity, the use and emphasis of select instructional strategies to teach skills make the Singapore Math approach distinct. For example, the use of skip counting, numberbonds, and oral language activities help develop proficient math students. Skip counting, often called counting with multiples, is an enjoyable, interactive method for students to become flexible with numbers and to recognize patterns in numbers. According to Salerno (2009), a Singapore Math advisor, skip counting occurs weekly in Singaporean classrooms. Students learn to count by numbers such as 2s, 3s, 5s, and 10s, as well as many other numbers, starting as early as first-grade. This counting is intended to be quickly executed forwards and backwards. In addition, teachers often ask students to start counting at various numbers to increase flexibility.

Numberbonds are also utilized throughout the Singapore Math approach. Numberbonds are simple diagrams showing the relationship between a whole number and the parts of the whole (see Figure 3). This diagram is referenced in lessons throughout the primary grades as a tool for understanding basic mathematical skills by building a strong number sense and foundation for learning (Salerno, 2009; Singapore Private Limited, 2008).

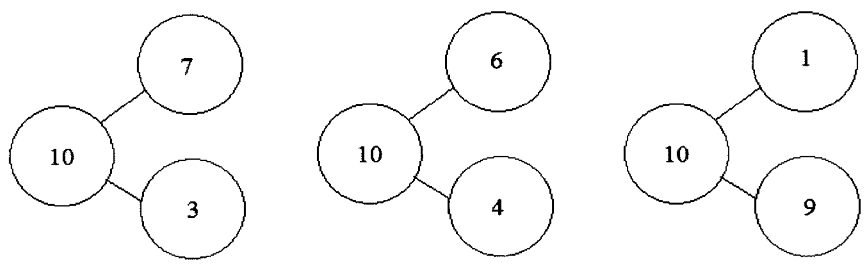


Figure 3. Numberbond examples.

Young Singaporean students learn their math lessons in English although they live in a multi-lingual nation. Since these children are English-language learners, oral language is heavily emphasized in their math instruction. Forsten and Richards (2009) stated after visiting Singapore and observing the use of oral language in lessons, the same approach was then personally used.

Educators in Singapore and America are in agreement on the importance of oral language. According to the National Council of Teachers of Mathematics (n.d.), language is a powerful tool and instruction should enable students to accomplish the following:

1. Organize and consolidate their mathematical thinking through communication;
2. Communicate their mathematical thinking coherently and clearly to peers, teachers, and others;
3. Analyze and evaluate the mathematical thinking and strategies of others; and
4. Use the language of mathematics to express mathematical ideas precisely.

In recent years, there has been emphasis on the need for reading instruction in content areas such as math. Often, the academic subjects of reading and math have been separate entities. However, with unacceptable literacy rates occurring in America, educators are integrating the two subjects in order to elevate performance in both areas. Phillips, Bardsley, Bach, and Gibb-Brown (2009), described a professional development project funded by the U.S. Department of Education to educate teachers on the importance and process of integration of literacy into their content area. Many literacy strategies focusing on vocabulary, reading texts, and thinking aloud were incorporated as part of the teacher training. This project proved to be successful with increased awareness of the need to teach students how to transfer their knowledge from one subject to another. In addition, teachers reported positive attitudes and increased knowledge on how to better teach math.

Research was also conducted on the use of number talks to aid in the development of number sense in fourth-grade students. Number talks are class discussions about possible solutions to simple mathematical problems. A study conducted in a large suburban school in Tennessee, utilized a pretest, posttest design to determine if number talks increased the number of problem solving methods students would employ as well as increase the number of two-digit addition problems the student could answer in two minutes. In addition, the researcher sought to determine if a relationship existed between the number of methods utilized and the number of problems solved in two minutes. A six-week treatment period occurred between the individually administered pretests and posttests. Results indicated number talks did increase the number of methods utilized and increased the number of problems solved in two minutes. However, a relationship did not exist between the two (O'Nan, 2003).

McIntosh (2004) reported the results of a study conducted by the Department of Education in Tasmania on the effect of developing informal written computation processes in young students. The thirty-seven teachers who participated in the study reported that focused attention on the problem solving process through the use of oral and written language greatly improved the mathematical competence of students and improved student attitudes.

To conclude, mathematical skills taught in Singapore and America are alike, but the approach to teaching and the emphasis on those skills are different. In Singapore, skills are taught through a concrete-pictorial-abstract approach and automaticity of skills is expected. In America, automaticity of skills is desired, but not always achieved because of lack of emphasis. Singapore and American educators do agree, however, on the importance of oral language in the mathematics classroom to increase mathematical skills.

Summary

Educators in the United States of America have recognized the small Asian country of Singapore as a model for success in the area of mathematics. Because of the success of Singaporean students on the TIMSS, American educators have considered the transferability of Singapore Math to American schools and school districts in an effort to elevate student knowledge and achievement in mathematics. The desired outcomes of the Singapore educational system are similar to the desires of American educators. Both countries strive for confident, determined, and resilient citizens who communicate effectively, take responsibility, and actively contribute to their country (National Council of Teachers of Mathematics, 2006; Singapore Ministry of Education, 2006a).

Comparisons of the educational systems of Singapore and the United States have yielded similarities, yet also numerous differences. Unique to Singapore is the Singapore Math framework consisting of five components designed to increase student knowledge and problem solving abilities: (a) concepts, (b) processes, (c) metacognition, (d) attitudes, and (e) skills. Curricula in American schools are not unified as they often differ between states and districts; no national mathematics curriculum exists. The Singapore Math framework provides a successful curriculum structure that emphasizes mastery learning, a contributing factor to the success in Singapore. American educators are often criticized for teaching too many concepts too quickly.

Concepts are taught to mastery in order for students to develop a solid foundation for future mathematical learning. Careful attention is given to the processes students undergo in mathematics as well as the monitoring of cognitive activities. Singaporean educators do not solely focus on outcomes. By focusing on the processes, student mathematical skill abilities are elevated. Enjoyment, appreciation, interest, confidence, and perseverance are all attitudes encouraged in Singaporean students. Such affective characteristics are also encouraged in America, but it is accepted for students to admit their dislike or struggles in mathematics. Skills taught in Singapore prove to be similar to skills taught in America. However, different emphasis on skills and varying instructional approaches aid in student achievement. For example, skills are taught through a concrete-pictorial-abstract approach that provides proper scaffolding for student learning. In America, the important pictorial stage is often skipped. Emphasis on skip counting, use of numberbonds and oral language, and emphasis on the automaticity of addition, subtraction, multiplication, and division facts, and mental calculation are key skills in the Singapore Math curriculum and approach to teaching. All components are interrelated, increase knowledge and appreciation for mathematics, and produce effective problem solvers, the primary goal the Singapore Math (Salerno, 2009; Singapore Ministry of Education, 2006a).

Many curricula for teaching mathematics exist. However, none have received the international attention of Singapore Math. Many studies on the success of American schools using Singapore Math have reported impressive gains that have received the attention of many American educators (Begley, 2010; Buzzard, 2010; Gabriella & Paul Rosenbaum Foundation, 2009; Jordan, 2009; Ramsey, 2010; Stewart, 2009; Waight, 2006). Since the turn of the millennium, each school year, numerous schools are adopting Singapore Math in an effort to increase students' metacognitive thinking, mathematical skills, and positive attitudes ultimately intended to produce effective problem solvers.

CHAPTER 3

METHODOLOGY

Introduction

This study investigated the effectiveness of Singapore Math on student enjoyment of mathematics and mathematical knowledge. Enjoyment and knowledge represent two of the five components of the Singapore Math pentagon framework, attitudes and skills. The other three components include concepts, processes, and metacognition. Enjoyment and knowledge were selected as the focus of this study because they are easily measured in a first-grade setting. In addition, student skills acquisition is a goal of mathematics educators, and student enjoyment is often linked to such achievement (Jenson, 2005; Ma & Kishor, 1997). Comparisons were made between schools using Singapore Math and schools using traditional math approaches. Traditional math refers to common American approaches to teaching mathematics, not a specific program or curriculum. Mathematics enjoyment was measured using a Math Enjoyment Inventory and knowledge was measured with a pre and posttest of mathematics skills. Additional descriptive data on participating teachers were obtained through the use of a Teacher Response Form. This chapter discusses the research design of the study, provides a description of the population and sample, and provides procedural details of the study. In addition, data collection procedures, instrumentation, data analysis, and limitations are discussed.

The U.S. Department of Education (n.d.) describes the role of educators as the provision of American students with an education that allows them to be successful in a global society. However, results from the Trends in International Math and Science Study (TIMSS) conducted in 1995, 1999, and 2003 indicate, overall, that students in America are not performing at a level that enables them to be globally competitive in the field of mathematics. These results have caused American educators to search for solutions to the existing achievement gap (Ginsburg et al., 2005). Since some schools are turning to Singapore Math, it is important to determine if Singapore Math is a useful method of teaching mathematics. Moreover, it is important to determine if student enjoyment of mathematics and knowledge in mathematics are elevated when American students are taught Singapore Math.

Research Questions

In examining the scores from the Math Enjoyment Inventories and the mixed skills pre and posttests, the following research questions are posed:

1. Is there a significant difference in student enjoyment in mathematics between students taught Singapore Math and students taught traditional math?
2. Is there a significant difference in student knowledge in mathematics between students taught Singapore Math and students taught traditional math?

Null Hypotheses

For the purpose of this study, the following null hypotheses were tested:

H1. There will be no significant difference between the scores on the Math Enjoyment Inventory for students taught Singapore Math and students taught traditional math.

H2. There will be no significant difference between the scores on the math mixed skills test for students taught Singapore Math and students taught traditional math.

Research Design and Analysis

The Singapore Math approach has shown to be effective in many schools in the United States of America (Begley, 2010; Buzzard, 2010; Fox News Arizona, 2010; Gabriella and Paul Rosenbaum Foundation, 2009; Jordan, 2009; Ramsey, 2010; Stewart, 2009; Waight, 2006). With more schools piloting Singapore Math each year, it is important to evaluate the usefulness of this curriculum and approach to teaching. This study was conducted to contribute to the limited body of research available on the effectiveness of Singapore Math in American schools.

The design of the study utilized quantitative data collection procedures. Data were gathered on students using a math mixed skills pre and posttest as well as the Math Enjoyment Inventory. A math mixed skills pre and posttest score and a Math Enjoyment score were obtained for each student in both the Singapore Math group and the traditional math group.

Data were analyzed separately for the two dependent variables (enjoyment and mathematics skills). Data from the Math Enjoyment Inventory were analyzed in an independent *t*-test between Singapore Math and traditional math. Data from the math mixed skills pretest were also compared between the Singapore Math group and traditional math group using an independent *t*-test to determine if the two groups were similar in mathematics skills at the start of the experiment. Any differences found on pretest scores were addressed in further analysis with an Analysis of Covariance (ANCOVA) with the pretest score as the covariate. Data from pre and posttest knowledge across the two groups (Singapore and traditional math) were analyzed in a 2(test) x 2(group) ANCOVA. This statistical tool controlled for the differences between the Singapore Math group and traditional math group at the onset of data collection. Alpha was set at $p < .05$ for all statistical tests.

Supplemental data were gathered using the Teacher Response Form and included information on teachers whose classes were used in the study. Quantitative data were collected regarding the number of years teaching, the number of years teaching mathematics, the number of years teaching first-grade mathematics, hours of participation in mathematics professional development, and degrees earned. Teachers were also asked to respond to an open-ended question that inquired how they felt about teaching mathematics.

Population and Sample

The north Louisiana district studied hosts two universities: Grambling State University and Louisiana Tech University. Due to the working relationship with the universities, the district leaders often strive to implement research-based practices in their schools. The district superintendent became interested in the Singapore Math approach after a visit to the laboratory school of Louisiana Tech University. The laboratory school was in its second year of implementation of Singapore Math in the 2009-2010 school year.

Singapore Math is most effective if initially implemented in the early primary grades and increased as children progress through each grade. Implementation in early grades is imperative because these are the years when foundational skills are mastered (Salerno, 2009). For this reason, leaders of the rural public school district of this study chose to implement Singapore Math in only selected kindergarten and first-grade classes for the 2010-2011 school year. Since first-grade is considered the foundation year for Singapore Math, first-grade was the focus of this study. The superintendent of the participating school district selected the schools to pilot Singapore Math. A total of seven schools were used in this project. Three schools piloted Singapore Math while four taught traditional math. A total of 410 first-grade students in the north Louisiana school district (of 6,710 students in grades kindergarten through twelfth grade) comprised the population of available participants (see Figure 4).

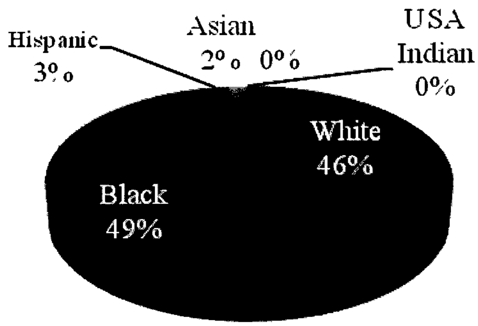
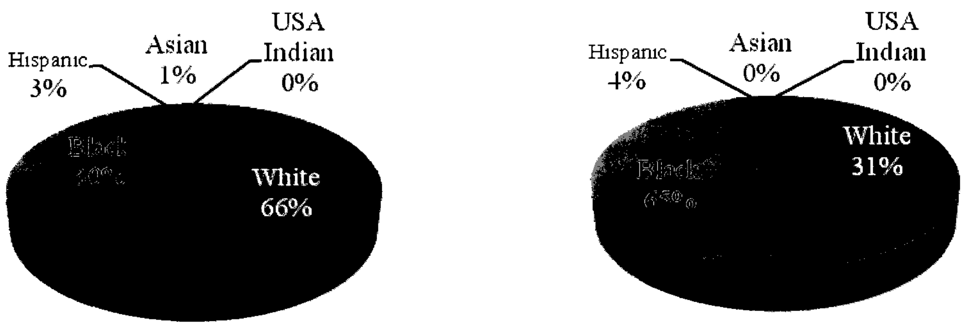


Figure 4. Participating district ethnic make-up/first-grade.

Although the Singapore Math and traditional math groups differed in ethnic make-up (see Figure 5) and the number of students receiving free and reduced lunches (see Figure 6), indicators of at-risk students, schools demonstrated similar achievement in mathematics on the Louisiana Educational Assessment Program for the 21st Century (LEAP 21) in 2009 (see Figure 7), the year this research began. LEAP 21 is the first standardized test elementary students take that determines whether they pass or fail the grade. This test is taken by fourth-grade students and is a culminating assessment of all skills learned in previous grades. Therefore, much importance is placed on LEAP 21 scores and the scores are often used to compare achievement among schools. While each class is different, scores from the LEAP 21 are the best available predictor of how first-graders in a particular school will perform in the future. Since this was the only school district piloting Singapore Math in the region available at the time of the study, this intact population was used.



Singapore Math Schools

Traditional Math Schools

Figure 5. Comparison of Singapore Math schools and traditional math schools ethnic make-up.

Procedural Details and Data Collection

Prior to data collection, the researcher gained permission to conduct the study from the Human Use Committee at Louisiana Tech University and the district superintendent. Permission was also obtained from each public elementary school principal as well as parents of participating students. All permission forms (see Appendix B) were securely stored in the office of the researcher. In addition to obtaining proper consent, the researcher solicited a teacher contact from each elementary school to oversee test administration at their respective schools. The researcher met separately with each of the seven teacher contacts to review data collection and confidentiality procedures. These teacher contacts then reviewed procedures with the first-grade teachers of the study.

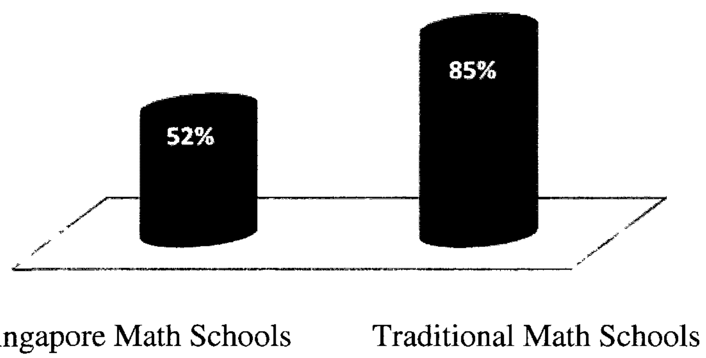


Figure 6. Free/reduced lunch comparison.

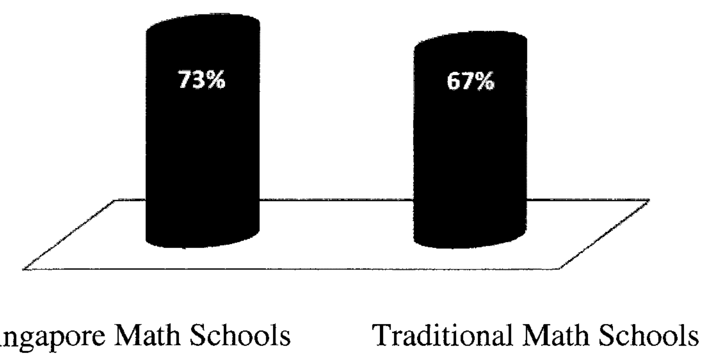


Figure 7. LEAP 21 passing rate comparison for fourth-grade students in 2009.

To further encourage uniformity in test administrations, a letter from the researcher with specific instructions for test administration and data collection was included in the testing instrument packets given to each teacher at each phase of the data collection (see Appendix C). The packet for the first phase of research included the following: (a) Human Subjects Consent Forms, (b) Teacher Response Forms, (c) Class List Form, (d) Math Enjoyment Inventories, and (e) Mixed skills pretests. Packets for the second phase included the following: (a) Previously completed Class List; to ensure only students with permission slips on file would participate, and (b) Mixed skills posttests.

In the first phase of research, a Math Enjoyment Inventory and a mixed skills pretest were administered by individual classroom teachers during the week of January 24, 2011. Due to research timelines, the pretest was not able to be administered at the onset of the school year. The mixed skills pretest evaluated participants' mathematics skills (knowledge) at this particular point in the school year. In the second phase of research, a mixed skills posttest was administered during the week of May 9, 2011. Thirteen weeks of instruction occurred between the first and second administration of the math knowledge tests. The posttest was administered in the latest possible week of the school year before year end class parties and field trips. During both phases of the study, the researcher traveled to each school to deliver testing instruments and to collect them at the completion of each phase.

To encourage honest responses from teachers and students, participant anonymity was assured. To protect student confidentiality, as required by the Institutional Review Board, no student names were written on any test instruments. This posed a problem because student pretest data could not be matched to posttest data. Thus, data were treated as group data instead of individual data for analysis. To protect teacher confidentiality, codes were used instead of teacher names to organize data throughout the study, and teacher names were not required on any document.

Instrumentation

Three instruments were used in this study: (a) a Math Enjoyment Inventory, (b) a mixed skills pretest, and (c) a mixed skills posttest. In addition, a Teacher Response Form enabled the researcher to collect descriptive data on teachers. The Math Enjoyment Inventory was adapted from the Math Interest Inventory developed by Little-Kaumo and Fritz (2001) (see Appendix E). Slight modifications made the instrument more suitable for first-grade students. Questions that were above the average first-grader's comprehension level were eliminated and directions were written more concisely. The format of the inventory was changed by enlarging the font and spacing the picture responses (to be circled), since the fine motor skills of young students are still developing. A panel of educators evaluated the modified inventory, and results from this evaluation will be discussed in further detail in the next subsection. For the modified inventory, a total score of 20 was possible. For each of the ten items, students were asked to circle a face symbol to depict their feelings about mathematics. A happy, neutral, or sad face was scored as +2, 0, -2 points, respectively.

The mixed skills pretest was obtained from a website for educators (Ed Helper, n.d.). Permission was granted by the representatives of the website to use the test materials. The pretest was designed to measure mathematical knowledge students should have acquired by the middle of the first-grade year, the point at which the pretest was administered (see Appendix F). The mixed skills pretest was selected for its ability to evaluate mathematics skills. The instrument was neutral to both Singapore Math and traditional math as it was not a testing instrument published with a mathematics series that either group was using in its daily learning. Nevertheless, the instrument satisfactorily aligned with numerous Grade Level Expectations (GLEs) for first-grade in Louisiana as well as standards from the National Council of Teachers of Mathematics (NCTM) (n.d.). Questions were eliminated from the original mathematics test obtained online in order to shorten the assessment. The original instrument had 20 questions; it was abbreviated to 15 questions for the purposes of this study. A total score of 16 was possible because one question required two responses. In addition, minor changes were made to the format of the test to improve the appearance of the instrument. It is important to note that a standardized assessment would be ideal; however, neither the district of the study nor the state of Louisiana uses a standardized test for first-grade.

A different knowledge test was used for the mixed skills posttest (see Appendix G). According to McMillian and Schumacher (2006), it is possible for the content of a testing instrument to raise awareness of a particular skill or item on the test. Consequently, the mixed skills posttest was designed in a manner to eliminate the possibility of students remembering test questions from the mixed skills pretest. The mixed skills posttest was created by the researcher using the mixed skills pretest as a guide. Test items were not created by the researcher but obtained directly from end-of-the-year first-grade assessments on the same website used to develop the mixed skills pretest. End-of-the-year test items were selected because the mixed skills posttest was administered at the end of the school year. The instrument was also neutral to both the

Singapore Math and traditional math students and aligned with GLEs for the first-grade in Louisiana and for National Council for Teachers of Mathematics standards.

Due to the uniqueness of the mixed skills pre and posttest instruments, careful consideration was given to the design of the posttest in order to successfully align the instruments. The instruments tested the same skills with a progression of difficulty from pretest item to posttest item. For example, the first four questions of the pretest assessed the knowledge of the students on place value regarding tens and ones; the first four questions on the posttest also assessed place value regarding tens and ones but required students to answer questions with a two step thought process to arrive at the solution. The fifth question on both mixed skills pre and posttest required students to identify the next shape in a pattern. The pretest item included simple shapes with the use of shading to define the pattern. The posttest item included more complex shapes without shading. Test items six through nine on each instrument (pretest and posttest) required students to identify numbers that come before or after certain numbers in a counting sequence. Pretest items included smaller numbers than posttest items. Test items ten through thirteen for both pretest and posttest consisted of addition and subtraction problems. On the pretest, single-digit items were included; on the posttest, double-digit items were utilized. On the final two test items, for both pretest and posttest, students were required to solve for missing numbers in a simple algebraic algorithm. On the pretest, pictures were used to aid in solving single-digit equations. On the posttest, no pictures were used to solve for the missing number on double-digit equations.

Reliability and Validity

Face validity was determined for the Math Enjoyment Inventory by consulting with a panel of experts. Eight educators (five practicing first-grade teachers and three university education professors) provided feedback on the instrument. The panel was asked to review the Math Enjoyment Inventory and complete a response form (see Appendix D). One evaluator turned in the response form after the deadline. Therefore, scores from the eighth evaluator were not included in the face validity calculation. Completion of the response form provided an opportunity for the evaluator to rate each question on a scale of one through ten to determine the appropriateness of each question in measuring mathematics enjoyment (see Table 2). In addition, evaluators were asked to rate the overall appropriateness of the instrument in measuring mathematics enjoyment. All seven evaluators rated the overall appropriateness of the instrument with a score of 10, the highest score possible. The Math Enjoyment Inventory, therefore, is considered to have a high level of face validity.

Table 2

Average Score for Math Enjoyment Inventory Questions Across Evaluators

Question	Score (Out of Ten)
1	9.86
2	9.3
3	10
4	9.57
5	9.71
6	10
7	10
8	10
9	10
10	9.57

Reliability of the Math Enjoyment Inventory was determined through a pilot study. One first-grade class (N=34) (not included in the study) was administered the Math Enjoyment Inventory on two separate occasions with nine days between each administration. A Pearson correlation coefficient (Pearson r) was calculated to determine the degree of agreement (reliability) between the two administrations of the Math Enjoyment Inventory. A strong positive correlation was found $r(24)=.799$, $p<0.01$, indicating that the instrument is highly reliable.

Limitations

Singapore Math is relatively new to the United States. Therefore, few school districts in the state of Louisiana have implemented Singapore Math as a mandatory curriculum. For this reason, the study was limited to one school district in north Louisiana. In addition, schools in the district using Singapore Math are in the early stage of implementation and have only kindergarten and first-grade students learning from this curriculum and approach to teaching; consequently, this study was limited to first-grade students.

CHAPTER 4

RESULTS

Introduction

The purpose of this study was to examine the effect of the Singapore Math curriculum and approach to teaching on student enjoyment and skills in mathematics, two components of the Singapore Math pentagon framework. The population of the study consisted of first-graders in one rural school district in north Louisiana. This district was in its first year of implementation of Singapore Math during the 2010-2011 school year. The superintendent chose three pilot schools while the remaining four elementary schools continued using more traditional approaches to teaching mathematics. Implementation of Singapore Math began in kindergarten and first-grade only. Since first-grade is considered the foundation year for Singapore Math, first-grade students were used as participants in the study. The results of the statistical analysis of data are reported in this chapter in relation to the two research questions proposed in Chapter 3. In addition, descriptive data about teachers are included.

Research Questions

The first research question assessed student enjoyment of mathematics. Enjoyment was measured using the Math Enjoyment Inventory. The Math Enjoyment Inventory included 10 questions that were read aloud by classroom teachers and required students to demonstrate how they felt about aspects of mathematics by circling a face symbol that depicted their feelings (see Appendix E). A happy, neutral, or sad face was scored as +2, 0, -2, respectively and allowed for the use of parametric statistics. This scoring allowed for inferences for enjoyment, or attitude, to be determined. If students circled more smile symbols than frown symbols, the overall score would be positive indicating a positive attitude towards mathematics. On the contrary, if students circled more frown symbols than smile symbols, the overall score would be negative indicating a negative attitude towards mathematics. A student score on the Math Enjoyment Inventory could range from +20 to -20.

The second research question assessed student mathematical knowledge. A mixed skills pretest (see Appendix F) and posttest (see Appendix G) were used to measure student skills/knowledge. Both the pretest and posttest included 15 test items. Each item was worth one point on each test (except a counting item, worth two points, that asked students to identify the numbers before and after a given number). A score of 16 points was possible on both the pre and posttest. The pre and posttest assessed the same skills with the exact number of test items representing each skill (such as place value, patterns, counting, addition, subtraction, and foundational algebra). These items represented important skills that students are expected to learn in the first grade, according to the National Council for Teachers of Mathematics (NCTM) and the Grade Level Expectations (GLEs) for first-grade set by the Louisiana Department of Education.

Teacher demographic information was obtained through a Teacher Response Form (see Appendix H). Teachers were asked to answer questions regarding the number of students in their class, years of teaching experience, years teaching mathematics, years teaching first-grade mathematics, hours of mathematics professional development received, and degrees obtained. Teachers were also asked to respond to one open-ended question that asked how they felt about teaching mathematics. Descriptive data are included in this chapter.

Sample

At the onset of this study, written permission to proceed was obtained from the district superintendent. The superintendent then helped to gain permission from each elementary school principal in the district, excluding the laboratory school because it was already in its third year of Singapore Math. A total of seven elementary schools participated in the study. All first-grade teachers at the seven elementary schools participated; however, class data from two teachers was excluded from the study because of improper completion of Human Subjects Consent Forms. Therefore, the sample included 22 classes.

Of the 410 Human Subjects Consent Forms sent home with first-grade students, 285 were returned for a return rate of 69.5 %. The student sample for the Math Enjoyment Inventory included 281 first-grade students; 4 students with permission forms on file were absent on the date the inventory was administered. The Singapore Math group contained 164 students, and the traditional math group contained 117 students. The student sample for the mixed skills pretest included 278 first-graders; 7 students were absent on the test administration day. The Singapore Math group contained 163 students and the traditional math group contained 115 students. The sample for the mixed skills posttest was 262 first-grade students. The Singapore Math group contained 157 students, and the traditional math group contained 105 students; 23 students were either absent or moved schools at the time the posttest was administered (see Table 3).

Table 3

Number of Participants by Group and Test

Test	Singapore Math	Traditional Math	Total
Math Enjoyment Inventory	164	117	281
Mixed Skills Pretest	163	115	278
Mixed Skills Posttest	157	105	262

Since confidentiality of participants was protected by anonymity, there was no way to remove pretest data for students failing to complete the posttest. Thus, all data received for the pretest was included in the analysis (N= 105 and 157 for traditional math group and Singapore Math group, respectively). The return rate was high, 91% of participants from the traditional math group and 96% of participants from the Singapore Math group completed both the pre and posttest. Thus, the use of group data rather than individual data is an accurate representation of the sample.

Hypothesis Testing

The first research question assessed student enjoyment of mathematics. The following null hypothesis was stated:

H1. There will be no significant difference between the scores on the Math Enjoyment Inventory for students taught Singapore Math and students taught traditional math.

Students were asked to respond to 10 statements regarding their feelings towards mathematics. Overall, the Math Enjoyment Inventory scores of both the Singapore Math group and the traditional math group indicated positive feelings about mathematics class. Furthermore, similar frequencies of responses were reported by both groups across statements (see Table 4). Students in the Singapore Math group and the traditional math group answered most favorably in regard to playing math games, working with a partner, learning new information, and being called on to answer mathematics questions. Other statements addressing addition, subtraction, and the explanation of the problem solving process received favorable scores. Working alone in math class and completing math homework received the lowest scores across groups although the scores still indicated positive feelings (see Table 5).

Table 4

Frequency of Responses by Group and Statement

Statement	Singapore Math			Traditional Math		
	☺	😐	☹	☺	😐	☹
1. Math class	120	27	17	92	15	10
2. Being called on to answer in math class	113	33	18	86	22	9
3. Working alone in math class	77	37	50	63	14	40
4. Working with a partner in math class	120	28	16	97	16	4
5. Doing math homework	82	41	41	69	15	33
6. Learning something new in math	130	25	9	96	12	9
7. Addition	112	29	23	80	19	18
8. Subtraction	95	50	19	79	19	19
9. Playing math games	149	8	7	107	6	4
10. Explaining how I solve problems	98	38	28	74	22	21
Frequency total	1,096	316	228	843	160	167

An independent *t*-test was calculated, comparing the inventory scores of students who were taught Singapore Math and students who were taught traditional math. Variability in scores was similar across group, and each group reported a broad range of scores. However, no significant difference was found $t(279) = .300$, $p > .05$. The mean of the students taught Singapore Math (M=10.59, SD= 7.96) was not significantly different than the mean of the students taught traditional math *(M*=11.56, *SD*=7.37). Therefore, the null hypothesis was accepted.

Table 5

Average Score by Group Across Statement

Statement	Singapore Math	Traditional Math
1. Math class	206	164
2. Being called on to answer in math class	190	154
3. Working alone in math class	54	46
4. Working with a partner in math class	208	186
5. Doing math homework	82	72
6. Learning something new in math	242	174
7. Addition	178	124
8. Subtraction	152	120
9. Playing math games	284	206
10. Explaining how I solve problems	140	106
Total points	1736	1352
Mean score	10.59 (*SD*=7.96)	11.56 (*SD*=7.37)

Note. The average scores across statements were obtained by multiplying the frequency for each question by the value assigned to each face symbol (+2, 0, -2). Mean scores for the two groups were calculated by dividing the total number of total points by the number of participants in each group. [a]Total points for the Singapore Math group were divided by 164. [b]Total points for the Traditional Math group were divided by 117.

The second research question assessed student mathematical skills. The following null hypothesis was stated:

H2. There will be no significant difference between the scores on the math skills test for students taught Singapore Math and students taught traditional math.

An independent *t*-test was calculated, comparing the pretest scores of students who were taught Singapore Math and students who were taught traditional math. A significant difference was found between the means of the two groups $t(276) = 4.72$, $p <$

.05. The mean of the students taught Singapore Math *(M*=13.47, *SD)*= 2.96 was significantly higher than the mean of the students taught traditional math *(M*=11.37, *SD*=4.50) for pretest scores. Therefore, to control for any differences between groups at the time of the pretest, an Analysis of Covariance (ANCOVA) was used on posttest data (see Table 6).

Table 6

Mean Score (Standard Deviation) for Mixed Skills Pretest and Posttest by Group

Singapore Math		Traditional math	
Pretest	Posttest	Pretest	Posttest
13.47 (*SD*=2.96)	12.80 (*SD*=3.08)	11.37 (*SD*=4.50)	10.80 (*SD*=3.11)

Upon scoring the pretests, erasures were noticed by the researcher. Multiple erasures could indicate teacher assistance on the test. A comparison was made between the percent of test items correct to the percent of erasures for each school and group. The number of erasures was similar across the seven schools and two groups. The comparison did not reveal any points of concern so no data was excluded from the study due to erasures (see Figure I.1.).

A 2(group) x 2(test) ANCOVA was performed on scores from the skills test using pretest as the covariate. Results indicated a significant main effect for group $F(1,259)=15.39$, $p<.05$. Similar variability in scores was reported, yet, posttest scores were higher for the Singapore Math group *(M*=12.8, *SD*=3.08) as compared to the traditional math group *(M*=10.8, *SD*=3.11). Additionally, Eta squared was =. 056 and Observed power=.974. The null hypothesis was rejected (see Table 6).

Teacher Demographic Data

In addition to the primary data obtained from students, teachers were asked to provide demographic information on a Teacher Response Form (see Table 7). Descriptive data provided by the teachers indicated that, overall, teachers in the Singapore Math group had been teaching more years than the traditional math group, had more hours of mathematics professional development, and obtained more advanced degrees. Most teachers in both groups reported a positive outlook on teaching mathematics; however, some teachers had concerns (see Appendix I). Few teachers did not answer the question regarding the hours of professional development. As a result, the numbers differed for that category.

As reported in this chapter, there was no apparent difference in enjoyment of mathematics between the students taught Singapore Math and the students taught more traditional math approaches. However, there was a significant difference between their math knowledge, or skills obtained; the students taught Singapore Math scored significantly higher on their mixed skills posttests. In addition, teacher demographic data indicated variance in teaching experience and education. The implications of these findings are discussed in chapter five.

Table 7

Descriptive Data from Teacher Response Form

		Teachers	
Question	Score	Singapore Math	Traditional Math
Number of Years Teaching	< 5	1	5
	5 - 10		5
	11 - 15	2	
	> 15	7	2
Number of Years Teaching Mathematics	< 5	1	5
	5 - 10	1	5
	11 - 15	1	
	> 15	7	2
Number of Years Teaching First-grade Mathematics	< 5	3	8
	5 - 10	3	3
	11 - 15		
	> 15	4	1
Hours of Participation in Mathematics Professional Development	< 10		8
	10 - 20	2	2
	21 - 30	1	
	> 30	3	
Highest Degree Obtained	Bachelors,	5	9
	Masters,	2	3
	Masters +30	3	

CHAPTER 5

FINDINGS AND RECOMMENDATIONS

Introduction

This study was designed to determine whether first-grade students taught Singapore Math enjoyed mathematics and demonstrated more knowledge of mathematics than students taught more traditional math approaches. In order to assess the impact of Singapore Math, a Math Enjoyment Inventory and mixed skills pre and posttest were utilized. In addition, supplemental descriptive data were gathered on participating teachers through the use of a Teacher Response Form. Findings and recommendations are discussed in this chapter.

Research Questions and Findings

The outcomes of this study showed student enjoyment in mathematics did not differ between the Singapore Math group and traditional math group. However, results indicated that first-grade students taught Singapore Math achieved higher scores on their mixed skills posttest than students taught a more traditional approach. Thus, Singapore Math students demonstrated more knowledge of mathematics than traditional math students.

Research question one was posed to determine if students taught Singapore Math differed from students taught traditional math in their enjoyment of mathematics. Earlier research indicates that student attitudes affect academic achievement (Ma and Kishor, 1997; Multon, Brown, & Lent, 1991). As a result, a positive attitude or enjoyment of mathematics is considered an important affective characteristic for a student to possess Emphasis on a positive attitude is depicted in the pentagon framework of the Singapore Math curriculum that fosters appreciation, interest, confidence, perseverance, and enjoyment of mathematics (Singapore Ministry of Education, 2006a). However, according to the results, the mean enjoyment score for students taught Singapore Math (M=10.59, SD=7.96) was not statistically different from the mean enjoyment score for students taught traditional math (M=11.56, SD=7.37) (see Tables 4 and 5).

Research question two was posed to determine if first-grade students taught Singapore Math differed from first-grade students taught traditional math in their knowledge of the subject. Singaporean students outperformed American students on the Trends in International Math and Science Study (TIMSS) conducted in 1995, 1999, and 2003. Many educators in America took notice and successfully implemented Singapore Math as their curriculum and approach to teaching (Begley, 2010; Buzzard 2010; Fox News Arizona, 2010; Gabriella & Paul Rosenbaum Foundation, 2009; Jordan, 2009; Ramsey, 2010; Stewart, 2009; Waight, 2006). The participating pilot schools of this study, which implemented Singapore Math in the fall of 2010, also demonstrated success. According to the mixed skills posttest scores, the mean of the students taught Singapore Math (M=12.8, SD=3.08) was significantly higher than the mean of the students taught traditional math (M=10.8, SD=3.11). The main effect for group was statistically significant (p<.05) (see Table 6).

To supplement the primary quantitative data collected, supplemental data were collected through the use of the Teacher Response Form which provided teacher demographic information and teacher feelings towards teaching mathematics (see Appendix H). Overall, the teachers using Singapore Math had taught mathematics longer, received more hours of mathematics professional development, and earned the highest degrees. The hours of mathematics professional development were obtained through Singapore Math training. The majority of teachers in this study enjoyed teaching mathematics, but few indicated concerns (see Appendix I).

Null Hypotheses

The null hypotheses tested in this study were as follows:

H1. There will be no significant difference between the scores on the Math Enjoyment Inventory for students taught Singapore Math and students taught traditional math. This hypothesis was accepted because there was no significant difference between these two groups.

H2. There will be no significant difference between the scores on the Math mixed skills test for students taught Singapore Math and students taught traditional math. This hypothesis was rejected because there was a significant difference between these two groups.

Limitations

Limitations of this study were as follows:

1. Few school districts in Louisiana have implemented Singapore Math.
2. Standardized tests scores were not available.

Singapore Math has only been used in the United States during the past decade. Although Singapore Math is rapidly gaining attention, few school districts in the country have implemented it as their curriculum and approach to teaching mathematics. In

Louisiana, the laboratory school at Louisiana Tech University was only the second school in the state to implement Singapore Math; the north Louisiana school district in this study learned of Singapore Math from this laboratory school. This district was one of the first to pilot Singapore Math, therefore, multiple districts across the state could not be studied.

It is often considered ideal to use standardized tests in research because validity and reliability have been previously determined. However, since the school district studied has only implemented Singapore Math in kindergarten and first-grade, no standardized assessments were available for such young students. Standardized testing begins at the third grade in Louisiana (few schools in the state had implemented Singapore Math in the third grade at the time of the study). Therefore, other testing materials were used.

Discussion

The news of Singapore Math is rapidly spreading in the United States. Although it has only been taught in America in recent years, school leaders are quickly deciding to try Singapore Math in an effort to elevate student learning in mathematics. Educators deciding on such an implementation are hoping their students can begin to experience success like the Singaporeans.

One aspect of Singapore Math studied in the rural school district in north Louisiana was enjoyment of mathematics. It is common to hear American students say that they 'hate' mathematics or are 'not good at' mathematics. This level of dissatisfaction is accepted much more than dislike or failure in subjects such as reading or social studies. Singapore Math, however, aims to instill appreciation, interest, confidence, perseverance, and enjoyment in students. Results of this study indicated that there was no significant difference in mathematics enjoyment between students taught Singapore Math and students taught traditional math.

The lack of difference could be due to factors beyond the researcher's control. For example, individual teacher personalities could have influenced students' enjoyment of the subject. Teachers who truly enjoy their profession usually exude an enthusiasm that is projected onto their students. In the same way, teachers who possess an appreciation and interest for their subject usually inspire their students to possess the same characteristics that can foster enjoyment.

Another point to consider is that Singapore Math teachers were new to this curriculum and approach to teaching. The year this research was conducted was the pilot year for Singapore Math, and the teachers were still learning how to best teach the curriculum. Their usual confidence and enthusiasm could have been affected by the uncertainty and anxiety that comes with change.

Student motivations were also beyond the researcher's control. First-graders have a desire to please their teacher, and students of this study may have felt uncomfortable reporting any negative feelings. Nevertheless, both groups reported a high level of enjoyment of mathematics that is to the credit of the teachers of the participating district.

The second aspect of Singapore Math studied was student knowledge, or skills. The results of this study confirm that Singapore Math did, in fact, elevate student learning of mathematical skills. Students' skills were likely improved because of the qualities of effective teaching and learning built into the curriculum and approach of Singapore Math. A common complaint of American educators is that material is taught "a mile wide and an inch deep" (Ginsburg et al., 2005, p. 41). In other words, much content is covered quickly, but it often is not covered sufficiently for students to arrive at a true understanding. One teacher from the traditional math group supported this notion by reporting the following on the Teacher Response Form: "I enjoy teaching math…but I feel we should teach less information each year so the students could retain more. I feel that we are cramming too much info too fast." Another teacher from the traditional math group expressed the same concern by explaining, "I do feel that our math series pushes the children too far too fast. The children do not master the material before having to move on to something." An opposite approach from this fast paced instruction is teaching concepts to mastery; a strength of the Singapore Math curriculum. By teaching to mastery, students are able to form a solid foundation of number sense before further learning is expected. This prevents learning gaps. When teaching to mastery, a relational understanding should be emphasized instead of simple memorization of rules.

Another strength of Singapore Math is that students are taught the "why" behind mathematics. To teach to this true understanding, a rich process of discussion, questioning, exploration, and reflection should also be present to aid students in constructing their own meanings. Through such processes metacognition is encouraged. In the Singapore Math curriculum and approach to teaching, students are taught to monitor their own thought processes and find multiple avenues to solve a problem. Lastly, effective teachers scaffold learning by teaching mathematics through the use of manipulatives and pictures before moving to abstract algorithms. This is evidenced in the concrete-pictorial-abstract approach to teaching lessons. Aforementioned qualities of effective teaching are all present in Singapore Math.

It is important to point out that the experience of the teachers, professional development received, and the degrees earned could have contributed to the success of the Singapore Math group. According to the demographic data obtained from the Teacher Response Form, teachers in the Singapore Math group had obtained more advanced degrees and had more experience teaching than the teachers in the traditional math group. Also, it is important to consider that teachers in the Singapore Math group received many hours of mathematics professional development as part of their training to implement the curriculum and approach to teaching. One might assume the traditional math students could have performed better if their teachers had the same resources and time spent to improving their practice through professional development, education, and teaching experience.

In addition to differences among teachers, student groups were also dissimilar. Differences in ethnic make-up exist and more students in the traditional math group were receiving free and reduced lunch, an indicator of poverty and factor to be considered in student achievement. All of the teacher and student factors previously discussed were beyond the researcher's control because an intact population had to be used.

The aforementioned differences could have potentially impacted the results of this study. Other factors surrounding the Singapore Math teachers could have also impacted the results. The Singapore Math teachers were in the pilot year of an implementation. In addition to attitudinal affects of an implementation, it is common for a decrease in student achievement to occur when implementing a new curriculum or approach in the classroom. Educators commonly refer to this phenomenon as an implementation dip. Student scores in the Singapore Math group surpassed the student scores in the traditional math group despite the pilot implementation, much to the credit of the Singapore Math teachers.

Finally, research began in January of the implementation year (2010-2011). From January to May a difference in scores was found. There possibly could have been a greater difference in student skills if the study could have begun in August instead of mid-year. All of the points previously mentioned could have affected the results of this study. These points for consideration were beyond the researcher's control for the current study, but could be considered and possibly controlled in further research.

Recommendations for Further Study

In order to add to the small body of research available on the effectiveness of Singapore Math in American schools, it is recommended that this study be replicated in other school districts as well as the district of study in the future. As time passes, rolling implementations of Singapore Math in the state of Louisiana will reach the upper elementary grades. This will provide an opportunity to compare students using state standardized tests. Also, since this study is quantitative in nature, a qualitative study would be beneficial to provide insight into the effectiveness of Singapore Math regarding student and teacher perceptions of the curriculum and approach to teaching.

The current study is important because it provides information to district leaders who are deciding to expand implementation to all elementary schools within the district. However, it would be beneficial to compare multiple school districts that are using Singapore Math and those that are using more traditional approaches. At the time of this research study, the option to research multiple districts in the region was not available.

With each new school year, more districts are piloting Singapore Math, and it is probable that this opportunity will soon arise.

Recommendations for Practice

This study did not find a significant difference in enjoyment between students taught Singapore Math and students taught traditional math. Nevertheless, it is important for teachers to continue to encourage positive attitudes in their students. Based on the research reviewed, it is recommended that teachers continually strive to create a comfortable, safe, and enjoyable learning environment for their students. Jensen (2005) states that emotions and student openness to learning are connected. There are no negative repercussions in creating such an environment, only happy and interested students primed to learn.

This study did indicate that teaching Singapore Math led to greater mathematics skills as compared to traditional math. Schools and districts implementing the curriculum and approach to teaching should start the implementation with kindergarten and first-grade only. Not only is this evidenced in the literature reviewed, but also in the experience of the participating school district. It is also recommended that district leaders or principals arrange ongoing professional development to support implementation, as did the district of the study. The participating district arranged for a two-day training session in the summer prior to the implementation in conjunction with a class at Louisiana Tech University in the fall of 2010.

Educators not looking to implement Singapore Math but hoping to improve instruction can learn much from its philosophy, approach, and curriculum framework. Teachers should teach at the pace of their students and ensure skills are mastered before moving on to more difficult skills. To do this, teachers should be in tune with student needs and progress as well as scaffold learning for their students. It is recommended that teachers incorporate the concrete-pictorial-abstract approach to teaching lessons. This is easy to implement because American mathematics teachers frequently use manipulatives and teach abstract algorithms. To bridge this learning gap, they could incorporate pictorial representations of real-life problems in their lessons. Additionally, teachers should focus on the process of student learning, not simply the end result by encouraging mathematical discussions. Finally, students should be encouraged to be deep thinkers by teaching them the "why" behind mathematical skills and showing students there is more than one way to solve a problem.

Summary

The purpose of this study was to examine the effect of Singapore Math curriculum and approach to teaching on student enjoyment of mathematics and mathematical knowledge. Results indicated that there was not a significant difference in student enjoyment between students taught Singapore Math and students taught traditional math. Results did, however, report that there is a significant difference in the mathematical skills between the two groups. The mathematics skills of students taught Singapore Math surpassed the skills of students taught more traditional math. Since schools throughout the United States all share a common goal of elevating student achievement and producing citizens that can succeed in a global society, it is important to consider if we should change how we teach mathematics. According to this study, three schools in a north Louisiana school district benefited from a change to Singapore Math. It is likely that the positive impact of Singapore Math will continued to be experienced.

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APPENDIX A

STUDY/PROJECT INFORMATION FOR HUMAN SUBJECTS COMMITTEE

STUDY/PROJECT INFORMATION FOR HUMAN SUBJECTS COMMITTEE
TITLE:
The Influence of the Singapore Math Program on Student Knowledge and Enjoyment in Mathematics

PROJECT DIRECTOR(S):
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PHONE: 318-255-2310 (home), 318-257-3469 (work), 318-773-0072 (cell)

DEPARTMENT(S): Education Department/Curriculum, Instruction, and Leadership

PURPOSE OF STUDY/PROJECT: To investigate the effect of the Singapore Math program on student enjoyment and knowledge in mathematics in one rural school district in north Louisiana.

SUBJECTS: 1st grade students in Lincoln District public schools (three public schools are implementing the Singapore Math program, and the others are using traditional math programs).

PROCEDURE: Approximately 500 first-grade students will voluntarily complete a Math Enjoyment Inventory and a mixed skills pretest and mixed skills posttest. Data will then be analyzed to determine if a difference exists in the enjoyment and knowledge of students learning from the Singapore Math program and the students learning from traditional math programs.

INSTRUMENTS AND MEASURES TO INSURE PROTECTION OF CONFIDENTIALITY, ANONYMITY:

Three instruments will be used in this study: (a) a Math Enjoyment Inventory, (b) a math mixed skills pretest, and (c) a math mixed skills posttest. The Math Enjoyment Inventory was adapted by the researcher from the Math Interest Inventory featured in *Figure This!* (2001), a publication by Little-Kaumo. This adaptation made the 10 items instrument more suitable for first-grade students. Face validity was established by a panel of educators (two university professors and five first-grade teachers), and a pilot test deemed the instrument reliable.

The fifteen items knowledge pretest and posttest were obtained from a website for educators (www.edhelpers.com). The first test is designed to measure mathematical knowledge a student should have acquired by the middle of the year in the first-grade. The second test is designed to measure student knowledge two months later in the school year. All collected information will be held confidential.

RISKS/ALTERNATIVE TREATMENTS: Participants are not at risk by participating in this study. Research procedures are similar to everyday activities in a first-grade classroom.

BENEFITS/COMPENSATION: This study will benefit educators in the Lincoln District Schools. School district leaders will decide the effectiveness of the Singapore Math program in meeting the needs of their student population before a full implementation in future school years. Determining the effectiveness of the Singapore Math program in increasing student enjoyment in mathematics and increasing student knowledge in mathematics would provide the district educators with useful information in the critical pilot year of implementation of the Singapore Math program. No compensation will occur.

SAFEGUARDS OF PHYSICAL AND EMOTIONAL WELL-BEING: This study involves no treatment or physical contact. Participants will provide anonymous answers to all instruments. No names of students will be needed. Completed instruments and informed consent forms (completed by the parent of each participating student and school principals) will be kept strictly confidential.

LOUISIANA TECH
UNIVERSITY
MEMORANDUM

OFFICE OF UNIVERSITY RESEARCH

TO Mrs Jenny Blalock and Dr Carrice Cummins

FROM Barbara Talbot, University Research

SUBJECT HUMAN USE COMMITTEE REVIEW

DATE January 14, 2011

In order to facilitate your project, an EXPEDITED REVIEW has been done for your proposed study entitled

"The Influence of the Singapore Math Program on Student Knowledge and Enjoyment in Mathematics"

 # HUC-826

The proposed study's revised procedures were found to provide reasonable and adequate safeguards against possible risks involving human subjects The information to be collected may be personal in nature or implication Therefore, diligent care needs to be taken to protect the privacy of the participants and to assure that the data are kept confidential Informed consent is a critical part of the research process The subjects must be informed that their participation is voluntary It is important that consent materials be presented in a language understandable to every participant If you have participants in your study whose first language is not English, be sure that informed consent materials are adequately explained or translated Since your reviewed project appears to do no damage to the participants, the Human Use Committee grants approval of the involvement of human subjects as outlined

Projects should be renewed annually ***This approval was finalized on January 14, 2011 and this project will need to receive a continuation review by the IRB if the project, including data analysis, continues beyond January 14, 2012*** Any discrepancies in procedure or changes that have been made including approved changes should be noted in the review application Projects involving NIH funds require annual education training to be documented For more information regarding this, contact the Office of University Research

You are requested to maintain written records of your procedures, data collected, and subjects involved These records will need to be available upon request during the conduct of the study and retained by the university for three years after the conclusion of the study If changes occur in recruiting of subjects, informed consent process or in your research protocol, or if unanticipated problems should arise it is the Researchers responsibility to notify the Office of Research or IRB in writing The project should be discontinued until modifications can be reviewed and approved

If you have any questions, please contact Dr Mary Livingston at 257-4315

APPENDIX B

PERMISSION REQUEST FORMS

HUMAN SUBJECTS CONSENT FORM/SUPERINTENDENT

The following is a brief summary of the project in which you are asked to participate. Please read this information before signing the statement below.

TITLE OF PROJECT: *The Influence of the Singapore Math Program on Student Knowledge and Enjoyment in Mathematics*
PURPOSE OF STUDY/PROJECT: The purpose of this study is to investigate the effect of the Singapore Math program on student enjoyment and skills in mathematics in one rural school district in north Louisiana
PROCEDURE: Approximately 500 first-grade students will voluntarily complete a Math Enjoyment Inventory and a mixed skills pretest and knowledge posttest Data will then be analyzed to determine if a difference exists in the enjoyment and knowledge of students learning from the Singapore Math program and the students learning from traditional math programs
INSTRUMENTS: Three instruments will be used in this study (a) a Math Enjoyment Inventory, (b) a math mixed skills pretest, and (c) a math mixed skills posttest The Math Enjoyment Inventory was adapted by the researcher from the Math Interest Inventory featured in *Figure This!* (2001), a publication by Little-Kaumo This adaptation made the 10 items instrument more suitable for first-grade students Face validity was established by a panel of educators (two university professors and five first-grade teachers), and a pilot test deemed the instrument reliable The fifteen items knowledge pretest and posttest were obtained from a website for educators (www edhelpers com) The first test is designed to measure mathematical knowledge a student should have acquired by the middle of the year in the first-grade The second test is designed to measure student knowledge two months later in the school year All collected information will be held confidential
RISKS/ALTERNATIVE TREATMENTS: Participants are not at risk by participating in this study Research procedures are similar to everyday activities in a first-grade classroom
BENEFITS/COMPENSATION: This study will benefit educators in the Lincoln District Schools School district leaders will decide the effectiveness of the Singapore Math program in meeting the needs of their student population before a full implementation in future school years Determining the effectiveness of the Singapore Math program in increasing student enjoyment in mathematics and increasing student knowledge in mathematics would provide the district educators with useful information in the critical pilot year of implementation of the Singapore Math program No compensation will occur

I, _________________________, attest with my signature that I have read and understood the following description of the study, "The Influence of the Singapore Math Program on Student Knowledge and Enjoyment in Mathematics", and its purposes and methods I understand that my district's participation in this research is strictly voluntary Further, I understand that students may withdraw at any time or refuse to answer any questions without penalty Upon completion of the study, I understand that the results will be freely available to me upon request I understand that the results of my district's Math Enjoyment Inventories as well as results from the pretests and posttests will be confidential, accessible only to the principal investigators, myself, or a legally appointed representative (The district's name will not be used in the published dissertation) I have not been requested to waive, nor do I waive any of my rights related to participating in this study

______________________________ ____________

Signature of Superintendent Date

CONTACT INFORMATION

The principal experimenters listed below may be reached to answer questions about the research, subjects' rights, or related matters

Mrs Jenny Blalock (318-257-3469)

Members of the Human Use Committee of Louisiana Tech University may also be contacted if a problem cannot be discussed with the experimenters

Dr Les Guice (257-3056)

Dr Mary M Livingston (257-2292 or 257-4315)

HUMAN SUBJECTS CONSENT FORM/PRINCIPAL

The following is a brief summary of the project in which you are asked to participate. Please read this information before signing the statement below.

TITLE OF PROJECT: *The Influence of the Singapore Math Program on Student Knowledge and Enjoyment in Mathematics*

PURPOSE OF STUDY/PROJECT: The purpose of this study is to investigate the effect of the Singapore Math program on student enjoyment and skills in mathematics in one rural school district in north Louisiana.

PROCEDURE: Approximately 500 first-grade students will voluntarily complete a Math Enjoyment Inventory and a mixed skills pretest and mixed skills posttest. Data will then be analyzed to determine if a difference exists in the enjoyment and knowledge of students learning from the Singapore Math program and the students learning from traditional math programs.

INSTRUMENTS: Three instruments will be used in this study: (a) a Math Enjoyment Inventory, (b) a math mixed skills pretest, and (c) a math mixed skills posttest. The Math Enjoyment Inventory was adapted by the researcher from the Math Interest Inventory featured in *Figure This!* (2001), a publication by Little-Kaumo. This adaptation made the 10 items instrument more suitable for first-grade students. Face validity was established by a panel of educators (two university professors and five first-grade teachers), and a pilot test deemed the instrument reliable. The fifteen items mixed skills pretest and posttest were obtained from a website for educators (www.edhelpers.com). The first test is designed to measure mathematical knowledge a student should have acquired by the middle of the year in the first-grade. The second test is designed to measure student knowledge two months later in the school year. All collected information will be held confidential.

RISKS/ALTERNATIVE TREATMENTS: Participants are not at risk by participating in this study. Research procedures are similar to everyday activities in a first-grade classroom.

BENEFITS/COMPENSATION: This study will benefit educators in Lincoln district. School district leaders will decide the effectiveness of the Singapore Math program in meeting the needs of their student population before a full implementation in future school years. Determining the effectiveness of the Singapore Math program in increasing student enjoyment in mathematics and increasing student knowledge in mathematics would provide the district educators with useful information in the critical pilot year of implementation of the Singapore Math program. No compensation will occur.

I, ________________________, attest with my signature that I have read and understood the following description of the study, "The Influence of the Singapore Math Program on Student Knowledge and Enjoyment in Mathematics", and its purposes and methods. I understand that my school's participation in this research is strictly voluntary. Further, I understand that my school may withdraw at any time or refuse to answer any questions without penalty. Upon completion of the study, I understand that the results will be freely available to me upon request. I understand that the results of my school's Math Enjoyment Inventories as well as results from the pretests and posttests will be confidential, accessible only to the principal investigators, myself, or a legally appointed representative. I have not been requested to waive nor do I waive any of my rights related to participating in this study.

______________________________   ____________

Signature of Principal   Date

CONTACT INFORMATION:
The principal experimenters listed below may be reached to answer questions about the research, subjects' rights, or related matters.

Mrs. Jenny Blalock (318-257-3469)

Members of the Human Use Committee of Louisiana Tech University may also be contacted if a problem cannot be discussed with the experimenters:

Dr. Les Guice (257-3056)

Dr. Mary M. Livingston (257-2292 or 257-4315)

HUMAN SUBJECTS CONSENT FORM/PARENT

The following is a brief summary of the project in which you are asked to participate. Please read this information before signing the statement below.

TITLE OF PROJECT: *The Influence of the Singapore Math Program on Student Knowledge and Enjoyment in Mathematics*

PURPOSE OF STUDY/PROJECT: The purpose of this study is to investigate the effect of the Singapore Math program on student enjoyment and skills in mathematics in one rural school district in north Louisiana.

PROCEDURE: Approximately 500 first-grade students will voluntarily complete a Math Enjoyment Inventory and a knowledge pretest and knowledge posttest. Data will then be analyzed to determine if a difference exists in the enjoyment and knowledge of students learning from the Singapore Math program and the students learning from traditional math programs.

INSTRUMENTS: Three instruments will be used in this study: (a) a Math Enjoyment Inventory, (b) a math mixed skills pretest, and (c) a math mixed skills posttest. The Math Enjoyment Inventory was adapted by the researcher from the Math Interest Inventory featured in *Figure This!* (2001), a publication by Little-Kaumo. This adaptation made the 10 items instrument more suitable for first-grade students. Face validity was established by a panel of educators (two university professors and five first-grade teachers), and a pilot test deemed the instrument reliable. The fifteen items mixed skills pretest and posttest were obtained from a website for educators (www.edhelpers.com). The first test is designed to measure mathematical knowledge a student should have acquired by the middle of the year in the first-grade. The second test is designed to measure student knowledge two months later in the school year. All collected information will be held confidential.

RISKS/ALTERNATIVE TREATMENTS: Participants are not at risk by participating in this study. Research procedures are similar to everyday activities in a first-grade classroom.

BENEFITS/COMPENSATION: This study will benefit educators in Lincoln district. School district leaders will decide the effectiveness of the Singapore Math program in meeting the needs of their student population before a full implementation in future school years. Determining the effectiveness of the Singapore Math program in increasing student enjoyment in mathematics and increasing student knowledge in mathematics would provide the district educators with useful information in the critical pilot year of implementation of the Singapore Math program. No compensation will occur.

I, ________________________, attest with my signature that I have read and understood the following description of the study, "The Influence of the Singapore Math Program on Student Knowledge and Enjoyment in Mathematics", and its purposes and methods. I understand that my child's participation in this research is strictly voluntary. Further, I understand that my child may withdraw at any time or refuse to answer any questions without penalty. Upon completion of the study, I understand that the results will be freely available to me upon request. I understand that the results of my child's Math Enjoyment Inventory as well as results from the pretest and posttest will be confidential, accessible only to the principal investigators, myself, or a legally appointed representative. I have not been requested to waive nor do I waive any of my rights related to participating in this study.

______________________________ ____________

Signature of Participant or Guardian Date

CONTACT INFORMATION:
The principal experimenters listed below may be reached to answer questions about the research, subjects' rights, or related matters.

Mrs. Jenny Blalock (318-257-3469)

Members of the Human Use Committee of Louisiana Tech University may also be contacted if a problem cannot be discussed with the experimenters:

Dr. Les Guice (257-3056)

Dr. Mary M. Livingston (257-2292 or 257-4315)

p. 2 Permission Request Form

Name of person requesting permission: Jenny Blalock
Date: 6/9/11

☒ Permission granted for the following request(s):

- Inclusion of pages 14 and 15 from Word Problems for Model Drawing Practice, Level 1, by Catherine Jones Kuhns, in dissertation.

Please add the following credit line to all reproduced material:

☐ Permission denied.

- Name of work: ______________________________

☐ We do not hold copyright to this material. Please contact:

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☐ Other Reason: ______________________________

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☐ We do not hold the copyright on this material. Please contact:

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☐ Other Reason: ______________________________

Miscellaneous Notes:

Permission granted is for a one time use. You will need to reapply for permission for any future use.
Good luck with your dissertation.

[signature]
SDE/CSB Permissions Department

APPENDIX C

RESEARCH PHASES I AND II TEACHER LETTERS

Dear Teachers,

Thank you for participating in the study of first grade students' mathematical skills and enjoyment of math in our district Below you will find administration information for Phase I of our study Please contact me with any questions

Jenny Blalock
A E Phillips, 1st grade
257-3469 jblalock@aep latech edu

Phase I Directions

1 **Send home Human Subjects Consent Forms immediately.** IMPORTANT Students may not participate in the study unless this permission form is signed by a parent or guardian Please consider incentives that may encourage participation All teachers who have **100% participation** will have their names put in a drawing for a School Aids gift card
2 Complete Teacher Response Form (No names please)
3 Complete Class List Form
4 Administer Math Enjoyment Inventory after permission forms are returned
   a Pass out Math Enjoyment Inventory (No names please)
   b Read directions aloud
   c Read each statement and allow students time to circle the face that represents their feelings For example, for item one the teacher would say "This is how I feel about math class "
   d Repeat for items 1-10
   e Collect Math Enjoyment Inventories from students
5 Administer mixed skills pretest
   a Pass out mixed skills pretest (No names please)
   b For each section, read directions and assessment items aloud Allow time for students to answer each item before moving on to the next Please do not give "hints" if a student struggles on a problem Simply, encourage them to do their best

---

Completed Envelope Checklist

_____ Signed Human Subjects Consent Forms (papers clipped together)
_____ Completed Teacher Response Form
_____ Completed Math Enjoyment Inventories (papers clipped together)
_____ Completed mixed skills pretests (papers clipped together)
_____ Class list (only those with permission slip signed)

Complete all forms and return your envelope to the teacher contact at your school by January 27, 2010

Dear Teachers,

Thank you again for participating in the study of first-grade students' mathematical skills and enjoyment of math in our district. Below you will find administration information for Phase II of our study. Please contact me with any questions.

Jenny Blalock
A. E. Phillips, 1st grade
257-3469: jblalock@aep.latech.edu

Phase II Directions:

IMPORTANT NOTE: Only students on your Class List Form may participate in Phase II of the study. (See Class List Form Returned to you with Phase II materials.) These are the students that have a signed Human Subjects Consent Form on file that was returned to me during Phase I.

1. Review class list you completed in Phase I of the study to determine which students will be participating.

2. Administer mixed skill posttest
   a. Pass out mixed skills posttest (No names please.)
   b. For each section, read directions and assessment items aloud. Allow time for students to answer each item before moving on to the next. **Please do not give "hints" if a student struggles on a problem. Simply, encourage them to do their best.**

Completed Envelope Checklist:

_____ Completed mixed skills posttests of only those students on class list (papers clipped together)
_____ Class List Form

Complete all forms and return your envelope to the teacher contact at your school by Thursday, May 12, 2011.

APPENDIX D

MATH ENJOYMENT INVENTORY PREPARATORY DOCUMENTS

October 23, 2010

Dear First-grade Teachers and University Math Instructors,

I am a doctoral student in the *Louisiana Education Consortium*, and I am studying first-grade students' mathematical skills and enjoyment of math as a function of the curriculum being used in a particular school. In an effort to establish face validity on the *Math Enjoyment Inventory* to be used in my research, I have selected a group of educators to provide feedback on the instrument. You were selected because of your commitment to teaching mathematics and improving practice.

Attached you will find the *Math Enjoyment Inventory* designed to assess the feelings of first-graders on a variety of mathematical topics. The ten question inventory will be read aloud to first-grade students selected for the study, and the students will be asked to circle the face that represents their feelings about each statement (☺😐☹). I will score each item by giving points for each response.

Also attached you will find a *Math Enjoyment Inventory Response Form* that asks you how appropriate the items are in measuring math enjoyment. You are asked to evaluate the overall appropriateness of the entire inventory. Directions for completion of the form are provided. You may email me upon completion, and I will pick it up from your office/school. If possible, please complete by Nov. 1, 2010.

Thank you for taking time to assist me in my research endeavors. I truly appreciate your feedback.

Sincerely,

Jenny T. Blalock
1st grade teacher
A. E. Phillips Laboratory School
jblalock@aep.latech.edu

Math Enjoyment Inventory Response Form

Please carefully consider each question on the Math Enjoyment Inventory in regards to the appropriateness of each item in measuring math enjoyment. Then, respond by circling the number on the scale that corresponds with the degree you believe each question measures mathematics enjoyment. A score of ten represents a high degree of appropriateness, and a score of zero represents the item is not appropriate in measuring mathematics enjoyment. Please provide corrective feedback on any test items you feel are not appropriate. In addition, please consider the overall appropriateness of the Math Enjoyment Inventory. Provide a response concerning the appropriateness of the instrument as a whole in measuring mathematics enjoyment

.

Question	Appropriate for measuring Math enjoyment										Not appropriate for measuring Math Enjoyment
1	10	9	8	7	6	5	4	3	2	1	0
2	10	9	8	7	6	5	4	3	2	1	0
3	10	9	8	7	6	5	4	3	2	1	0
4	10	9	8	7	6	5	4	3	2	1	0
5	10	9	8	7	6	5	4	3	2	1	0
6	10	9	8	7	6	5	4	3	2	1	0
7	10	9	8	7	6	5	4	3	2	1	0
8	10	9	8	7	6	5	4	3	2	1	0
9	10	9	8	7	6	5	4	3	2	1	0
10	10	9	8	7	6	5	4	3	2	1	0

Comments:

	Appropriate for measuring Math enjoyment										Not appropriate for measuring Math enjoyment
The Math Enjoyment Inventory as a whole	10	9	8	7	6	5	4	3	2	1	0

Comments:

APPENDIX E

MATH ENJOYMENT INVENTORY

Math Enjoyment Inventory

Directions: For each statement, circle the face that matches how you feel about the statement.

This is how I feel about:

1. Math Class ....

2. Being called on to answer in math class........

3. Working alone in math class......................

4. Working with a partner in math class...........

5. Doing math homework..............................

6. Learning something new in math................

7. Addition ....

8. Subtraction..

9. Playing math games ....

10. Explaining how I solve problems................

APPENDIX F

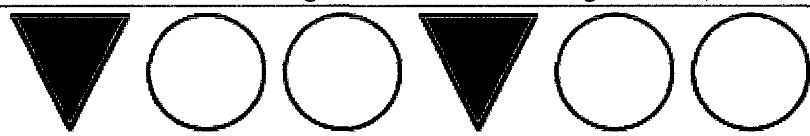
MIXED SKILLS PRETEST

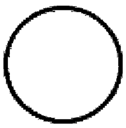
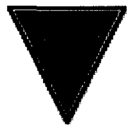
Mixed Skills Pretest

Write the number.
(Mathematics GLE 2, 5/ NCTM Number and Operations and Problem Solving standards)

1. 3 tens and 7 ones = ______	2. 1 ten and 6 ones = ______
3. 1 ten and 1 one = ______	4. 4 tens and 9 ones = ______

Select the shape that comes next in the pattern.
(Mathematics GLE 36/ NCTM Algebra and Problem Solving standards)

5.  ______

(A)  (B) 

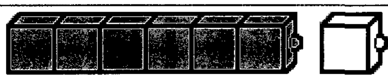
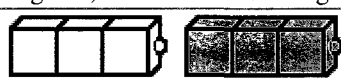
Fill in the missing numbers.
(Mathematics GLEs 2, 10, 11/ NCTM Number and Operations and Problem Solving standards)

6. Just before _____, 37, 38	7. Between 27, _____, 29
8. Just before and after _____, 45, _____	9. Just after 56, 57, _____

Write the sum or difference.
(Mathematics GLEs 2, 12/ NCTM Number and Operations and Problem Solving standards)

10. $\begin{array}{r} 7 \\ \underline{+3} \end{array}$	11. $\begin{array}{r} 3 \\ \underline{+1} \end{array}$	12. $\begin{array}{r} 6 \\ \underline{-2} \end{array}$	13. $\begin{array}{r} 8 \\ \underline{-2} \end{array}$

Fill in the missing number to complete the addition fact.
(Mathematics GLEs 2, 19/ NCTM Number and Operations, Algebra, and Problem Solving standards)

14.  6 + _____ = 7	15.  _____ + 3 = 6

APPENDIX G

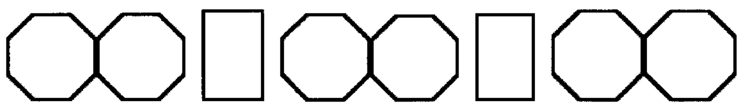
MIXED SKILLS POSTTEST

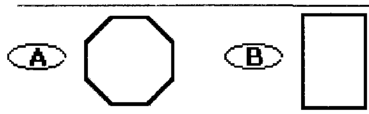
Mixed Skills Posttest

Circle the smaller number in each set.
(Mathematics GLE 5/ NCTM Number and Operations and Problem Solving standards)

1. 1 ten and 4 ones 4 tens and 3 ones	2. 3 tens and 6 ones 2 tens and 1 one
3. 2 tens 9 ones	4. 3 tens and 8 ones 1 ten and 2 ones

Select the shape that comes next in the pattern.
(Mathematics GLE 36/ NCTM Algebra and Problem Solving standards)

5.  ____



Fill in the missing numbers.
(Mathematics GLEs 2, 10, 11/ NCTM Number and Operations and Problem Solving standards)

6. Just before _____, 69, 70	7. Between 76, _____, 78
8. Just before and after _____, 94, _____	9. Just after 100, 99, _____

Write the sum or difference.
(Mathematics GLEs 2, 12/ NCTM Number and Operations and Problem Solving standards)

10. 4 2 + 3 5	11. 5 6 + 2 2	12. 7 9 - 4 4	13. 8 7 - 1 6

Fill in the missing number to complete the addition fact.
(Mathematics GLEs 2, 19/ NCTM Number and Operations, Algebra, and Problem Solving standards)

14. $\boxed{}$ + 3 9 9	15. $\boxed{}$ + 5 8 6

APPENDIX H

TEACHER RESPONSE FORM

Teacher Response Form

Number of students in your class	
Number of students participating in the study (parent permission form received)	
Number of years teaching	
Number of years teaching mathematics	
Number of years teaching 1st grade mathematics	
Hours of participation in mathematics professional development	
Degrees and certifications obtained	

Please describe your feelings towards teaching mathematics.

____

____

____

____

APPENDIX I

SUPPLEMENTAL DATA

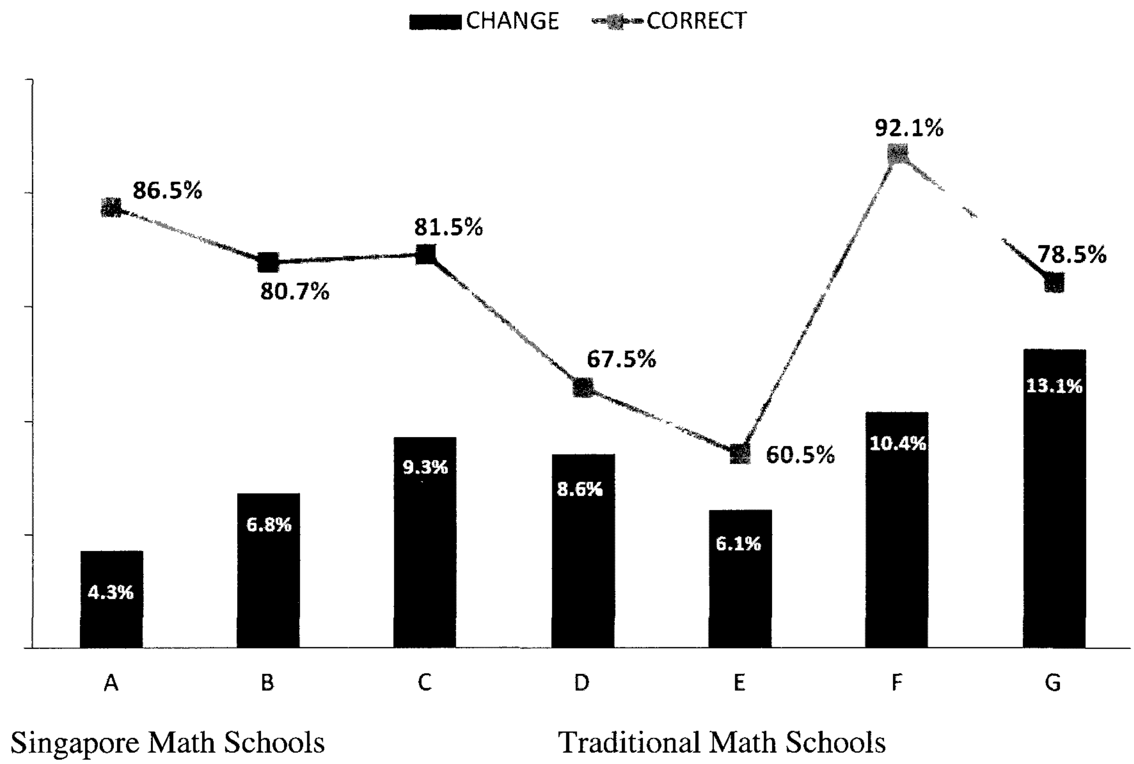


Figure I.1. Pretest responses/percent changed vs percent correct.

Singapore Math Teachers' Feelings About Teaching Math
(Obtained from the Teacher Response Form)

"Math is easy to teach because there are so many fun things you can do and use to teach it."

"I love teaching math. This has been a challenging year because Singapore Math has been very difficult for several of my students to grasp."

"Math is my favorite subject to teach. I love using many hands-on manipulatives in my classroom to make math meaningful for my students."

"I enjoy teaching math and seeing the children respond positively."

"I like teaching math especially Singapore Math."

"Math is one of my favorite subjects to teach. I especially enjoy it when the material is such that it can be hands-on."

" I love teaching math. I have taught math at all grade levels k-6th."

"I love the manipulatives and opportunities to relate math to daily activities. Math is all around us. Students enjoy supplemental math activities and games."

"Love it!"

"One of my favorite things to teach."

"I enjoy teaching math. Most students tend to enjoy math than any other subject."

Traditional Math Teachers' Feelings About Teaching Math
(Obtained from the Teacher Response Form)

"Math is not my most comfortable subject to teach. I would like to be involved in more professional development workshops."

"Love it! Hope to help kids have an early appreciation and fondness for math."

"I like teaching mathematics. It is challenging and I like to see the aha moment when children actually get what it is all about. I like the strategies used now as opposed to when I was in school 39 years ago."

"I can teach math all day."

"I prefer ELA over math. I enjoy teaching math when all the students get it, but I struggle in my reteaching."

"I would love the opportunity to teach more of it, but it seems there is never enough time to effectively teach mathematics."

"I enjoy teaching math…but I feel we should teach less information each year so the students could retain more. I feel that we are cramming too much info too fast."

"I enjoy teaching many of the Comprehensive Curriculum Activities. I do feel that our math series pushes the children too far too fast. The children do not master the material before having to move on to something."

"I enjoy watching students learn about the world of numbers. Math is an easy subject for me to teach because it is never boring. I can always find a fun, interesting way to a concept. I also like the repetition and cumulative aspect of math."

"I love watching them discover and understand math and numbers through manipulatives and hands-on learning. I feel they grasp the concept more when they can manipulate objects to represent the numbers in addition and subtraction problems. I always will find a fun, interesting way to present the math concept."

"I enjoy teaching math, but I enjoy ELA more. I prefer our math book (Houghton-Mifflin) to the Comprehensive Curriculum."

"Love math-love teaching math concepts!"