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A comparison of elementary mathematics achievement in everyday math and saxon math schools in illinois

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A COMPARISON OF ELEMENTARY MATHEMATICS
ACHIEVEMENT IN EVERYDAY MATH AND
SAXON MATH SCHOOLS IN ILLINOIS

A dissertation

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Department of Educational Leadership

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ABSTRACT

This study compared mathematics achievement in Illinois elementary schools using the *Everyday Math* and *Saxon Math* curricula. The Illinois Standards Achievement Test (ISAT) was used as the measure of student achievement. Multiple correlation analyses showed that the type of curriculum used was a significant predictor of mathematics achievement at the third and fifth grade levels. *Everyday Math* was found to support greater student achievement in these grades. When holding other variables constant, *Everyday Math* schools can be expected to have an average of 2.1% more questions correct on the multiple choice portion of the ISAT than *Saxon Math* schools at the third grade level. At the fifth grade level, *Everyday Math* schools are predicted to have an average of 4.3% more questions correct than *Saxon Math* schools. The type of curriculum used was not a significant predictor at the fourth grade level.

Analysis of student achievement by subgroup found that *Everyday Math* supported significantly greater student achievement than *Saxon Math* for White students in third and fifth grades, non-Asian minorities in fifth grade, girls in third grade, non low-income students in third grade, and non-IEP students in third grade.

Multiple correlation analyses for content strands found that curriculum was a significant predictor for elementary student achievement on each mathematics content strand tested in Illinois. *Everyday Math* was found to support significantly greater student achievement for each content strand. After analyzing the correlation coefficients

for curriculum, schools using *Everyday Math* were found to have between 2.1% and 3.5% more questions correct on the content strand portions of the ISAT.

Though *Saxon Math* was not found to support significantly greater achievement in any area statistically, average scores for low-income students using *Saxon Math* were better than those of low-income students using *Everyday Math* at each grade level. This suggests a potential weakness of the *Everyday Math* curriculum.

PREFACE

This dissertation was undertaken for a variety of reasons. I have worked in a university mathematics department in Illinois for the past nine years and taught many math education courses to elementary and middle-level education majors. Some of these students come to college with deficiencies in procedural skills and others struggle with understanding topics conceptually. The two curricula examined in this study have reputations that are quite different. *Everyday Math* is known for its emphasis on teaching for understanding, and *Saxon Math* has a reputation of producing students with excellent procedural fluency. As a student myself, I was exposed to *Saxon Math* in middle school and another curriculum in high school that had a stronger focus on understanding.

My goal was to see which curriculum supported greater student achievement in Illinois. Results may help school administrators evaluate mathematics curricula and make program selections. In my field, results help to determine areas of emphasis that are needed in the courses we offer for education majors.

ACKNOWLEDGMENTS

I would like to thank the many supporters that I had during the writing of this dissertation. My wife, daughter, family, and friends have shown nothing but love and encouragement throughout this project, giving me space and time to work alone when I needed to and pulling me away at times for much needed breaks. I have been lucky throughout life to have people around who value education greatly and support any efforts on my part to continue to take classes and learn new things.

Academically, I give a toast to my English and mathematics teachers from middle school to graduate school. It takes considerable writing ability and mathematical understanding to complete a quantitative dissertation, and many excellent teachers have helped to polish those skills over the years.

Finally, I would like to thank my dissertation committee. My advisor, Dr. Terry McDaniel, has been critical in keeping me on schedule and providing guidance throughout the process. The other committee members, Dr. Corey and Dr. Gruenert, have also been essential in giving advice and direction.

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CHAPTER 1

INTRODUCTION TO THE STUDY

In 1989, the National Council of Teachers of Mathematics (NCTM) released *Curriculum and Evaluation Standards in School Mathematics (Standards)*. The *Standards* called for an increase in technology use, discovery learning, group work, communication, and conceptual understanding with a de-emphasis on paper-and-pencil calculations, teaching by telling, and memorization of rules and algorithms (Latterell, 2005; Ocken, 2001; Peressini, Knuth, Morrow, & Kenney, 1998). After the release of the *Standards*, the National Science Foundation (NSF) began supporting the creation and development of curricula aligned to the NCTM *Standards* (Klein, 2003). *Everyday Math* was one such elementary curriculum that has grown in popularity since the release of the first edition in 1998, and can be found in over 185,000 classrooms across the country (University of Chicago School Mathematics Project [UCSMP], n.d.a).

Though *Everyday Math* has grown in popularity, many schools have maintained a more traditional approach, placing greater value on direct instruction, memorization, and repetition with standard arithmetic procedures. *Saxon Math* is a popular choice throughout the country for elementary schools choosing more traditional mathematics curricula (Slavin & Lake, 2008).

Across the United States and in the State of Illinois, the approach to teaching mathematics at the elementary level can vary greatly (Usiskin, 2010). Elementary schools adopting traditional programs emphasize the traditional algorithms for arithmetic, with a focus on drill-and-practice of computational skills (Latterell, 2005). At the other extreme are reform programs supporting student-invented, alternative, and multiple algorithms, with a focus on conceptual understanding (National Research Council, 2001). The focus of this study was on comparing the effects of *Everyday Math* (a “reform” curriculum) and *Saxon Math* (a “traditional” curriculum) on the achievement of elementary students.

Statement of the Problem

The approach to teaching elementary mathematics that is most effective is still an item for debate. The National Mathematics Advisory Panel (Panel, 2008), made up of 19 mathematicians and educators in the United States, addressed the issue of comparing different types of mathematics instruction. The Panel’s conclusion was that there is a need for more high-quality research with clear definitions of instructional techniques. The NCTM, in response to the Panel, agreed that more research in mathematics instruction is needed (NCTM, n.d.).

Mathematics curriculum and instruction has become an increased focus of school administrators. Grigsby, Schumacher, Decman, and Simieou (2010) asserted that school principals have the ideal position for reviewing and evaluating curriculum and instruction, and principals must immerse themselves in instructional leadership as they face increased pressure each year for students to perform well on standardized tests. Accountability in mathematics imposed by the federal No Child Left Behind Act (NCLB) challenges

district administrators to increase their emphasis on leadership in mathematics instruction (Hatfield, Edwards, Bitter, & Morrow, 2008). Although many types of curriculum programs vary in their instructional approaches, administrators need to be informed of various mathematics curricula and instructional techniques, as well as the research behind them, in order to make appropriate decisions in their schools.

Aside from choosing a program that will help avoid sanctions from NCLB, school administrators have a duty to improve elementary students' future enrollment and success in advanced mathematics courses. Programs that contribute to computational fluency and maintain student interest are ideal. Arithmetic computation proficiency forms the foundation for success in more advanced courses, and struggles in arithmetic can eventually deprive students from reaching their mathematic potential (Hatfield et al., 2008).

The greatest predictor for earning a science, technology, engineering, or mathematics (STEM) degree is student interest and engagement in mathematics and science (Maltese, 2008). STEM openings are projected by the Bureau of Labor Statistics (2005) to number more than two million by 2014 while the number of STEM degrees awarded each year remains flat (Kuenzi, 2008). Student interest and engagement in mathematics and science are essential in building the workforce of the future.

Globally, students in the United States have lagged behind their international counterparts in mathematics. Three studies were used to compare mathematics performance of the twelve industrialized nations in 2003. The Trends in Mathematics and Science Studies for Grades 4 and 8 (TIMSS-4 and TIMSS-8) and the Program for International Student Assessment (PISA) for 15-year-old students placed the United

States near the bottom in mathematics. Ginsburg, Cooke, Leinwand, Noell, and Pollack (2005) reported that these studies ranked the United States eighth out of twelve on the TIMSS-4 assessment and ninth on the TIMSS-8 and PISA assessments.

Many school districts across the country have changed mathematics curricula in recent years in hopes to improve standardized test scores and increase student interest. Change in curricula, however, is often not supported by independent research and often involves conflict (Waite, 2000). Teachers, parent groups, and community members all have opinions on “the right way” to teach mathematics, and those opinions often do not agree with the reform efforts initiated by the NCTM (Royer, 2003). School leaders need evidence to either support or resist change in mathematics curricula, and there are few research projects to rely on operating independently of the textbook companies they support. The U. S. Department of Education’s What Works Clearinghouse has identified a total of only three elementary curriculum studies of *Everyday Math* and *Saxon Math* that meet evidentiary standards (What Works Clearinghouse, 2010a; 2010b). An exhaustive search of curriculum studies found no studies comparing the two programs.

Purpose of the Study

The purpose of this study was to determine if *Everyday Math* or *Saxon Math* schools support greater student achievement in Illinois. This provides information useful to school administrators making program selections and evaluating instructional methods for elementary mathematics. Results of the study should prove useful to parents, organizations, and individuals concerned with the education of elementary children. Teacher-educators benefit from the study as well, as the two programs being compared reflect two very different teaching philosophies. The study provides insight on whether

one philosophy might be better to emphasize in preservice mathematics courses for elementary education majors.

Research Questions

This study addressed the following questions.

1. Are there correlations between curriculum (*Everyday Math* or *Saxon Math*) and third, fourth, and fifth grade mathematics achievement in Illinois?
2. Are there significant differences in elementary student achievement of *Everyday Math* and *Saxon Math* schools in Illinois when groups are examined with regard to ethnicity, gender, socioeconomic status, and IEP status?
3. Is there a correlation between curriculum (*Everyday Math* or *Saxon Math*) and mathematics achievement in each content strand tested in Illinois schools (*number sense; measurement; algebra; geometry; data-analysis, statistics, and probability*)?

Delimitations

This study was delimited to public schools in Illinois that were using the *Everyday Math* or *Saxon Math* curriculum in 2010. The study was further delimited to only third, fourth, and fifth grades in these schools. Other schools and grade levels were purposely excluded from the study to fit within the constraints of my resources. The measure of student achievement considered in this study was the Illinois Standards Achievement Test (ISAT). Other measures of achievement for schools and students were not considered.

Limitations

This study used a quasi-experimental design with ex post facto data from 2010 ISAT scores. Schools that chose to use *Everyday Math* or *Saxon Math* are self-selected and do not represent a random sample.

The complexities of students' lives, teacher quality, and interrelationships among those within school and community cultures may have effects on student achievement that are not addressed in this study. Although school administrators were contacted to determine the level of implementation of the curricula studied, there were no classroom observations by to confirm implementation levels. It is possible that some students and schools included in the study were exposed to supplemental materials or that the school administrators contacted falsely reported the level of implementation.

This study relied on school grade-level data to allow for timely acquisition. Although efficiently obtained, school-level data have the disadvantages of ignoring individual student variation as well as creating smaller sample sizes. As such, this study is not as sensitive to differences that may exist between *Everyday Math* and *Saxon Math* schools as compared to *Everyday Math* and *Saxon Math* students.

Hypotheses

The following represent the null hypotheses for the study:

1. It was hypothesized that there is not a significant correlation between curriculum (*Everyday Math* or *Saxon Math*) and third, fourth, and fifth grade mathematics achievement in Illinois.
2. It was hypothesized that there is no significant difference in elementary mathematics achievement of *Everyday Math* and *Saxon Math* schools in

Illinois when groups are broken down according to ethnicity, gender, socioeconomic status, and IEP status.

3. A third hypothesis was that there is no significant correlation between curriculum (*Everyday Math* or *Saxon Math*) and mathematics achievement in each content strand tested in Illinois schools (*number sense; measurement; algebra; geometry; data-analysis, statistics, and probability*)?

Definitions

1. Reform or standards-based curricula—Curricula developed with the support of the NSF to reflect the ideas of the 1989 *NCTM Standards* are commonly referred to as *reform* or *standards-based curricula*. This type of mathematics curriculum puts emphasis on problem-solving, conceptual understanding, and constructivist learning while de-emphasizing manual arithmetic with traditional algorithms (Goldsmith & Mark, 1999). *Everyday Math* is considered a reform curriculum.
2. Traditional curricula—*Traditional curricula* tend to use primarily direct instruction, emphasizing the mastery of procedures of standard algorithms over conceptual understanding (Latterell, 2005). *Saxon Math* is considered a traditional curriculum.
3. Algorithms—Latterell (2005) defined *algorithms* as “step-by-step processes that one can follow to solve a mathematics problem” (p. 29). The treatment of algorithms for arithmetic is highly different in the two curriculum programs being compared in this study.
 - a. Traditional or standard algorithms—Algorithms referred to as *traditional* or *standard* were developed for paper-and-pencil efficiency by the Italians

and English in the 14th and 15th centuries by altering ancient Arabic techniques (W. W. Ball, 1960). These algorithms are prominent in elementary schools still today. Most adults are familiar with these algorithms that work right-to-left with *carrying* for addition and multiplication and *borrowing* for subtraction. Long division fits into this category of algorithms as well. *Saxon Math* works exclusively with traditional algorithms.

- b. Alternative algorithms—Approaches other than the traditional techniques are employed by many reform curricula, including *Everyday Math*. Left-to-right techniques for addition and subtraction, partial-product multiplication, and scaffolding division are some examples of *alternative algorithms*. These alternatives are often easier to understand conceptually. (Kennedy, Tipps, & Johnson, 2008).

CHAPTER 2

REVIEW OF RELATED LITERATURE

This study compared the student achievement of third, fourth, and fifth grade students in Illinois who have been taught using the *Everyday Math* curriculum to those who have been taught using *Saxon Math*. Three specific research questions were examined:

1. Are there correlations between curriculum (*Everyday Math* or *Saxon Math*) and third, fourth, and fifth grade mathematics achievement in Illinois?
2. Are there significant differences in elementary student achievement of *Everyday Math* and *Saxon Math* schools in Illinois when groups are examined with regard to ethnicity, gender, socioeconomic status, and IEP status?
3. Is there a correlation between curriculum (*Everyday Math* or *Saxon Math*) and mathematics achievement in each content strand tested in Illinois schools (*number sense; measurement; algebra; geometry; data-analysis, statistics, and probability*)?

Chapter 2 includes a brief history of mathematics education leading up to the controversy of the *math wars* that is still present today. The *math wars* began in 1989 with the NCTM's release of *Curriculum and Evaluation Standards*. Curricula aligned with these *Standards* were developed and implemented in many districts in the 1990s with support of the NSF (Latterell, 2008). Debate has continued over the last 20 years

concerning best practices in mathematics education. Some believe traditional curricula (such as *Saxon Math*) serve children better and others believe reform curricula aligned with the NCTM *Standards* (such as *Everyday Math*) are the better option. Unique differences between the two types of curricula will be explained later in this chapter. This chapter will also highlight historical and current controversies revolving around algorithms (step-by-step procedures to solve problems). Algorithms are a large factor in the controversy surrounding the *Everyday Math* curriculum. Differences between traditional and reform curricula will be examined and relevant studies of the effectiveness of *Saxon* and *Everyday Math* at the elementary level will be reviewed.

A Brief History of U.S. Mathematics Education

The teaching of mathematics in the United States has a rich history. This review does not attempt to give an exhaustive history of mathematics education, but will focus on key events and major influences and trends, providing a framework for understanding how mathematics education has come to its current state in the U.S. today.

Faculty Psychology

In early colonial times, mathematics was not an area of focus in schools. The first colleges did not offer nor require mathematics (Latterell, 2005). It was not until 1745 that Yale made arithmetic an entrance requirement. Princeton and Harvard followed in 1760 and 1807, respectively. As colleges began requiring arithmetic proficiency for admission, arithmetic became the focus of instruction for secondary students. In the 1820s, arithmetic began to infiltrate the elementary schools (NCTM, 1970).

Ideas of the German philosopher and mathematician Christian Wolff dominated the views of instruction in much of the 19th century (NCTM, 1970). His theory of faculty

psychology divided the mind into several faculties, each thought of as a muscle that needed exercise to become stronger. This theory contributed to the idea that math should be taught to strengthen the mind and that difficult arithmetic could be used to develop the faculties of reasoning and will (NCTM, 1970). Edward Brooks (1883) stated the faculty psychology philosophy as follows:

As a muscle grows strong by its use, so any faculty of the mind is developed by its use and exercise. An inactive mind, like an unused muscle, becomes weak and unskillful. . . . Let the mind remain inactive, and it acquires a mental flabbiness that unfits it for any severe or prolonged activity. An idle mind loses its tone and strength, like an unused muscle; the mental powers go to rust through idleness and inaction. (p. 47)

Elementary educational materials in the 19th century progressed from ciphering books (books of blank pages to take dictation), to a single text for all grades, to two separate texts for primary and intermediate students (NCTM, 1970). The typical instruction in mathematics involved presentation of a rule, student memorization of a rule, and then drill and practice (Bidwell & Clason, 1970).

Thorndike

With compulsory attendance laws adopted by states in the late 19th and early 20th centuries, schools saw an increase in students and diversity (NCTM, 1970). At the same time, psychologist William James began to discredit the idea of faculty psychology (Thayer, 1965). Research by one of James's students, Edward Thorndike, scientifically discredited the theory of faculty psychology (NCTM, 1970). Thorndike became president of the American Psychological Association in 1912 and began leading

colleagues with a charge of efficiently and effectively educating the masses. Thorndike and his associates emphasized the benefits of drill and practice of compartmentalized procedures, ignoring reasoning skills and experiences of young children as part of the learning process (Ellis & Berry, 2005). The drill and practice emphasis and disconnection of mathematical topics were embraced by much of the nation and heavily influenced mathematics education throughout history. Under the ideas of Thorndike, drill and practice became a device to become proficient in mathematical skills rather than strengthen the mind.

Progressive Era

Partially in response to Thorndike's theories, the progressive movement developed in the 1920s. The Progressive Education Association (PEA), composed of concerned parents and teachers, formed in 1919 with principles including (a) the freedom of students to develop naturally, (b) student interest as the motive for all work, and (c) the teacher as a guide and not a taskmaster (NCTM, 1970). The progressive movement focused math instruction on practical purposes for the masses and advanced topics were reserved for the elite few determined to have a perceived future need for math (Ellis & Berry, 2005). The sentiment of the progressive movement is exemplified well by the following excerpt from an article in the 1924 issue of *School Science and Mathematics*:

A large number of students do not like math and are therefore unsuccessful in their attempt to master the subject. Students who are not mathematically inclined should not waste their time with the study of math. Although math is considered by many as the most difficult subject, it is of least value when judged from a utility point of view. (as cited in NCTM, 1970, p. 214)

William Heard Kilpatrick, a professor of education at Columbia University and protégé of John Dewey, became one of the nation's most influential progressive leaders. His views argued for ability tracking, suggesting that algebra and geometry were taught to too many students (Klein, 2003). Ability tracking became standard practice by the 1940s, with most students placed into vocational mathematics tracks (Ellis & Berry, 2005).

The progressive movement was not without some opposition. The NCTM was formed in 1920, in part to counter the progressive movement. The NCTM issued the *1923 Report*, emphasizing the importance of teaching math for its practical and intrinsic values and encouraging advanced topics for every student. However, Kilpatrick and the progressive movement maintained its dominant influence over mathematics education through the 1930s and 1940s (Klein, 2003).

New Math

World War II (1939-1945) brought about much reflection on mathematics education. Many army recruits were found incapable of doing basic arithmetic proficiently (Klein, 2003), and the connection of mathematics to war-related innovations such as radar and guided missiles came to light in the public eye (NCTM, 1970). During and after the war, the applications of mathematics in other areas, such as linear programming and statistics, grew rapidly as well. As the prestige of mathematics and science increased, the need for “more advanced training . . . for more students at an earlier time” and “teaching for meaning and understanding” (NCTM, 1970, p. 70) became important goals of mathematics education. Born out of these goals was the New Math era.

The New Math era began with the creation of the NSF in 1950. The NSF funded several projects to reform mathematics education, but the influence was not widespread at first. It was after Russia's launch of Sputnik in 1957 that the U.S. government felt pressure to expedite change in math and science education. The government used NSF funds to create the School Mathematics Study Group (SMSG). The SMSG quickly created textbooks and distributed them nationwide (Ellis & Berry, 2005). These textbooks reflected curricula heavy in abstraction, even at the elementary level. Topics such as set theory and different number bases were introduced. The average parent was unable to understand the language in the books, and many teachers were unprepared to teach using the new materials (Klein, 2003).

Back-to-Basics

By the early 1970s, dissatisfaction led the NSF to stop funding the New Math programs. There was a public "back-to-basics" call, and many states developed minimum competency tests in the 1970s to measure proficiency in basic skills (Ellis & Berry, 2005). The focus on basic skills led to textbooks and instruction emphasizing the learning of disjoint procedures and a renewed emphasis on drill and practice reminiscent of the ideas of Thorndike (Ellis & Berry, 2005). Despite the renewed emphasis on drill and practice of basic skills, standardized test scores decreased and bottomed out in the early 1980s (Ravitch, 2000).

Many reports came out in the 1980s highlighting the deteriorating quality of mathematics education in the United States. The NCTM released *An Agenda for Action* in 1980 calling for decreased emphasis on paper-and-pencil calculations, and increased emphasis on calculator use, group work, and problem solving (Klein, 2003). The 1983

report, *A Nation at Risk*, written by a commission appointed by U.S. Secretary of Education Terrell Bell, highlighted the inadequacies of U.S. education. Mathematics education was particularly targeted in comments regarding the high number of students needing mathematics remediation at the college level, the shortage of quality mathematics teachers, and the need for more rigorous textbooks (U.S. Department of Education, 1983).

The concern of the 1980s was not new. However, Ellis and Berry (2005) saw this period as the beginning of a paradigm shift in which educators and researchers began addressing how students learn mathematics and not just the content. Attention was beginning to focus on children's active role in learning and the ability of all students to learn important mathematics concepts.

The Paradigm Shift in Math Education

Through the eras of faculty psychology, Thorndike, the progressive movement, New Math, and back-to-basics, the paradigm had remained constant, viewing mathematics as “an objective set of logically organized facts, skills, and procedures that have been optimized over centuries. This body of knowledge exists apart from human experience, thus making it inherently difficult to learn” (Ellis & Berry, 2005, p. 11). Ellis and Berry (2005) called this the “procedural-formalist” paradigm. Under this paradigm, learning is accomplished by watching demonstrations of skills and procedures, memorizing and practicing those procedures independently, and being tested on knowledge of those procedures. The procedural-formalist paradigm reserves more advanced mathematics only for the elite, “capable” individuals.

The paradigm beginning to develop in the 1980s was termed the “cognitive-cultural” paradigm by Ellis and Berry (2005). Under this paradigm, mathematics is seen as “a set of logically organized and interconnected concepts that come out of human experience, thought, and interaction—and that are, therefore, accessible to all students in a cognitively connected and culturally relevant way” (Ellis & Berry, 2005, p. 12).

Communicating, sharing common experiences, making connections, critical thinking, and flexibility are key components emphasized in the teaching and learning of mathematics under the “cognitive-cultural” paradigm.

NCTM Standards and NCLB

Ideas of the “cognitive-cultural” paradigm were expressed in the highly influential NCTM *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989). Released in 1989, the *Standards* called for an increase in technology use, discovery learning, group work, communication, and conceptual understanding. The *Standards* also called for a de-emphasis on paper-and-pencil calculations, teaching by telling, and memorization of rules and algorithms (Latterell, 2005; Ocken, 2001; Peressini et al., 1998). The NSF made the influence of the *Standards* possible. The NSF began funding the creation and development of K-12 curricula aligned to the NCTM *Standards* in the 1990s, and by 1997 most states had adopted standards aligned with the NCTM *Standards* (Hatfield et al., 2008; Klein, 2003).

The *Standards* were not welcome by many, including a number of parents and mathematicians. Public resistance to NCTM-oriented curricula began in the 1990s and continues today. Critics have argued that the reform curricula take authority away from the teacher, rely too heavily on calculators, ignore the importance of traditional

algorithms, and encourage aimless group and discovery work (Klein, 2003; Latterell, 2005). As previously stated, the debate between these critics and proponents of NCTM-oriented curricula has come to be known as the *math wars* (Latterell, 2005).

The NCTM consulted with mathematicians, teachers, and educational researchers to develop a revised set of standards. In 2000, *Principles and Standards of School Mathematics* was released. Though the new *Standards* brought little controversy, the principal message of the 1989 *Standards* was still in place (NCTM, 2000).

In 2002, NCLB was signed into law, increasing accountability of school districts in meeting measurable adequate yearly progress (AYP) on state-developed standardized tests in mathematics and reading. The goal of NCLB is 100% proficiency in mathematics and English by 2014. NCLB demanded proficiency for entire schools as well as certain demographic subgroups (Linn, Baker, & Betebenner, 2002). The law encouraged schools to operate under the “cognitive-cultural” paradigm in some ways, but not in others. Focusing energy toward improving mathematical learning of all students, and not just those who seem to have high aptitude in math, fits the mold of the “cognitive-cultural” paradigm. However, preparation for standardized tests often involved heavy memorization, drill, and little community learning. This was contrary to the goals of the *Standards* and the “cognitive-cultural” paradigm.

Movement Toward National Standards

The last five years have seen increased efforts at setting a framework for a national mathematics curriculum. The NCTM published *Curriculum Focal Points for Prekindergarten through Grade 8 Mathematics* in 2006. This document represented a national framework for consistent grade placement of topics in K-8 mathematics, and

NCTM suggested *Focal Points* be used to build “the next generation of state and district-level mathematics curricula” (p. 7). Contrary to the 1989 and 2000 NCTM *Standards*, the new document relays the importance of including the standard algorithms for arithmetic in mathematics instruction. The table below provides a summary of how the NCTM’s position on traditional algorithms has evolved over the last several years, as interpreted by language in published documents. There is still no clear direction provided by the NCTM on implementing alternative algorithms or encouraging students to invent their own algorithms.

Table 1

NCTM’s Evolving Position on Algorithms

Document	Position
<i>1989 Standards</i>	De-emphasize traditional algorithms
<i>2000 Standards</i>	Investigate traditional algorithms
<i>2006 Focal Points</i>	Include traditional algorithms

Reform programs have altered their curricula in recent years to align with *Focal Points*. A website containing family resources for *Everyday Math* states:

Based on three decades of validated student achievement, students using the Everyday Mathematics program demonstrate superior proficiency using many algorithmic methods, including traditional forms. We have found that students are most successful when they understand how an algorithm works (as opposed to merely memorizing rote steps without understanding them). However, given the wide consensus that proficiency with U.S. traditional algorithms is an important

expectation in U.S. culture, effective fall 2008, they will become more prominent in the Everyday Mathematics program. (UCSMP, n.d.b, p. 9)

The National Governors Association Center for Best Practices and the Council of Chief State School Officers developed the Common Core Standards (CCS) for grades K-12 in English language learning and mathematics in 2010. The CCS formed specific national grade-level expectations that have been adopted by 42 states. Like the NCTM *Focal Points*, the CCS provided specific grade level expectations for students in an attempt to nationally standardize grade-level expectations (*Common Core State Standards Initiative* [CCSI], n.d.).

The CCS make it clear that the standard algorithms for addition and subtraction are to be mastered by Grade 4, the standard algorithm for multiplication by Grade 5, and the standard algorithm for division by Grade 6. Although fluency with standard algorithms for arithmetic are apparent, a Grade 3 objective indicates the appropriateness of multiple algorithms for addition and subtraction, and other objectives in the CCS also suggest the use of multiple strategies based on place value (CCSI, n.d.). Corresponding objectives related to algorithms are given in Table 2.

Table 2

Objectives From the Common Core Standards Related to Algorithms for Arithmetic

Grade	Objective
3	Fluently add and subtract within 1000 using strategies and algorithms based on place value, properties of operations, and/or the relationship between addition and subtraction.
4	Fluently add and subtract multi-digit whole numbers using the standard algorithm.
5	Fluently multiply multi-digit whole numbers using the standard algorithm.
6	Fluently divide multi-digit whole numbers using the standard algorithm.

Illinois adopted the CCS on June 24, 2010 (CCSI, n.d.), aligning the Illinois Learning Standards in mathematics and English language arts to the objectives in the CCS. The Illinois standards for mathematics are appropriately similar to the objectives in the CCS, but there is a distinct difference in the phrasing involving algorithms. In many standards involving arithmetic computation, the Illinois Learning Standards distinctly express the option to use multiple algorithms. State tests in Illinois will be aligned to the CCS starting in 2014, leaving district leaders a few years to make curricular decisions best suited to preparing students for the new wave of state tests (Illinois State Board of Education, n.d.). Table 3 provides examples of Illinois Learning Standards that give the option of using multiple algorithms in instruction.

Table 3

Illinois Learning Standards Expressing the Option to Use Multiple Algorithms

Grade	Illinois Standard
3	Use place value understanding and properties of operations to perform multi-digit arithmetic. Fluently add and subtract within 1000 using strategies and algorithms based on place value, properties of operations, and/or the relationship between addition and subtraction. (A range of algorithms may be used.)
4	Use place value understanding and properties of operations to perform multi-digit arithmetic. Fluently add and subtract multi-digit whole numbers using the standard algorithm. (Grade 4 expectations in this domain are limited to whole numbers less than or equal to 1,000,000. A range of algorithms may be used.)

The Controversy of the First Algorithms

A large portion of the *math wars* revolves around the treatment of algorithms in mathematics education. This section is provided to give a background of the historical development and controversy surrounding algorithms.

The word *algorithm* is derived from the name of the Persian scholar al-Khwarizmi, who lived from about 780 to 850. The Latin translation of his treatise on Hindu arithmetic in the 12th century was used throughout medieval Europe as a guide to the Hindu-Arabic number system (the system used today) and its operations (Stankus 1991; Uspenskiĭ & Semenov, 1993). Fibonacci further spread the Hindu-Arabic system through Europe with his explanations of the system in *Liber Abaci*, written in 1202 (Smith & Karpinski, 1911). Prior to algorithms with Hindu-Arabic numerals, calculations in European countries were made using Roman numerals and a counting board called an abacus (W. W. Ball, 1960).

Since the first use of the word *algorithm*, there has been controversy. There was considerable resistance to using the new, Hindu-Arabic system of calculation. Many did not trust the new techniques, some saw the new algorithms as useless, and some European countries even outlawed calculating with algorithms (Fink, 1900; Moscovich, 2006; Smith & Karpinski, 1911; Stone, 1972).

A symbolic image of the debate between the abacus and Hindu-Arabic algorithms can be seen in Gregorius Reisch's *Margarita Philosophica*, published in the early 1500s. The picture (Figure 1) shows a supervised competition between two familiar math icons. Boethius is using procedures with Hindu-Arabic numerals and Pythagoras is using an abacus.



Figure 1. Algorithm vs. abacus. A Picture from Reisch's *Margarita Philosophica*. This image is in the public domain.

The first dated European Manuscript containing Hindu-Arabic numerals was *Codex Vigilanus*, written in Spain in 976; calendars and documents increasingly included the use and explanations of the system through the next several centuries (W. W. Ball, 1960). Translations of Arab texts, Fibonacci's *Liber Abaci*, and other texts advocating

the Hindu-Arabic system were strong forces in spreading the use of the system, but the Hindu-Arabic numerals and their algorithms were very slow to catch on (W. W. Ball, 1960; Smith & Karpinski, 1911; Struik, 1967).

There were reasons other than personal beliefs limiting the use and transmission of the new system. Affordable paper and pencils used to calculate using Hindu-Arabic algorithms were not available until the 16th century. Also, printing was not invented until the middle of the 15th century, making it hard to transmit information to a wide audience (Fink, 1900; Smith & Karpinski, 1911). The majority of European merchants had yielded to the efficiency of calculating with Hindu-Arabic numerals by the latter part of the 16th century, but colleges and monasteries were more resistant to change, continuing with the use of Roman numerals and counting boards until about 1650 (W. W. Ball, 1960).

Development of the U.S. Traditional Algorithms

The development of the U.S. traditional algorithms for whole numbers came from alterations of the Arab techniques by the Italians and English during the 14th and 15th centuries. W. W. Ball (1960) attributed the creation of the traditional algorithms for addition and subtraction to the English. Addition and subtraction used by the Arabs worked left-to-right, identifying partial sums, while the English altered this technique to a right-to-left approach with *carrying* for addition or *borrowing* for subtraction. This revision represents the traditional algorithms for addition and subtraction used in the U.S. today.

Fibonacci's *Liber Abaci* and translations of Arab texts displayed multiple techniques for multiplication, including techniques involving partial products and the lattice method, as well as various techniques for division. W. W. Ball (1960) believed

the U.S. traditional methods of multiplication and division evolved in Italy. The current long-division algorithm was used in Italy as early as the 14th century, but did not gain widespread use in Europe until the 18th century.

It is important to mention why the algorithms of the Arabs were altered. In the 15th century, calculations used for commerce needed to be as efficient as possible. Though the Arab algorithms were just as effective and in some cases easier to conceptually understand (Nickerson, 1988), the alterations were developed to save paper and time (Swetz & Smith, 1987). It is also important to note that algorithms that made their way to the United States to become traditional in our nation are not universally traditional throughout the world (Woodward & Montague, 2000).

The Current Algorithm Debate

The dominance of algorithms that have become “traditional” in the United States has been challenged in the last few decades. With calculators and computers readily accessible, efficient paper-and-pencil calculations outside the classroom have been replaced by technology. The 1989 NCTM *Standards* suggested increased technology in the classroom and a de-emphasis on memorizing rules and drilling paper-and-pencil computations using traditional algorithms (Latterell, 2005; Ocken, 2001; Peressini, Knuth, Morrow, & Kenney, 1998).

After the release of the 1989 *Standards*, the NSF began funding the development of instructional programs and materials reflecting the reform called for by the NCTM (Hatfield, 2008). Common to the elementary programs developed with NSF funding was an emphasis on alternative algorithms for multi-digit arithmetic and a de-emphasis on traditional procedures. Some elementary curricula, such as *Everyday Math*, originally

abandoned the teaching of nearly all of the traditional algorithms in favor of alternative techniques and student-invented strategies (Klein, 2007). Ironically, many of the algorithms endorsed by reform curricula closely resembled the old Arabic techniques altered by the Italians and English for efficiency in the 14th and 15th centuries.

The treatment of algorithms for addition, subtraction, multiplication, and division of multi-digit whole numbers in the elementary classroom has become a major issue in the *math wars* of the past 20 years. Organizations and individuals arguing against reform programs have cited the lack of focus on traditional algorithms for whole number operations as a major complaint (Garellick, 2005; Groth, 2007; Klein, 1999). Others see a benefit in teaching multiple and alternative algorithms (Carroll & Porter, 1998; Kennedy et al., 2008). Still, there are some who believe we should not teach algorithms at all but only allow students to invent their own procedures (Kamii & Dominick, 1998).

Many researchers believe the exclusive teaching of traditional algorithms to be harmful to children. Some scholars state that traditional algorithms for arithmetic are not understood by many children, are not easily internalized, and are carried out without thought (Kennedy, et al., 2008; Plunkett, 1979; Reys, 1994; Sowder, 1992). The Calculator Aware Number (CAN) project in Britain in the 1980s studied elementary students who were allowed to invent their own arithmetic methods and use calculators, without being taught traditional algorithms (Shuard, 1990; Thompson, 1994). Researchers found that student enthusiasm for math increased and children worked with large, negative, and decimal numbers much earlier (Shuard, 1990; Thompson, 1994).

Many researchers have claimed that traditional algorithms cause a student's number sense to deteriorate. To explain number sense, Reys (1994) stated

Someone who values and uses number sense

1. will look at a problem holistically before confronting details,
2. will look for relationships among numbers and operations and will consider the context in which a question is posed,
3. will choose or invent a method that takes advantage of his or her own understanding of the relationships between numbers or between numbers and operations and will seek the most efficient representation for the given task,
4. will use benchmarks to judge number magnitude, and
5. will recognize unreasonable results for calculations in the normal process of reflecting on answers. (p. 115)

There have been observational studies of elementary students using alternative and invented algorithms instead of traditional algorithms in many countries, all with similar conclusions. Studies in the United States (Kamii & DeClark, 1985; Kamii & Jones-Livingston, 1994; Kamii & Joseph, 1989; Narode, Board, & Davenport 1993), South Africa (Olivier, Murray, & Human, 1990), and Sweden (Hedren, 1995, 1996) all claimed student number sense and concepts of place value are strengthened when alternative and student-invented procedures are used over traditional methods.

Other scholars favor using traditional algorithms for various reasons. Some believe understanding and thinking about every calculation we do is not important. This sentiment is often explained using a quote from Alfred North Whitehead (1911),

It is a profoundly erroneous truism, repeated by all copy-books and by eminent people when they are making speeches, that we should cultivate the habit of thinking of what we are doing. The precise opposite is the case. Civilization

advances by extending the number of important operations which can be performed without thinking about them. Operations of thought are like cavalry charges in battle—they are strictly limited in number, they require fresh horses, and must only be made at decisive moments. (p. 61)

Other arguments for traditional algorithms usually take one of the following forms: (a) They have been invented and refined through centuries to be the most efficient and effective. (b) They can be applied universally to a variety of problems, and the calculations can be carried out in about the same way, regardless of how complicated the numbers are. (c) They are linked to formal procedures of algebra and calculus, and denying children experience with formal procedures hinders their success in advanced math. (d) They are an important part of our history and culture that should not be discarded (Hedren, 1999; Ocken, 2001). Ocken (2001) also argued that not all students have the ability to invent their own techniques and that alternative algorithms only work well for some problems.

The Controversy of *Everyday Math*

Everyday Math was one of the elementary curricular programs developed with support of NSF funds in the 1990s. The first edition was released in 1998, inciting near-immediate conflict. After its release, the U.S. Department of Education issued a report in October 1999 labeling *Everyday Math* as one of five “promising” programs. This endorsement by the government outraged many mathematicians and scholars, and an open letter was submitted to Secretary of Education Richard Riley, asking him to withdraw the report. Over 200 reputable scholars, including Nobel laureates, Fields medalists, and mathematics department chairs, signed the letter (Klein, 2003).

The government report was not withdrawn, however, and *Everyday Math* has increasingly infiltrated elementary classrooms. The second edition was released in 2002, and the third in 2007, and *Everyday Math* has become a part of the lives of three million students in 185,000 classrooms across the country. In Illinois, 119 public elementary and unit school districts use *Everyday Math* (UCSMP, n.d.a).

Everyday Math has also continued to be the subject of debate at the state and local levels. California rejected *Everyday Math* in 2001 for failing to meet content standards and it remained off the state's textbook list until 2007 when a special California version was created that emphasized more traditional arithmetic (California Department of Education, 2009). The Texas State Board of Education rejected the third edition of *Everyday Math* while approving 162 other texts in 2008. The Texas rejection of *Everyday Math* came after more than 70 districts (including Dallas) in the state had used the previous two editions. The Texas State Board's rejection was made without the majority vote giving a reason for their decision, and the decision led to questioning of the Board's legal authority (Smith, 2008).

Parent organizations have popped up across the country using the Internet as a vehicle to communicate distaste for *Everyday Math* and other reform curricula. Klein (2003) identified a few of the organizations that formed in the 1990s to resist math reform in their respective regions:

1. Mathematically Correct, California.
2. Honest and Open Logical Debate (HOLD), California.
3. Parents Raising Educational Standards in Schools (PRESS), Wisconsin.
4. MathChoice, Texas.

5. New York City HOLD (NYC HOLD), New York.

Mathematically Correct and NYC HOLD maintain active websites that continue to advocate for traditional curricula in favor of reform curricula. In 2008, a Facebook page was developed on the web entitled *Parents Against Everyday Math* (n.d.). The page remains active, providing a popular forum for complaints against reform programs. The *About* section of the page states, “Tell us about how you are making an impact against Everyday Math, TERC, Investigations or other constructivist math programs in your district” (para. 1).

The parent group against math reform in Illinois is Illinois Loop. This web-based organization provides information on mathematics curricular programs in the state and heavily criticizes districts using *Everyday Math* and other reform curricula. In its description of *Everyday Math*, the Illinois Loop (n.d.) website states, “It is legendary for its problems without solutions, incredibly frustrating ‘games,’ shallow interest in effective algorithms, heavy use of the demoralizing practice of spiraling and oddball methods such as ‘lattice multiplication’” (“UCSMP Everyday Mathematics,” para. 1). Although the *Everyday Math* curriculum promised an increased emphasis on traditional algorithms by 2008, the curriculum materials still give heavier attention to alternative and student-invented algorithms.

Comparing Traditional and Reform Curricula

Illinois Loop praises *Saxon Math* as much as it criticizes *Everyday Math*. *Saxon* is considered to be a traditional mathematics curriculum, whereas *Everyday Math* is considered a reform (or nontraditional) curriculum (Waite, 2000). Illinois does not have a state-mandated textbook list, and schools are free to choose their math curricula. *Saxon*

Math can be found in about 10% of elementary schools in Illinois (Illinois Loop, n.d.), and *Everyday Math* can be found in about 15% of Illinois elementary schools (*Everyday Mathematics*, n.d.). Other programs are used in the remaining schools.

Algorithms

Traditional curricula use only traditional algorithms, and reform programs use multiple algorithms (including the traditional) and encourage student-invented techniques for arithmetic.

Pedagogy

Waite (2000) described the typical pedagogy when traditional curricula, such as *Saxon*, are used: (a) introducing a concept, (b) teaching an algorithm, (c) having guided practice and independent practice, and (d) testing. The phrase *drill and practice* is often used to describe traditional techniques and correctness is considered highly important. Resnick (1987) added that “in many traditional classrooms, learning is conceived of as a process in which students passively absorb information, storing it in easily retrievable fragments as a result of repeated practice and reinforcement” (p. 31). Conversely, reform curricula assign action to student learning, using verbs such as *investigate*, *formulate*, *find*, and *verify* to describe the student’s role (NCTM, 1989).

Waite (2000) explained that reform curricula

stress real-world problems and situations. Students are encouraged to develop and explain algorithms to solve the problem with teachers acting as guides, introducing new ideas, and allowing the students to assimilate these in solutions to problems.

In the nontraditional type of mathematics curricula, students are encouraged to work in groups, reporting solutions to each other and analyzing one another’s

attempts. Many nontraditional mathematics curricula use journals and encourage writing. The use of calculators is acceptable and even is promoted in some programs. (p. 18)

An article by Barr and Tagg (1995) described the paradigm shift in math education leading to reform curricula. Key differences between reform and traditional curricula are explained in the article. Table 4 summarizes these differences.

Table 4

Differences Between Traditional and Reform Curricula

Traditional	Reform
Knowledge is “out there” and is presented by the teacher.	Knowledge is specific to one’s mind and is constructed by the student.
Learning is teacher-centered.	Learning is student-centered.
Students are passive.	Students are discoverers.
Learning is measured by recalling information on tests.	Learning is measured by using frameworks for students to understand and act.
The teacher lectures and controls the classroom.	Students are actively involved in activities designed by the teacher.
Environment is individualistic and competitive.	Environment is team-oriented, collaborative, and supportive.
Learning is presumed to be linear and cumulative.	Learning consists of interactive and nested frameworks.
Few students can achieve at high levels.	All students can achieve at high levels.
The goal is to cover a certain amount of material.	The goal is to accomplish learning objectives.

Learning Theory

The difference between traditional and reform curricula might best be explained by the learning theories associated with each. Traditional curricula follow the behaviorist learning theory. Behaviorism emphasizes the passive absorption of material by students. Knowledge is passed from the teacher (or text) to the student through modeling of step-by-step procedures, and the student is expected to repeat the behavior modeled by the teacher. Rote learning, memorization of formulas, single solutions, and repetitive drill and practice are common behaviorist practices (Handal & Herrington, 2003).

Traditional curricula follow the social constructivist learning theory. In social constructivism, the learner combines prior experiences, new experiences, and social interactions to actively construct their own knowledge and understanding. Constructivist classrooms include reflective learning activities, problem solving, inquiry-based learning, and peer interaction (Hedren, 1996; Wood, Cobb, & Yackel, 1991).

Assessment

The treatment of student assessment is another area where traditional and reform curricula differ. The focus of assessment in traditional curricula tends to be primarily summative, providing information on what a student knows at some point in time. For instance, after content is covered for a particular unit, students take a test to see if they have mastered the material covered. A grade is assigned to the test and can be used to compare the relative standing of a student in the class (Garrison & Ehringhaus, 2007; Van der Zalm, 2010).

Although reform programs use summative assessments as well, they tend to focus much attention on formative assessment. Formative assessment is ongoing, non-

threatening feedback that helps to guide students and the teacher in the necessary directions to achieve learning objectives (Garrison & Ehringhaus, 2007). Examples of formative assessments in math classes “include diagnostic assessments, observational notes taken while students are expressing their problem-solving process, and activities based on real-life situations where students work in small groups to present a solution to a problem” (Van der Zalm, 2010, p. 42). An extensive literature review of 580 studies by Black and Wiliam (1998) found formative assessment to have large positive effects on improved learning. Taras (2007), however, described formative assessment as “inefficient and often contradictory” (p. 363).

Traditional and reform curricula differ in their treatment of homework as well. Traditional texts view homework as an opportunity to master concepts independently, but reform curricula view homework as an opportunity to be enriched by a variety of problem-solving experiences, often involving family members, peers, and the teacher (Waite, 2000).

In first through third grades, *Everyday Math* calls homework *Home Links* and these activities provide opportunities for members of the family to participate. In Grades 4-6, homework is called *Study Links*. Many of these activities are taken home as well, but some can be done alone or with a partner at the instructor’s discretion (UCSMP, 2002).

Technology

A final distinction between traditional and reform curricula is the incorporation of technology. Elementary reform curricula incorporate calculators as early as kindergarten and encourage the use of technology frequently throughout the early grades. Traditional curricula reserve calculators and other technology use for more advanced topics in later

grades (Garellick, 2005).

Although the *Everyday Math* curriculum is designed to reflect the NCTM *Standards* and the *Saxon Math* curriculum is designed to be more traditional, the effect of the teacher must not be discounted. A limitation of this study is the possibility that some teachers do not follow the mold designed by the creators of the curriculum. However, Latterell (2008) stated that course materials are the greatest indicator of the instruction that takes place in the classroom.

Challenges of Reform Curricula

Challenges accompany a school district's decision to implement a reform curriculum such as *Everyday Math*. Traditional programs, like *Saxon Math*, are often referred to as teacher-proof (Russell, 1997), requiring little more than direct instruction and grading of answers. Reform-curricula, however, require an understanding beyond simply being able to perform mathematical procedures and mark correct or incorrect answers. Building the cooperative-learning environment, understanding multiple solution paths, managing a student-centered classroom, and providing quality formative assessment require sustained professional development. D. Ball (1996) noted that teachers using nontraditional course materials and teaching methods are most often the products of the tradition they are attempting to reform. Teachers in reform classrooms are, therefore, expected to teach in a manner in which they were not taught and likely have not observed. Adjusting teaching techniques and classroom practices to fit the mold of a reform curriculum requires ongoing support and training. In a qualitative study of math teachers, Groth (2007) found that teachers adopting constructivist reform curricula struggle to let go of the "presenter" role when professional development is not used.

There is a plethora of research that has shown parental involvement to be positively correlated to student achievement and attitudes toward learning (Chiu & Xihua, 2008; DePlanty, Coulter-Kerr, & Duchane, 2007; Englund, Luckner, Waley, & Egeland, 2004; Friedel, Cortina, Turner, & Midgley, 2006). The role of the parent is highly affected by implementing a reform curriculum. Many parents are resistant to the change of a reform curriculum's divergence from traditional methods. Parents are often crippled in their ability to help students with homework at the elementary level when unfamiliar algorithms and instructional strategies have been emphasized. Most adults have trouble bridging their own experience of mathematics grounded in traditional computational proficiency with the problem solving and constructivist approaches used in nontraditional classrooms (Van der Zalm, 2010). Districts are pressed to educate parents on new teaching strategies and alternative algorithms in order to successfully implement a nontraditional math curriculum (Hendrickson, Siebert, Smith, Kunzler, & Christensen, 2004).

Curriculum Studies

Many studies exist endorsing both *Saxon* and *Everyday Math* at the elementary level. However, few studies can be found that do not have some connection with the publisher, hold some other potential for bias, or possess design weaknesses. Studies that meet the U.S. Department of Education's What Works Clearinghouse (WWC) evidence standards or meet the WWC standards with reservations will be reviewed in this section.

Studies of *Saxon Math*

A study meeting WWC evidence standards compared four math programs using math achievement of first graders taking a nationally-normed math assessment developed

for the Early Childhood Longitudinal Study-Kindergarten Class (Agodini et al., 2009). This randomized control study included approximately 1,300 first graders in 39 schools across four districts in Nevada, New York, Minnesota, and Connecticut. The study found that students in *Saxon Math* schools scored significantly higher on math assessments than those using *Investigations in Number, Data, and Space* (a reform curriculum) and significantly higher than the three comparison curricula considered jointly (Agodini et al., 2009).

Two studies met WWC standards with reservations. Good, Bickel, and Howley (2006) matched a sample of elementary schools using *Saxon Math* with a group of comparison schools using a range of other curricula. This quasi-experimental study matched schools based on size, type, grade-level configuration, and student demographics. The study included 57 schools across the country and a sample of 1,476 kindergarteners through third graders. Findings of the study concluded no significant effect of *Saxon* on the math subtest of the Stanford Achievement Test, Ninth Edition (Good et al., 2006). Resendez and Manley (2005) matched 170 intervention schools using *Saxon Math* with 172 comparison schools in Georgia using various other curricula. This retrospective study examined school data from 2000 to 2005 and reported no significant effects of *Saxon* on math achievement in Grades 1-5 on Georgia's Criterion-Referenced Competency Test.

Everyday Math Study

Only one study of the *Everyday Math* curriculum met WWC evidence standards with reservations. Waite (2000) studied third- through fifth-grade students in a large urban district in Texas. A group of 732 students using the first edition of *Everyday Math*

were compared to a group of 2,704 students using a more traditional curriculum. This quasi-experimental study found *Everyday Math* to have significant positive effects on overall math achievement as measured by the math portion of the Texas Assessment of Academic Skills.

Summary

Elementary mathematics education has historically evolved to include reform programs that include alternative algorithms and nontraditional approaches to teaching mathematics. *Everyday Math* is one such highly controversial program, while *Saxon Math* maintains a traditional approach to mathematics education advocated by many. Studies exist supporting both approaches, and this study will add to the body of research analyzing the effectiveness of mathematics programs.

CHAPTER 3

METHODOLOGY

This study compared student achievement in elementary schools using *Everyday Math* with that of elementary schools using *Saxon Math*. The following questions were explored:

1. Are there correlations between curriculum (*Everyday Math* or *Saxon Math*) and third, fourth, and fifth grade mathematics achievement in Illinois?
2. Are there significant differences in elementary student achievement of *Everyday Math* and *Saxon Math* schools in Illinois when groups are examined with regard to ethnicity, gender, socioeconomic status (SES), and IEP status?
3. Is there a correlation between curriculum (*Everyday Math* or *Saxon Math*) and mathematics achievement in each content strand tested in Illinois schools (*number sense; measurement; algebra; geometry; data-analysis, statistics, and probability*)?

Confrey and Stohl (2004) analyzed 95 studies comparing effectiveness of math curricula. In their analysis, characteristics of high-quality comparison studies were identified and advice for such future studies was given. The list below summarizes the advice given by Confrey and Stohl, which served as a model for the design of this study.

1. Use the correct unit of analysis (classroom level at minimum).
2. Identify comparative curricula by name.

3. Discuss comparability of samples.
4. Document extent of implementation fidelity.
5. Disaggregate by content strand.
6. Disaggregate by characteristics such as gender, race/ethnicity, and socioeconomic status.
7. Express constraints as to the generalizability of the study.
8. Conduct appropriate statistical tests and report effect size.

Subjects and Setting

The subjects analyzed in this study were elementary schools in Illinois using *Saxon Math* and *Everyday Math*. According to Confrey and Stohl (2004),

The school itself provides a culture in which the curriculum is enacted as it is influenced by the policies and assignments of the principal, by the professional interactions and governance exhibited by the teachers as a group, and by the community in which the school resides. This would imply that the school might be the appropriate unit of analysis. (p. 113)

Although many curriculum studies compare schools using a named curriculum to schools using a gamut of other unnamed curricula (Confrey & Stohl, 2004), this study clearly names the two curricula being compared (*Saxon Math* and *Everyday Math*). A sample of *Saxon Math* schools and a sample of *Everyday Math* schools were collected for comparison. Generalizability is limited in this study, as schools had chosen their math programs and were not randomly assigned to a curriculum.

Assessment Instrument

The instrument used to compare *Saxon Math* schools and *Everyday Math* schools was the mathematics portion of the 2010 Illinois Standards Achievement Test (ISAT). The ISAT is given each year to all students in Illinois in third through eighth grade (ISBE, 2010). The focus of this study, however, was only on third, fourth, and fifth grade scores. Generalizability of this study is further limited to school performance on the ISAT at the third, fourth, and fifth grade levels.

The mathematics portion of the ISAT in 2010 consisted of three 45-minute sessions. The first session included 40 multiple-choice questions, of which the first 30 were an abbreviated version of the Stanford Achievement Test, 10th Edition (SAT 10). The second session included 30 multiple-choice questions, five of which were pilot questions, and three short-response items, one of which was a pilot question. The final session included two extended-response items, one of which was a pilot question. Aside from the SAT 10 items, each item was written and reviewed by Illinois educators (ISBE, 2010).

Scores on the ISAT were determined by evaluating the number correct on the non-piloted items of the test. The multiple-choice items were weighted at 85% of the score, and, together, the short-response and extended-response items carried a weight of 15% of the score (ISBE, 2010).

Questions on the ISAT were divided among five content strands. Table 5 shows the number of questions in each content strand for third, fourth, and fifth grades on the multiple-choice portions of the ISAT in 2010 (ISBE, n.d.).

Table 5

Mathematics Item Counts by Content Strand, 2010 ISAT

Content Strand	Grade 3	Grade 4	Grade 5
Number Sense	23	23	20
Measurement	12	13	10
Algebra	6	6	12
Geometry	14	14	13
Data Analysis, Statistics, & Probability	10	9	10

All students were provided with a ruler for the ISAT, and students beyond third grade were allowed to use calculators. A variety of accommodations was allowed by the state for students with disabilities and for those with individualized education plans (ISBE, n.d.).

Data Collection Procedures

Populations being examined in this study were *Everyday Math* and *Saxon Math* elementary schools in Illinois. Samples of *Everyday Math* and *Saxon Math* schools were collected in order to make inferences concerning the differences in these populations. This study was a quasi-experimental design, as schools were not randomly assigned a curriculum. Rather they were self-selected, having already chosen either *Everyday Math* or *Saxon Math* as their school mathematics program.

Sales representatives of both curricula were contacted to identify elementary schools in Illinois purchasing the materials in the last several years. The McGraw-Hill Company, publisher of *Everyday Math*, was quick to provide a list of schools using

Everyday Math in Illinois. Houghton Mifflin Harcourt (HMH), publisher of *Saxon Math*, was not willing to provide such a list. After several failed attempts at acquiring a user list from various HMH sales representatives in the Midwest, I was directed to the HMH research manager. The research manager requested and was given specific details of the study, and after a month of consideration, his decision was to not provide a list. HMH informed me that its company policy is to not provide these lists unless the study is sponsored by HMH.

Not having a list of potential *Saxon Math* schools presented a significant roadblock, and I decided to contact every elementary and unit school district in Illinois to overcome the roadblock. Though time consuming, this ensured attainment of the largest sample possible. A list of all 768 elementary and unit districts was obtained from the Illinois Interactive School Report Card (IIRC) website (<http://iirc.niu.edu>). I went through the list alphabetically, searching each school's website for appropriate contact information. For larger districts with multiple elementary schools, curriculum directors, assistant superintendents, and superintendents were contacted. Principals and assistant principals were contacted in districts with only one elementary school.

All schools identified as *Everyday Math* or *Saxon Math* schools were filtered by level of implementation and the number of years they had used their respective curriculum. School administrators were first contacted by e-mail and then by phone if there was no reply within a week. The following questions were asked to these administrators to analyze fidelity of implementation:

1. Are you currently using (*Everyday Math* or *Saxon Math*) for third, fourth, and/or fifth grades?

2. If so, how long has your school used the curriculum? If not, you do not have to answer the following questions.
3. Which statement best describes math instruction at your school?
 - a. Teachers use the school-adopted curriculum exclusively with no supplemental materials. The publisher's recommendations for order of topics, time on each topic, activities, etc. are strictly followed.
 - b. Teachers use the school-adopted curriculum with few, if any, supplemental materials. The publisher's recommendations are mostly followed.
 - c. Teachers use the school-adopted curriculum, but frequently supplement with other materials. Teachers frequently alter the publisher's recommendations.
4. Is there any reason your school should not be included in a study examining the effects of your adopted curriculum on the student achievement of elementary students in third, fourth, or fifth grade? If so, explain.

Schools were included in the study if they

1. were currently using *Everyday Math* or *Saxon Math*,
2. had used their curricula since the 2007-2008 school-year,
3. affirmed that *a* or *b* from question three best described math instruction at their school, and
4. had no other administrator reservations.

After the two samples were determined, the IIRC website was used to gather several data items for each school at the third, fourth, and fifth grade levels. The

percentage meeting or exceeding standards on the ISAT for each school at each grade level was recorded, along with the percentage of students meeting or exceeding standards by subgroup for each grade level. Additionally, the IIRC website was used to collect data on several demographic characteristics that research has connected to student achievement. These characteristics included the percentage of low-income students (Peard, 2002; Steinberg, Brown, & Dornbusch, 1996), the minority (African-American and Hispanic) population percentage (Bouchey & Harter, 2005; Demie, 2001; Tate & D'Ambrosio, 1997), school size (Fowler, 1995; Lee & Loeb, 2000; Leithwood & Jantzi, 2009), female enrollment percentage, and percentage of students with IEPs (Illinois Interactive Report Card [IIRC], n.d.).

Data concerning content strands were also collected from the Illinois Interactive School Report Card website (IIRC, n.d.). The average percentage of questions correct on the multiple-choice portion of the ISAT for each content strand at each grade level was recorded, as well as the average percentage of all questions correct on the entire multiple-choice portion of the test.

A spreadsheet was created using Microsoft Excel. Rows in the spreadsheet represented schools included in the study, and columns represented the following:

1. Grade level (3, 4, or 5).
2. Curriculum (1 for *Everyday Math* and 2 for *Saxon Math*).
3. Percent of students meeting or exceeding standards on the ISAT.
4. Percent of low-income students meeting or exceeding standards on the ISAT.
5. Percent of non-low-income students meeting or exceeding standards on the ISAT.

6. Percent of White students meeting or exceeding standards on the ISAT.
7. Percent of non-White students meeting or exceeding standards on the ISAT.
8. Percent of IEP students meeting or exceeding standards on the ISAT.
9. Percent of non-IEP students meeting or exceeding standards on the ISAT.
10. Percent of male students meeting or exceeding standards on the ISAT.
11. Percent of female students meeting or exceeding standards on the ISAT.
12. Average percent of questions correct on the multiple-choice portion of the ISAT.
13. Average percent of questions correct for each content strand.
14. Percent of low-income students.
15. Percent of IEP students.
16. Percent of African American and Hispanic students.
17. Percent of female students.
18. School size (determined by the number of students in the respective grade).

Formulas were created to calculate some values not reported by the IIRC. For instance, the number of questions correct by content strand was converted to the percentage of questions correct by content strand. Some schools had fewer than 10 students in certain subgroups. Since the IIRC does not report data for subgroups with fewer than 10 students, some schools do not have data available for certain subgroups. Missing items were given a value of -999. All data were later transferred to the Statistical Package for Social Sciences, version 19 (SPSS 19). The value of -999 was coded as missing data in SPSS.

Data Analysis

Data analysis began with comparing the two samples. The *Everyday Math* and *Saxon Math* samples were compared using the aforementioned characteristics that research has connected to student achievement. Mean percentages of low-income students, Black and Hispanic minorities, girls, students with IEPs, and the mean school size for both samples were calculated and compared by grade level.

Analysis of Overall Curriculum Effect

Descriptive statistics were calculated and displayed for the mean number of questions correct on the multiple-choice portion of the ISAT for each level of curriculum (*Everyday Math* and *Saxon Math*) at each grade level. The null hypothesis for the first research question was, It is hypothesized that there is not a significant correlation between curriculum (*Everyday Math* or *Saxon Math*) and third, fourth, and fifth grade mathematics achievement in Illinois.

Multiple linear regressions were used to test this null hypothesis. A multiple linear regression model was used for each grade level to test for a significant correlation between the math curriculum used in combination with minority enrollment percentage, percentage of female students, percentage of low-income students, percentage of IEP students, and school size (predictor variables) and the average percentage of questions correct on the multiple choice portion of the ISAT (criterion variable). The significance of each individual predictor was tested. Regression coefficients for curriculum were analyzed to determine the effect of curriculum when holding other predictors constant.

Analysis by Subgroup

Descriptive statistics concerning the percentage meeting or exceeding standards for each subgroup were calculated and displayed by grade level and curriculum. The null hypothesis for the second research question was: It is hypothesized that there is no significant difference in elementary mathematics achievement of *Everyday Math* and *Saxon Math* schools in Illinois when groups are broken down according to ethnicity, gender, socioeconomic status, and IEP status.

This hypothesis was tested using independent means *t*-tests. Mean percentages of students meeting or exceeding standards on the ISAT for each subgroup were analyzed at each grade level using independent means *t*-tests to test the significance of differences in *Everyday Math* and *Saxon Math* schools. Cohen's *d* effect size was calculated and interpreted for each significant result.

Analysis by Content Strand

Descriptive statistics concerning the percentage of questions correct for each content strand were calculated and displayed by curriculum. The null hypothesis for the third research question was: There is no significant correlation between curriculum (*Everyday Math* or *Saxon Math*) and mathematics achievement in each content strand tested in Illinois schools (*number sense; measurement; algebra; geometry; data-analysis, statistics, and probability*).

Multiple linear regressions were used to test this null hypothesis. A multiple linear regression model was used for each content strand to test for a significant correlation between the math curriculum used in combination with minority enrollment percentage, percentage of female students, percentage of low-income students,

percentage of IEP students, and school size (predictor variables) and the average percentage of questions correct on each content strand portion of the ISAT (criterion variable). The significance of each individual predictor was tested. Regression coefficients for curriculum were analyzed to determine the effect of curriculum when holding other predictors constant.

Summary

Methods employed in this study included collecting samples of *Everyday Math* and *Saxon Math* schools and using ISAT data and statistical tests to measure differences in the achievement levels of the samples. Multiple regression models and *t*-tests were the statistical tests employed in the analysis of data.

CHAPTER 4

RESULTS

The purpose of this study, as previously stated, was to determine if *Everyday Math* or *Saxon Math* schools support greater student achievement in Illinois. Specifically, school-level ISAT data were analyzed to determine if there were significant differences in the effects of implementing the curricula on third, fourth, and fifth grade achievement. Overall effects of the curricula were compared, in addition to effects by subgroup and content strand. Following a brief discussion comparing the *Everyday Math* and *Saxon Math* samples, this chapter gives the statistical results of the study. All statistical tests were assessed at the .05 significance level.

Comparison of Samples

Data collection resulted in a sample of schools using *Everyday Math* and a sample of schools using *Saxon Math* in Grades 3 through 5. The number of schools in each sample is summarized in Table 6 by curriculum and grade level.

Table 6

Number of Schools Using Everyday Math and Saxon Math Included in Each Sample

Grade	<i>Everyday Math</i>	<i>Saxon Math</i>
Third	128	57
Fourth	126	56
Fifth	123	55

A comparison of the demographic make-up of *Everyday Math* and *Saxon Math* schools was completed for each grade level using the averages of each of the following characteristics: percentage of low-income students, percentage of black and Hispanic minorities, percentage of IEP students, percentage of female students, and school size. The number of students who completed the ISAT determined school size. Data was obtained from the Illinois Interactive School Report Card (IIRC). A summary of this descriptive data can be found in Table 7.

Though considerable differences exist between schools using *Everyday Math* and *Saxon Math* in the areas of low-income percent, Black and Hispanic minority percent, and school size, these factors were accounted for in the multiple regression analysis of overall curriculum effect and for the analysis by content strand.

Table 7

Demographic Characteristics for Everyday Math and Saxon Math Schools

Demographic	Third grade		Fourth grade		Fifth grade	
	<i>Everyday Math</i>	<i>Saxon Math</i>	<i>Everyday Math</i>	<i>Saxon Math</i>	<i>Everyday Math</i>	<i>Saxon Math</i>
Low-Income Percent	28.5	45.2	28.3	43.5	27.9	41.6
Black/ Hispanic Percent	20.7	10.3	20.8	10.3	20.8	10.3
IEP Percent	12.2	16.7	14.3	15.3	13.5	14.3
Female Percent	49.1	50.1	48.8	47.8	48.0	51.5
School Size	75.7	54.3	78.0	57.8	76.1	58.1

Analysis of Overall Curriculum Effect

The first research question in this study asked, Are there correlations between curriculum (*Everyday Math* or *Saxon Math*) and third, fourth, and fifth grade mathematics achievement in Illinois? Table 8 displays the mean percentage of questions correct, by grade level and curriculum, on the multiple-choice mathematics portion of the ISAT, along with sample sizes and standard deviations.

Table 8

Statistics for Overall Mathematics Achievement

Curriculum	Third grade			Fourth grade			Fifth grade		
	<i>N</i>	<i>M</i>	<i>SD</i>	<i>N</i>	<i>M</i>	<i>SD</i>	<i>N</i>	<i>M</i>	<i>SD</i>
<i>Everyday Math</i>	128	76.2	.06	126	72.6	.06	123	67.4	.06
<i>Saxon Math</i>	57	72.4	.06	56	69.6	.05	55	62.4	.07

Note. Achievement is measured here by the average percentage of questions correct on the multiple-choice portion of the ISAT.

Though mathematics achievement for *Everyday Math* schools is greater at each grade level than that of *Saxon Math* schools, tests needed to be employed to determine if the differences could be attributed to curriculum. A multiple linear regression model was used for each grade level to test for a significant correlation between the math curriculum used in combination with minority enrollment percentage, percentage of female students, percentage of low-income students, percentage of IEP students, and school size (predictor variables) and the average percentage of questions correct on the multiple choice portion of the ISAT (criterion variable).

A regression model was developed, and the significance of each predictor was tested. Finally, the regression coefficients for curriculum were analyzed to determine the influence of curriculum when other predictors were held constant. This portion of the analysis resulted in three linear regression models, one for each grade level.

The initial step in each regression model was determining the Pearson product-moment correlation coefficient (multiple R), followed by the coefficient of determination R^2 and adjusted R^2 , to allow for the sample size and number of predictors. The

coefficients of determination were used to approximate the amount of variation in the criterion variable that can be explained by the predictor variables. Next it was necessary to determine whether the multiple R -value was statistically significant. It was found that the regression models at each grade level were significantly better at predicting mathematics achievement than the mean. Tables 9, 10, and 11 display the regression analysis summary for predictors.

Table 9

Regression Analysis Summary for Variables Predicting Third Grade Math Achievement

Predictors	B	$SE\ B$	β
Curriculum	-.020	.009	-.146*
Low-income percent	-.002	.000	-.561***
Black/Hispanic percent	-.001	.000	-.166*
IEP percent	-.001	.001	-.064
Female percent	.000	.001	.009
School size	.000	.000	-.093

Note. All values are rounded to three significant digits. $N = 181$; $R^2 = .47$; Adjusted $R^2 = .45$. * $p < .05$; *** $p < .001$, two-tailed.

Table 10

Regression Analysis Summary for Variables Predicting Fourth Grade Math Achievement

Predictors	<i>B</i>	<i>SE B</i>	β
Curriculum	-.015	.009	-.112
Low-income percent	-.001	.000	-.481***
Black/Hispanic percent	-.001	.000	-.212**
IEP percent	-.001	.001	-.081
Female percent	.000	.001	.017
School size	.000	.000	-.007

Note. All values are rounded to three significant digits. $N = 177$; $R^2 = .43$; Adjusted $R^2 = .41$. ** $p < .01$; *** $p < .001$, two-tailed.

Table 11

Regression Analysis Summary for Variables Predicting Fifth Grade Math Achievement

Predictors	<i>B</i>	<i>SE B</i>	β
Curriculum	-.043	.012	-.286***
Low-income percent	-.001	.000	-.301**
Black/Hispanic percent	-.001	.000	-.147
IEP percent	-.001	.001	-.083
Female percent	.001	.001	.083
School size	.000	.000	-.014

Note: All values are rounded to three significant digits. $N = 177$. $R^2 = .30$; Adjusted $R^2 = .27$. ** $p < .01$; *** $p < .001$, two-tailed.

Results of the regression analysis confirmed that approximately 47%, 43%, and 30% of the variation in mathematics achievement can be explained by the model predictors for third, fourth, and fifth grades respectively. When adjusted for sample size and number of predictors, approximately 45%, 41%, and 27% of the variance in mathematics achievement can be explained by the predictors for third, fourth, and fifth grades respectively.

IEP percentage, female student percentage, and school size were not significant predictors in the regression models for any of the three grades analyzed. Low-income student percentage was a significant predictor for all grades, while Black and Hispanic minority student percentage was a significant predictor for third and fourth grades. The type of curriculum used was a significant predictor for third and fifth grades. When holding other variables constant, *Everyday Math* schools can be expected to have an average of 2.0% more questions correct than *Saxon Math* schools at the third grade level. At the fifth grade level, *Everyday Math* schools are predicted to have an average of 4.3% more questions correct than *Saxon Math* schools.

Analysis by Subgroup

The second research question in this study asked, Are there significant differences in elementary student achievement of *Everyday Math* and *Saxon Math* schools in Illinois when groups are examined with regard to ethnicity, gender, socioeconomic status, and IEP status? Independent means *t*-tests were used to test the null hypothesis that there is no significant difference in elementary mathematics achievement of *Everyday Math* and *Saxon Math* schools in Illinois when groups are broken down according to ethnicity, gender, socioeconomic status, and IEP status. Data linking the number of questions

correct and subgroups was not available from the IIRC website, so percent meeting or exceeding standards was used as the independent variable in the analysis of subgroup performance. Thus, mathematics achievement for subgroup analysis is determined by the percent of students meeting or exceeding state standards on the mathematics portion of the ISAT.

Analysis by Ethnicity

The mean percentages meeting or exceeding state standards on the ISAT for whites and non-Asian minorities of *Everyday Math* and *Saxon Math* schools are displayed in Table 12, along with sample sizes and standard deviations. As achievement gaps for Asian minorities have not been a concern for schools in Illinois, Asians were not included in the analysis. All schools included had a majority of their minority population formed by Black and Hispanic students. Other minority groups identified by the IIRC include Native Americans and multiracial individuals.

Independent means *t*-tests were used to examine the significance in differences between *Everyday Math* and *Saxon Math* percentages meeting and exceeding standards by ethnicity. Results of the *t*-tests showed that White students at the third grade level performed significantly better with *Everyday Math* ($M = 95.7, SD = 4.18$) than with *Saxon Math* ($M = 91.3, SD = 6.96$); $t(73.31) = 4.43, p < .001, d = .85$. Cohen's *d* effect size of .85 signified a large effect of curriculum on the percent of third grade White students meeting or exceeding standards on the ISAT. White students at the fifth grade level also performed significantly better with *Everyday Math* ($M = 92.9, SD = 6.02$) than with *Saxon Math* ($M = 89.6, SD = 8.00$); $t(80.86) = 2.69, p = .009, d = .49$. Cohen's *d* effect size of .49 signified a medium effect of curriculum on the percent of fifth grade

Table 12

<i>Mathematics Achievement by Ethnicity and Curriculum</i>				
Ethnicity	Curriculum	<i>N</i>	<i>M</i>	<i>SD</i>
Third Grade				
White	<i>Everyday Math</i>	125	95.7	4.18
	<i>Saxon Math</i>	56	91.3	6.96
Non-Asian minority	<i>Everyday Math</i>	112	86.4	13.56
	<i>Saxon Math</i>	43	84.3	20.01
Fourth Grade				
White	<i>Everyday Math</i>	125	93.8	10.08
	<i>Saxon Math</i>	55	92.6	9.11
Non-Asian minority	<i>Everyday Math</i>	111	86.2	12.09
	<i>Saxon Math</i>	41	84.8	23.11
Fifth Grade				
White	<i>Everyday Math</i>	121	92.9	6.02
	<i>Saxon Math</i>	54	89.6	8.00
Non-Asian minority	<i>Everyday Math</i>	112	83.8	12.81
	<i>Saxon Math</i>	37	68.9	34.19

Note. Achievement is measured here by the average percent of students meeting or exceeding standards on the ISAT.

White students meeting or exceeding standards. Results showed no significant difference in the percentage of fourth grade White students meeting or exceeding standards with *Everyday Math* ($M = 93.8$, $SD = 10.08$) and *Saxon Math* ($M = 92.6$, $SD = 9.11$); $t(178) = .78$, $p = .439$, $d = .12$.

Analysis of non-Asian minority achievement found fifth grade students in this category had greater mathematics achievement with *Everyday Math* ($M = 83.8$, $SD = 12.81$) than with *Saxon Math* ($M = 68.9$, $SD = 34.19$); $t(39.39) = 2.59$, $p = .013$, $d = .74$. Cohen's d effect size of .74 signified a fairly large effect of curriculum on the percent of fifth grade non-Asian minorities meeting or exceeding standards. Results showed no significant differences in achievement of non-Asian minorities using *Everyday Math* and *Saxon Math* at the third ($t(57.45) = .63$, $p = .529$, $d = .13$) and fourth ($t(48.31) = .37$, $p = .715$, $d = .09$) grade levels.

Analysis by Gender

The mean percentages meeting or exceeding state standards on the ISAT for each gender and curriculum are displayed in Table 13, along with sample sizes and standard deviations.

Independent means t -tests were used to examine the significance in differences between *Everyday Math* and *Saxon Math* percentages meeting and exceeding standards by gender. The only significant result of these tests was for girls at the third grade level, with girls performing better using *Everyday Math* ($M = 92.7$, $SD = 6.30$) than with the *Saxon Math* ($M = 88.4$, $SD = 8.19$) curriculum; $t(76.92) = 3.36$, $p = .001$, $d = .62$. Cohen's d effect size of .62 signified a medium effect of curriculum on the percent of third grade females meeting or exceeding standards on the ISAT.

Table 13

Mathematics Achievement by Gender and Curriculum

Gender	Curriculum	<i>N</i>	<i>M</i>	<i>SD</i>
Third Grade				
Boys	<i>Everyday Math</i>	128	92.1	10.01
	<i>Saxon Math</i>	54	91.5	9.30
Girls	<i>Everyday Math</i>	127	92.7	6.30
	<i>Saxon Math</i>	52	88.4	8.19
Fourth Grade				
Boys	<i>Everyday Math</i>	125	90.3	9.32
	<i>Saxon Math</i>	52	90.8	9.11
Girls	<i>Everyday Math</i>	125	91.7	8.58
	<i>Saxon Math</i>	49	91.7	8.17
Fifth Grade				
Boys	<i>Everyday Math</i>	122	88.1	11.20
	<i>Saxon Math</i>	50	85.4	11.62
Girls	<i>Everyday Math</i>	122	90.0	7.44
	<i>Saxon Math</i>	53	88.8	7.34

Note. Achievement is measured here by the average percent of students meeting or exceeding standards on the ISAT.

Boys in third grade and both genders in fourth and fifth grades showed no significant differences in achievement as measured by the percent meeting or exceeding standards on the ISAT. The *t*-test results for gender analysis are given in Table 14.

Table 14

Summary of t-tests for Gender Analysis

Gender	<i>t</i>	<i>df</i>	<i>p</i>	<i>d</i>
Third Grade				
Boys	.39	180.00	.699	.06
Girls	3.36	77.92	.001	.62
Fourth Grade				
Boys	-.29	175.00	.769	-.05
Girls	.01	172.00	.992	.00
Fifth Grade				
Boys	1.43	170.00	.155	.24
Girls	.96	173.00	.338	.16

Analysis by Socioeconomic Status (SES)

The mean percentages meeting or exceeding state standards on the ISAT for low-income and non low-income students are displayed in Table 15 by curriculum, along with sample sizes and standard deviations. Independent means *t*-tests were used to examine the significance in differences between *Everyday Math* and *Saxon Math* percentages meeting and exceeding standards by SES. The only significant result of these tests was for non low-income students in third grade, with non low-income students performing better with *Everyday Math* ($M = 96.6$, $SD = 3.47$) than with the *Saxon Math* ($M = 93.9$, $SD = 6.28$) curriculum; $t(64.24) = 2.93$, $p = .005$, $d = .60$. Cohen's *d* effect size of .60

Table 15

<i>Mathematics Achievement by Socioeconomic Status (SES) and Curriculum</i>				
SES	Curriculum	<i>N</i>	<i>M</i>	<i>SD</i>
Third Grade				
Low-income	<i>Everyday Math</i>	122	88.1	11.20
	<i>Saxon Math</i>	50	85.4	11.62
Non low-income	<i>Everyday Math</i>	127	92.7	6.30
	<i>Saxon Math</i>	52	88.4	8.19
Fourth Grade				
Low-income	<i>Everyday Math</i>	125	84.8	11.68
	<i>Saxon Math</i>	56	87.4	10.91
Non low-income	<i>Everyday Math</i>	123	94.6	5.11
	<i>Saxon Math</i>	51	95.5	4.88
Fifth Grade				
Low-income	<i>Everyday Math</i>	121	81.4	11.56
	<i>Saxon Math</i>	55	81.8	13.39
Non low-income	<i>Everyday Math</i>	120	93.2	6.57
	<i>Saxon Math</i>	54	92.3	6.88
<i>Note.</i> Achievement is measured here by the average percent of students meeting or exceeding standards on the ISAT.				

signified a medium effect of curriculum on the percent of third grade non low-income students meeting or exceeding standards on the ISAT. Low-income students in third grade and both SES categories in fourth and fifth grades showed no significant

differences in performance as measured by the percent meeting or exceeding standards on the ISAT. The *t*-test results for SES analysis are given in Table 16.

Table 16

Summary of t-tests for SES Analysis

SES	<i>t</i>	<i>df</i>	<i>p</i>	<i>d</i>
Third Grade				
Low-income	-1.05	181.00	.296	-.17
Non low-income	2.93	64.24	.005	.60
Fourth Grade				
Low-income	-1.40	179.00	.162	-.23
Non low-income	-1.12	172.00	.265	-.18
Fifth Grade				
Low-income	-.23	174.00	.815	-.03
Non low-income	.81	172.00	.417	.13

Analysis by IEP Status

The mean percentages meeting or exceeding state standards on the ISAT for IEP and non-IEP students are displayed by curriculum in Table 17, along with sample sizes and standard deviations.

Table 17

Mathematics Achievement by IEP Status and Curriculum

IEP status	Curriculum	<i>N</i>	<i>M</i>	<i>SD</i>
Third Grade				
IEP	<i>Everyday Math</i>	127	77.8	19.58
	<i>Saxon Math</i>	57	76.5	22.91
Non IEP	<i>Everyday Math</i>	128	94.8	5.93
	<i>Saxon Math</i>	56	92.7	6.77
Fourth Grade				
IEP	<i>Everyday Math</i>	126	74.3	19.11
	<i>Saxon Math</i>	55	72.7	24.92
Non IEP	<i>Everyday Math</i>	126	94.4	6.00
	<i>Saxon Math</i>	56	95.4	5.19
Fifth Grade				
IEP	<i>Everyday Math</i>	123	64.3	25.70
	<i>Saxon Math</i>	53	65.2	26.98
Non IEP	<i>Everyday Math</i>	123	93.2	6.01
	<i>Saxon Math</i>	55	92.1	7.51

Note. Achievement is measured here by the average percent of students meeting or exceeding standards on the ISAT.

Independent means *t*-tests were used to examine the significance in differences between *Everyday Math* and *Saxon Math* percentages meeting and exceeding standards by IEP status. The only significant result of these tests was for non-IEP students in third grade, with non-IEP students performing better with *Everyday Math* ($M = 94.8$, $SD =$

5.93) than with the *Saxon Math* ($M = 92.7$, $SD = 6.77$) curriculum; $t(182) = 2.09$, $p = .038$, $d = .34$. Cohen's d effect size of .34 signified a relatively small effect of curriculum on the percent of third grade non-IEP students meeting or exceeding standards on the ISAT. IEP students in third grade and both IEP categories in fourth and fifth grades showed no significant differences in performance, as measured by the percent meeting or exceeding standards on the ISAT. The t -test results for IEP analysis are given in Table 18.

Table 18

Summary of t-tests for IEP Status Analysis

IEP status	t	df	p	d
Third Grade				
IEP	.36	94.22	.721	.06
Non-IEP	2.09	182.00	.038	.34
Fourth Grade				
IEP	.44	82.93	.662	.08
Non-IEP	-1.00	180.00	.317	-.17
Fifth Grade				
IEP	-.21	174.00	.831	-.03
Non-IEP	1.00	176.00	.317	.17

Analysis by Content Strand

The final research question in this study asked: Is there a correlation between curriculum (*Everyday Math* or *Saxon Math*) and mathematics achievement in each content strand tested in Illinois schools (*number sense*; *measurement*; *algebra*; *geometry*;

data-analysis, statistics, and probability)? Abbreviations that were used for the content strand names are listed.

1. NUM – *number sense*
2. MSR – *measurement*
3. ALG – *algebra*
4. GEO – *geometry*
5. DSP – *data-analysis, statistics, and probability*

Content strand data were not analyzed by grade level, thus data in this section combined third, fourth, and fifth grade data. Table 19 displays the mean percentage of questions correct on the ISAT, by content strand and curriculum, along with standard deviations. The sample included 377 *Everyday Math* elementary grades and 168 *Saxon Math* elementary grades.

Though mathematics achievement for *Everyday Math* schools is greater for each content strand than that of *Saxon Math* schools, tests needed to be employed to determine if the differences could be attributed to curriculum. A multiple linear regression model was used for each content strand to test for a significant correlation between the math curriculum used—in combination with minority enrollment percentage, percentage of female students, percentage of low-income students, percentage of IEP students, and school size (predictor variables)—and the average percentage of questions correct for the content strand (criterion variable).

Regression models were developed, and the significance of each predictor was tested. Finally, the regression coefficients for curriculum were analyzed to determine the

influence of curriculum when other predictors were held constant. This portion of the analysis resulted in five linear regression models, one for each content strand.

Table 19

Elementary School Achievement by Content Strand

Content strand	<i>Everyday Math</i>		<i>Saxon Math</i>	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
NUM	70.3	8.15	66.6	8.54
MSR	73.1	9.46	69.7	9.88
ALG	78.9	7.67	73.8	8.52
GEO	70.0	6.83	65.6	7.60
DSP	72.6	7.66	69.0	8.35

Note. Achievement is measured here by the average percentage of questions correct for each content strand.

The initial step in each regression model was determining the Pearson product moment correlation coefficient (multiple R), followed by the coefficient of determination R^2 and adjusted R^2 , to allow for the sample size and number of predictors. The coefficients of determination were used to approximate the amount of variation in the criterion variable that could be explained by the predictor variables. Next it was necessary to determine whether the multiple R -value was statistically significant. It was found that the regression models for each content strand were significantly better at predicting math achievement than the mean for each content strand.

Table 20 displays the regression analysis summary for predictors of achievement on the *number sense* content strand. Results of the regression analysis confirmed that the model predictors could explain approximately 23% of the variation in elementary *number*

sense achievement. When adjusted for sample size and number of predictors, the predictors explained approximately 22% of the variance. IEP percent, female percent, and school size were not significant predictors in the regression model. Low-income percent, Black and Hispanic minority percent, and curriculum were significant predictors. When holding other variables constant, *Everyday Math* schools were expected to have an average of 2.4% more questions correct than *Saxon Math* schools on the *number sense* portion of the ISAT.

Table 20

Regression Analysis Summary for Variables Predicting Elementary NUM Achievement

Predictors	<i>B</i>	<i>SE B</i>	β
Curriculum	-.024	.008	-.129**
Low-income percent	-.001	.000	-.348***
Black/Hispanic percent	-.001	.000	-.130**
IEP percent	-.001	.001	-.074
Female percent	.000	.000	.007
School size	.000	.000	-.041

Note. All values are rounded to three significant digits. $N = 535$; $R^2 = .23$; Adjusted $R^2 = .22$. ** $p < .01$; *** $p < .001$, two-tailed.

Table 21 displays the regression analysis summary for predictors of achievement on the *measurement* content strand. Results of the regression analysis confirmed that the model predictors could explain approximately 16% of the variation in elementary *measurement* achievement. When adjusted for sample size and number of predictors, the predictors explained approximately 16% of the variance. Female percent and school size

were not significant predictors in the regression model. Low-income percent, Black and Hispanic minority percent, IEP percent, and curriculum were significant predictors.

When holding other variables constant, *Everyday Math* schools were expected to have an average of 2.4% more questions correct than *Saxon Math* schools on the *measurement* portion of the ISAT.

Table 21

Regression Analysis Summary for Variables Predicting Elementary MSR Achievement

Predictors	<i>B</i>	<i>SE B</i>	β
Curriculum	-.024	.010	-.111*
Low-income percent	-.001	.000	-.261***
Black/Hispanic percent	-.001	.000	-.139**
IEP percent	-.002	.001	-.112**
Female percent	.000	.000	.015
School size	.000	.000	-.051

Note. All values are rounded to three significant digits. $N = 535$; $R^2 = .16$; Adjusted $R^2 = .16$. * $p < .05$; ** $p < .01$; *** $p < .001$, two-tailed.

Table 22 displays the regression analysis summary for predictors of achievement on the *algebra* content strand. Results of the regression analysis confirmed that the model predictors could explain approximately 24% of the variation in elementary *algebra* achievement. When adjusted for sample size and number of predictors, the predictors explained approximately 23% of the variance. IEP percent, female percent, Black and Hispanic minority percent, and school size were not significant predictors in the regression model. Low-income percent and curriculum were significant predictors. When holding other variables constant, *Everyday Math* schools were expected to have an

average of 3.5% more questions correct than *Saxon Math* schools on the *algebra* portion of the ISAT.

Table 22

Regression Analysis Summary for Variables Predicting Elementary ALG Achievement

Predictors	<i>B</i>	<i>SE B</i>	β
Curriculum	-.035	.008	-.191***
Low-income percent	-.002	.000	-.376***
Black/Hispanic percent	.000	.000	-.046
IEP percent	-.001	.001	-.048
Female percent	.000	.000	.013
School size	.000	.000	-.051

Note. All values are rounded to three significant digits. $N = 535$; $R^2 = .24$; Adjusted $R^2 = .23$. *** $p < .001$, two-tailed.

Table 23 displays the regression analysis summary for predictors of achievement on the *geometry* content strand. Results of the regression analysis confirmed that the model predictors could explain approximately 25% of the variation in elementary *geometry* achievement. When adjusted for sample size and number of predictors, the predictors explained approximately 24% of the variance. IEP percent, female percent, and school size were not significant predictors in the regression model. Low-income percent, Black and Hispanic minority percent, and curriculum were significant predictors. When holding other variables constant, *Everyday Math* schools were expected to have an average of 3.4% more questions correct than *Saxon Math* schools on the *geometry* portion of the ISAT.

Table 23

Regression Analysis Summary for Variables Predicting Elementary GEO Achievement

Predictors	<i>B</i>	<i>SE B</i>	β
Curriculum	-.034	.007	-.212***
Low-income percent	-.001	.000	-.314***
Black/Hispanic percent	-.001	.000	-.169***
IEP percent	.000	.000	-.042
Female percent	.000	.000	.044
School size	.000	.000	-.017

Note. All values are rounded to three significant digits. $N = 535$; $R^2 = .25$; Adjusted $R^2 = .24$. *** $p < .001$, two-tailed.

Table 24 displays the regression analysis summary for predictors of achievement on the *data-analysis, statistics, and probability* content strand. Results of the regression analysis confirmed that the model predictors could explain approximately 33% of the variation in elementary *data-analysis, statistics, and probability* achievement. When adjusted for sample size and number of predictors, the predictors explained approximately 33% of the variance. IEP percent, female percent, and school size were not significant predictors in the regression model. Low-income percent, Black and Hispanic minority percent, and curriculum were significant predictors. When holding other variables constant, *Everyday Math* schools were expected to have an average of 2.1% more questions correct than *Saxon Math* schools on the *data-analysis, statistics, and probability* portion of the ISAT.

Table 24

Regression Analysis Summary for Variables Predicting Elementary DSP Performance

Predictors	<i>B</i>	<i>SE B</i>	β
Curriculum	-.021	.007	-.122**
Low-income percent	-.002	.000	-.410***
Black/Hispanic percent	-.001	.000	-.197***
IEP percent	-.001	.000	-.055
Female percent	.001	.000	.058
School size	.000	.000	-.004

Note. All values are rounded to three significant digits. $N = 535$; $R^2 = .33$; Adjusted $R^2 = .33$. ** $p < .01$; *** $p < .001$, two-tailed.

Summary

Chapter 4 was designed to provide an analysis of the data concerning differences in mathematics achievement of schools using *Everyday Math* and *Saxon Math*. Multiple linear regressions were used to identify significant correlations between curriculum and achievement overall and by content strand. Independent means *t*-tests were used to identify significant differences between *Everyday Math* and *Saxon Math* schools by subgroup. Further discussions of the results are provided in Chapter 5.

CHAPTER 5

FINDINGS, CONCLUSIONS, AND FUTURE RESEARCH

Chapter 5 includes a summary of the study, along with significant findings. Conclusions and recommendations based on those findings are discussed. In addition, recommendations for future research are presented.

Summary of the Study

The purpose of this study was to determine if *Everyday Math* or *Saxon Math* schools support greater elementary mathematics achievement in Illinois. The two curricula represent the two philosophies in the continuing *math wars*. *Everyday Math* was one of the curricula developed in response to the *Standards*, released in 1989 by the NCTM. The *Standards* called for an increase in technology use, discovery learning, group work, communication, and conceptual understanding, with a de-emphasis on paper-and-pencil calculations, teaching by telling, and memorization of rules and algorithms. *Saxon Math* is a popular choice throughout the country for elementary schools choosing more traditional mathematics curricula, placing greater value on direct instruction, memorization, and repetition with standard arithmetic procedures.

The literature review briefly examined the historical influences on mathematics education leading up to today, and discussed basic differences in *reform* curricula (i.e., *Everyday Math*) and *traditional* curricula (i.e., *Saxon Math*). Particular focus was given

to comparing the treatment of algorithms for arithmetic in the two types of curricula. In addition, related studies were reviewed in the literature review.

A sample of 128 *Everyday Math* schools and 57 *Saxon Math* schools was identified in which school administrators verified fidelity of implementation at the third, fourth, and/or fifth grade levels. Data on these schools were collected from the Illinois Interactive School Report Card, and performance on the ISAT was used to measure achievement. Methods employed to compare the two curricula included multiple linear regressions to examine the correlation of curriculum with student achievement overall and by content strand and independent means *t*-tests to compare the mathematics achievement of subgroups using *Everyday Math* and *Saxon Math*. A significance level of $p < .05$ was used for all statistical tests.

Results of the study should provide information useful to school administrators making program selections and evaluating instructional methods for elementary mathematics. Results should also prove useful to parents, organizations, and other individuals concerned with the education of elementary children. Teacher educators benefit from the study as well, as the two programs being compared reflect two very different teaching philosophies. The study provides insight on whether one philosophy might be better to emphasize in preservice mathematics courses for elementary education majors.

Findings

A brief demographic analysis of the sample schools was completed. Some key differences were noted. *Saxon Math* schools averaged roughly 14% more low-income students than *Everyday Math* schools, and *Everyday Math* schools averaged about 10%

more Black and Hispanic minorities. *Everyday Math* schools also averaged roughly 20 more students per grade level than *Saxon Math* schools. The remainder of this section is organized by research question, giving the results of data analysis presented previously in Chapter 4, along with further discussion on the results.

Research Question 1

Are there correlations between curriculum (*Everyday Math* or *Saxon Math*) and third, fourth, and fifth grade mathematics achievement in Illinois? For this question, mathematics achievement was measured by the average percentage of questions correct on the multiple-choice portion of the ISAT. Mathematics achievement, as shown in Figure 2, was higher with *Everyday Math* at each grade level.

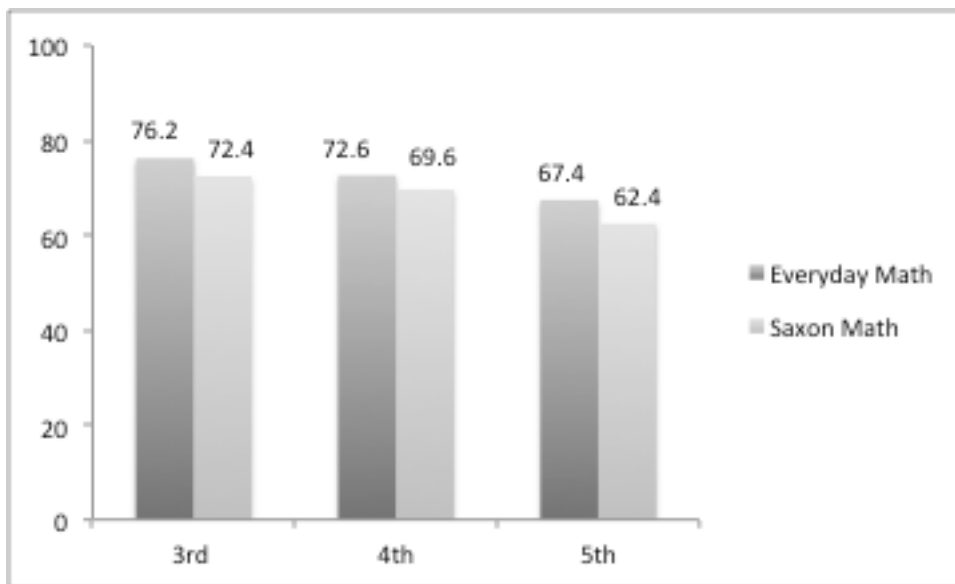


Figure 2. A comparison of mathematics achievement for *Everyday Math* and *Saxon Math* schools. Mathematics achievement is measured here by the average percentage of questions correct on the multiple-choice portion of the ISAT.

Multiple linear regression models were used to determine if curriculum had a significant effect on the achievement of students at each grade level. The models included curriculum (*Everyday Math* or *Saxon Math*), low-income percent, Black and Hispanic minority percent, IEP percent, female percent, and school size as predictors and

were found to be significantly better at predicting school achievement than the mean. When controlling for other predictors identified, curriculum was found to be a significant predictor of third and fifth grade mathematics achievement. However, curriculum was not a significant predictor of fourth grade mathematics achievement.

Although using *Everyday Math* instead of *Saxon Math* accounts for a significant increase in mathematics achievement in the third and fifth grades, the practical significance should be examined. The correlation coefficients for curriculum were examined to determine the unique effects of curriculum on student achievement, when other predictors in the model were held constant. At the third grade level, the correlation coefficient of $-.020$ signified an expected increase of 2.0% more questions correct on the multiple-choice portion of the ISAT when using *Everyday Math* instead of *Saxon Math*. At the fifth grade level, the increase was larger, with 4.3% more questions correct. Given that the mathematics portion of the ISAT contains 65 questions, *Everyday Math* schools could expect to outperform similar *Saxon Math* schools, with an average improvement of approximately 1.3 and 2.8 more questions correct for third grade and fifth grades, respectively.

Research Question 2

Are there significant differences in elementary student achievement of *Everyday Math* and *Saxon Math* schools in Illinois when groups are examined with regard to ethnicity, gender, socioeconomic status, and IEP status? For this question, mathematics achievement was measured by the percentage of students meeting or exceeding state standards on the ISAT. Independent means *t*-tests were used to identify significant differences in achievement for subgroups using *Everyday Math* and *Saxon Math*.

The first subgroups analyzed were White students and non-Asian minorities. Asians were not included in the analysis of minority achievement because their math achievement, on average, is higher than that of all other ethnic groups in Illinois. Asian mathematics achievement, therefore, is not a matter of concern in Illinois.

As seen in Figure 3, white students have higher mathematics achievement with *Everyday Math* at all three grade levels. Statistical analysis found that achievement was significantly higher with *Everyday Math* for White students in both third and fifth grade, but not in fourth grade. Cohen's d effect sizes of .85 and .49 for third grade and fifth grade, respectively, signified a high and medium effect of curriculum on mathematics achievement. *Saxon Math* schools should be concerned with these results.

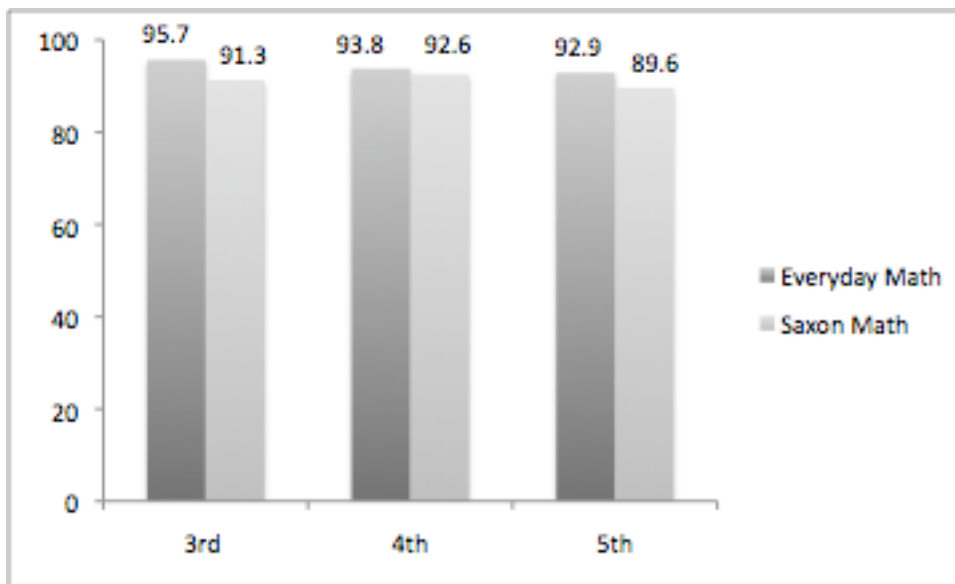


Figure 3. A comparison of White student achievement by curriculum. Performance is measured here by the average percent of students meeting or exceeding standards on the ISAT.

Non-Asian minority achievement results are displayed in Figure 4. Though this subgroup had higher mathematics achievement with *Everyday Math* in all grades, the only significant result was at the fifth grade level. Cohen's d effect size of .74 signified a

fairly large effect of curriculum on mathematics achievement of non-Asian minorities.

This result should be a major concern for *Saxon Math* schools, as mathematics achievement is nearly 15% less than that of *Everyday Math* schools for non-Asian minorities.

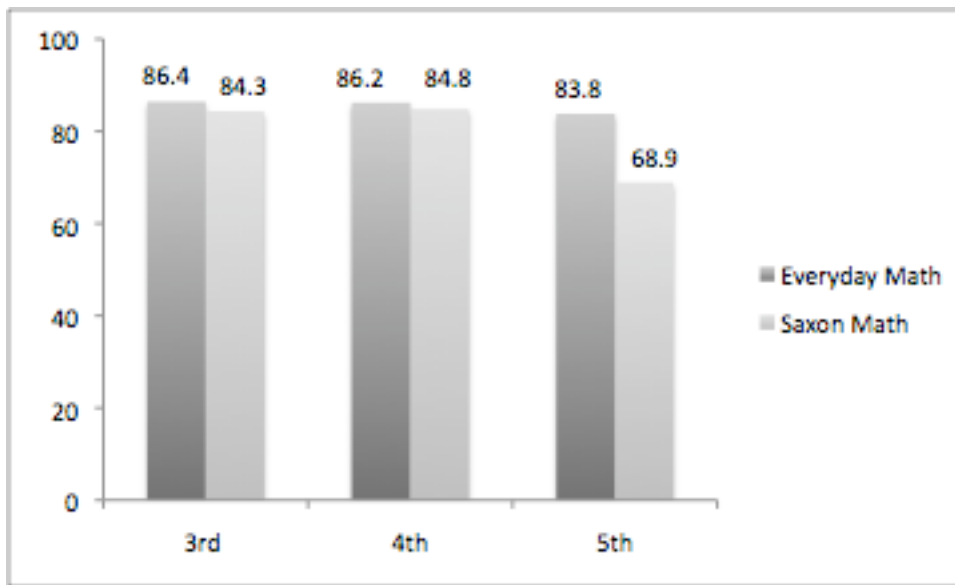


Figure 4. A comparison of non-Asian minority achievement by curriculum. Achievement is measured here by the average percent of students meeting or exceeding standards on the ISAT.

After considering ethnicity, gender subgroups were analyzed. *Everyday Math* schools had higher male student achievement in third and fifth grades, and *Saxon Math* schools had higher male student achievement in fourth grade. These results are displayed in Figure 5. None of the differences in male student mathematics achievement were significant.

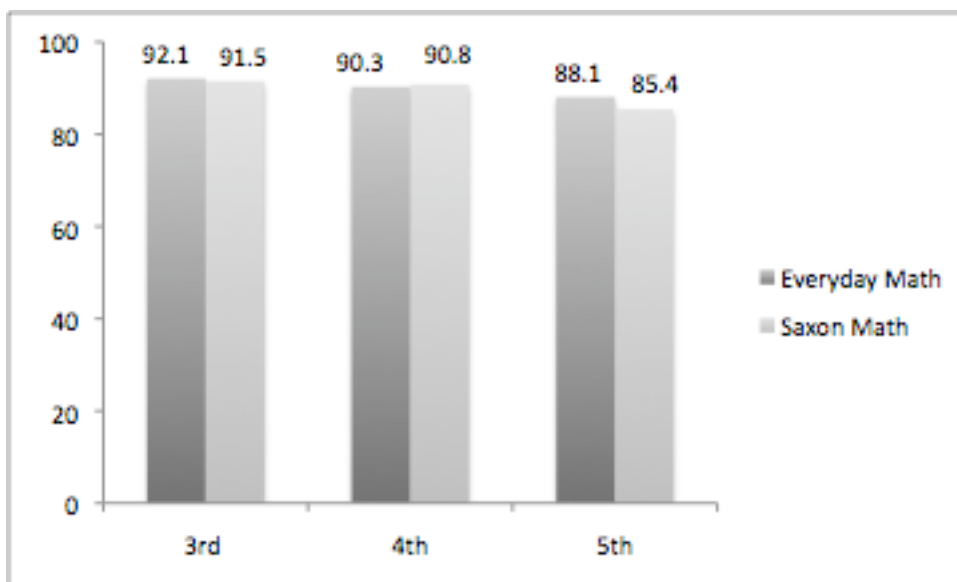


Figure 5. A comparison of male student achievement by curriculum. Achievement is measured here by the average percent of students meeting or exceeding standards on the ISAT.

Analysis of female student mathematics achievement found that female students had higher achievement with *Everyday Math* in third and fifth grades, but there was no difference in achievement at the fourth grade level. These results are displayed in Figure 6. The only significant difference in achievement was found at the third grade level, in which *Everyday Math* female students had significantly higher mathematics achievement. *Saxon Math* schools should be concerned with elements of their math curriculum that may cause lower achievement in third grade female students.

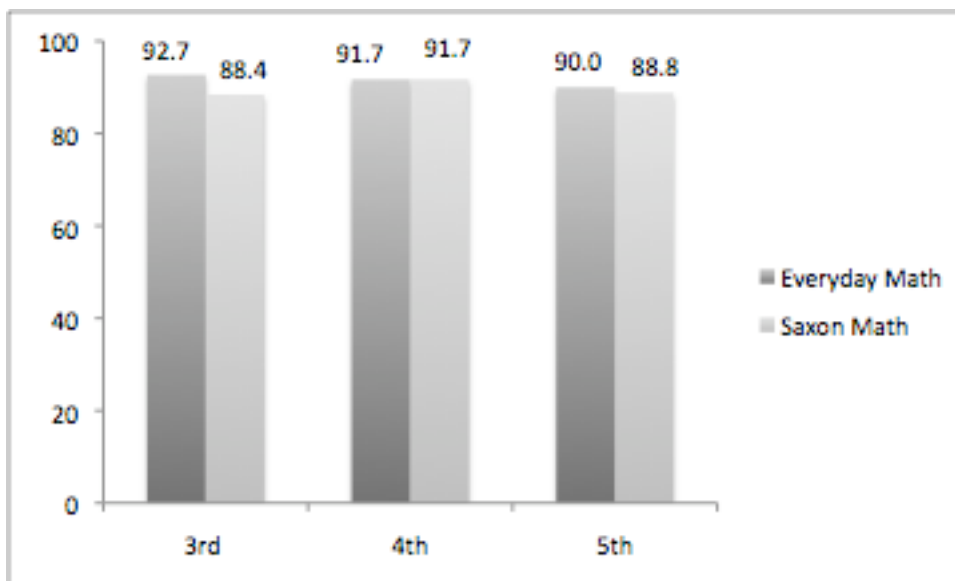


Figure 6. A comparison of female student achievement by curriculum. Achievement is measured here by the average percent of students meeting or exceeding standards on the ISAT.

Analysis of subgroups by socioeconomic status (SES) was completed next. Low-income mathematics achievement was found to be higher in *Saxon Math* schools at each grade level. These results are displayed in Figure 7. Differences between low-income achievement in *Saxon Math* schools and *Everyday Math* schools were not found to be significant. However, the higher mathematics achievement for low-income students in all grades in *Saxon Math* schools identifies a potential weakness in the *Everyday Math* curriculum.

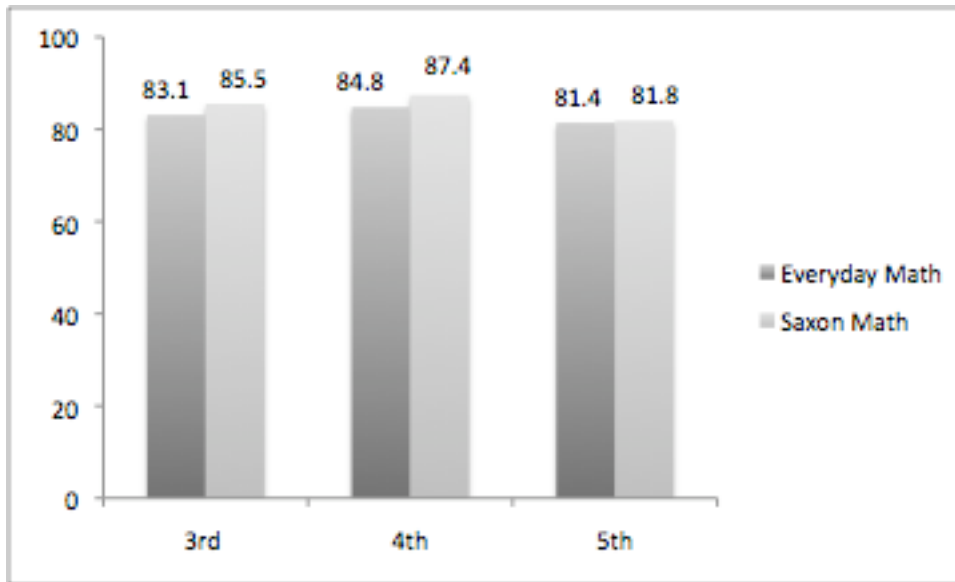


Figure 7. A comparison of low-income student achievement by curriculum. Achievement is measured here by the average percent of students meeting or exceeding standards on the ISAT.

Analysis of non low-income achievement found that *Everyday Math* schools had higher mathematics achievement for third and fifth grades, but *Saxon Math* schools had higher achievement for fourth grade. These results are displayed in Figure 8. The only significant difference found for non low-income mathematics achievement was at the third grade level, with *Everyday Math* schools having higher achievement than *Saxon Math* schools. Cohen's d effect size of .60 signified a medium effect of curriculum on the mathematics achievement of non low-income third graders. This adds to concern for *Saxon Math* schools at the third-grade level.

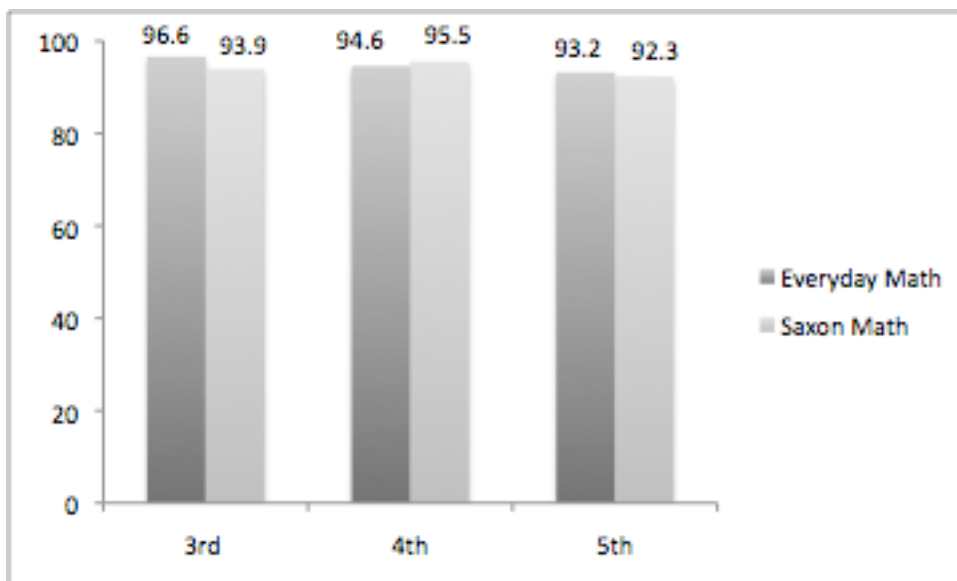


Figure 8. A comparison of non low-income student achievement by curriculum. Achievement is measured here by the average percent of students meeting or exceeding standards on the ISAT.

The final subgroup analysis examined differences in mathematics achievement by IEP status. IEP student achievement was found to be higher for *Everyday Math* schools in third and fourth grade, but higher for *Saxon Math* schools in fifth grade. These are displayed in Figure 9. None of the differences in mathematics achievement for the IEP subgroup were found to be significant.

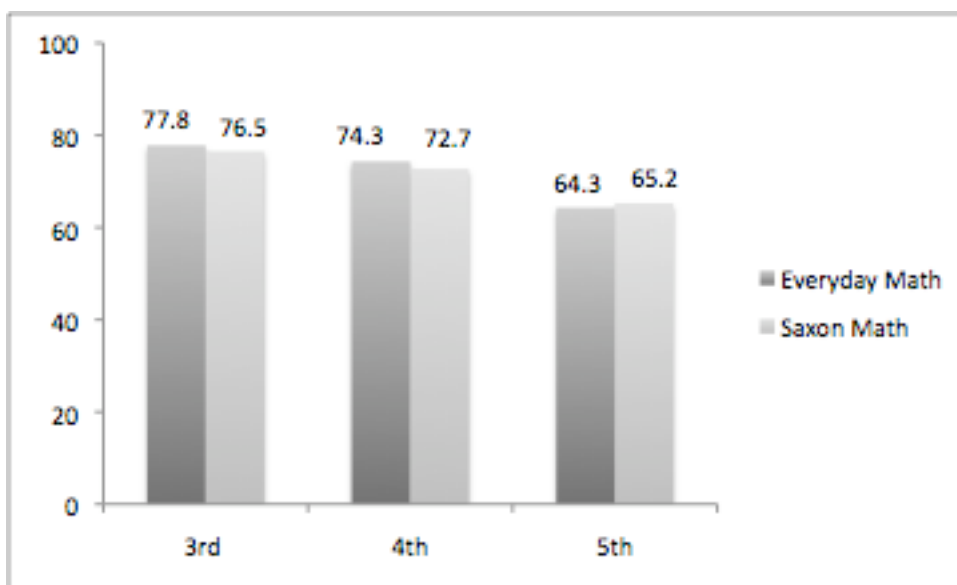


Figure 9. A comparison of IEP student achievement by curriculum. Achievement is measured here by the average percent of students meeting or exceeding standards on the ISAT.

Analysis of non-IEP achievement found *Everyday Math* schools to have higher mathematics achievement in third and fifth grade, but *Saxon Math* schools posted higher achievement in fourth grade. These are displayed in Figure 10. The only significant difference in non-IEP achievement was found at the third grade level, with *Everyday Math* having higher mathematics achievement. Again, there is reason for concern for *Saxon Math* schools at the third grade level.

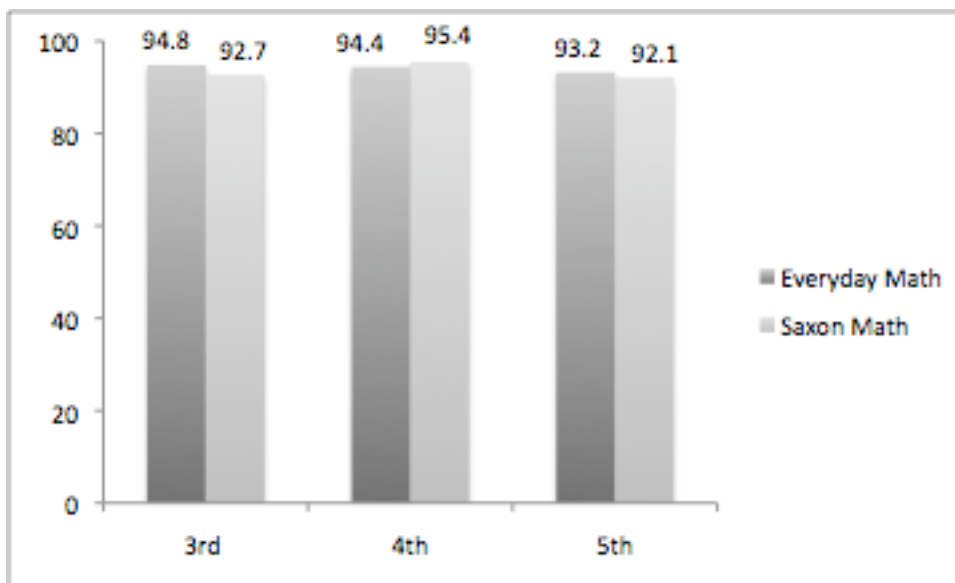


Figure 10. A comparison of non-IEP student achievement by curriculum. Achievement is measured here by the average percent of students meeting or exceeding standards on the ISAT.

Research Question 3

Is there a correlation between curriculum (*Everyday Math* or *Saxon Math*) and mathematics achievement in each content strand tested in Illinois schools (*number sense; measurement; algebra; geometry; data-analysis, statistics, and probability*)?

Abbreviations that were used for the content strand names are listed.

1. NUM – *number sense*
2. MSR – *measurement*
3. ALG – *algebra*
4. GEO – *geometry*
5. DSP – *data-analysis, statistics, and probability*

For this final research question, mathematics achievement was measured by the average percentage of questions correct on each content strand of the ISAT. Analysis by content strand was not broken down by grade level, but Grades 3, 4, and 5 (elementary grades)

were examined together. Mathematics achievement, as shown in Figure 11, was higher with *Everyday Math* for each content strand.

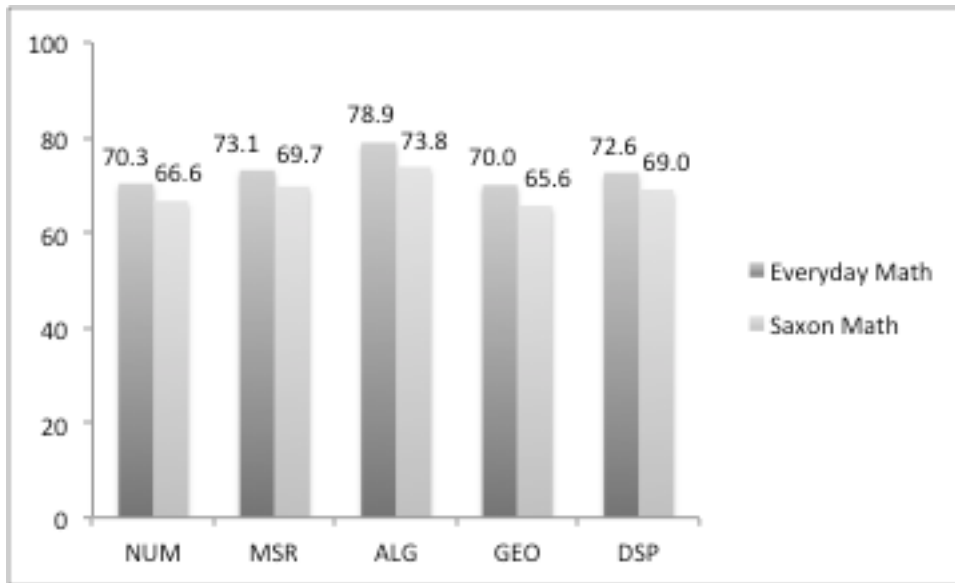


Figure 11. A comparison of content strand achievement by curriculum. Achievement is measured here by the average percentage of questions correct for each content strand.

Multiple linear regression models were used to determine if curriculum had a significant effect on the achievement of students on each content strand. The models included curriculum (*Everyday Math* or *Saxon Math*), low-income percent, Black and Hispanic minority percent, IEP percent, female percent, and school size as predictors, and were found to be significantly better at predicting school achievement for each content strand than the mean. When controlling for other predictors identified, curriculum was found to be a significant predictor of achievement for each content strand.

Although using *Everyday Math* instead of *Saxon Math* accounts for a significant increase in mathematics achievement for each content strand, the practical significance should be examined. The correlation coefficients for curriculum were examined to determine the unique effects of curriculum on student achievement for each content

strand, when other predictors in the model were held constant. For the content strands of *number sense* and *measurement*, the correlation coefficients of $-.024$ signified an expected increase of 2.4% more questions correct when using *Everyday Math* instead of *Saxon Math*. For the content strands of *algebra* and *geometry*, the increase was larger, at 3.5% and 3.4% more questions correct, respectively. For the content strand of *data-analysis, statistics, and probability* there was an increase of 2.1% more questions correct with *Everyday Math*.

Recommendations and Conclusions

This study found several statistically significant results, which led to recommendations and conclusions. The primary target of recommendations is the school administrator tasked with curriculum selection and evaluation. Recommendations for administrators currently using the *Saxon Math* or *Everyday Math* curriculum are given. Additionally, recommendations are provided for other administrators making an elementary mathematics curriculum selection.

Recommendations for *Saxon* Administrators

None of the significant results of this study pointed to *Saxon Math* supporting greater student achievement than *Everyday Math*, but *Everyday Math* showed significantly greater achievement in several areas. It is quite possible that there is something in the *Everyday Math* curriculum that *Saxon Math* is missing. *Saxon Math* showed similar deficiencies compared to *Everyday Math* across all content strands, and, therefore, one content area cannot be blamed. It is likely that none of the content in the *Saxon Math* curricula is deficient, but the delivery is deficient. The incorporation of technology use, discovery learning, group work, communication, and conceptual

understanding inherent in the use of *Everyday Math* may be the factors leading to gains in student achievement. One recommendation would be to ensure that teachers in districts with *Saxon Math* incorporate these items in math instruction through supplemental materials or teacher-created activities. Another option would be to adopt a curriculum that exhibits qualities that encourage more involvement of the child in the learning process.

Some specific areas of concern for *Saxon* schools, identified by subgroup analysis, include

1. White students in third and fifth grades.
2. Non-Asian minorities in fifth grade.
3. Female students in third grade.
4. Non-low-income students in third grade.
5. Non-IEP students in third grade.

Saxon Math schools had significantly lower student achievement than *Everyday Math* schools in each of these areas. Administrators should be mindful of the performance of these groups, including measures to raise student achievement for these groups within school-improvement plans.

Recommendations for *Everyday Math* Administrators

Though *Everyday Math* showed significantly higher student achievement overall for third and fifth grades and in several areas, there is still cause for concern for schools using the curriculum. Despite the typical intensive professional development and resources available to *Everyday Math* schools, the positive effects of using *Everyday Math* as opposed to *Saxon Math*, when controlling for demographic characteristics, may

not be as large as administrators would hope in third and fifth grade and is non-existent in fourth grade. Teacher training, resources needed to support the curriculum, and controversies that typically accompany *Everyday Math* should be analyzed to determine if a relatively small potential increase in student achievement is justified. It is possible that a curriculum such as *Saxon Math*, with additional supplements, would be more cost-effective.

A specific area of concern for *Everyday Math* schools is the achievement of low-income students. Although significant differences in mathematics achievement were not found between *Everyday Math* and *Saxon Math* schools in this subgroup, there were differences in favor of *Saxon Math* at each grade level. This suggests there may be issues with the effectiveness of *Everyday Math* on low-income students that were simply not found to be significant with this study. Perhaps low-income students would benefit from supplementing *Everyday Math* with direct instruction and activities involving repetition of arithmetic procedures that are typical of a more traditional curriculum.

Conclusions

This study provided evidence supporting the use of *Everyday Math* over *Saxon Math* when looking at student achievement by content strand and overall student achievement, but not for every elementary grade and not for every subgroup. Fourth grade students appeared to perform equally with both curricula, and an in-depth curriculum analysis should be carried out to determine differences at the third and fifth grade level that are not as pervasive at the fourth grade level.

Minority students showed greater student achievement with *Everyday Math* at the fifth grade level, but not in other grades. This points to an increased widening of the

minority achievement gap with *traditional* methods, as students get older, and shows a possible benefit of maintaining a *reform* curriculum for minorities in the long run.

Longitudinal studies would be useful to determine the long-term effects of the different curricula as students continue on to middle and high schools.

Female students showed significantly higher achievement with *Everyday Math* than with *Saxon Math* at the third grade level, but not at the fourth and fifth grade levels. Again, an in-depth analysis of the two curricula should be performed to look for differences in third grade materials that may be causing greater female student achievement. *Everyday Math* and *Saxon* schools could learn from such an analysis to alter instruction at all levels.

One concern for *Everyday Math* schools is their low-income mathematics achievement. Low-income students often do not have the resources and home support to facilitate meaningful learning opportunities outside of school. The repetition needed to become proficient with basic arithmetic is often slighted with *reform* curricula, and more focus is given to activities, discussion, and social interaction in mathematics instruction. Those with higher socioeconomic status often have greater involvement in these activities and greater home support with basic skills, placing low-income students at a great disadvantage when significant practice with basic skills is not a focus in the classroom.

Saxon schools showed deficiencies in comparison to *Everyday Math* schools for white students at the third and fifth grade levels, and non-low-income, and non-IEP students at the third grade level. These students typically have more educational advantages, and are often ignored in school improvement, so that the focus is on bringing other subgroups up to average levels. However, *Saxon* schools (and all schools, in fact)

might find benefit in further challenging all students to perform to their maximum potential, including those that are already meeting state standards. Enrichment activities, extracurricular opportunities such as math clubs, and additional math time for those that have no deficiencies are just a few ways schools can challenge those with interest and strong performance. Few elementary schools have such opportunities, but perhaps this would be the best time to provide challenge, intrigue, and future advantages to these students who are not left behind, but are most often not encouraged or motivated to get ahead.

This study showed that a *reform* mathematics curriculum fared significantly better than a *traditional* curriculum in supporting student achievement on many levels. However, there are possible concerns with the effectiveness of the *reform* curriculum on low-income students and a positive overall effect on student achievement was not found at the fourth grade level. A suggestion when making curriculum selection for mathematics is to find materials that are balanced in the approach to learning. Materials that incorporate discovery learning and conceptual understanding as well as repetition with arithmetic procedures and some direct instruction are ideal. School administrators should influence teachers to find a healthy balance between procedures and understanding, pilot new ideas in their classrooms, and draw on action research to help guide decisions, regardless of the mathematics curriculum used.

A final conclusion is that mathematics instruction does not come in a one-size-fits-all package. Though a curriculum may be designed to cover all of the appropriate content and provide meaningful experiences to all students, what works for one student or group of students may not work for others. The quality of the teacher must not be

discounted. It is the teacher that wields the power to adjust the materials they are given, and to differentiate instruction for the unique individuals they have in their classrooms each day.

Future Research

Further research could take on many forms. As mentioned before, there would be benefits from longitudinal studies and analysis of the two curricula. Studies similar to this one could also be carried out in other states to determine if the effects of curriculum are different for different state assessments. Additionally, student-level data could be used as opposed to school-level data. This would result in larger sample sizes and allow for correlation analysis with individual data.

In 2014, the state assessments in Illinois will be aligned to the Common Core Standards. This study could be repeated using the new assessments as the measure of student achievement. Assessment instruments or surveys could also be developed to determine which curriculum fosters more student interest and engagement.

A number of qualitative studies could be completed. Classroom observations in schools using *Everyday Math* and *Saxon Math* could be compared to search for common and divergent themes. Schools using either curriculum and having success, despite high low-income or minority populations could be observed to identify common patterns of success in unlikely places. Teachers and administrators could be interviewed regarding their experiences with different mathematics curricula.

Summary

This study compared the effects of a *reform* curriculum, *Everyday Math*, and a *traditional* curriculum, *Saxon Math*, on elementary student achievement in Illinois.

Though *Everyday Math* came out ahead statistically overall in third and fifth grades, in each content strand, and for many subgroups, significant positive effects were not found at the fourth grade level. Though *Saxon Math* was not found to support significantly greater achievement in any area statistically, average scores for low-income students using *Saxon Math* were better than those of low-income students using *Everyday Math* at each grade level. This suggests a potential weakness of the *Everyday Math* curriculum. More research is needed before the ongoing *math wars* are ended.

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