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The Effects of Response to Intervention on the Mathematics Achievement of Seventh and Eighth Grade Students

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THE EFFECTS OF RESPONSE TO INTERVENTION ON THE MATHEMATICS ACHIEVEMENT OF SEVENTH AND EIGHTH GRADE STUDENTS

by

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Dedication

This dissertation is dedicated, first and foremost, to my very supportive husband who always loved me even when I was not too loveable. He patiently endured many lonely days and nights as he encouraged and aided me in reaching this goal. He is, and always has been, the wind beneath my wings. However, I must also mention the tremendous impact my mother had on me reaching this goal. She always wanted and expected me to be the best that I could be. And to the rest of my very special family, I am also grateful for your patience and understanding when I missed special times, ballgames, swim meets, gymnastic meets, and just fun times. You all are, and always will be, the joy in my life. Always remember how much I love each of you: Jon and Deanna, Kate, Ellen, and Audrey; Beth and Bo, Maddie and Brayden.

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Abstract

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The purpose of this quantitative study was to investigate the effectiveness of a system-wide Response to Intervention (RTI) program on the mathematical achievement of seventh and eighth grade students. The study consisted of five district schools with a total of 502 participants.

The students were identified as belonging to one of two tiers, which differed in regard to amount of intervention. The first tier (Tier 1) of students only received the regular classroom instruction while the second tier (Tier 2/3) received an additional thirty minutes of intervention strategies. The students receiving interventions, the Tier 2/3 students, were divided into two groups. One group received primarily teacher-directed instruction (TDI) as an intervention while the other group received computer-assisted instruction (CAI) as an intervention. For the purpose of this study, the CAI intervention involved the use of the commercial program, Odyssey Math.

The students were benchmark tested at the beginning and end of the 2010-2011 school year using the STAR Math assessment program and also progress monitored on a regular basis. In an attempt to determine the effectiveness of the RTI program, a gain score ANOVA was conducted using the scaled scores of the two tiers from the beginning and the end of the school year. The analysis indicated that Tier 2/3 students did demonstrate greater growth than the students in Tier 1. The gain scores of the two groups of Tier 2/3 students were also used in a gain score ANOVA to measure differences in

growth. An additional analysis of their mean scores was also conducted using ANCOVA. Both analyses indicated that the CAI group demonstrated greater gains. A third analysis was conducted in order to determine how accurately the STAR Math assessment program could predict student success (reaching either a Proficient or Advanced level) on the state assessment. While the STAR Math program did not accurately predict the students' level in every case, the logistic regression analysis did indicate that the program was successful in identifying struggling students.

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Chapter 1

Introduction

The mathematical achievement of our nation's students is an ongoing source of concern (National Mathematics Advisory Panel, 2008). With the rapidly increasing technological advances of our global society, the demands for a mathematically literate citizenry in the workplaces and in social and economic institutions have increased (Smith, 1999; U.S. Department of Education, 2008a). Yet our schools are not currently meeting these demands. While the National Council of Teachers of Mathematics (NCTM) in its 2000 publication *Principles and Standards for School Mathematics* described the end of the last decade as a time of "extraordinary and accelerating change" (p. 4), the U.S. Department of Education disagreed. Its 2009 report stated that our country's schools did not keep pace, saying schools are "not producing the math excellence required for global economic leadership and homeland security in the 21st century" (para.1).

Low mathematical achievement not only affects our country on an international and national level, but also on an individual citizen's level. Mathematical illiteracy and the inability to reason mathematically have become filters rather than pumps in the American education pipeline (National Research Council, 2001; Thomas, 1992). Lost career options, decreased opportunities for educational advancement, and closed doors await unsuccessful mathematics students (National Mathematics Advisory Panel, 2008; National Research Council, 2001). The National Research Council (2001) acknowledged the importance of improved mathematical achievement in its statement that "all young

Americans must learn to think mathematically, and they must think mathematically to learn" (p. 1) if they are to be competent in everyday activities.

Evidence of our failure to meet the challenges of developing a mathematically literate citizenry can be seen in the results of both national and international assessments. Internationally, the Trends in International Mathematics and Science Study (TIMSS) has compared mathematics and science achievement of fourth and eighth graders every four years since 1995. The 2007 assessment involved fourth graders from 36 countries and eighth graders from 48 countries, including the United States. At first glance, the results for U.S. students might not appear alarming, as the average mathematics scores of the U.S. fourth graders (529) and the eighth graders (508) were higher than the TIMSS scale average score (500). In addition, the fourth-grade score was higher than 23 of the 35 other countries (about 66%), and the eighth-grade score was higher than 37 of the 48 other countries (about 77%) (Gonzales et al., 2008). Despite these results, the Alliance for Excellent Education (2008) reported that the United States may actually be faring far worse in international comparisons. Citing a 2008 *Education Week* commentary by Mark Schneider, the Alliance reported that many of the lower performing countries in the TIMSS are also significantly less developed than the United States. It is also noteworthy that while both grade levels registered percentages above the international percentage median, only 10% of the fourth graders and 6 % of the eighth graders performed at or above the advanced mathematics benchmark.

At a national level, there are also reasons for concern. Studies have revealed small improvements in mathematics proficiency over the past twenty years, but the growth rate in recent years has flattened, with many students continuing to struggle with mathematics

(National Center for Education Statistics, 2011; The IRIS Center for Training Enhancements, 2010). The latest findings of the National Assessment of Educational Progress (NAEP), which has conducted periodic national core subject assessments for students in the fourth, eighth, and twelfth grades since 1969, were published *The Nation's Report Card: Mathematics 2011* in November, 2011 (National Center for Education Statistics, 2011). Comparing the 2011 assessments to previous NAEP mathematics assessments and summarizing the national findings, the NAEP report found that the average mathematics scores of fourth and eighth graders have increased by 28 points and 21 points respectively since 1990, and that each has increased by one point since the 2009 assessment. However, the report also indicated that while the percentages of students performing at the *Proficient or above* level were higher in 2011, only 40% of the fourth graders and 35% of the eighth graders performed at the *Proficient or above* level.

Of specific interest for this research is the performance of students in the state of Tennessee. The average score of Tennessee students, as reported in 2011, was lower than 44 states or jurisdictions, and higher than three states or jurisdictions. While not significantly different from the average score in the 2009 assessment, the average score of the eighth graders in Tennessee continued to be lower than the national public school student average. Additionally, while 76% of the state's eighth grade students performed at the *Basic or above* level, only 34% of Tennessee's eighth grade students performed at or above the NAEP *Proficient* level. The Report Card also indicated that little progress has occurred in closing the achievement gap between African American and White students (as listed categories on the Tennessee Report Card) over the last 10 years or for economically disadvantaged students over the last 5 years. The reported performance gap between African American and White students was not statistically different than the gap in 1992, and the performance gap for economically disadvantaged students was not significantly different from that in 1996.

Federal mandates, such as those included in the *No Child Left Behind Act of 2001* (NCLB) and the reauthorization of the *Individuals with Disabilities Education Improvement Act* in 2004 (IDEIA 2004), have commanded greater accountability from state Departments of Education as well as from local school districts (Individuals with Disabilities Education Improvement Act [IDEIA], 2004; No Child Left Behind [NCLB], 2002). In moving toward the goals set by NCLB, most Tennessee districts, including the one involved in this study, feel pressured to better address the instructional needs of every student and to boost the achievement level of all of their students on state assessments, such as the Tennessee Comprehensive Assessment Program (TCAP). The classifications on the Tennessee Report Card provide indication of areas of need for the districts. According to the 2011Tennessee Report Card, all five schools included in this study have received a C, D, or F in mathematics achievement for one or more of the years between 2009 and 2011, with one school receiving an F each of the three years. The 2011 Report Card reported that only two of the five schools included in the study had a *Good Standing* Status. The other three schools were listed as follows: a *Target school*, a *School Improvement 1* school, and a *School Improvement 2* school.[1]

[1] The first year that a school or system did not meet all the federal benchmarks for making AYP, the school or system was classified as a Target school or system and received no sanctions or penalties. A school or system failing to meet the same federal benchmark for more than one consecutive year was then classified as High Priority and was targeted for federal initiatives. Within the High Priority classification, schools were ranked as follows: School

In 2012, using the performance data from the Report Cards and a projection by the Tennessee Department of Education (TDOE) that revealed at least 40% of the districts and 80% of the schools would have failing Adequate Yearly Progress (AYP) scores under the current NCLB guidelines, the TDOE secured a waiver from some parts of NCLB (Tennessee Department of Education, 2012b). This waiver allows the state to focus on growth and improvement in student achievement rather than specific AYP scores and to direct its attention to demonstrating academic growth for all students and closing achievement gaps. Under the current waiver, the district in this study was classified as *In Need of Subgroup Improvement* due to the percentage of students with disabilities that did not pass the state mandated Algebra I Gateway Test. Additionally, two of the schools included in the study were classified as *Focus schools* and another school in the study was classified as a *Priority school* (Tennessee Department of Education, 2012a).[2]

As indicated with the issuance of this waiver, the Tennessee Department of Education, using scores from the Tennessee Comprehensive Assessment Program (TCAP), accepted the responsibility of demonstrating an increase in the number of seventh grade students scoring at the *Proficient* level from 29 % (2009–2010) to 51 % by

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Improvement 1, School Improvement 2, Corrective Action, Restructuring 1 Restructuring 2, and a Reconstitution Plan.

[2] Under the waiver, districts are classified as *Exemplary*, *In Need of Improvement*, or *In Need of Subgroup Improvement*. The first two classifications differentiate between the districts' abilities to meet or not meet the majority of their achievement and gap closure goals. The last classification, *In Need of Subgroup Improvement*, indicates that while a district may have met its achievement or gap closure goals or both, it experienced declining achievement in a particular subgroup of students. Low performing schools are now classified as either *Focus Schools* or *Priority Schools*, consisting of the 10% and 5% of the state's schools with the largest student achievement gaps, respectively.

2014–15. The state is also expected to reduce the achievement gap by approximately six percentage points annually. This reduction in the achievement gap is intended to shrink the gap by one-half over an eight-year period (Roberts, 2012). While the waiver allows Tennessee to be exempted from the punitive actions prescribed by NCLB, students' test performance remains important. Districts, including the one in this study, are driven to focus increasingly on low performing, at-risk students and on strategies that will improve their achievement levels and the resulting performance records of their schools.

Statement of the Problem

Research points to the importance of early intervention in the improvement of student learning and achievement in mathematics. Studies spotlight the critical need for development of early mathematics skills in a variety of subgroups of students. Demonstrated mathematics skills, even as early as kindergarten, have been determined to be strong predictors of later mathematics skills, as well as of overall academic achievement (Duncan et al., 2007). A meta-analysis of six data sets involving more than 16,000 children, conducted by Duncan et al. (2007), revealed that "rudimentary mathematics skills appear to matter " (p. 1437) even more than reading/language skills and attention behaviors (the other strong predictors) to subsequent academic success. In the conclusion of the report, the researchers supported early mathematics interventions.

While researchers point to the importance of early interventions, there is also "a sense of urgency" for successful interventions at the middle and high school levels (Fuchs, Fuchs, & Compton, 2010; Johnson & Smith, 2008). Unfortunately, struggling middle school students often develop patterns of failure resulting from earlier disappointments and frustrations (Ehren, n.d.). The foundation for success in, and even for graduation from, high school is laid in the middle school years (Morris, Ehren, & Lenz, 1991; Wimberly & Noeth, 2005). Consequently, effective instructional interventions at this level are imperative. Moreover, schools need instructional interventions that are effective for all students if they are to close the current achievement gaps between various groups.

Purpose of Study

Given the individual and national importance of mathematical literacy and the cited low levels of mathematics achievement for specific groups of students, this research explores the effectiveness of a district-wide Response to Intervention (RTI) model in the content area of mathematics. Because the RTI process was first applied in the reading content area, the preponderance of published research regarding it has been in reading. (Hughes & Dexter, n.d.; Mokhtari, Porter, & Edwards, 2010; Samuels, 2009). Although more math-related published research has emerged in recent years, many of the grade level studies have been focused on specific types of interventions in early elementary years, grades K–3 (Bryant, Bryant, Gersten, Scammacca, & Chavez, 2008; Fuchs, Fuchs, Compton, Bryant et al., 2007; Newman-Conchar, Clarke, & Gersten, 2009). Studies have indicated the need for more research on the impact of Response to Intervention on general education students beyond these early primary years and specifically in the content area of mathematics (Dexter, Hughes, & Farmer, 2008; Gartland & Strosnider, 2005). This study adds to the research on Response to Intervention by focusing on the content area of mathematics in the middle school, grades 7 and 8.

As RTI is ultimately “designed to enhance all students’ educational outcomes” (Brown-Chidsey & Steege, 2005), a major premise of the process is that underachieving students will improve if they are provided timely, effective, specific instruction that targets their deficiencies (Newman-Conchar et al., 2009). This study compares the achievement gains of the students who received instructional interventions (referred to as Tier 2/3) to those students who did not receive the added interventions (referred to as Tier 1). Of interest is whether or not the RTI process enabled the Tier 2/3 students to experience achievement gains equal to or greater than the Tier 1 students.

The type of intervention is also important as educators want to select the most effective, research-based intervention. This study can inform districts seeking validation of effective methods to address struggling learners. A variety of research-based interventions are available, but this study investigated two general categories of instruction, teacher-directed and computer-assisted, to determine any differential effectiveness. Because computerized instructional interventions require substantial capital outlays at the district level, proof of their effectiveness is desired in order to rationalize the expenditures. Not only is there a capital outlay for the computer programs being used, but their use also necessitates that districts provide classroom space and an adequate number of available computers for the required amounts of time. As districts face budgetary decisions, administrators are concerned that resources are applied to those areas that will provide the most benefit.

The heightened level of accountability required by many states coupled with the risks of punitive actions by State Departments of Education have driven districts to seek programs and strategies that will advance student achievement on state-mandated assessments (Hintze & Silberglitt, 2005; McGlinchey & Hixson, 2004; Yeo, 2009). One component of such strategies (including RTI) is the use of regular benchmark assessments. Such assessments are intended to predict students' future success on standardized tests. However, more research has been conducted to explore the relationship between benchmark assessments and state mandated assessments in reading than has been conducted in the area of mathematics. In addition to examining the success of RTI with regard to student growth, this study also considers the predictive value of the benchmark assessments in relation to the state assessment.

The specific research questions addressed this study include the following:

1. Were there significant differences between the fall and spring STAR benchmark assessment gain scores for students receiving RTI interventions (Tier 2/3) and the gain scores for students who did not receive RTI interventions (Tier 1)?

2. Within the group of students who received RTI interventions (Tier 2/3 students), did the students who received computer-assisted instruction demonstrate statistically significant differences between the fall and spring STAR benchmark assessment gain scores as compared to the gain scores of those students who primarily received teacher-directed interventions?

3. For all Tier 1 and Tier 2/3 students, to what degree did the STAR Math benchmark assessment scores accurately predict success (a rating of *Proficient* or *Advanced*) on the mathematics subcategory score of the TCAP test?

Significance of Study

As indicted earlier, Response to Intervention implementation (RTI) began with a focus on reading skills and with the vast majority of early studies applying to the content area of Reading. In recent years, the focus has expanded to other areas, including mathematics. Because of the stated importance of mastery of early and basic skills, the initial studies in the area of mathematics were concentrated in the lower primary grades. With the expanded implementation of RTI, studies widened their scope to include students in upper elementary grades, in middle schools, and most recently, in high schools. This study analyzed data from one district's RTI implementation in mathematics in grades 7 and 8.

In using data to respond to the above questions, districts, including the one in this study, will be able to make evidenced-based decisions regarding continuation of programs like RTI. These decisions have become increasingly important for districts, given federal demands for accountability and their ties to federal funding (NCLB, 2001). Additionally, since budgetary constraints compel districts to utilize the most cost-efficient interventions and those which will provide the greatest gains, advanced knowledge regarding the likely success of students on state-mandated proficiency exams would enable the districts to provide targeted support for struggling students prior to the scheduled assessments. This study seeks to provide insight that can assist districts in building more efficient and effective interventions.

Definitions

The following general definitions are provided to facilitate understanding and uniformity throughout the study and are adapted from definitions found in the *RTI Manual* located on the National Research Council on Learning Disabilities Web site or in the RTI manual of the Pilot District,[3] as well as from definitions found in other cited sources.

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[3] The pseudonym Pilot District is used for the name of the district included in this study. The pseudonym is also used on the Reference page in the citation of the district's RTI manual.

Benchmark assessments. In this study, benchmark assessments will refer to the universal screening assessments that are administered three times during the school year. In the Pilot District, STAR Math assessments, a product of Renaissance Learning™, are used as benchmark assessments and are given in the fall, winter, and spring. For the purpose of this study, only the fall and spring administrations of these assessments will be included.

Computer-Assisted Instruction (CAI). In a broad definition, computer-assisted instruction may be defined as any instructional method which uses a computer to deliver instruction. However, in this study, the computer-assisted instruction was limited to the use of the CompassLearning Odyssey®Math (Odyssey Math) commercial program. According to the CompassLearning® Web site, this computer program presents individualized, adapted instruction for each student according to the student's specific needs.

Data-based decision making. In the RTI process, instructional decisions regarding needed interventions are often based on scores from benchmark assessments as well as progress monitoring assessments. The specific criteria used for the evaluation of the scores may include national norms or other preset criteria. The district in this study compared the students' benchmark assessment and progress monitoring assessment scores to national norms. Decisions were then made by a team of professionals using the process described in Chapter 3.

Progress monitoring. Progress monitoring refers to regular, ongoing, brief assessments, usually performed weekly, given over specific curriculum objectives. Analyses of multiple assessment scores were used to monitor student improvement rates and the effectiveness of the instruction/intervention, as well as to guide decisions regarding interventions and tier placement.

Response to Intervention (RTI). Response to Intervention (RTI) is broadly defined as an assessment and intervention program that includes a systematic monitoring of student progress and prescriptions of instruction to address deficiencies (Brown-Chidsey & Steege, 2005; NRCLD, 2006). According to the National Center on Response to Intervention (2010), RTI specifically identifies and monitors the progress of academically at-risk students and prescribes research-based interventions that appropriately address the students' academic needs as indicated by the level of their response to instruction. A definition given by the National Research Center on Learning Disabilities (2006) refers to RTI as "an assessment and intervention process" that provides data to support the need for either instructional modifications or intensified educational services.

Research-based interventions. Research-based interventions may also be referred to as evidence-based or scientifically-based interventions. These terms refer to instructional programs that have been researched and documented in scientific, peer-reviewed journals as to their effectiveness (Klotz & Canter, 2007). Additionally, the RTI manual of the Pilot District (2011) specified that the research must have involved the "application of rigorous, systematic, and objective procedures" and data analyses that adequately justified the general conclusions and that could be replicated (p. 13).

STAR Math. STAR Math is a commercial assessment program by Renaissance Learning™ that was used as a progress-monitoring tool by the district involved in this study. According to the Renaissance Learning™ Web site, STAR Math is a computer-adaptive testing program that uses a student's responses to determine the level of difficulty of subsequent questions.

Teacher-Directed Instruction (TDI). In this study, teacher-directed instruction is defined as any research-based instructional intervention a classroom teacher used that was not the Odyssey Math program. These materials included supplemental instructional items provided by the district's adopted textbook series, as well as other commercial materials, such as Teacher Created Materials, Targeted Mathematics Intervention, and SRA Corrective Math.

Tier. A tier in RTI identifies a level of instructional intensity or intervention. Beginning with Tier 1, the tiers provide increasingly intensive, instructional interventions for identified groups of at-risk students and are characterized by decreasing group sizes. While only data from Tiers 1 to 3 are included in this study, the district identified four tiers in their RTI program. A brief definition of each tier, as defined by this district, is provided here. A more complete description of the tier classification system used by the district is provided in Chapter 3.

Tier 1. Tier 1 includes all students in the general education setting. The Pilot District (2011) stipulates that Tier 1 students receive core curriculum instruction provided by the regular classroom teacher using "validated practices" (p. 32) such as whole group instruction, small group instruction, and differentiated instruction. Students whose assessment data falls below the 10^{th} percentile receive "*intense* interventions" (p. 32) for a period of four to eight weeks in Tier 1 before a tier change is considered.

Tier 2. According to the Pilot District manual, a student is considered non-responsive and is classified as Tier 2 if the student's assessment data continues to fall below the 10th percentile after the four-to-eight-week Tier 1 interventions. The student remains in Tier 2 for a minimum of eight weeks. At the end of the eight weeks, the student may return to Tier 1 or be classified as Tier 3, depending on the continuing assessment data.

Tier 3. In this district, Tier 2 students who continue to score below the 10th percentile are moved to a Tier 3 classification. Students remain in Tier 3 for a minimum of eight weeks. A Tier 3 student may move back to Tier 1 if the assessment data rises above the 10th percentile. However, if the assessment data continues to be below the 10th percentile, the RTI team may recommend that the student either remain at Tier 3 or be considered for Tier 4.

Tier 2/3. For the purposes of this study, the Tier 2/3 classification will refer to those students who are in either Tier 2 or Tier 3. The classifications differ only by the length of time the student has scored below the 10th percentile, and the interventions applied in this district are consistent within these tiers.

Tier 4. Students whose data indicates that they continue to be non-responsive to instruction or to other explored educational options may be recommended for assistance through the IDEIA 2004. These students are then classified as Tier 4. Tier 4 generally involves special education services and is beyond the scope of this study.

Universal screening. As the first step in the RTI process, universal screening consists of brief assessments, typically given three times a year, to the universal school population for the purpose of identifying levels of proficiency and students in need of interventions. Universal screening also informs curriculum decisions, both on the classroom level and school wide. In this study, universal screenings are usually referred to as the initial benchmark assessments.

Chapter 2

Literature Review

The Literature Review begins with a history of the RTI model and defining information about RTI and its design. Following this discussion, there will be a brief examination of progress monitoring prior to a section summarizing the research regarding RTI. This chapter will conclude with a brief outline of the research on computer-assisted instruction and the STAR Math assessment program.

History of Response to Intervention (RTI)

Beginning in the 1960s and early 1970s, educational rights for children, specifically children with disabilities, became the focus of state and federal governments (Martin, Martin, & Terman, 1996). In the years prior to 1975, the systematic denial of services for the disabled student resulted in a judicial review and Congressional action that endeavored to correct the discriminatory practice. In the following years, the history of special education in the United States recorded many successes in identifying and placing struggling students. Unfortunately, there were few attempts to assess the effectiveness of these placements, even as more educators began presuming that any student who experienced failure in the general education classroom was disabled and in need of referral for special education services (Prasse, 2012). Subsequently, professional educators began to question this reasoning and to express the philosophy that all students should be given maximum opportunities to succeed in the regular public education classroom.

When results from national and international assessments created concerns about the achievement of America's students, the federal government responded with initiatives and programs designed to increase expectations and address the needs of all learners. When President Lyndon Johnson, as part of his War on Poverty, signed the *Elementary and Secondary Education Act of 1965* (ESEA) into law, the necessity of "adequate educational programs" for all learners, specifically those from lower socio-economic families, was emphasized (U.S. Department of Education, 2005). In 1994, as a reauthorization of this act, the U.S. Congress passed the *Improving America's Schools Act of 1994* (IASA) which accentuated the need for more accountability from schools by requiring proof that all students have the opportunity to achieve high academic performance standards. This legislation, along with *Goals 2000: Educate America Act,* also enacted in 1994, was to provide the impetus needed for states and local districts to raise achievement levels of all students, with the following specific categories listed: "diverse students, including females; minorities, individuals with disabilities, limited English proficient individuals, and economically disadvantaged individuals."

Three years later, in 1997, President Bill Clinton signed into law the *Individuals with Disabilities Education Act* (IDEA) in an effort to increase expectations and further intensify accountability for children with disabilities. This law was also intended to narrow the achievement gap that often exists between students with disabilities and students without. In the implementation of this act, children were largely identified with learning disabilities through a variety of discrepancy calculations, including the IQ-achievement discrepancy calculation model (Fuchs & Fuchs, 2006; Kovaleski & Prasse, 2004). This model for identifying learning disabled students, widely applied since the 1970s, compared a student's results on an achievement test with the student's identified IQ. If the discrepancy between these scores was severe enough, generally one to two standard deviations, then the student was classified as learning disabled (Greer, 2005; Strangeman, Hitchcock, Hall, & Meo, et al., 2006).

As this model increasingly became the primary criterion in the identification of learning disabilities, criticisms began to surface (Dean & Burns, 2002; Kavale, 2002; Kovaleski & Prasse, 2004; Sawyer & Bernstein, 2002). Kavale (2002) indicated that while this model is a useful component in identifying learning disabilities, it should not be the sole consideration for identification. Additionally, as the interpretation, computation, and application of the criteria by districts and states varied, large inconsistencies in identification of learning disabled students occurred and resulted in disparities. Some critics argued that the discrepancy model more appropriately indicated the presence of underachievement rather than learning disabilities (Kavale, 2002). As a result, not only were students being incorrectly or arbitrarily labeled, but there were also students who did not receive warranted services (Fuchs & Fuchs, 2006).

A second major criticism advocated the need for a more timely identification process. Since identified deficits were required before students could qualify for specialized instruction, the process became criticized as a "wait to fail" practice (Brown-Chidsey, 2007; Fuchs & Fuchs, 2006; Kovaleski & Prasse, 2004; Sornson, 2007). Delays in the identification of disabled students often resulted in several years of declining achievement and more difficult remediation (Hale, 2008). Consequently, often those students who could most benefit from special education services experienced years of academic failure before receiving the needed and appropriate interventions (Bradley, Danielson, & Doolittle, 2007; Fuchs & Fuchs, 2006). Aaron (1997) argued that more time should be spent providing effective and responsive instruction than in carrying out the unnecessary, and often belated, identification process. The President's Commission on Excellence in Special Education (PCESE) reported in 2002 that waiting for a child to fail was an outdated model and recommended a prevention and early intervention model.

Additional federal legislation, such as the reauthorization of the Elementary and Secondary Education Act of 1965, which is also referred to as the *No Child Left Behind Act of 2001*(NCLB), was enacted to provide the impetus for improving academic achievement and to close achievement gaps between high- and low-performing students. In his initial announcement of the NCLB, President George W. Bush expressed concern that "too many of our neediest children" were being left behind. According to NCLB, the purpose of this legislation was "to ensure that all students have a fair, equal, and significant opportunity to obtain a high-quality education and reach, at a minimum, proficiency on challenging state academic achievement standards and state academic assessments." The legislation addressed needs of specific groups of children, including minority students, disadvantaged students, low achieving students, and students with disabilities.

Recommendations regarding the implementation of IDEA also included a greater emphasis on results-oriented methods with a specific recommendation for more research regarding implementation of RTI models (U.S. Department of Education, 2002). In view of the mounting data and recommendations, educators and policymakers concluded that alternative screening and identification models were needed in determining special education eligibility (Brown-Chidsey, 2007).

The *Individuals with Disabilities Education Improvement Act of 2004* (IDEA 2004), or the reauthorization of IDEA, opened the door for other special education screening models, allowing schools to use proof of a student's failure to respond to targeted instruction as a means of determining learning disabilities (Stepanek & Peixotto, 2009). This law also allowed local districts to eliminate severe discrepancies between student achievement and IQ scores as a requirement for identifying learning disabilities. Response to intervention, as described by Fuchs (2003), was based on the principle that the identification of students as learning disabled should result from the documentation of responses to effective instructional interventions that are dramatically lower than their peers. The use of targeted, research-based instruction placated critics of the discrepancy model who suggested that the presumed disability may actually have been low achievement resulting from inadequate instruction (Fuchs & Fuchs, 2006). Moreover, Sawyer and Bernstein (2002) suggested that the discrepancy model did not sufficiently address the identification and needs of the struggling student who may not be in need of special education services, but was still specifically at risk for failure.

Both the *No Child Left Behind Act of 2001* (NCLB) and IDEA 2004 emphasized that all students should receive scientifically research-based instruction. Consequently, soon after the enactment of IDEA 2004, districts and school systems began scrambling to identify and utilize researched programs that would enable them to reach the new levels of expectations. The stipulations for mandated scientific, research-based interventions, prescribed through data-driven decisions and the regular monitoring of students' academic progress, further enhanced the appeal of the RTI programs (Hale, 2008; Hoover, Baca, Wexler-Love, & Saenz, 2008).

While a position paper by the National Joint Committee on Learning Disabilities stated that "the concept of RTI has always been the focus of the teaching/learning process and a basic component of accountability in general education" (Gartland & Strosnider, 2005, p. 249), general educators turned to this familiar special education model, which has long addressed individual students' needs.in an effort to "improve access to educational opportunities for all students" (Brown-Chidsey & Steege, 2005, p. 13), Districts began adopting an RTI model that was recognized as an acceptable process for identifying learning disabilities with the 2004 reauthorization of the *Individuals with Disabilities Education Act of 1997*. As an additional benefit, the wording of the 2004 reauthorization allowed districts to allocate a percentage of the federal funds to provide early intervention services to at-risk students in the general education population.

After the legislative changes in special education laws like IDEA 2004 specifically identified RTI as a recommended practice and provided local districts with options and flexibility in its implementation, RTI was thrust into the limelight, with expectations for student achievement and school accountability reaching new levels. Surveys conducted in 2007 indicated that 86% of the states were involved in either developing or implementing an RTI program (Hoover et al., 2008). According to the national 2011 Adoption Survey conducted by Spectrum K-12 School Solutions, Inc., some degree of actual RTI implementation was reported by 94% of the 1,390 responding districts nationwide, with 24% reporting full implementation. The definition of full implementation by a district includes a number of practices ranging from a specified number of screenings and scheduled progress monitoring to requirements impacting instruction and organization. Among elementary schools, 80% of the responding districts reported full implementation in at least one of the following areas: reading, mathematics, science, writing, or behavior. Full implementation in all buildings across a district was only reported in 7% of the responses. While RTI programs in the area of reading continue to dominate, programs focusing on mathematics have grown in number in recent years (Spectrum K12 School Solutions, 2011).

What is Response to Intervention?

The model referred to in early literature as Responsiveness to Intervention (Fuchs, Mock, Morgan, & Young, 2003) became identified in later writings as simply Response to Intervention (RTI) (Fuchs & Fuchs, 2006). In order to present a more comprehensive description of RTI, several definitions, components, and broad goals are provided; this combination of information provides a more inclusive picture of the elements of RTI.

RTI, as defined by the National Research Center on Learning Disabilities (NRCLD), is “an assessment and intervention process for systematically monitoring progress and making decisions about the need for instructional modifications or increasingly intensified services using progress-monitoring data" (NRCLD, 2006). According to the Web site of the NRCLD’s, program the RTI Action Network, RTI is a multi-tiered intervention process that assists struggling students through research-based instruction and scheduled monitoring of student progress. Brown-Chidsey and Steege (2005) describe RTI as “an objective examination of the cause-effect relationship(s) between academic or behavioral *intervention* and the student’s *response* to the intervention” (p. 2). In the broader descriptions of RTI, the data provided by students’ responses to interventions become the basis for instructional decisions as well as for decisions made about eligibility for more specialized educational services (National Joint Committee on Learning Disabilities, 2005). Clarke, Gersten, and Newman-Gonchar

(2010) expanded these definitions by saying that “RTI is integrally linked to the concept of providing intensive early intervention *to prevent later academic failure*” (p. 189).

An identifying feature of RTI that distinguishes it from other instructional and assessment models is that the interventions are required to be systematic and data-based. Research stipulates that the interventions be scientifically research-based or evidence-based (Brown-Chidsey & Steege, 2005; Burns, 2010; Justice, 2006), which means that instructional decisions must have supporting evidence from the needs of the students as well as from documented research. Through regular and continuous assessment, educators track student progress and provide specific applicable and timely interventions designed to student achievement (Brown-Chidsey & Steege, 2005; Gresham, 2002).

While the implementation of RTI may vary, the following common components have been identified: universal screening, progress monitoring, scientifically research-based instructional interventions, data-based decision making, and systematic documentation of implementations (Fox, Carta, Strain, Dunlap, & Hemmeter, 2010). The essential core elements of this model has been described as including “the provision of scientific, research-based instruction and interventions in general education; monitoring and measurement of student progress in response to the instruction and interventions; and use of these measures of student progress to shape instruction and make instructional decisions” (Klotz & Canter, 2007). Brown-Chidsey and Steege (2005) listed these elements simply as “high quality instruction, frequent assessment, and data-based decision making” (p. 11). A number of organizations, including the NCLD, have developed a more comprehensive and specific list of important common features of RTI and published it. This list, published in 2007 by the National Association of School

Psychologists in a *Primer for Parents* (Klotz & Canter, 2007), includes the following elements:

- High, quality, research-based instruction and behavioral support in general education,
- Universal (school-wide or district-wide) screening of academics and behavior in order to determine which students need closer monitoring or additional interventions,
- Multiple tiers of increasingly intense scientific, research-based interventions that are matched to student need,
- Use of a collaborative approach by school staff for development, implementation, and monitoring of the intervention process,
- Continuous monitoring of student progress during interventions using objective information to determine if students are meeting goals,
- Follow-up measures providing information that the intervention was implemented as intended and with appropriate consistency,
- Documentation of parental involvement throughout the process, and
- Documentation that special education evaluation timelines specified in IDEA 2004 and in the state regulations are followed, unless both the parents and the school team agree to an extension.

Two overarching goals of RTI are to improve the learning outcomes of all students, those with and those without learning disabilities (Fuchs et al., 2003; Gartland & Strosnider, 2005), and, through high-quality, effective instructional practices, reduce the number of special education placements (Brown-Chidsey, 2007). Since their implementation, RTI programs have aided in differentiating between students who are actually learning disabled and students who have either simply not responded to the prevailing instructional methods or who have been a victim of ineffective instruction (Gartland & Strosnider, 2005). Therefore, while RTI programs offer a means of possible early identification of disabilities, they also provide a method of intervention for any struggling student. As targeted interventions and specific strategies are used in the general education setting prior to a special education setting referral, all students are monitored and receive high quality instruction (Bradley et al., 2007; Harris-Murri, King, & Rostenberg, 2006). According to a paper presented by Kovaleski (2003), providing this effective, research-based instruction to all students has produced an added outcome of reducing the number of students enrolled in special education programs. Fuchs (2003) further indicated that one underlying belief about RTI is that it can "differentiate between two explanations for low achievement: poor instruction and disability" (p. 172). Therefore, RTI has implications for identifying and serving all children, learning disabled or not, who are at risk for school failure, thus increasing the likelihood of notable gains for all students (Brown-Chidsey & Steege, 2005; Fuchs & Fuchs, 2006). As expressed by Brown-Chidsey and Steege (2005), implementation of RTI is actually "a general education initiative," as its "activities begin and end in general education" (p. 10).

The Design of RTI

As the focus of RTI expands beyond improving learning outcomes of students with disabilities (Sugai & Horner, 2009), RTI has become a means of early identification of academically at-risk students, with a subsequent matching of research-based instruction that addresses their deficiencies (Fuchs & Fuchs, 2006). In this section, the composition of the RTI process and its design as "a multi-tiered prevention system" (National Center on Response to Intervention, 2010) will be delineated.

Beginning with its framework, RTI is based on two critical components: 1) research-based instruction or interventions, and 2) ongoing, frequent monitoring of the students' responses to the instruction or interventions (Richards, Pavri, Golez, Canges, & Murphy, 2007). High quality instruction in the general classroom is of fundamental importance in the RTI process, and students must receive this high quality instruction, grounded in research, in the general classroom setting before they are assigned to more specialized interventions. In other words, students are to receive adequate opportunity to achieve before they are moved to another tier. RTI advocates that learning is in reality the sum of targeted instruction and time (Buffum, Mattos, & Weber, 2010). Equally important to the foundation of RTI is the premise that, if interventions are prescribed promptly following the identification of learning difficulties, academic failure or special education placements can be averted (Newman-Gonchar et al., 2009).

Universal screening assessments. The RTI process begins with assessment. The initial needs' assessments are generally referred to as universal screening assessments and are a type of Curriculum-Based Measurement (CBM) usually administered three times during a school year, in the fall, winter, and spring. As referenced earlier, the National Center on Response to Intervention (2010) has described universal screening as being comprised of "brief assessments that are valid, reliable, and demonstrate diagnostic accuracy for predicting which students will develop learning or behavioral problems" (p.

8). Earlier studies have endorsed the validity and reliability of CBM in determining student growth (Ridgeway, Price, Simpson, & Rose, 2012).

These assessments are administered to all students in order to identify struggling students who are at risk of academic failure and in need of more intensive intervention to supplement the regular curriculum (National Center on Response to Intervention, 2010). Results from the scheduled universal screenings are analyzed and compared to clearly identified benchmarks, thus creating the term *benchmark tests*. Determination is then made as to which students are at risk of academic failure (Jenkins, Hudson, & Johnson, 2007). Research regarding the validity of the results from universal screening suggested that the documented accuracy of an instrument to identify at-risk students should be one of the determining factors in choosing the instrument to be used (Jenkins, 2003; Jenkins et al., 2007). While the criteria used to identify at-risk students vary with local systems, the most commonly used criteria are either pre-established cut-off scores (benchmark performance) or percentile ranks (norm-referenced) (Fuchs & Fuchs, 2007). Although these universal screenings frequently over-identify the pool of at-risk students, research in the area of reading found that when universal screening was coupled with progress monitoring, more accurate instructional decisions and classifications occurred (Fuchs & Fuchs, 2007; Jenkins, 2003; Jenkins et al., 2007).

Tier 1. At each level or tier of the RTI process, the instructional interventions increase with intensity, precision, and duration. The size and composition of the instructional groups in each tier also become more defined and structured (Bradley et al., 2007; Fuchs & Fuchs, 2006). The first tier (Tier 1) of instruction, as indicated earlier, is provided in the general education classroom and is expected to be quality, research-based, core instruction that is presented generally in a whole group setting. The instructional practices of the general educator must be effective and include high quality programs (Stecker, Fuchs, & Fuchs, 2008). At the beginning of Tier 1 instruction, a preliminary universal screening of all students assists in identifying which students may be at risk and may not be meeting grade-level benchmarks (Bradley et al., 2007). According to Stecker et al. (2008), the best model for Tier 1 also includes weekly progress monitoring for five to eight weeks of students who are suspected to be at risk, and other periodic progress monitoring of the entire class. Progress monitoring can then be used to determine deficiencies in specific skills. Research has indicated that the instruction in Tier 1 will meet the needs of 70% to 80% of general education students (Richards et al., 2007). The other 20% to 30% percent of the students who do not respond appropriately to Tier 1 instruction within predetermined time frames and criteria will then receive the second tier (Tier 2) of interventions.

Tier 2. Tier 2 interventions are usually presented in pulled-out, small group settings (three to five students), daily or twice a week, and typically last over eight to twelve weeks (Bradley et al., 2007; Stecker et al., 2008). Based on identified deficiencies, the groups are homogenously formed, and then research-based interventions are targeted to the specific curriculum deficiencies that were identified in the Tier 1 screenings. The goal is remediation, not just enhancement of the general curriculum (Buffum et al., 2010; Vaughn & Fuchs, 2003). During Tier 2, regular progress monitoring is used to further identify students that may not be responsive to the tier's interventions. While the classroom teacher, as in Tier 1, often administers the interventions in the classroom, the interventions may also be administered by a para-professional. These interventions usually require twenty to thirty minutes (Richards et al., 2007). While the interventions used in Tier 2 are often left to the discretion of the classroom teacher, districts typically provide the teacher with resources from which to choose. Students who do respond to the Tier 2 interventions and reach curriculum benchmarks may be returned to Tier 1. However, in a 3-tier model, if the students who received Tier 2 interventions continue to fail to meet grade-level benchmarks, a third tier of more intensive interventions is provided.

Tier 3. Tier 3 interventions are specifically targeted and individualized and are often not administered by the classroom teacher. While Tier 3 instruction may not be delivered on an individual basis, it is again recommended for instruction to be delivered to small groups of students with like deficiencies (Stecker et al., 2008). Tier 3 interventions may include special education services and typically require longer periods of intervention that are often provided outside of the regular classroom (Fuchs & Fuchs, 2007; Richards et al., 2007) and outside of the control of the classroom teacher. In addition, continued use of progress monitoring in Tier 3 on a weekly or biweekly basis is a recommended practice (Stecker et al., 2008). Even in Tier 3, the prescribed interventions may enable students to sufficiently improve their academic performance and eliminate the need for special education services (Richards et al., 2007). Some models of RTI expand the number of tiers to four, five, or six so that the need for special education services is delayed through additional interventions (Fuchs & Fuchs, 2007). Marston (2005) reported that studies have shown positive outcomes in the use of a three-tier model, with instruction intensifying with each tier. The model used by this study's district is theoretically a 3-tier model, but it has four tiers identified because Tier 3 is a continuation of Tier 2 and is assigned to those students who need another round of intervention but are not considered in need of Tier 4 (Special Education) services.

RTI Models

Decisions regarding the differentiation of instruction are generally determined by one of two RTI implementation models: the standard protocol model and the problem-solving model (Fuchs & Fuchs, 2007; Shapiro, 2009; Shores & Chester, 2009). The models differ both in the extent of deficit analysis used in determining interventions and in the amount of individualization in implementation (Christ, Burns, & Ysseldyke, 2005).

The standard protocol model of RTI uses specific research-based instructional methods that are usually easily accessible, prescriptive, and identified as being effective for most students. Subsequent to the identification of deficiencies, the interventions are prescribed for groups of students with similar deficiencies and are applied in well-defined, explicit steps (Shores & Chester, 2009). Programs using the standard protocol model provide the same research-based, structured intervention for each of the students in the at-risk group (Shapiro, 2009).

The problem-solving protocol model provides more flexible assignment of interventions (Christ et al., 2005; Shores & Chester, 2009). This model reflects earlier historical efforts used in prescribing instructional interventions. Indicative of its name, this model uses instructional interventions deemed appropriate that are recommended on an individual student basis by a team of professionals (Fuchs & Fuchs, 2007; Kovaleski & Black, 2010). The team of professionals (e.g., the classroom teacher, school psychologist, and instructional facilitator) reviews the monitored assessments and classroom work of individual students to determine skill deficits and to make specific recommendations regarding interventions or an appropriate RTI plan for the student (Shores & Chester, 2009).

Progress Monitoring

Progress monitoring, the measuring of student progress through the regular administration, usually weekly or monthly, of brief, targeted assessments, is an integral component of the RTI process. This section will discuss the purpose and documented effectiveness of progress monitoring in the RTI process.

Progress monitoring assessments are critical to RTI and have been promoted in the field of special education for several decades (Deno, 1985; Stecker et al., 2008). A progress monitoring assessment may be referred to as a curriculum-based measurement (CBM) as it directly measures specific curriculum objectives. Since the RTI progress monitoring process is applied to all students, the classroom teacher is supplied with the data needed to identify inadequate progress and to make appropriate instructional decisions regarding needed interventions for each individual student, regardless of disability status. As a student's beginning level of achievement is contrasted with the annual learning goal, a desired rate of progress is determined that will enable the student to reach the learning goal by the end of the year. The student's actual progress rate is then measured against the desired progress rate, and the effectiveness of instruction is evaluated. Using results from these assessments at all levels of the RTI process, adjustments in instruction or interventions are prescribed (Dexter & Hughes, n.d.; Fuchs & Fuchs, 2007).

Progress monitoring stands in contrast to "mastery measurement" as it relates the students' "rate of improvement needed" to achieve predetermined annual learning goals rather than simply measuring whether or not students have mastered specific skills (Safer & Fleischman, 2005, p. 81). Additionally, Fuchs and Fuchs (2007) pointed out that assessments used in mastery measurement often possess too many differences to allow results to be compared or used in analysis of progress. Stecker et al. (2008) maintained that diligent progress monitoring provides the data that assists teachers in making appropriate instructional decisions.

In 2006, research in the content area of reading indicated that more than one hundred and fifty studies confirmed the ability of progress monitoring to document growth in student achievement and to provide reliable information relating to instructional needs (Olinghouse, Lambert, & Compton, 2006). While the greater number of RTI-related studies have focused on literacy skills, a study published in 2007 by Foegen, Jiban and Deno, examined progress monitoring measures in mathematics and its effectiveness. In reviewing the literature regarding progress monitoring in the area of mathematics, two applied approaches were identified in the development of the type of CBMs used. One approach utilizes probes that are comprised of samples from the specific grade level curriculum, and the other approach utilizes probes that are more reflective of broader mathematical proficiency. The study by Foegen et al. was not able to discern conclusive evidence as to the effectiveness of one approach over the other at the elementary school level. However, the recommendation was given to schools to select probes that had a high level of match "between the content of the measures and that of their curriculum" (p. 136). Other researchers specified that in order for the interventions to have positive effects, the assessments need to be "instructionally relevant" (Ysseldyke, Burns, Scholin, & Parker, 2010, p. 56). The study indicated a limited number of studies investigating the impact of progress monitoring on students' growth and achievement levels in mathematics.

RTI Research

Centering on beginning reading skills, the early research base for RTI focused on literacy instruction and programs that were predominately implemented in the early grades of elementary school (Stecker, 2007). Following a brief overview of this research, research in the application of the model to older elementary and middle school students, as well as in the content area of mathematics, will be presented.

In 2003, at a Responsiveness-to-Intervention Symposium sponsored by the National Research Center on Learning Disabilities, Vaughn (2003) presented research on a 3-tier reading model introduced as a prevention model that was intended to address the instructional needs of struggling young readers before they displayed significant deficiencies. Vaughn reported on two studies, one with kindergarten students and one with second grade students, who were identified as at risk for reading problems. While the studies possessed different characteristics that impacted the outcomes, such as the amount of time students received interventions, both studies indicated that gains were made by students that received interventions.

Additional research in reading continues to support the effectiveness of the RTI model. Findings of a synthesis of fourteen studies examining the efficacy of RTI provided some discussion concerning the details of interventions (duration, focus, and intensity) but supported the model as an identifier of at-risk learners and as an intervention delivery vehicle (Coleman, Buysse, & Neitzel, 2006). In other studies that followed kindergarten students (Lesaux & Siegel, 2003) and first grade English Language

Learners (ELL) through second grade, it was concluded that ELLs benefit from RTI's "explicit, systematic, and intensive interventions" (Linan-Thompson, Vaughn, Prater, & Cirino, 2006, p. 397) and were at a decreased risk of needing special education services. In a similar finding, the recommendation for "intensive, systematic reading instruction" was extended to any struggling reader who scored below the benchmark on universal screening assessments (Gersten, Compton, et al., 2008, p. 40). Findings from a longitudinal reading study, beginning in first grade with a three-year follow up, revealed that a higher level of performance on progress monitoring assessments and specific standardized reading assessments was demonstrated by students receiving a Tier 2 intervention of small-group tutoring, as opposed to those students who did not receive the intervention (Fuchs, Compton, Fuchs, Bryant, & Davis, 2008). Other reading studies focusing on CBMs, a common element in RTI, reported that CBMs did prove to be valid assessment tools and were able to provide a measure of predictability of performance on state reading assessments (Hinkle, 2011; McGlinchey & Hixson, 2004; Nese, Park, Alonzo, & Tindal, 2011).

In September, 2009, the Northwest Regional Educational Laboratory issued a report on models of RTI that were supported by the education agencies in the region's five states. This report indicated that four of its states were still primarily implementing the model in reading at the elementary level (Stepanek & Peixotto, 2009). According to this report, one contributing factor for the focus on reading in early RTI programs was the federal program, Reading First. The Reading First initiative is a grant program which provides funding support for the establishment of scientifically-based reading programs in grades kindergarten through third grade (U.S. Department of Education, 2008b). RTI programs in reading also share similar methodology with other programs such as Reading Recovery, a program that advocates early identification of reading deficiencies, progress monitoring techniques, and personalized, individualized instruction (Mokhtari et al., 2010).

Reviewed studies indicated a broad research base exists in the early grades, including grades K–3, and that more research to demonstrate that RTI improves achievement in general education students beyond the primary years is needed (Gartland & Strosnider, 2005). Research about RTI in the middle school setting is limited but emerging and includes behavior applications as well as specific content applications (Burns, 2008; Johnson & Smith, 2008; Manzi, Alderton, & Erdmann, 2010). While in the area of reading, Faggella-Luby and Wardwell (2011) provided evidence for explicit instruction, a general characteristic of RTI interventions, in the middle school setting. Other studies examining the effectiveness of RTI interventions in the area of reading with middle and high school students revealed positive, but not always substantial, differences (Edmonds et al., 2009; Vaughn et al., 2010). The explanation for the less than impressive results included references to the lack of extensive knowledge regarding effective interventions for these age groups. Again, while not specifically targeting mathematics achievement, a study of over 300 middle grades schools in California found six practices that were common among the higher achieving schools, two of which are found in the RTI process. One predictor practice was that everyone involved in the education of the students used student assessments and similar data to “evaluate and improve teacher practice and student outcomes” (Williams, Kirst, Haertel, et al., 2010). Another predictor practice, also found in RTI, indicated that the academic programs were targeted and provided quick interventions for at-risk students.

RTI research in the area of mathematics has increased over recent years. Yet as in the area of reading, many studies are situated in the early elementary years (Bryant et al., 2008; Jordan, 2007; Newman-Conchar et al., 2009). Findings suggested that explicit, systematic instruction, a prevalent characteristic in Tier 2 interventions, resulted in improvements in mathematical outcomes as it did in reading. While not situated in the RTI setting, one large study recorded statistically significant, positive effects when an explicit instruction approach, similar to the general RTI characteristic, was used with students who possess learning difficulties in the area of mathematics (Gersten, Chard et al., 2008). A study that specifically addressed middle school mathematics reported increased student engagement and positive student responses to the applied intervention of peer-assisted learning (Kroeger & Kouche, 2006).

In a 2008 review of 11 field studies of RTI implementations, results revealed improved academic achievement. While the studies contained both standard protocol and problem-solving protocol models, the only study in the area of mathematics was a standard protocol model involving low performing fourth graders. The recommendation of more research to establish the magnitude of the impact of RTI programs on mathematical performance was indicated (Dexter et al., 2008), and the field studies were revisited in 2012 with the addition of five studies. Using prescribed criteria, only one additional study measured mathematics performance and again involved a standard protocol model (Hughes & Dexter, n.d.). The district included in this study is using a problem-solving protocol in its RTI implementation.

As indicated in the above information, the number of studies involving the content area of mathematics is increasing. However, studies in the upper grade levels and in middle school are limited and often focus on a particular type of intervention.

Computer-Assisted Instruction in Mathematics

One option for districts implementing RTI, as in the district involved in this study, is the use of computer-assisted instruction (CAI) as one of the possible intervention models. Although not limited to RTI, the use of CAI has received growing attention in recent years. Computer-assisted instruction can broadly be defined as any instruction that involves the use of a computer program, ranging from computer games that provide skill practice and problem solving activities to a more sophisticated computer application that adapts and adjusts the instruction in response to the individual student's skills and needs. In this section, studies revealing the impact of CAI are presented.

In 2006, a study involving at-risk first graders provided some evidence that computer-assisted instruction does present possibilities for increasing successful student outcomes when the young students are provided with adequate supervision. Statistically significant results were reported in the area of the addition of number facts, but the results were not as statistically notable in the area of subtraction and story problems (Fuchs et al., 2006). Another study with older at-risk students, grades 3 and 4, reviewed the impact of CAI on math fluency as well as on the overall risk for failure (Burns, Kanive, & DeGrande, 2012). Students who participated in the intervention demonstrated significant gains and grew at a rate equal to or greater than those who did not have the intervention.

Other studies have focused on specific types of computer-assisted instruction programs. A 2007 report by Nummery and Ross provided insights regarding the use of a program called Accelerated Math (AM) by Renaissance Learning™. While this program differs in design from the CompassLearning Odyssey® Math (Odyssey Math) program used in this study and is actually classified as a computer-managed program, the program does allow students to practice appropriate skill level problems and then administers a computer-scored assessment. The generated reports provide teachers with the opportunity to diagnose errors and make individual instructional plans. While less research is available on Accelerated Math than on the Accelerated Reader program provided by the same company, studies of AM suggest that the program has a positive impact. Using a repeated-measures analysis, two cohorts of students were followed from grades 3 through 5 and then grades 6 through 8.The overall findings suggested that, while they were not large, there were statistically significant increased levels of achievement in mathematics in both the upper elementary and the middle school cohorts among those who participated in AM.

The National Mathematics Advisory Panel (2008) recommended in its Final Report the use of "high-quality CAI tutorials, implemented with fidelity" (p. 51). The panel went on to indicate that, while results are somewhat mixed, research has revealed that the appropriate implementation of good quality programs has yielded positive effects on the mathematics achievement of students at the middle school and high school level. Several studies have concurred with the panel's findings. According to an analysis by Schacter (1999) of the impact of computer technology, fourth grade and eighth grade students who received computer-assisted instruction demonstrated positive achievement gains on a variety of tests, including standardized tests. In a later study involving sixth graders, the CAI program Assessment and Learning in Knowledge Spaces (ALEKS) was used as an intervention in an after-school program for struggling mathematics students (Hu et al., 2011). The study applied two different types of interventions, teacher-led interventions and an intervention using ALEKS, and compared the current year's TCAP scores with the previous year's scores. Although the mean scores did increase for both groups of students, the group of students using ALEKS did demonstrate a small advantage. While the study did not find the difference to be statistically significant, the program was deemed effective.

As Odyssey Math is the computer-assisted instruction used by the district involved in this study, research involving this program is of particular interest. Consistent with some of the previously reviewed findings, research on Odyssey Math has also indicated positive effects. For example, a report by the Institute of Education Sciences examined whether fourth grade classrooms that used Odyssey Math as an instructional tool displayed greater achievement on the mathematics subtest of a standardized test than those that did not. Their conclusion, in keeping with the other studies, stated that the CAI resulted in a very small differential effect which was not statistically significant overall (Wijekumar, Hitchcock, Turner, PuiWa, & Peck, 2009).

In addition to studying the effects on achievement, other researchers have explored the impact of Odyssey Math on students' attitudes and interest. In 2009, Liang and Zhou published results from a qualitative study involving the use of Odyssey Math that explored the interest in learning mathematics in a group of third grade students. Their findings, resulting from focus group interviews and observations, indicated that the computer activities fostered greater interest in and use of mathematics learning.

As this review has indicated, however, the results on the use of computer programs for mathematics instruction are not conclusive. Several studies report gains, but these are not always practically or statistically significant. For example, a meta-analysis conducted by Cheung and Slavin (2011) reported findings that were consistent with other cited reviews stating that educational technology in general does have a positive, yet small, effect on mathematics achievement. A wide variety of technology tools were included in this study, but the “supplemental CAI” programs reported the largest effect on mathematics achievement (+0.18). Several recommendations for future studies, including more randomized studies and use of non-standardized tests, were given.

Predictive and Prescriptive Assessment Systems

As a means of assessing student achievement and growth in content learning, many districts are turning to assessment systems which advertise their ability to predict student success on state assessments. Given the high stakes of many of these state-mandated assessments, districts like the one in this study can benefit from early detection of learning deficiencies and from prescriptive remediation strategies. As indicated earlier, the predictive and prescriptive powers of progress monitoring assessments, including CBMs, have been validated in the content area of reading (Foegen et al., 2007; Fuchs et al., 2008; Hinkle, 2011; McGlinchey & Hixson, 2004, Nese et al., 2011). As also discussed, the scope of the research in the content area of mathematics is narrower, but increasing. This district used STAR Math, a commercial assessment program by Renaissance Learning™, as a progress monitoring tool and in benchmark testing. STAR Math has been described by Renaissance Learning (2009) as being a computer-adaptive testing program as well as a program that uses item response theory (IRT). In computer-adaptive testing programs, the computer adapts the questions, or refines the test items, based on the students' responses and/or ability level while an IRT design evaluates and adjusts the difficulty level of the test item (Shapiro & Gebhardt, 2012). STAR Math uses continuous progress monitoring and requires that teachers make decisions in keeping with acquired data.

A regression analysis, published in 2012, indicated that while STAR Math was a valid predictor on a Pennsylvania state assessment for third and fourth graders, it did not reach a recommended .90 level of sensitivity in identifying at-risk students (Shapiro & Gebhardt, 2012). STAR Math has been included in other studies (Spicuzza et al., 2001; Ysseldyke & Bolt, 2007), but primarily as a placement tool or as a means by which students demonstrate growth.

Summary

The expanded use of RTI in the area of mathematics is supported by the recommendations of various groups. For example, the National Mathematics Advisory Panel (2008) indicated that teachers need to be provided with feedback from recurring and frequent assessments. Their meta-analysis revealed that when instruction was driven by data, the students demonstrated significant gains. The features of the design of RTI support this model of instruction (Brown-Chidsey & Steege, 2005; Burns, 2010; Justice, 2006). Similarly, a panel of researchers for IES acknowledged that early detection and intervention of mathematical difficulties enables students to be more successful later and recommended an RTI framework to assist these struggling learners (Gersten et al., 2009). While the existing research on RTI includes studies of its effectiveness in reading and in the early grades, there remains a need to address the impact of RTI in middle grades mathematics and to examine the factors that might influence the effectiveness of RTI (e.g., the use of CAI versus teacher-directed instruction).

Chapter 3

Methods

This chapter presents a brief overview of the methodology of this study, including a description of the setting, the participants, the interventions, and the data collection and analysis methods. The purpose of the study was to investigate the effectiveness of the district-wide implementation of the RTI model on the mathematical achievement of seventh and eighth grade students during the 2010–2011 school year.

Setting

The study was conducted in a rural, west Tennessee school district, Pilot District, with a student population of approximately 3,900 in Grades PK–12. All of the schools in Pilot District are Title 1 Schools. Of the nine district schools, the five schools that house Grades 7–8 are included in this study. Three of the schools are elementary schools that serve Grades PK–8. One school is a middle school for Grades 6–8. The fifth school is a combined junior high and senior high school serving Grades 7–12.

In the fall of 2007, in response to the Tennessee State Board of Education's recognition of RTI evaluation programs and its initial recommendations (Yquierdo & Tyler, 2009), the district's Board of Education implemented an RTI program as a pilot study for the State of Tennessee. According to the National Center for Response to Intervention, Pilot District became an RTI Demonstration Site for the state. In the RTI manual, published by Pilot District, the district stated that the intent of its Board of Education is to provide every student an opportunity to experience success in the regular public education classroom (Pilot District, 2011). Recognizing that reading skills are crucial to academic success, and as characteristic of the early RTI implementations across the country (Coleman, Buyssee, & Neitzel, 2006; McGlinchey & Hixson, 2004), the district began with a system-wide implementation of a literacy RTI program for Grades K–3 in the fall of 2007. In the 2008–2009 academic year, the literacy RTI program was expanded to include Grades K–5. The following year, the literacy RTI was extended into Grades 6–8. In the fall of 2009, acknowledging that many students also struggle with mathematics, the district further expanded its RTI program to also include mathematics for Grades K–8. Additionally, an experimental high school RTI program was initiated in the fall of 2009 but is still described by district personnel as a "work in progress" (C.D. Smith, personal communication, March 23, 2012).

Beyond the state's overall interest in the effectiveness of the RTI process, statistics from the TDOE Report card pointed to several reasons why Pilot District might be concerned and interested in the effectiveness of their implemented program. In describing the district's schools, three of the five schools in the study were classified as either a Target or a High Priority school by the TDOE for at least one year between 2008 and 2011. According to the 2010 and 2011 TDOE Report Cards, one descriptor of the district reveals the Academic Achievement Grades of D and C in the area of Mathematics. The grades for the five individual schools were distributed from B to F. In 2010, three schools received a C, one school received a D, and one received an F. In 2011, two schools received a grade of B, and one each received a grade of C, D, or F. Also, as reported earlier, in 2012, under a waiver granted to the state, Pilot District was classified as *In Need of Subgroup Improvement* because of results from the Algebra I End-of-Course Test.

More recent TDOE Report Card data supported the need for the district to remain focused on its established goal of increasing the percentage of students scoring *Proficient* and *Advanced* on the Mathematics section of the TCAP Achievement Test in all subgroups (TCSPP, 2007; Tennessee Department of Education, 2012b). In the district's *Tennessee First to the Top Local System Scope of Work* (Pilot District, 2010), the system projected an increase of the seventh grade mathematics TCAP scores from 21% *Proficient* in the 2009 – 2010 academic year to 37.4% *Proficient* by the 2012 – 2013 academic year, as well as a planned 2% reduction in the number of newly identified learning disabled students.

Participants

Participants for this study came from 580 students in Grades 7–8 in the Pilot District during the 2010–2011 school year. Mathematics students in Grades 7–8 were categorized as either Tier 1, Tier 2, Tier 3, or Tier 4 as determined by the students' scores on regularly scheduled mathematics benchmark tests as well as by any history of their responses to interventions. (See Tiers and Intervention section for description of tier classification process and descriptions of the interventions used.) Of the 580 students, 61 were classified as Tier 4 students, including students who received special education services. Due to their specialized instruction, Tier 4 students were not included in this study. Additionally, 17 students were omitted from the study due to incomplete or missing data. Some of these students moved out of the district during the school year or were absent on specific testing dates. Without the omitted students, the study included 502 students in all.

For this study, any student who received instructional interventions in the content area of mathematics in either Tier 2 or Tier 3 for a minimum of eight weeks is listed as a Tier 2/3 student. (See Tiers and Interventions section for further explanation.) As seen in Table 1, 105 of the 502 students (approximately 21%) were Tier 2/3. Additionally, in this study, the Tier 2/3 students were separated into two groups, those who received computer-assisted instruction (CAI) as an intervention and those who did not. Students who did not receive CAI most often received teacher-directed instruction for interventions. Of the 105 Tier 2/3 students, 60 students (about 57%) received CAI interventions.

In order to further describe the student population, information regarding their racial subgroups is presented in Table 1. Using data from the 2011 TDOE Report Card, the two largest racial subgroups among the schools were African American and White (labels consistent with those listed on the Tennessee Report Card). These subgroups totaled 475 students and represented about 95% of the students. The remaining categories as labeled on the Tennessee Report Card (Asian, Hawaiian/Pacific Islander, Hispanic, and Native American) are listed as Other. As seen in Table 1, almost three-fourths (76) of the students in Tier 2/3 were categorized as African American or Other. This is in contrast to a little more than one-half (209) of the Tier 1 students being categorized as African American or Other.

Table 1

Racial Demographics of Students

Tier	African American	White	Other	TOTAL
1	189	188	20	397
2/3	69	29	7	105
TOTAL	258	217	27	502

Tiers and Interventions

This section will describe the tier classification and determination process and the types of interventions used by the district during the 2010 – 2011 school year with its seventh and eighth grade students. As Tier 4 data were not included in this study, information regarding this tier and its interventions are not provided. Tier 4 interventions were prescribed on an individual basis and were more extensive than those included in this study. The information used to describe the tier classifications and determinations was provided by the Pilot District’s 2011 RTI manual.

Students in this study (Grades 7 – 8) were provided with whole group instruction and small group instruction in mathematics by their classroom teachers. Additionally, the students were given a mathematics universal screening without modifications, referred to as the benchmark tests, using the commercial assessment program STAR Math by Renaissance Learning™, in the fall, winter, and spring. The fall benchmark was given after about four weeks of school, while the winter benchmark was given at the beginning of the second semester. The spring benchmark was administered near the end of the school year. This study includes only the fall and spring benchmark tests.

Tier 1 refers to the general education setting which provided "validated practices (whole group instruction, small group instruction, and differentiated activities)" for all students (Pilot District, 2011, p. 32). As students' progress was regularly monitored, small group instruction was provided in accordance with the level of student performance.

Students who scored at and below the 10th percentile of the program's national norms were identified as "at-risk" and were progress monitored weekly, also using STAR Math assessments (Pilot District, 2011, p. 32). These at-risk students continued to receive interventions during the Tier 1 small group instruction for an additional four to eight weeks. If a student continued to score at or below the 10th percentile, the student's data (progress monitoring and classroom work) were reviewed by a designated team of professionals, usually consisting of five members. This team of professionals varied by school but was chaired by the school's RTI facilitator and also included a mixture of the following school personnel: principal or assistant principal, guidance counselor, psychologist, librarian, and classroom teacher. Parents were always invited to participate. Upon review of the students' data, the team designated which students were classified as Tier 2. Tier 2 students were scheduled for an additional 30 minutes of small group interventions.

The students' data included the results of the progress monitoring assessments as recorded by STAR Math. These results were reported as a list of scores by test date, matched with the applied intervention as well as in a graphic display using a trend line analysis. If the student responded to the intervention, the trend line would approach or coincide with the goal line. If the student did not respond to the intervention, the trend line would be far below the goal line. Changes in interventions were also documented in the report so the school personnel could determine which interventions were most effective for the student.

At the end of eight weeks of interventions, the student data were again reviewed. Students who demonstrated progress and no longer scored at or below the 10^{th} percentile were returned to a Tier 1 classification. If a student continued to score at or below the 10^{th} percentile, the team classified the student as Tier 3 and the student received further, more intense and altered-in-design interventions. Once a student was classified as Tier 3, the student remained at Tier 3 for a minimum of eight weeks and until such time that the student's scores rose above the 10^{th} percentile. As Tier 3 is primarily differentiated from Tier 2 by the amount of time the student received the interventions, both Tier 2 and Tier 3 students are referred to as Tier 2/3 students in this study.

Students failing to respond to the instructional interventions after a minimum of sixteen weeks either received an additional eight weeks of intervention or were referred to the district RTI team in order to receive approval for eligibility for special education services. If the student was deemed as eligible and received the team's approval, then the student was, with school and parental consensus, moved to the next Tier of services which included special education. Tier 2/3 students who did respond to the instructional interventions, or who scored above the 10^{th} percentile on the benchmark assessments, were usually reclassified as Tier 1. Once a student was classified as Tier 3, the student either remained a Tier 3 student, moved into Tier 4, or, based on the benchmark tests' scores, was reclassified as a Tier 1student. The student did not move back to a Tier 2 classification.

The interventions used during the Tier 2/3 instruction varied by school and depended largely on the availability of the specific materials. Decisions regarding which specific intervention was used were made by members of the RTI team, which included the classroom teacher. The instruction was delivered by highly trained para-professionals. As indicated earlier, for this study, interventions were broadly classified as either teacher-directed instruction (TDI) or computer-assisted instruction (CAI). While the term CAI often generally includes any use of the computer, for the purpose of this study, the term CAI will only include the computer-adaptive instruction provided by the commercial program CompassLearning Odyssey® Math (Odyssey Math). Computer-adaptive instruction provides instruction that adjusts an individual student's questions or problems according to the responses of the student. According to Odyssey Math's Web site, this computer-adaptive program provides personalized learning activities that address the specific needs of each student (CompassLearning Odyssey®, 2012). Due to sporadic use and the types of programs, other computer programs that were used were not included in the scope of this study at the recommendation of district personnel.

The teacher-directed interventions were required to be research-based and ranged from materials supplied by the district's adopted textbooks to other commercially prepared programs. The district's adopted textbook series was identified as Glencoe Intervention supplemental material. Other materials were identified as programs including Teacher Created Materials, Targeted Mathematics Intervention, Accelerated Math, and SRA Corrective Math.

The assurance of the fidelity of the interventions began with the stipulation that the interventions were required to have a scientific research base in order to be appropriate and acceptable. Among the list of criteria for the research of the interventions, the district's RTI manual includes the following: proof of rigorous data analyses through experimental or quasi-experimental designs, reliable and valid data, and detailed studies that can be replicated (Pilot District, 2011). As the implementation of the interventions was also of concern, the district included very specific, defined responsibilities of classroom teachers and of administrative personnel, characterized by classroom walk-throughs, lesson observations, and documentation of classroom procedures. Inadequately performing teachers were monitored more frequently with procedures in place for coaching, problem solving, and action plans. Student progress was also closely monitored with an expectation of improvement to indicate teacher and intervention effectiveness.

Data Sources and Analysis

The research is a quantitative study to evaluate the effectiveness of a system-wide RTI implementation (RTI-Math) on struggling mathematics students in grades 7 – 8. The effectiveness of the implementation was analyzed through achievement gains of students and through the achievement levels attained on the mathematics subcategory test of the TCAP assessment.

For the purpose of this study, the following data sources were used:

- Student-scaled scores on the fall and spring STAR Math benchmark assessments. The scaled scores from the fall and spring benchmark tests were compared to compute gain scores;
- Information on student tier placement (Tier 1 or Tier 2/3);
- Information on the type of intervention the Tier 2 student received (CAI or TDI);
- Student level of achievement on the math subcategory test of TCAP. Students attaining a level of *Proficient* or *Advanced* (as determined by the Tennessee Department of Education) were designated as "successful." Students whose scores were *Basic* or *Below Basic* were designated as "unsuccessful;"
- Student level of achievement as determined by the STAR Math interpretation of the spring math benchmark assessment. As with the TCAP, students whose STAR Math scores were identified as *Proficient* or *Advanced* were designated as "successful," while students whose scores were identified as *Basic* or *Below Basic* were designated as "unsuccessful."

The data analyses that were used to address the three research questions guiding this study are discussed by individual research question in the following section. The questions are listed as well as the statistical analysis that was used. The next chapter presents the results obtained through these analyses.

Research Question 1. Were there significant differences between the fall and spring STAR Math benchmark assessment gain scores for students receiving RTI interventions (Tier 2/3) and the gain scores for students who did not receive RTI interventions (Tier 1)?

For research question 1, an Analysis of Variance of Gain Scores was conducted to determine whether the demonstrated achievement growth of the Tier 2/3 students, resulting from the interventions, was significantly greater than the achievement growth of the Tier 1 students, who did not receive additional interventions. The fall and spring STAR Math benchmark scores of these two groups of students were used to calculate gain scores for each student. The gain score, which represented the gain or achievement growth, was the dependent variable. The identified tier classification was the independent variable and included two groups, Tier 1 and Tier 2/3.

Research Question 2. Within the group of students who received RTI interventions (Tier 2/3 students), did the students who received computer-assisted instruction demonstrate statistically significant differences between the fall and spring STAR Math benchmark assessment gain scores as compared to the gain scores of those students who primarily received teacher-directed interventions?

For research question 2, an Analysis of Variance (ANOVA) of Gain Scores, derived from the differences in the fall and spring STAR Math benchmark assessments, was also run to determine whether the Tier 2/3 students who received an intervention of computer-assisted instruction (CAI) demonstrated significantly greater achievement growth on the benchmark assessments than those Tier 2/3 students who primarily received teacher-directed interventions (TDI). The independent variables were the two types of interventions (CAI and TDI), with the dependent variable being the gain scores on the benchmark assessments.

Research Question 3. For all Tier 1 and Tier 2/3 students, to what degree did the STAR Math benchmark assessment scores accurately predict success (a rating of *Proficient* or *Advanced*) on the mathematics subcategory score of the TCAP test?

Research question 3 examines how accurately the STAR Math assessment program predicted success on the mathematics subcategory test of the TCAP assessment. Success was defined as achieving either a *Proficient* or *Advanced* achievement level on the mathematics subcategory test of the 2011 TCAP. To determine this, a logistic regression statistical analysis was performed. A successful rating of *Proficient* or *Advanced* on the mathematics subcategory on the TCAP assessment was the dependent variable. The level of achievement determined by the spring STAR Math score was the independent or predictor variable and was categorized as either successful or not successful.

Chapter 4

Results

This chapter begins with a brief overview of the study's setting and then presents the results of the data analyses for each research question. The purpose of this research study was to examine the effectiveness of the implementation of the RTI model on the mathematics achievement of seventh and eighth graders in Pilot District during the 2010–2011 school year. As the RTI model was implemented throughout the district, all the seventh and eighth graders in the district were included, with the exception of the students who were receiving special education services and those students who had incomplete data. Out of the 580 seventh and eighth graders, 61 were excluded because they were special education students, and 17 were excluded because of incomplete data. A total of 502 students housed across five district schools, approximately 52% female and 48% male, were included in the study.

All of the data used in the study were archival data from the 2010-2011 school year. For all participants in the research (N = 502), the study used fall and spring benchmark tests' scaled scores as well as level of achievement ratings on the mathematics subcategory of 2011 TCAP assessment. Additionally, all Tier 2/3 students (N = 105) were categorized as either having received CAI (N = 60) or not having received CAI (N = 45) during the 2012 – 2011 school year. While both groups did receive some teacher-directed instruction, those categorized as not having CAI received very little applicable CAI with a variety of teacher-directed instructional methods (TDI).

The remainder of this chapter provides the results of the quantitative analyses of the research questions. Each question is followed with the interpretation of the data revealed in the analyses.

Research Question 1. Were there significant differences between the fall and spring STAR Math benchmark assessment gain scores for students receiving RTI interventions (Tier 2/3) and the gain scores for students who did not receive RTI interventions (Tier 1)?

This research question addressed whether the Tier 2/3 students (N = 105) who received the interventions demonstrated greater growth as reflected by gains on the STAR Math benchmark assessment test than those students who did not receive the interventions. In order to measure differences in student growth, an Analysis of Variance of Gain Scores (ANOVA) was conducted using the differences in the students' fall and spring STAR Math benchmark assessment scores to calculate a gain score, which was the dependent variable. While other studies measuring growth have used a regression-discontinuity design (Bryant et al., 2008), quasi-experimental design is only appropriate if a predetermined cut-off score is strictly applied, which was not the case in this set of data. Therefore the ANOVA of Gain Scores was used.

For this analysis, the students' tier classification was the independent variable and included two groups, Tier 1 and Tier 2/3. As indicated on Table 2, there were 397 students in Tier 1 and 105 students in Tier 2/3, for a total of 502 students. Table 2 is a presentation of the descriptive statistics for the two tier groups and provides the fall and spring means as well as the gain score mean and standard deviation of each tier's gain score.

Table 2

STAR Math Assessment Mean Scores and Standard Deviations by Tier

Tier	*N*	Fall Mean	Spring Mean	Gain Mean	Gain Score Std. Deviation
1	397	738.99	765.88	26.89	59.95
2/3	105	602.42	659.35	56.93	71.13
Overall	502	710.42	743.60	33.18	63.79

Levene's Test resulted in a *p*-value of .011 ($p = .011$), which violated the assumption of homogeneity of variance at $\alpha = .05$ level. Therefore, a more stringent α level of .025 was adopted. The alpha level was determined by dividing .05 by the numbers of groups (2) being compared.

According to the ANOVA, the significance level, F (1, 500) = 19.133, $p = .000$, was lower than the adopted $\alpha = .025$, so there was a statistically significant difference in the means of the gain scores, the dependent variable, of the two groups. On the average, the Tier 2/3 students showed greater gains (56.93) than the Tier 1students (26.89). The higher gain scores' mean for the Tier 2/3 students demonstrated statistically significant greater growth for the Tier 2/3 students as compared to the gain scores of the Tier 1 students. A Cohen's *d* was calculated to examine the effect size. The result showed an effect size of $d = .51$, which is often interpreted as a medium effect size (Hinkle, Wiersma, & Jurs, 2003).

Research Question 2. Within the students who received RTI interventions (Tier 2/3 students), did the students who received computer-assisted instruction (CAI) demonstrate statistically significant differences between the fall and spring STAR benchmark assessment gain scores as compared to the students who primarily received teacher-directed interventions (TDI)?

Research question 2 compared the amount of growth demonstrated by both groups of students in Tier 2/3, the students who were categorized as CAI (N = 60) and the students who were categorized as TDI (N = 45). Again, as in question 1, in order to measure differences in student growth, an Analysis of Variance of Gain Scores (ANOVA) was conducted, using the differences in the students' fall and spring STAR Math benchmark assessment scores to calculate a gain score, which was the dependent variable. The students' intervention type was the independent variable and included two groups, CAI and TDI. Table 3 indicates that there were a total of 105 students in Tier 2/3, with 60 identified as having received an intervention of CAI and 45 having received primarily an intervention of TDI. Table 3 is a presentation of the descriptive statistics for the two intervention groups, providing the means and standard deviations of the gain scores.

Table 3

STAR Math Assessment Mean Scores and Standard Deviations by Intervention

Intervention	*N*	Fall Mean	Spring Mean	Gain Mean	Gain Score Std. Deviation
CAI	60	601.78	673.72	71.93	71.34
TDI	45	603.27	640.20	36.93	67.98
Total	105	602.42	659.35	56.93	72.73

According to Levene's Test the assumption homogeneity of variance was satisfied. Levene's Test resulted in *p*-value of .363 ($p = .363$), which is greater than the applied critical value of .05 ($\alpha = .05$). As there was no violation of homogeneity, an ANOVA was conducted at the .05 level.

Results from the analysis of variance (ANOVA) determined a statistically significant difference, F (1,103) = 6.443, $p = .013$ (lower than the adopted $\alpha = .05$), in the means of the gain scores for the type of intervention received by the students in Tier 2/3. The students receiving CAI demonstrated a higher mean (71.93) on the spring STAR Math benchmark assessment gain score than the students that primarily received TDI (36.93). A Cohen's *d* was calculated to examine the effect size. The result showed an effect size of $d = .46$, which is often interpreted as just a little below a medium effect size (Hinkle et al., 2003).

This statistically significant difference was also revealed through an Analysis of Covariance (ANCOVA), which resulted in a higher spring mean score (673.72) for the

CAI students than the spring mean score (640.22) for the TDI students. The ANCOVA used the fall STAR Math scores as the covariate, thereby controlling for the students' initial ability. This analysis provided added support that the resulting difference can therefore be attributed to the type of intervention.

Research Question 3. For all Tier 1 and Tier 2/3 students, to what degree did the STAR Math benchmark assessment scores accurately predict success (a rating of *Proficient* or *Advanced*) on the mathematics subcategory assessment of the TCAP test?

For question 3 in this study, a logistic regression analysis was conducted, using the students' level of achievement on the mathematics subcategory test of the 2011 TCAP assessment as the dependent variable. A rating level of *Proficient* or *Advanced* was identified as a success, while a rating level of *Basic* or *Below Basic* was deemed not successful. The level of achievement determined by the spring STAR Math scores was the independent or predictor variable. The STAR Math scores were examined and rated as either a success or not a success. In congruence with the definition of success on the TCAP, scores that received a *Proficient or Advanced* rating were listed as a "success," and those that received a *Basic* or *Below Basic* rating were listed as "not a success." As the STAR Math's range of possible scores differed from the range of possible TCAP scores, the adjusted cut-off score, 823, as determined by STAR Math, was used to designate "success" or "not a success." As listed in Table 4, the classified data indicated that the number of students who actually scored *Proficient* or *Advanced* (success) on 2011 TCAP was 119 compared to 383 students who scored at the *Basic* or *Below Basic* level (not a success). After categorizing the STAR Math scores, STAR actually predicted that 100 of the 502 students would score *Proficient* or *Advanced* and that 402 would score at the *Basic* or *Below Basic* level.

Table 4

Accuracy of TCAP Predictions by STAR Math

	Actually Observed on TCAP	Accurately Predicted for TCAP	% Correctly Predicted
Success on TCAP	119	64	53.8
Not Success on TCAP	383	347	90.6
Total	502	411	81.87

As represented in Table 4, the STAR Math program accurately predicted that 347 of the students would not be successful on the TCAP and that 64 of the students would be successful. The success of the remaining 91 students was not accurately predicted by the STAR Math program, with 55 of the students being inaccurately predicted as unsuccessful and 36 students being inaccurately predicted to be successful. In this set of scores, the STAR Math benchmark score was more accurate in predicting unsuccessful TCAP scores (90.6%) than in predicting a successful score (53.8%). Overall, the data from the logistic regression analysis indicated that with an $\alpha = .05$, the regression analysis reported a significance level of .000 ($p = .000$) for the STAR Math score as a predictor of the TCAP mathematics subcategory score.

Nagelkerke R^2, which indicates the amount of variability in the dependent variable, the 2011 TCAP Mathematics subcategory score, that may be explained by the independent variable, the spring STAR Math benchmark assessment score, was listed at .267. Another interpretation would be that about 27% of the time, the amount of variability in the identified TCAP score could be explained by the level achieved on the spring STAR Math assessment. In light of this Nagelkerke R^2 and the Cox and Snell R^2 (.178), the spring STAR Math benchmark score did qualify as a predictor of the 2011 TCAP score, but would not be listed as a strong predictor.

Chapter 5 will present the implications and limitations of the study as well as recommendations for further research.

CHAPTER 5

Discussion

This final chapter will present a discussion of the findings drawn from the statistical analysis, the limitations of the study, and the study's implications. In conclusion, the recommendations for further study are presented.

Discussion of the Findings

The findings of this study suggest that the implementation of an RTI mathematics program for grades 7 – 8 did result in increased growth in mathematics achievement. The findings will be presented in the context of each of the research questions.

Research Question 1. Were there significant differences between the fall and spring STAR Math benchmark assessment gain scores for students receiving RTI interventions (Tier 2/3) and the gain scores for students who did not receive RTI interventions (Tier 1)?

The results from the statistical analysis of Question 1 appear to indicate that the additional 30 minutes of instructional time spent in the interventions provided some measure of gap closure between the achievement levels of the Tier 1 and Tier 2/3 students. This was evident by the higher mean in the gain scores for Tier 2/3 students as compared with Tier 1 students. While the spring mean for Tier 2/3 did not reach the level of the spring mean for Tier 1, the gain scores did reveal that the Tier 2/3 students experienced greater growth. The narrowing of this gap was one of the goals of the RTI program for this district. This finding supported the findings of earlier studies, most of which involved younger students, which revealed that an RTI program did result in some degree of improvement in mathematics achievement (Bryant et al., 2008; Dexter et al., 2008; Gersten, Chard, et al., 2008; Hughes & Dexter, n.d.; Newman-Conchar et al, 2009; Nummery & Ross, 2007). Additionally, this study added to the research base on RTI, as studies that included grades 7 and 8 were either limited in number (Gersten, Chard, et al., 2008; Nummery & Ross, 2007) or focused on specific intervention strategies (Kroeger & Kouche, 2006). The indicated achievement growth also suggested that there were Tier 2/3 students who were able to move back into a Tier 1 level and were prevented from becoming a Tier 4 student needing special education services. This finding is congruent with earlier research (Burns, Appleton, & Stehouwer, 2005; Marston, 2005).

Research Question 2. Within the students who received RTI interventions (Tier 2/3 students), did the students who received computer-assisted instruction (CAI) demonstrate statistically significant differences between the fall and spring STAR benchmark assessment gain scores as compared to the students who primarily received teacher-directed interventions (TDI)?

The second finding addressed the type of intervention that was applied. As the RTI implementation in this district included five schools of various configurations, a variety of types of interventions were applied. Within the large category described as teacher-directed interventions (TDI), several different research-based programs were used, depending on school choices and teacher preferences. The computer-assisted intervention in this study was defined to include only the use of CompassLearning Odyssey® Math (Odyssey Math) program. Other computer programs that provided skill and drill exercises were not identified as computer-assisted instruction for this research. A significantly higher mean gain score was derived through the ANOVA for the CAI group of Tier 2/3. Additionally, a secondary ANCOVA concurred that the actual mean score on the spring STAR Math benchmark assessment was higher for the Tier 2/3 students who received the CAI intervention. These results are consistent with the results of an earlier study examining the effects of CAI on early primary students. This prior study, which focused on specific skills, also revealed significant improvement (Fuchs, Fuchs, Hamlet et al., 2006). Additional studies, involving students ranging from grades 3 to 6 with varying levels of ability and employing a variety of computer-assisted instructional programs, also revealed equal or increased achievement levels (Burns et al., 2012). A meta-analysis of over forty studies conducted since 1990, including studies that applied a variety of CAI models with students of a variety of grade and achievement levels, indicated that there was an overall positive effect, of varying degrees, on mathematics achievement (Li & Ma, 2010). While the levels were often statistically significant with the inclusion of CAI, some of the gains were small.

As noted earlier, the results on CAI have not been compelling or conclusive. Thus, the results of the current study are not consistent with some previous research on CAI. For example, a 2009 randomized controlled trial assessing the effect of Odyssey Math on fourth grade students did not yield a statistically significant result regarding student achievement (Wijekumar et al., 2009). The results of the current study, while certainly not conclusive, contribute to the larger body of research on CAI. This study's focus on upper grades and broader content goals (as compared to some earlier studies of specific skills) suggests, at a minimum, the need for further research on the potential impact of CAI.

Research Question 3. For all Tier 1 and Tier 2/3 students, to what degree did the STAR Math benchmark assessment scores accurately predict success (a rating of Proficient or Advanced) on the mathematics subcategory assessment of the TCAP test?

The results from the third research question indicated that while the STAR Math program was able to correctly determine whether a student would reach a *Proficient* or *Advanced* level on the TCAP about 54% of the time, it was also able to correctly determine whether or not the student would reach a *Basic* or *Below Basic* level about 91% of the time. This finding provides a measure of validity to claims made by the STAR Math program. While there are a limited number of outside research studies involving STAR Math and its correlation to high stakes tests such as the TCAP, Shapiro and Gebhardt (2012) did indicate that STAR Math was a valid predictor for a Pennsylvania assessment at the third and fourth grade level. Their results, however, were not conclusive as to whether the program actually identified the at-risk students as stated by the STAR MATH program. According to the STAR Success Stories on the Renaissance Learning™ Web site, STAR Math programs enable districts to identify which students are struggling and need additional help in ensuring their success on state-mandated assessment tests, such as the TCAP. Given the important role of universal screening in the RTI process, the results of this study on the predictive validity of the benchmarking assessment remain potentially significant.

Conclusions

Federal legislation, and primarily *No Child Left Behind*, has spotlighted programs such as the RTI process as a means to close achievement gaps and to address the educational needs of all students. From its roots in special education, RTI has evolved into a general education initiative. Having first sprouted in the early grades and in the content area of reading, the RTI process has expanded into intermediate, middle, and high school grades and into other content areas, such as mathematics. As educational institutions seek to address the academic deficiencies of students, RTI provides a vehicle for monitoring and assessing progress, as well as for prescribing instruction. This study adds to the research of how effectively RTI and its varied components address the instructional needs of the struggling student, as specifically identified by the district in this study. More than simply giving information regarding the effectiveness of the overall process, the results from this study also provide educators with additional information regarding the use of computer-adaptive instruction to promote growth in mathematical achievement. Furthermore, the study also indicated that educators can use commercially available assessment instruments (such as the STAR Math program) to identify the struggling student, then prescribe and administer effective treatment.

Implications

The research in this study has potentially important implications. The implications of this research begin with the content area and the grade levels included in this study. Outside of the substantial research in the content area of reading, the existing research for RTI in mathematics is weighted in the early and intermediate primary grades. As this study is centered on the mathematics achievement of seventh and eighth graders, the findings provide additional knowledge regarding the effectiveness of RTI at the middle and junior high school level.

Regardless of grade level, however, RTI programs present extra challenges and demands on school personnel, both in the classroom and in administration (Brown-

Chidsey & Steege, 2005). Since RTI impacts school time and scheduling decisions for interventions and testing, educators and administrators are duly concerned about how it benefits student achievement levels. The positive results of increased growth rates and higher achievement levels of the Tier 2 students provide evidence in support of its continued implementation.

The study also afforded information regarding specific types of implementation and the risk levels of the students. The significantly higher mean gain score attained by the CAI group of Tier 2/3 provides a degree of justification for the utilization of the more costly computer-adaptive program as an intervention for this group, concurring with a variety of studies involving computer-assisted instruction. However, as this study's results did conflict with results from an earlier study involving CAI with younger students, further studies may be indicated in order to provide conclusive evidence regarding its effectiveness. In tight budgetary times, school districts need documentation that limited funds are being spent in areas that will provide the most benefit. The study's results, while not conclusive, at least indicate to districts that this is a strategy worthy of further exploration.

The results regarding the ability of the STAR Math program to identify at-risk students before the state-mandated assessment are potentially significant, as they point to an important intervention tool. The use of the assessment would provide direction in assisting these students with targeted resources and time allotment. With the current trend toward increased district and teacher accountability for student achievement and growth, these results provide educators with prescriptive information and an identified pool of students that need additional instruction in order to be successful on the high stakes tests.

Limitations

This study did have limitations that may have impacted the outcomes of the analyses. Some caution may be needed in assessing the validity of the findings.

First, the RTI model was implemented district-wide. As a result, no control group was available. Without having a control group with baseline data, the research has increased threats to its validity relative to its experimental design. While the researcher is aware that such practices are not uncommon in the implementation of new programs in education, the researcher was not able to conclusively determine that the achievement gains were a result of the interventions.

Another limitation related to the district-wide implementation was that the students in grades 7 through 8 were housed across five schools. As indicated earlier in this document, the schools were of different grade configurations, including three elementary schools, one middle school, and one junior high school. Also, because of the number of locations, a number of individuals were involved in actually recording the types of interventions and the duration. These differences may have influenced the quality and consistency of the implementation. For example, there were some inconsistencies among the schools regarding the amount of time spent in small group interventions. Similarly, a portion of the district personnel seemed to be confused as to what the actual applied definition of computer-assisted instruction (CAI) was for this study. In order to address this particular factor and to apply a consistency to this variable, this study applied the narrow definition of CAI, as presented earlier, to only include the computer-adaptive program, CompassLearning Odyssey® Math (Odyssey Math).

As a result of these possible inconsistencies in implementation, some caution is warranted in the interpretation of the findings. However, it is worth noting that the lack of fidelity might be expected to reduce the impact of the intervention. Thus, the practical significance of the results is not necessarily diminished due to questions of fidelity. Rather, the results are potentially more noteworthy, given the differences in the conditions of implementation across the district schools.

Future Research

In the course of this study, the limited research on the RTI process in the upper grades in mathematics became evident, including high school mathematics. Given the high stakes testing of specific subjects, such as algebra, future study is warranted to determine if the interventions received during the RTI program for this group of seventh and eighth graders will result in a higher passing rate on the algebra examination that is required for high school graduation in this district. Additionally, the effectiveness of an RTI implementation in algebra courses is also of interest.

As a former high school mathematics teacher, the researcher also has interest in effective ways to stem the debilitating effects of the lack of self-confidence, even to the level of crippling anxiety, that often infect older mathematics students. A relevant future study would investigate whether an RTI program can reduce these emotional responses of self-doubt as well as increase the mathematical achievement and growth rate among middle and high school students who often continue to possess mounting skill deficiencies. Also of interest would be a study on the long lasting effects of an RTI program on the mathematical achievement of high school students who had participated in an RTI program in elementary or middle school.

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