MATHEMATICS INTERVENTIONS: A CORRELATIONAL STUDY OF THE
RELATIONSHIP BETWEEN LEVEL OF IMPLEMENTATION
OF THE ACCELERATED MATH PROGRAM
AND STUDENT ACHIEVEMENT
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ABSTRACT

Mathematics Interventions: A Correlational Study of the Relationship Between Level of Implementation of the Accelerated Math Program,

Conducted under the direction of Dr. Brian Yates, Liberty University.

Current legislation, such as No Child Left Behind (2001) or the Individuals with Disabilities Education Act (2004), has increased accountability for schools for the education of all students. These laws require schools to provide interventions for struggling learners, as part of the Response to Intervention process (IDEA, 2004).

Accelerated Math (AM), published by Renaissance Learning, is a scientifically based program designed to supplement quality instruction as part of the RtI process. This correlational study examined ex post facto data using pre and posttest scores on the STAR Math Test in relation to amount of classroom time dedicated to AM instruction.

This computer-based program was examined as part of the existing school day, in public school systems in the rural Arkansas area. The results of the study showed a strong correlation between the amount of time and student performance and a decrease in the achievement gap when AM is implemented. Some concerns were noted about lower student gains in older grades and lack of participation in younger grades. Several reasons were explored for this issue, including teacher evaluation, math anxiety, and stereotypes.

Findings from the study may help streamline instructional strategies and processes, and improve teacher effectiveness and evaluation procedures for mathematics instruction of all students.

Key Words: mathematics, interventions, instructional strategies, response to intervention, Accelerated Math, Renaissance Learning
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List of Abbreviations

ACSD………………………...Association for Supervision and Curriculum Development
ADE……………………………………...Arkansas Department of Education
AM……………………………………...Accelerated Math
AYP……………………………………...Adequate Yearly Progress
CAI……………………………………...Computer Aided Instruction
CBA……………………………………...Curriculum Based Assessment
CBE……………………………………...Curriculum Based Evaluation
CBM……………………………………...Curriculum Based Measures
IDEA………………………………...Individuals with Disabilities Education Act
MLD……………………………………...Mobile Learning Devices
NCLB……………………………………...No Child Left Behind
NCTM……………………………..National Council for Teachers of Mathematics
NMAP………………………………...National Mathematics Advisory Panel
PD………………………………………..Professional Development
RAND………………………………...Research and Development Corporation
RtI………………………………………..Response to Intervention
SES……………………………………...Socioeconomic Status
STAR……………………………………...Standardized Testing and Reporting
STEM…………………………………...Science, Technology, Engineering and Mathematics
TESS……………………………………...Teacher Excellence and Support System
US DOE………………………………......U.S. Dept. of Education
CHAPTER ONE: INTRODUCTION

Current legislation, such as No Child Left Behind (2001) and the Individuals with Disabilities Education Act (2004), has increased the accountability for schools for the education of all students. Schools are compelled to provide interventions for struggling learners, as part of the Response to Intervention (RtI) process (IDEA, 2004). Teachers endeavor to find scientifically based, research-proven instructional strategies, especially in mathematics. Renaissance Learning’s Accelerated Math (AM) program is a scientifically based program intended to supplement quality instruction as part of the intervention process. This study presents a quantitative synthesis of the relationship of increased time using the AM program with student performance in mathematics as measured by the STAR Mathematics scores.

Background

The wellbeing of a nation is anchored in that nation’s ability to deal with sophisticated ideas. Furthermore, for a society to be a leader in the global community, quantitative skills are a necessity. For most of the 20th century, the United States was one such nation as measured by the quantity and quality of technological innovations, financial leadership, and scale of engineering (National Mathematics Advisory Panel [NMAP], 2008). Recent trends indicate a much different outlook for the United States because a large portion of the scientific and mathematics community of this nation will be retiring soon. The National Science Board indicates that more than 40% of the doctoral degree holders in math or science are age 50 or over (National Science Board, 2009). Educators have taken steps to overcome this, but despite the recent growth trends,
American students continue to fall significantly behind other nations in academic areas. In fact, America currently ranks 23rd in the area of mathematics (NMAP, 2008).

Professionals ask questions about how best to improve student mathematics achievement in the United States. It seems that most efforts only help the higher-performing students get better and ignore students with lower abilities. One of many methods to reduce this achievement gap is to provide low-performing students with specific interventions tailored to their individual needs. Following results from the NMAP studies, the U.S. government has passed legislation mandating just that (IDEA, 2004). These laws require teachers to provide scientifically based interventions, called Response to Intervention (RtI), to help struggling students.

Research on the reading process and reading interventions dates back over the past four decades. The mathematics learning process and math intervention analysis, in contrast, only go back about 10 to 20 years (Isaacs, Carroll, & Bell 2001). Reading research has centered on both quantity and quality of intervention, showing immense success when both areas are improved (Conner et al., 2009; Wanzek & Vaughn, 2008). Math intervention research that is available has thus far concentrated on the specific program of intervention (quality) rather than the intensity, or amount of time spent on the intervention (quantity). In an attempt to provide for a more balanced instructional strategy, Slavin and Lake (2007) found that when students were presented with an inclusive design focused on the combination of problem solving, conceptual learning, and real-world applications, it increased their understanding of mathematics. Given the limited number of programs available with this multi-faceted design, few studies truly
examine the combination of increased quantity of intervention with a comprehensive quality program.

In response to current literature, many states are adopting Common Core State Standards (CCSS), attempting to make the educational process more consistent across states. One of the key changes in the curriculum is to stress quality of learning rather than quantity of knowledge. Currently in Arkansas, each grade has between 80 and 200 mathematics objectives to teach. With CCSS, based on current NCTM research, each grade would range from 25 to 40 standards (ADE, 2011). Teachers, therefore, will spend more time teaching key concepts to student mastery rather than racing to cover all the objectives before the state test. This new teaching strategy supports learning research in that children learn math by doing math. Children need adequate time to fully integrate new knowledge to cement learning (ADE, 2011). Using CCSS, more time is available for students to practice what they learn.

Problem Statement

The No Child Left Behind (NCLB) Initiative of 2001 from the United States Department of Education requires all schools to implement research-proven scientifically based programs in an attempt to meet adequate yearly progress (AYP) goals. Typically, research has centered on the strategies involved in the intervention process, usually math computation or fluency (Burns, 1996), but more recent literature has focused on mathematics problem solving (Rhoton, 2010). Baker, Gersten, and Lee (2002) stated that methods of balancing instruction in a comprehensive program are much less clear. Research in other subject areas did indicate that interventions are successful for struggling students, with greater success for increased time devoted to the intervention
(Conner et al., 2009; Wanzek & Vaughn, 2008), but little is available for math instruction. Though researchers agree that students require frequent monitoring of any intervention, little research supports one form over another (Ysseldyke & Bolt, 2007).

Qualitative studies have indicated that teachers are sympathetic to struggling learners, but report that they lack the underpinning knowledge about how best to help. They believe that curricular changes are necessary but deem themselves to be unqualified or not authorized to make these important decisions (Wilson & Rasanen, 2008). Consequently, there appears to be a barrier between what happens in the classroom and learning support, which means that schools may not be making the best use of perspectives of learning support expertise to improve classroom instruction. Even within the classroom, teachers question their own mathematical ability, best practice with new changing standards, and best use of assessment and tests.

To truly improve mathematics instruction, teachers require extensive support to bring about the necessary adaptations in instruction to be truly inclusive for all learners, and schools need to develop a whole-school or whole-class approach to learning that embraces all learners (Wilson & Rasanen, 2008). This support may come in the form of professional development on a variety of topics, but especially in mathematics instruction and mathematics interventions.

Several delivery methods for interventions are available for schools to choose from, including organizational, whole class, small group, individual, and peer tutoring. Each has benefits, but studies have inconsistent results. When comparing the different interventions, small group, individual, and peer tutoring have the same or less effect than whole-class interventions, especially at older ages (Krosbern & van Luit, 2003; Xin &
Jitendra, 1999). In fact, other studies in whole-class mathematics interventions have shown that whole-class interventions have the longest lasting effects on student performance (Griffin, 2004). The problem is that, because of the paucity of research on math interventions and time constraints in schools, many teachers find themselves unable to fully reap the complete benefits of any instructional strategy to benefit all students.

**Purpose Statement**

The purpose of this study is a quantitative synthesis of the effectiveness of whole-class individualized mathematics instruction in the RtI process to improve instructional strategies for all students. Recent literature has supported increasing intensities of interventions, but schools struggle to find both the time and the resources to provide interventions on an individual basis (Duhon, Mesmer, Atkins, Greguson, & Olinger, 2009). Given that many schools already use AM as a supplement to the existing curriculum, the study closely examined the relationship between the intensity, or amount of time spent on this whole-class RtI method, and student performance. Specifically, the study analyzed the correlation of the amount of time dedicated to AM instruction and student performance.

**Significance of the Study**

In the search to discover what genuinely works for students, schools will spend thousands of dollars on curriculum and programs. Research conducted on these scientifically based programs shows inconsistent results. Effective interventions vary in each school; in other words, what works in one school may not work in another. Some studies on behavioral or reading instruction indicated that individualizing instruction to each child’s unique learning needs is beneficial to student success (Conner et al., 2009).
Additional studies have further shown that increased intensity of general interventions correlates with comprehensive student achievement (Duhon et al., 2009). The results of this study may help researchers better understand the effects of increased time intensity of whole-class intervention combined with individualized curriculum on student performance.

Technology integration is paramount to the future of education. However, research has been inconsistent with how much and what kind of technology needs to be implemented for student success. The results of this study can significantly demonstrate that a mixed methods approach combining technology and paper-pencil activities maximizes student success in mathematics. The results of this study can also assist technology directors, teachers, and administrators as they select computer hardware and software for students.

This study was expected to establish a correlation between the amount of time devoted to a whole-class intervention and student success in mathematics. The results of this study can be used to maximize teacher effectiveness and productivity during all phases of instruction: planning, implementing, and evaluating student progress. This study can provide significant input as it demonstrates the importance of computer-aided support for planning, implementing, and evaluating student progress. This support will allow the teacher to provide direct instruction to each student while minimizing the time required for planning and evaluating student progress.

The results of this study may also prove to be useful as they contribute to the heretofore underdeveloped area of research related to mathematics interventions and student achievement. Research in other subject areas established the long-term effects of
interventions, but there exists a significant gap in research with mathematics interventions. This study can validate the interrelated correlation between student achievement in mathematics and the time devoted to interventions.

Despite the fact that Griffin (2004) demonstrated the long-term efficacy of whole-class interventions, very few studies have examined them in research. Knowledge and understanding of the effectiveness of using individualized curriculum for whole-class interventions will maximize teacher effectiveness, with the added benefit of maximizing student performance. Due to the limited amount of time in an instructional day, teachers struggle to find adequate time to meet the needs of all learners. Small-group and individualized interventions are successful in the short term but still require hours of planning and implementation, which take away from the rest of the class. This study could enable schools and teachers to streamline their efforts to improve student outcomes in math.

Furthermore, qualitative research studies have indicated teachers do not sense adequate support from administration; some may claim they lack the foundational knowledge about how best to help students (Wilson & Rasanen, 2008). As a result, there continues to be a barrier between what happens in the classroom and learning research, which means that schools may not be making the best use of current research to support teachers and improve classroom instructional delivery. This study can show that CAI, as part of the RtI process, provides the support that teachers are asking for to more effectively implement an individualized whole-class curriculum.

Current literature leaves several unanswered questions. This study contributes to educational research in mathematics instructional strategies as it relates to the intensity of
math interventions using a scientifically proven individualized curriculum. Whole class interventions, such as the one in this study, can improve student performance significantly, with the greatest effect seen in the long term. Utilizing a curriculum that encompasses the unique needs of individual students helps incorporate whole-class intervention strategies into the daily teaching and learning process. Teachers who understand the whole-class intervention process can seamlessly integrate it into their daily routine.

The results of this study can enable schools and teachers to simplify their efforts to improve student outcomes in mathematics. This study demonstrated the effectiveness of whole-class interventions and serve as a possible catalyst for embedding the intervention process into daily routines.

**Research Questions**

Two questions were addressed in this study, as follows:

- Does increasing the amount of time spent on the whole-class RtI method of the AM program increase student achievement as measured by the STAR Math Test scores?
- Does the amount of time spent on the AM program decrease the achievement gap as measured on the STAR Math Test Scores?

**Research Hypothesis**

Two hypotheses were examined during this study, as follows:

- $H_1$: Student achievement is related to the amount of time dedicated to AM instruction as measured on the STAR Math Test.
• Null $H_{01}$: Student achievement is not related to the amount of time dedicated to AM instruction as measured on the STAR Math Test.

• $H_2$: The achievement gap between student ability levels is related to the time devoted to AM interventions as measured on the STAR Math Test.

• Null $H_{02}$: The gap between student ability levels is not related to AM interventions as measured on the STAR Math Test.

**Identification of Variables**

The study examined two predictor variables: (1) Instruction that employs the AM program with varying degrees of intensity as measured by the amount of instructional time each teacher dedicates to the AM program and (2) ability level as measured by pre and posttest STAR Math Test scores. AM is a program that individualizes lessons for each student, allowing the student to progress at his or her own pace and enabling the teacher to differentiate instruction for each student (Renaissance Learning, 2011).

The criterion variable was student scores on the STAR Math Test, which is designed to identify a student’s level of functioning in mathematics. The schools in the study use the STAR Math as a method of student monitoring student achievement. Renaissance Learning’s STAR Math Test is a criterion-referenced assessment designed to identify student achievement, monitor strengths and weaknesses, and collect data used to support the student interventions (Renaissance Learning, 2010a).
Assumptions and Limitations

Assumptions.

This study had several assumptions, including (1) students maintain regular attendance during the study and (2) all teachers have been trained in the AM and STAR Math programs. This training consists of 2-hour conferences with school administration and teacher leaders prior to the school year and at least quarterly 30-minute team conferences with teacher leaders and other teachers to review procedures and progress. This study also assumed that proper administration of the AM and STAR Math Test was followed at all times as defined during the training conferences.

Limitations.

This correlational study was limited to students in 3rd to 8th grades in public schools in the north central Arkansas area. The small sample size may skew the results of the study. Further, randomization of subjects was not possible because students were already identified by school administration and had previously been assigned to a teacher. Causation cannot be determined due to the nature of the study; rather the demonstrated a relationship or lack of relationship among the variables. Further investigation is warranted to determine a cause and effect relationship among the variables. Threats to external validity were controlled by a matched group design and by using statistical control methods. Finally, any posttest validity threats and the maturation effect were controlled by ensuring the pre and posttests were different enough and by using a standardized test administration.

Research Plan

The study was quantitative in nature and used an ex post facto correlational study
design. Descriptive research attempts to explain a phenomenon. Correlational research designs are descriptive investigations that seek to identify or describe statistical (covariation) relationships between two or more variables (Gall, Gall, & Borg, 2007). Strict standards may be met when treatments are semi-randomized and selection effects are correct by appropriate statistical methods (Gerring, 2011). As part of this study, the intensity, or amount of time devoted to AM, was categorized. Groups were categorized based on minimal implementation (10 minutes or less), recommended time (15-30 minutes), and high implementation (35-40 minutes) of AM. Student scores were also categorized in relation to ability level as measured on the pretest. Scores were categorized into high achievement (top 5% of test scores), low achievement (bottom 5% of scores), and median (middle 90% of scores). The pre and posttest scores of both groups were analyzed for any statistically significant relationships.

**Definitions**

Several key terms are addressed in this study.

- **Accelerated Math (AM)**—a computerized program that produces individualized lessons tailored to fit the learning needs of each student.

- **Achievement Gap**—the difference between the highest and lowest performing groups of students in a subject. For the purposes of this study, the achievement gap only relates to ability level in the upper 25% and lower 25% of the STAR Math Test scores.

- **Assessment**—the comprehensive daily tasks used to evaluate or appraise status, value, or importance. It gathers data over a period of time and evaluates the data to determine the outcome.
• At-Risk Student—a student who is struggling with the general curriculum and may fail or is failing the class. These students are typically one half to one full grade level behind.

• Efficacy—the ability or capacity to produce an effect. Self-efficacy is a personal measure of one’s own ability to complete a specific task or reach a set goal.

• Intervention Intensity—the amount of time devoted to interventions, usually measured in minutes.

• Response to Intervention (RtI)—interventions, as required by NCLB (2001), to provide struggling learners with extra, tiered support to improve academic achievement.

• Testing—a critical examination of a student’s skills, abilities, or knowledge in a specific content area.

• Traditional (Existing) Curriculum—curriculum that involves instruction based on a commercially prepared textbook.
CHAPTER TWO: LITERATURE REVIEW

The purpose of this study was to examine the effectiveness of mathematics interventions in the Response to Intervention (RtI) process in order to improve instructional strategies for all students. Current legislation requires schools to offer interventions to struggling learners. Researchers have spent considerable time evaluating reading instruction and improving curriculum and teacher practices in the process. In contrast, research on math interventions is much less available. Mathematics research, when available, has concentrated more on the specific program of intervention (quality) rather than the amount of time spent on the intervention (quantity). This chapter reviews the available literature on students’ mathematical learning and interventions.

Theoretical Framework

Researchers are concerned about improving mathematical thinking. Traditional instructional models typically have the teacher presenting information with the goal of student mastery. Behavioral theory provided the framework for the mastery-oriented curriculum of the 1950s to 1980s (Woodward, 2004). This behaviorist perspective of teaching and learning sees knowledge as a quantity, and the teacher serves as the medium to deliver that quantity to students (Handrigan & Koening, 2007). It theorizes that learning is based on factual rules and specific behaviors (Anderson, Reder, & Simon, 2000).

Cognitive psychology developed in answer to behaviorism’s scripted concepts (Anderson et al., 2000). Researchers then began to focus on cognitive theories of development, including the information processing theory. This theory stressed the importance of knowledge organization and the role of conceptual understanding in the
learning process. Further, students were taught metacognitive and visual imagery strategies (Woodward, 2004). Information processing theory presented the goal of teaching as identifying the way a student will learn a skill best. Teachers during this time would present students with multiple ways to solve problems. Students were instructed to practice the different models and then choose the best one for their needs.

The “one size fits all” approach to education did not take students’ individual cultures into account and failed to truly answer the question of how students learn. Most current research in the mathematics learning process, thus, centers on constructivism (Matthews, 2000). The constructivist theory presents the idea that children build knowledge, incorporating this new knowledge into already existing schemas of understanding (Handrigan & Koenig, 2007; Ishii, 2003). Woodward (2004) identified culture and development as a key foundation to the formation of these schemas.

Two subtypes of constructivism have been examined in literature. (1) Radical constructivism theorizes that student learning comes only from within the student and cannot be influenced by outside forces (Stiff, 2001). (2) Social constructivism, or situated learning, theorizes that students can work cooperatively with each other to gain new knowledge (Anderson et al., 2000; Stiff, 2003).

Constructivism focuses on how students learn and how teachers can best facilitate the learning (Stiff, 2001). Stressing the importance of visual imagery as an aid to mathematical learning, it theorizes that math comprehension results as students form cognitive models after actively engaging in a mathematics-rich environment, rather than simply memorizing information. The teacher’s role in the classroom is to establish
developmentally appropriate activities and experiences that support each student’s own past familiarity with the mathematical models.

Isaacs, Carroll, and Bell (2001) stated that students who learn math using a constructivist approach to instruction will gain a more purposeful understanding of the activity. In education, this means the teacher should establish situations to enable the student to foster the constructs. Based on research by Piaget and Vygotsky, constructivism engages the student on his or her sociocultural and developmental levels as the student learns to support mathematical learning with the application of models needed to make sense of the knowledge (Ishii, 2003; Woodward, 2004). Sociocultural perspectives of educational theory, such as constructivism, continue to be the prevailing framework for understanding mathematical teaching and learning (Woodward, 2004).

**Review of the Literature**

**Historical Perspectives.**

Mathematics education reform has evolved over the past 70 years. Beginning in the 1950s and 1960s, considerable federal funding for mathematics research came in response to the technological advances of the 1940s and 1950s. The United States attempted to produce more scholars, teacher educators, secondary mathematics teachers, engineers, and highly technical professions who would help America stay competitive in the global society. At the same time, universities noticed a troubling decline in students enrolling in math classes, and a surprising number of students with little mathematical knowledge (Klein, 2003; Woodward, 2004). This general concern about student performance in mathematics led the way for educational reform of that age.
Mathematics education shifted from manipulating symbols to an understanding of mathematical concepts (Woodward, 2004). Teachers presented the information to students, stressing the importance of rote practice and memorization in younger grades. Some schools of thought, though, questioned the need for more difficult math classes in upper grades (Klein, 2003). The idea of memorizing facts evolved into discovery learning in the 1960s, in which students were encouraged to develop their own answers to problems, rather than follow scripted rules. Called “New Math,” this method of math instruction focused on combining skills instruction with understanding (Klein, 2003). More rigorous courses were developed, and students were encouraged to study higher levels of mathematics.

Some mathematicians and educators, in contrast, favored guided learning approaches to mathematics (as cited in Woodward, 2004). In this approach, teachers present the information, complete sample problems with students, then monitor students’ independent work. During this era, the notion of learning disabilities first appeared in literature.

Students who were identified with arithmetic disorders were offered remediation. Researchers increased the use of manipulatives, symbolic and pictorial representations, or verbal modes of instruction to help remediate problems and improve student performance (Burns, 1996). This approach was effective with slow learners but not with students who had true learning disabilities. In response to this, mathematics reform looked to the relationship between classroom teaching and student achievement (process-product research) (as cited in Woodward, 2004). Research in this era worked to describe the critical teaching behaviors that directly relate to student performance on standardized
tests. This active teaching model showed mathematics teachers with specific behaviors: good management skills, teaching to the whole class (middle students), keeping a brisk pace throughout the class (Woodward, 2004). Questions asked by teachers concentrated on lower level thinking skills. The belief during this era was that direct instruction is the most effective method of teaching lower achieving students (Woodard, 2004).

Education reform shifted away from scripted teaching and moved to critical thinking in mathematical understanding (metacognition) (Klein, 2003; Woodward, 2004). Students were taught explicit problem-solving strategies to be used with a conceptual understanding of the mathematical models. In regard to students with learning disabilities, educators stressed the importance of strategy instruction, direct instruction, or curriculum-based measurement as remediation strategies. Some of the first basic interventions in this process included keyword strategies for word problems, technology-based learning, and algorithmic proficiency, though. Many educators found these strategies were essentially ineffectual (Woodward).

Education reform changed to teaching pedagogy, and the National Council for Teachers of Mathematics (NCTM), as well as the U.S. government, identified the need for more rigorous standards in education. The NCTM developed a set of 13 mathematics standards to address content and emphasis (Burris, 2004). Reform-based curricula and conceptual analysis of mathematical problems were developed and adopted. However, there was a lack of research during this time on how the proposed changes affected students with learning disabilities (Woodward, 2004). Students needing special services were remediated with systematic skills instruction.
Baker et al. (2002) and Gersten and Baker (1998) attempted to improve special education by combining skills-based teaching and learning with open-ended problem-solving instruction. However, research showed that extended drill on algorithms does not lead to any long-term understanding of the information (Goldman, Hasselbring, & the Cognition and Technology Group at Vanderbilt, 1997). In fact, Woodward and Howard (1994) also found that direct instruction methods were ineffectual for many special-needs students. Research did show that instruction grounded in context (contextual learning) was effective for special-needs students. However, this conceptual understanding of mathematical processes was not addressed in special education literature until much later (Baroody & Hume, 1991).

**Current Issues.**

Contemporary issues in education stemmed from this lack of research for special-needs students in mathematics. At that time, the existing model used in schools to identify students with learning disabilities was known as the discrepancy model. This model, also known as the “wait to fail” approach, used a student’s IQ score and a student’s achievement score, then analyzed them for severe discrepancy. This method usually relied on a minimum of 1.5 grade-level difference between the expected (IQ) and actual (achievement) student performance (Hoover, Baca, Wexler-Love, & Saenz, 2008). Problems arose as students were being over identified as having learning disabilities. In fact, the diagnosis of learning disabilities had grown over 300% since 1976 (Woodward, 2004). This discrepancy model of identification has been found in research to be harmful to students (Gamm, 2005). Some of the difficulties include the fact that students are not acknowledged until after they fail, usually in higher grades (Gamm, 2005). Since
students do not get the help they need early in their educational career, their learning difficulties become increasingly challenging to remediate (Coulter, 2002).

Leaders in education struggled to find the balance between sustained educational reform and accountability. In fact, since 1999, multiple national advisory panels have been appointed to address this need and develop suggestions to improve mathematics education (The RAND Mathematics Study Panel, The National Mathematics Advisory Panel, The National Research Council, The National Commission on Mathematics and Science, and Teaching for the 21st Century). Though each served a different purpose, they all determined that mathematics teaching and learning are a complex process that continues to require additional research (Steedly, Dragoo, Arateh, & Luke, 2008).

The U.S. government attempted to increase student achievement, as suggested by the panels, by passing No Child Left Behind (NCLB) in 2001 and the reauthorization of the Individuals with Disabilities in Education Act (2004). These laws required schools to be more accountable for all students, not just the middle and high-achieving students. In response to this, education reform has now shifted to differentiation. Differentiation is the theory that teachers work to accommodate and build upon each student’s diverse learning needs, thus decreasing the need for special education services (Tomlinson, 1999). Education becomes less teacher driven and more student centered. Education now must focus on more individualized education methods.

The No Child Left Behind Act (2001) set the standard that all children would be working at grade level by the year 2014. The law mandated that schools identify students who are or may become at risk for academic failure. In 2004, the Individuals with Disabilities Education Act was reauthorized and updated to improve the quality of
education for all students. The law endeavored to reduce the number of students in special education, while ensuring that all students who needed special services were provided with them in the least restrictive environment possible.

The IDEA model of identification included not only allowing for a discrepancy model, but also encouraged schools to use a Response to Intervention (RtI) model to identify at-risk students. The law provided that interventions had to be scientifically based, research-driven methods at increasing levels as the student requires. Gresham, VanderHeyden, and Witt (2005) highlighted several advantages that RtI has over previous models of identification, including (a) use of a risk model, (b) earlier identification of academic difficulties, (c) reduction of bias, and (d) focus on student products.

As states and schools move forward with education reforms, some provisions of the NCLB hinder student progress with unintended consequences. The lofty goal of all students achieving at or above grade level by 2014 was deemed by some to be impossible (Forte, 2010). States were compelled to lower their standards, punished school failure rather than rewarded successful programs, focused on student test scores, and prescribed a pass or fail set of interventions for schools that had problems meeting their goals (Forte, 2010).

In response to this in 2011, the current administration allowed some states flexibility on the NCLB law in order for them to pursue comprehensive plans to improve educational outcomes for all students, reduce achievement gaps between groups of students, and improve the overall quality of teaching (U.S. Department of Education, 2011). To qualify for this flexibility, states must have a clear plan to apply rigorous
college and career-ready standards and create comprehensive structures of professional
development, evaluation, and multifaceted support for all schools (U.S. Department of
Education, 2011). States must also identify and reward successful schools and support
and improve the low-performing schools. This model gives states and districts more
flexibility to design improvement strategies that best meet their individual needs (U.S.

In the Race to the Top Initiative, the U.S. government offered states strong
initiatives to improve teaching and learning to help failing schools and classes. Four
specific areas of reform include rigorous standards and better assessments, data systems
to monitor student progress, more effective teacher support, and challenging interventions

Keeping the recent legislative changes, need for student achievement to improve,
and the updated NCTM standards, many states are turning to a common set of standards,
called Common Core State Standards. These standards aim to create college and career-
ready students while ensuring a continuity of education across the United States. The
new standards provide for increased accountability with higher standards and are
internationally benchmarked by the academic content, difficulty, and organization of the
standards compared to higher-performing nations (Common Core State Standards
Initiative, 2010). CCSS stresses the importance of technology and 21st century skills.
The standards have also sought to address special-needs students, including minorities,
special education students, and limited English proficiency learners. The standards give
individual states the freedom to choose and develop their own curriculum and assessment
based on these standards.
Response to Intervention.

Response to Intervention (RtI) is a term that relates back to NCLB of 2001 and IDEA of 2004. RtI is a method of academic intervention used to assist students who may be struggling, at risk for failure, or at risk for special education referral (Fuchs, Mock, Morgan, & Young, 2003). RtI is a multi-tiered, data-driven process used to differentiate between a student who is just struggling and needs extra assistance to succeed and one who has a learning disability (Cummings, Atkins, Allison & Cole, 2008). The ultimate goal of RtI is to prevent academic failure through multileveled early interventions (Fuchs, et al., 2003; Harlacher, Walker, & Sanford, 2010).

Tier I of RtI encompasses all students in every academic class (Werts, Lambert & Carpenter, 2009). This tier involves whole-group instructions and provides interventions available to all students equally. To ensure this level of intervention is applied correctly, teachers must provide explicit and systematic instruction in all academic areas (Gersten, Chard, Jayanthi, Baker, & Morphy, 2009).

Tier II interventions are more intense than Tier I, involve only those students considered at risk or some risk for failure, and should be no more than 20% of the student population (Burns, Appleton, & Stehouwer, 2005). These interventions involve supplemental exercises and instruction, often delivered outside the larger group settings. Some Tier II models include extra practice and small-group or some individual instruction. Gersten et al., (2009) found that this small-group intervention should first identify the specific needs of the students, be implemented three to five times weekly, and build skills gradually.

Tier III is the most intense intervention level and is reserved for those students
suspected of developing a true learning disability, usually less than 5%-10% (Gersten et al., 2009). Many students who reach this level are referred for special education testing. This level of intervention increases the intensity of services (Burns et al., 2005). This may be delivered individually or in small groups but must be specific to student needs and must use enough resources to address those needs (Burns et al., 2005).

To evaluate the effectiveness of any intervention, instructors categorize students as responders or nonresponders to the specific intervention (Fuchs et al., 2003). The instructor then makes a decision based on benchmark criteria whether to move the student up to a more intensive intervention or continue at the same level. Both legislation and current literature leave several unanswered questions regarding students’ responsiveness to interventions. For example, IDEA does not regulate a specific definition of RtI when used as a procedure to identify students with disabilities (Duhon et al., 2009). Further, there has been little agreement on the nature and focus of interventions, the duration and intensity, and the benchmark criterion to evaluate student progress (Coleman, Buysse, & Neitzel, 2006).

One component of RtI is progress monitoring. When receiving interventions, student progress is reviewed routinely to determine growth. Many school psychologists, teachers, and interventionists use curriculum-based measures (CBM), curriculum-based assessment (CBA), or curriculum-based evaluations (CBE) to monitor progress. Salvia, Ysseldyke, and Bolt (2007) stressed the importance of these forms of progress monitoring as part of the RtI process, allowing teachers or interventionists to make changes to the intervention as the student needs. As such, it is imperative that progress monitoring occur frequently and consistently (Salvia, Ysseldyke, & Bolt, 2007).
Qualitative studies in RtI show that teachers may feel uncomfortable with the process (Hewlett, Crabree, & Taylor, 2008). The teachers described themselves as being unprepared or lacking the foundational knowledge about student cognition and effective intervention approaches for learning. Teachers also reported that they want to help students, but perceive that the organizational requirements of intensive interventions are a massive burden, and they lack the underpinning knowledge about learning and cognition (Hewlett et al., 2008). Overall, current qualitative research indicates that schools need to develop whole-school and whole-class approaches to learning that embrace the unique needs of all learners. To accomplish this, teachers need additional support from administration to bring about the necessary adaptations in instruction (Hewlett et al., 2008).

Additional research concerning RtI is warranted. For example, legislation does not provide a working definition of RtI or a procedure for its implementation (Duhon et al., 2009). Fuchs et al. (2003) also expressed concerns about the legitimacy of RtI as a diagnostic tool for learning disabilities. The process must be operationalized, and the idea of responsiveness needs to be quantified in order for RtI to become an equitable means of identifying students (Barnett, Daly, Jones, & Lentz, 2004).

**Interventions.**

The achievement gap in education refers to the disproportion in educational performance among groups of students. Often the term *achievement gap* describes the difference among races or genders, measured by student grades, state and standardized test scores, course selection, high school dropout rates, and college graduation rates (NCLB, 2001). Since the passage of No Child Left Behind (2001), closing the
achievement gap has become a focus of federal education accountability, and schools are presently required to disaggregate student data to enable comparisons between groups. This attention highlighted the need for more targeted interventions for different groups of students; however, it has not closed the achievement gap.

Multiple delivery methods are available for teachers to use when working with lower performing students. Wilson and Rasanen (2008) investigated various types of interventions and their effect on student performance in mathematics. Organizational interventions include student retention, ability grouping, and reducing class size. However, Hattie (2005) suggested that these have little or no effect. Steedly, Dragoo, Arateh, and Luke (2008) outlined four specific interventions: explicit instruction, self-instruction, peer tutoring, and visual representations. These approaches have been shown to be moderately effective (Baker, et al., 2002; Xin & Jitendra, 1999).

Whole class interventions have been shown to have the longest lasting effects (Griffin, 2004). Small-group and individual interventions include tutoring or pull-out programs for specific needs. Dowker (2005) and Xin and Jitendra (1999) showed that these interventions are most effective in the short term for specific learning needs only. Peer tutoring is another option for interventions. Results of this type of intervention show inconsistent results. Initially, this approach has been shown to be ineffective (Kroesbergen & van Luit, 2003). Kunsch, Jitendra, and Sood (2007) contrasted previous findings to show moderate effects for younger students. A final method of intervention is targeted interventions, which involve identifying a student’s specific strengths and weaknesses. This method includes an individualized curriculum and delivery and has yet to be scientifically validated, but specific components have been effective (Dowker,
A closer look at interventions shows that they may vary in the intensity of, or time allotted for, the intervention. Shorter interventions typically focus on specific skills, whereas longer interventions are more general. Wilson and Rasanen (2008) indicated that interventions do not need to consume much time. Malofeeva (2005) showed that the length of the intervention made little difference in student performance, but Kroesbergen and van Luit (2003) showed that shorter, more intense interventions were more effective for specific skills. For long-term results, however, Xin and Jitendra (1999) discovered that longer interventions were more effective in the maintenance and generalization of skills.

Mathematics Interventions.

RtI has improved the educational process as it provides the framework in which data is the basis for making relative judgments about student needs and for distributing educational resources for benefit of the greatest number of students (vanDerHeyden, 2013). RtI is the science of decision making, focuses on improving student learning, and applies to most problem behaviors in mathematics. It is imperative that the RtI process begin early in a child’s educational career for maximum benefit. Researchers have identified that mathematics development during the primary grades increases achievement in more challenging math classes (Gersten, et al., 2005).

The U.S. Department of Education (2002) examined student performance and found that most students do not meet minimal mathematics proficiency standards by the end of high school. Students with learning disabilities perform lower and grow at a considerably slower pace when compared to non-disabled peers, in mathematics. Past
research in mathematics interventions shows that children who have not had adequate exposure to mathematics and mathematical concepts and numeracy at early ages are at high risk for mathematical failure (Griffin & Case, 1997). Math has been shown in research to be a process that builds on previous knowledge for successful learning. As a result, students who struggle with mathematical concepts early in their educational career have even more trouble as they grow (NCTM, 2000). Additionally, the NMAP shows that the existing curriculum and curricular tools do an inadequate job of covering the important principles for learning in mathematics (NMAP, 2008).

Extensive research has shown that early mathematics interventions not only repair students’ deficits, but also prevent future problems (Clements & Sarama, 2007; Fuchs, Fuchs, & Karns, 2001). RtI in mathematics follows the same steps as in other subjects. Areas where most children perform poorly in mathematics simply indicate the need for system-wide interventions (Tier I). More in-depth interventions need to be in place for the 20% who continue to struggle (Tier II). Finally, students who continue to struggle will need intensive Tier III interventions.

Several intervention options are available for teachers to choose from. Mathematics requires many factors to ensure understanding. Students must have a strong number sense, spatial and logical reasoning, verbal memory, and language skills (Wilson & Rasanan, 2008). Since the different domains in mathematics will require varying levels of each component, intervention effects must fluctuate according to the nature of the difficulty the student might be having (Wilson & Rasanan, 2008). The key domains of mathematics learning and interventions are as follows:

1. Number sense—students’ ability to quickly comprehend, assess, and
manipulate numerical quantities (Gersten & Chard, 1999). Number
sense is the focus of most early childhood interventions (Malofeeva,
2005).

2. Computation–includes basic number facts and multilevel arithmetic
and is the most common intervention for elementary and middle
school students (Kroesbergen & van Luit, 2003).

3. Fractions, decimals, and place value–concentrating on middle to high
school interventions, very few studies have been conducted in this area
(Maccini, Mulcahy, & Wilson, 2007).

4. Problem solving–because of the large language component of problem
solving/word problems, this has been the most extensively studied in
research. These interventions have been the least effective in research
of all domains (Kroesbergen & van Luit, 2003).

Mervis (2006) noted that instructional methods may be used as interventions in
mathematics. Constructivist-based interventions are sometimes referred to as “discovery
learning,” and are most commonly seen in number-sense lessons in early childhood
settings (Malofeeva, 2005). Behavioral interventions in mathematics involve the teacher
modeling a target skill, then the student repeating it with drill and practice. This method
is most effective with elementary students in number sense and computation lessons
(Kroesbergen & van Luit, 2003), but almost ineffectual in early childhood (Malofeeva,
2005). Cognitive interventions use metacognitive strategies and may teach mnemonics,
or strategies for following computation/problem-solving procedures. This intervention
style has been most extensively studied in middle to high school situations for word
problems (Maccini et al., 2007, Xin & Jitendra, 1999). This method of intervention was also found to be effective for elementary-age students (Kroesbergen & van Luit, 2003; Mastropieri, Scruggs, & Shiah, 1991). Other instructional methods may include representational, which highlights the development of internal representations of the concepts (Mastropieri et al., 1991, Xin & Jitendra, 1999), or situated cognition, which relates mathematical learning to daily life (Kroesbergen & van Luit, 2003).

Regardless of the program or method of instruction for interventions, research shows that it is imperative to ensure deliberate planning and monitoring of intervention implementation to increase student achievement. RtI efforts should be integrated with current reform efforts, and implementation fidelity must be measured at all tiers of instruction. This can be accomplished through frequent progress monitoring of student skills (Koellner, Colsman, & Risley, 2011).

**Teacher Quality.**

Researchers examine teacher ability to determine what impact it has on student math achievement, though the results are inconsistent. Studies attribute these differences to questions on how to measure teacher credentials or on how to measure student achievement (Xin, Xu, & Tatsuoka, 2004). The National Commission on Teaching for America’s Future (1996) developed a report that influences current teaching practices. What teachers know and can do (ability) has greater impact on student achievement compared to other factors such as certification. Secondly, they stressed the importance of recruiting, preparing, and retaining high-quality teachers, and the idea that school reform cannot succeed without effective teachers (National Commission on Teaching for America’s Future, 1996). NCLB (2001) supports this, requiring teachers to be highly
qualified in their subject matter. This may be difficult in elementary ages because each teacher is responsible for multiple subjects. School administrators seek to hire quality teachers but often struggle in identifying effective teachers during the interview process (Gray, 2012).

Noting positive effects, Bali and Alvarez (2003) found that teacher credentials, as required by NCLB, had a statistically significant effect on student performance. Citing a 10% increase, all genders and races exhibited benefits (Bali & Alvarez, 2003). These gains accumulated over students’ educational careers, increasing student achievement. These studies further showed that the most influential factor in student achievement is teacher quality (Nye, Konstantopoulos, & Hedges, 2004; Rivkin, Hanushek, & Kain, 2005).

Research establishes that teachers’ prior mathematical knowledge correlates with student achievement in math in elementary years (Hill, Rowan, & Ball, 2005). Darling-Hammond (1999) also showed that when teachers have taken additional college courses, especially enough to have a minor or dual major in the subject, student achievement increases.

Further, Alexander, Cleste, & Fuller (2004) examined math teachers and compared student scores on state achievement tests. They found a significant relationship between teachers’ certification levels and math achievement. Another study showed that elementary students also greatly improved in math achievement with fully certified teachers in the subject matter (Laczko-Kerr & Berliner, 2002). Likewise, Darling-Hammond (1999) found a positive correlation between student achievement and the teacher’s level of certification. This same study also found a significant negative
relationship between achievement and the presence of a high proportion of uncertified teachers in the school (Darling-Hammond).

No Child Left Behind (2001) defines “highly qualified” as a teacher who has obtained certification and/or passed the state teacher licensure examination. Teacher certification is important, but these qualifications do not necessarily ensure quality teaching. Highly effective teachers exhibit multiple qualities. Formal education for teachers is just the beginning for quality teaching. Successful teachers are committed to student learning, are responsible for managing student learning, know the subjects they teach, think systematically about teaching practice, and are active members of a learning community (ADE, 2012).

Teacher quality also has a large impact on the achievement gap between the highest and lowest performing students. Multiple studies have examined teacher quality and determined that schools and districts do not distribute it equally. The highest performing students are more likely to get higher quality teachers. The reverse is true as well; disadvantaged districts and lower performing students are more apt to get less qualified teachers (Darling-Hammond, 1999).

Quality teachers can learn from teaching experience. Schoen, Cebulla, Finn, and Fi (2003) noted several variables that effective teachers used, which had a positive influence on student achievement. First was the successful completion of a professional development workshop focused on teaching the course effectively. A collaborative attitude with peer teachers and self-confidence in skills to manage the course content were also important. Effective teachers used more group and pair work, with less teacher presentation/lecture and whole-class discussions during lessons. A variety of assessment
techniques was also combined with high expectations on homework and grading. Finally, thorough knowledge and implementation of the content standards were imperative for effective teaching (Schoen, et al.).

**Computerized Assisted Instruction.**

With the increased accountability and the need for more individualized instruction, many schools are turning to computer-based learning to enrich instruction. Computer-assisted instruction (CAI) is defined as remediation or instruction that is presented on computers as part of the instructional process. Schools can choose from whole class technology, such as interactive whiteboards, interactive video-based computers, individual computer systems, or mobile learning devices. Although CAI has the potential to influence teaching and learning, its presence does not guarantee success without sound teaching and learning processes (Li & Ma, 2010).

There are many forms of mathematics CAI, the most common being basic arcade-style games in which the student solves math problems to achieve a prize or reward, often used as extra practice. CAI also may be used as the basis for, or to supplement, instruction (Barrow, Markman, & Rouse, 2007). Some interactive programs tailor questions based on a student’s previous answer. Other technology, such as virtual manipulatives, is used to replace hands-on manipulatives while completing paper-based class work.

In the area of mathematics, computer-assisted instruction has mixed results, depending on the learning environment (Li & Ma, 2010). When used in conjunction with best practices in education, technology use enhances mathematics education. Li and Ma, (2010) found that the use of multimedia presentations and calculating aids had a strong
correlation with mathematics achievement but little effect in other subjects. Using an experimental design, Handrigan and Koenig (2007) found that CAI mathematics instruction improved math achievement scores for fourth-grade students. Barrow, Markman, and Rouse (2007) supported this, showing that students learning through CAI are 26% of a school year ahead of their peers. In 2009, Hande and Bintas showed success with using computer-aided instruction for sixth-grade students when learning specific topics (lowest common multiple/greatest common factors). Trying to determine a cause-effect relationship, Ash (2009) found that even one hour per week of increased computer access improved students’ mathematics achievement scores.

More recent trends in CAI have included mobile learning devices (MLD). These devices may include students’ personal smart phones, media devices, tablet computers, and more. Many students already employ MLD to take photos, capture videos, communicate with peers, or create artifacts and personal forms of expression (i.e., documents, photo slideshows), all of which correspond to the core aspects of STEM (Science, Technology, Engineering, and Mathematical) fields (White & Martin, 2012). White and Martin (2012) noted several advantages to using MLD in the learning environment. Since Students are already familiar with the MLD, they are more motivated to complete learning activities on an MLD. Franklin and Peng (2008) noticed increased student achievement when an MLD was used to complete projects on algebraic equations, concept of slope, absolute value, and elimination on iPods. Students working on tablet computers outperformed students working on the same problems on paper worksheets (Hayden et al., 2012).

Technology-based instruction is not without challenges. Oldknow (2009)
discussed the idea that technology is almost completely globally accessible. Schools seek to encourage students to specialize in science, technology, engineering, and mathematics (STEM) (Oldnow, 2009). Thus, teachers and students have increasingly more technological tools they can use to support instruction. The dilemma is in a lack of training or understanding of the tools. Much of the technology is going unused because of this quandary (Oldnow, 2009).

Math Instruction.

Best practices in mathematics have been examined in literature. The Education Alliance (2006) called for set standards-based math lessons that included several conditions. First, students must be highly engaged in the teaching and learning process. Also, learning tasks are built on previous knowledge. Instruction must scaffolded to ensure connections to procedures, understanding, and concepts. Teachers model high-level performance. Students are expected to explain their thinking and self-monitor progress. In addition, an appropriate amount of time is allotted for tasks.

Mathematics basic skills fluency is the ability of a student to recall basic math facts quickly and consistently. Math facts are the foundational knowledge of any math lesson, such as number identification and sense, basic operations (e.g., addition/subtraction, multiplication/division), shapes, etc. (Codding, Hilt-Panahon, Panahon, & Benson, 2009).

Research supports the idea that knowledge of basic facts to the point of automaticity needs to come at a young age if higher thinking skills are to develop (Jitendra & Xin, 1997; Schopman & Van Louit, 1996). If automaticity is not fully developed in a student, he or she will continue to fall further behind as math instruction
becomes increasingly more difficult (Gersten et al., 2005a). Math fact retrieval has also been shown to be an indicator of performance on math achievement tests (Jordan, Glutting, Ramineni, & Watkins, 2010; Royer, Tronsky, Chan, Jackson, & Marchant, 1999).

Researchers have examined several methods to improve mathematics computation. Caron (2007) studied self-checking worksheets and noted improved student motivation. Explicit time drills were found to be effective in improving automaticity with basic facts (Rhymer et al., 2002; Skinner, Pappas, & Davis, 2005; Woodward, 2006).

The National Council for Teachers of Mathematics (NCTM) stressed problem solving as a primary process in learning, one that was integral to mathematics instruction and that should not be taught in isolation (National Council for Teachers of Mathematics, 2000). The NCTM Standards (NCTM, 2000) and the National Research Council report entitled Adding It Up highlight the change from procedural knowledge to conceptual understanding of mathematics (as cited in Giles, 2009).

Wilson, Fernandez, and Hadaway (2010) confirmed that the primary aim of teaching math is to show students how to solve a wide variety of complex math problems. Mathematics problem solving involves direct, explicit instruction in strategies to solve word problems. Most studies of mathematical learning attribute the foundations of problem solving within the original problem solving stages from the 1960s: understand the problem, make a plan, carry out the plan, and look back (Williams, 2003). Previous studies have looked at the different strategies as well as the problem types and strategy use. Jitendra and Xin (1997), for example, found a strong connection between reading
skills and mathematical word-problem solving.

Research in specific mathematics problem-solving approaches has also been covered in literature. Van Garderen (2006) found significant success when students were asked to draw a picture of the problem. Math journaling is another effective method of instruction, allowing students to communicate about math issues and work individually (Baxter, Woodward, & Olson, 2005). In an examination of third graders, Griffin and Jitendra (2009) found success with general teaching strategies but did not support one specific strategy for student success. Other researchers have studied cases in which students are encouraged to explore possible solutions (Fancella, 2011). Isaacs et al (2001) supported this exploratory approach to problem solving. Other, more recent research indicates that problem-solving strategies need to be taught early in students’ educational careers for students to have success later (Slavin & Lake, 2007).

General mathematics instructional approaches vary in literature. Some have called for teachers to concentrate on test-preparation strategies (Hong, Sas, & Sas, 2006). Others have proposed interactive lessons, including math talks (Cooke & Adams, 1998), peer-guided pauses during lessons (Hawkins & Brady, 1994), and response cards (Lambert, Cartledge, Heward, & Lo, 2006). Carnine (1997) further found that teachers can best improve student performance by allowing extended guided practice with shorter assignments and by providing teacher supervision.

Research in the area of mathematics interventions and best practices has been inconsistent. Baker et al. (2002) called for mathematics instructors to provide a blend of teaching and learning to meet the needs of all students. Despite this, many call instruction a pendulum swing; going from one extreme approach to another. In today’s
world of higher accountability (e.g., IDEA, 2004; NCLB, 2001), teachers need to have a strong arsenal of interventions to draw from as they implement the RtI process.

**Math Assessment.**

Assessment of mathematics skills is an essential component of math instruction. Assessment consists of more than just gathering student test scores. Though assessments may often involve tests, they also include a variety of other data collection methods. Davies (2004) claimed the key principle of assessment is the partnership that exists between teaching and learning. Assessment becomes the triangulation of evidence over time from multiple sources to determine preset criteria, such as student artifacts, observations, and student interviews. Assessment can be a complicated process because of student differences in learning needs, diverse backgrounds, and multiple intelligences that students bring (Davies).

Tests are defined as a process or are used to measure specific skills, usually measuring mastery of the subject (Diamond, 2005). Assessments, in contrast, are more comprehensive and might require collecting test scores over a period of time, measuring a student’s understanding (Diamond, 2005). Two kinds of tests are available for use: classroom-based tests created by the teacher and externally imposed tests, such as those designed by specialized test developers or those required by state or district authorities (Popham, 2003). Though the current focus of researchers has been on standardized tests, many researchers have disregarded the importance of assessments. However, the current Common Core Standards stress the value of performance assessments. Popham (2007) suggested these performance assessments are best used as interim assessments to be administered periodically to predict student performance on upcoming tests.
ASCD (Association for Supervision and Curriculum Development) advocates the use of multiple assessment measures, rather than reliance on a single test to monitor student achievement adequately (Carter, 2004). These researchers stress that assessment systems must be impartial, unbiased, and based on scientific research on learning. The assessments must also reflect curricular goals after the student has had many opportunities to learn the skills (Diamond, 2005). Assessments are designed to inform and expand instruction, as well as being planned to accommodate the unique requirements of special-needs students. Finally, good assessments have validity, reliability, and the support of professional ethical principles.

Black and William (1998) stated that the current spotlight on standards and accountability fails to take into account the process of teaching and learning in classrooms. Teachers make assessment decisions within these processes, based on either the organization of the tests or student performance on the tests (Popham, 2003). Decisions that teachers need to make include nature and function of curriculum, determination of prior student knowledge, length of time for each lesson, and the efficacy of instruction. Occasionally, the content standards are not adequately worded for use at the classroom level and may lead to varying interpretations of the standard. The focus, then, needs to be on particular curricular objective (Black & William, 1998).

**Diagnostic Assessment.**

The purpose of the diagnostic assessment, typically given at the beginning of a school year, is to ascertain a student’s prior knowledge, skill level, strengths, and weaknesses. Teachers use diagnostic assessments to amend curriculum or provide remediation, especially as part of the Response to Intervention process. Diagnostic
assessments can also help identify learning-style preferences and interests. They also help with planning for differentiated instruction (Tomlinson, 2008). When used as a pretest, teachers can isolate what students already know and what needs to be taught (Popham, 2003). This process contributes to how teachers determine their own instructional impact.

Diagnostic assessments can be employed as a progress-monitoring tool during Response to Intervention processes. The purpose of assessments is not just to determine individual student ability, but also to help teacher and student do something with the results. As a result, progress monitoring is an imperative step in student learning. Many researchers describe progress monitoring as a scientifically based practice (Bolt, Ysseldyke, & Patterson, 2010; Fuchs et al., 2008). Implementation of progress monitoring involves assessing a student’s current levels of performance and setting goals for student learning to take place over a set time. Students are evaluated with the diagnostic assessment on a regular basis, and teaching is adjusted as needed to meet the student’s individual learning requirements (Bolt et al., 2010). Renaissance Learning’s STAR Math Test is one such diagnostic assessment.

**Formative Assessment.**

Formative assessment is assessment for learning. These assessments provide immediate corroboration of student learning and are used to help advance the quality of instruction and monitor progress in achieving learning outcomes. Formative assessment is comprised of both formal methods--paper/pencil exams--and informal methods--quizzes, oral questions, observations, student-constructed concept maps, peer-response
groups and portfolio reviews, and student conferences (Tomlinson, 2008). Homework also can be in this category.

The key idea behind formative assessments is to monitor learning and adjust instruction to ensure success on the summative assessments (Chappuis & Chappuis, 2008). Students can help determine learning objectives and self-assess how they are progressing toward those goals. The descriptive feedback provided by formative assessments identifies strengths and weaknesses and suggests corrective actions to take.

**Summative Assessment**

Summative assessments are assessments of learning. Summative assessments include comprehensive tests given at the end of a unit or school year. The purpose of summative assessments is to provide accountability. Traditionally, these may include multiple-choice, true/false, and matching questions. Other response choices may include open-response questions, essays, portfolios, oral presentations, and skill demonstrations. New Common Core State Standards stress performance assessments and extended response questions as well.

The purpose of classroom tests and assessments may vary (Popham, 2003), but teachers must first identify the kinds of instructional decisions that will be made based on the test results. Teachers must ascertain that there are no curricular variances and that all tests equally represent the important measured content standards (Popham, 2011). Scheid (2010) stressed four elements to consider on tests: directions, format, readability, and legibility as part of this decision-making process.

According to Popham (2007), tests and assessments, for the most part, should be supplied to teachers, rather than having them create their own to ensure testing fidelity.
However, many suppliers are not providing the types of assessments that educators truly need. For most educators, formative diagnostic and interim assessments are necessary to predict student success on state assessments. Teachers need the skills to evaluate a test to determine its validity and reliability. Popham (2007) recommended that teachers keep the following questions in mind as they evaluate curricular assessments and tests:

1. Does the test cover a manageable number of important curricular goals?
2. Do the accompanying materials communicate the testing targets?
3. Are there enough items on the test to adequately measure each curricular goal on the test to ensure student mastery?
4. Are the test questions truly assessing the material rather than a student’s background knowledge?

**Professional Development.**

Current legislation, such as No Child Left Behind, emphasizes college and career-ready standards and high-stakes accountability for schools and teachers. In response to this, teachers face increasing pressure to educate students effectively. This reality leads school administration to focus on continuing professional development (PD) for teachers. Forty states have some sort of requirement for teacher PD programs (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009). No Child Left Behind supports this, requiring that districts provide high-quality, effective professional development (Borko, 2004).

Traditional PD historically involves a workshop or institute setting outside the teacher’s classroom. The presenters in this form of PD typically have specialized knowledge in the field, but the presentation is geared toward a general classroom idea.
rather than within a specific school context (Garet, Porter, Desimone, Birman, & Yoon, 2001). There has been interest in reforming this type of PD, moving it to within the school, on a long-term basis, with coaches and small groups of teachers applying skills to their own specific context. These activities aim to be highly collaborative and engage teachers in active learning by reflecting on their own teaching practices, student work, and student activities (Garet et al., 2001). These self-reflective activities are a necessary element of a quality PD program (Schmocker, 2012).

Researchers who examine PD have shown that quality PD programs share certain important characteristics. These characteristics include duration—of time spent in the PD program, frequency of the PD, and follow-up of the PD. Effective PD seeks to expand teachers’ understanding of pedagogy, content, and diverse learning styles of students. Quality PD programs also engage teachers in some form of collaborative learning opportunities with other teachers. In fact, research shows that the most effective PD programs involve hands-on activities that build a logical framework by aligning the PD framework to curriculum and standards.

Many studies have shown that the amount of PD a teacher receives effects how much the teacher learns (Garet et al., 2001; Guskey, 2003; Guskey & Yoon, 2009; Yoon, 2007). Additional researchers have shown that teachers who spend more time attending professional development report feeling more equipped to apply more classroom activities and more adept in teaching the particular content areas (Parsad Lewis, Farris & Greene, 2001). Yoon (2007) also found that increased time in PD does increase student achievement.
Time spent during and after the PD program is very important to the teaching and learning process. Duration of PD alone, however, cannot make teachers more effective. Implementers must carefully design and implement the teacher’s PD time (Garet et al., 2001). Researchers have suggested that for PD to be more helpful in supporting the implementation of innovative teaching strategies, the program should include time for instructional planning, discussion, and reflection of the underlying principles of the curriculum (Penuel, Riel, Krause, & Frank, 2009). Other researchers have found that duration did not yield statistically significant results, further suggesting that quality of PD might be more important than simply the time spent in PD activities (Desimone, Porter, Garet, Yoon, & Birman, 2002).

Teachers’ active participation in professional learning increases both teachers’ learning and students’ conceptual understandings. A longitudinal study of PD characterized by active learning, where teachers are passive recipients of information, increases the impact of PD lessons (Desimone et al., 2002). A study by Saxe, Gearhart, and Nasir (2001) examined the effect of “reformed” types of PD on students’ outcomes. The study grouped elementary math teachers into three categories of professional development: traditional, support, and reform groups. The traditional teachers received no additional professional development. The teachers in the reform group participated in an intensive summer institute followed up by small-group meetings throughout the school year. The groups examined student work and discussed problems, successes, and continued challenges. The study found that students of PD participants scored higher on both conceptual and skills-based questions related to the units (Saxe et al., 2001). These
results highlight the importance of active learning and reflective practice within collaborative environments as part of the PD process.

The active engagement and learning of teachers through ongoing, collaborative work also improves the quality of professional development. Collaborative teacher groups support implementation of new strategies and curricula even after accounting for the teachers’ amplified knowledge of content and pedagogy (Garet et al., 2001; Penuel et al., 2009). PD that occurs within professional learning communities, consisting of teachers grouped by schools, departments, and grades, provides ongoing support for teachers’ implementation (Stoll & Louis, 2007). These professional learning communities based on the establishment of a school-wide culture focused analyzing current teaching and learning practices to improve student achievement (Seashore, Anderson, & Riedel, 2003). In more recent quasi-experimental research of Title I schools that cultivated these professional learning communities, student achievement on standardized achievement tests significantly improved over the control school that did not use professional learning communities (Gallimore, Ermeling, Saunders, & Goldenberg, 2009).

What educators learn during professional development sessions does matter. Some research has found that PD needs to address the daily challenges involved in learning specific subjects rather than generalized ideas and theories (Darling-Hammond et al., 2009). These results reflect what other studies have found and what many teachers themselves report as most beneficial (Darling-Hammond et al., 2009; Garet et al., 2001). PD activities that focus on specific approaches increase the likelihood that the participants will use those strategies. The probability further increases when coupled with
effective learning opportunities set within a collaborative peer network and linked with teachers’ prior knowledge and experiences (Desimone et al., 2002). Numerous other studies have examined the positive effect of content-area focus on student outcomes in those specific areas. Despite this understanding, though, a recent study conducted on behalf of the Council of Chief State School Officers found that many of the examined math and science professional development programs lacked a focus on activities that address teachers’ content knowledge and skills (Blank, de Las Alas, & Smith, 2007).

PD activities are more effective when part of a consistent set of learning opportunities. One study found that activities that were connected to teachers’ other experiences and that encouraged professional communication among colleagues supported change in teaching practices (Garet et al., 2001). Additionally, PD programs that align with district goals as well as teachers’ own personal goals and awareness of student needs will lead to elevated levels of teacher commitment to apply the PD activity in daily teaching practice (Desimone et al., 2002; Penuel et al., 2009).

Recently the National Staff Research Council conducted research examining this question. They found that 92% of teachers reported participating in some sort of PD, with 88% of teachers engaging in PD related to the content area that they teach (Wei, Darling-Hammond, & Adamson, 2010). Unfortunately, only two thirds of teachers rated their PD effective, regardless of the length or format of the PD. Given the importance of time, only 23.8% of teacher reported that they engaged in four or more days of PD (Wei et al., 2010). Supporting previous research, Wei et al. (2010) found a positive relationship between the time spent in PD and the activity’s usefulness. Their report noted that teachers in different contexts received different types of professional development.
Elementary schoolteachers received more and better professional development than their secondary peers. Despite research that shows the importance of teacher collaboration, only 16% of teachers reported a climate of collaboration at their school systems (Wei et al., 2010). Finally, access to new teacher introduction programs varied across school contexts, with teachers in high-poverty districts reporting significantly less introduction activities (Wei et al., 2010).

Although American teachers report high levels of participation in PD activities, the type and quality of these activities is questionable. This is despite research effectively showing that some countries require continual PD opportunities. As reported in Professional Learning in the Learning Profession: A Status Report on Teacher Development in the United States and Abroad, teachers in the highest achieving nations report spending 15-20 hours a week on collaborative, student-learning-centered activities. Many of these schools reported allowing PD during the school workday (Darling-Hammond et al., 2009). Additionally, new teacher preparation and induction programs are compulsory and focus on developing effective teaching skills while developing mentoring relationships between veteran and new teachers (Darling-Hammond et al., 2009).

Accelerated Math.

Renaissance Learning’s Accelerated Math (AM) program is a computerized, individualized practice and progress-monitoring tool that helps educators manage daily classroom tasks as it produces daily, personalized math practice for students, scores student tests, and reports results immediately. AM automatically keeps records of student work and gives teachers progress-monitoring information each day. This computer
assisted learning program helps teachers personalize instruction for every child, often used as an intervention, and provides the formative feedback teachers need to make instructional decisions.

Renaissance Learning stresses the importance of practice when learning a new skill. AM is intended to be used to support existing curriculum (Renaissance Learning, 2011). The teacher provides a lesson, using the school’s choice of curriculum, assigns the objectives on the AM program, and then students practice individually prepared lessons. Four assignment types are available for use: diagnostic tests, practices, exercises, and tests. The quantity of time has not been reviewed by Renaissance Learning, except to stress the need for “routine math practice” (Renaissance Learning, p 8).

When built into the math curriculum, AM serves as an intervention tool for students with gaps in mathematics knowledge. These results emerge regardless of student grade level. It allows struggling students to focus on working toward mastery of skills deficits a few at a time at an individualized pace. Schoppek and Tulis (2010) specifically examined word problem skills in students. They found that even moderate amounts of individualized practice, such as AM, minimized the time needed for training students in specific skills.

AM is designed to be implemented within a typical classroom setting. Figure 1 demonstrates the mastery learning cycle suggested by Renaissance Learning (2010c). Renaissance Learning (2010a) suggests the best practices to ensure mastery learning in a whole class setting (see Figure 1):
• Choose an objective in the AM library related to the content. Assign the objective to the whole class, and provide practice assignments for all students.

• Present the lesson to the entire class, small group or individually.

• Students complete the practice assignment, submit the assignment for grading, and may print a report. The teacher should monitor students as they work problems, guide learning and correct any misunderstandings.

• Teachers regularly check TOPS Reports and the Assignment Book to see how students are doing. Identify students who may need help. (See Appendix for sample AM Reports)

• Provide interventions and reteach the skills to the students who did not master the objective.

• Print new practices, repeat procedures.

• When the student is ready, print the test.
Figure 1. AM Mastery Learning Cycle

Renaissance Learning (2010c)
Several studies have examined AM since its implementation in 1998. For the purposes of this literature review, 28 experimental or quasiexperimental studies were examined that support the effectiveness of AM. The first large-scale research on how AM supports differentiated instruction and a wide range of diverse learning styles was conducted in 2003. Ysseldyke and Tardrew (2003) found that gains arise in only one semester of AM implementation across all ability, socio-economic status, and grade levels. In fact, student performance increased an average of 14% across the board. Further, in this study, teachers in AM classes spent more time individualizing instruction for each student.

AM is designed for all ages, and students in AM classrooms have consistently improved scores on most standardized tests regardless of age (Springer, Pugalee, & Algozzine, 2007; Ysseldyke, Spicuzza, Kosiolek, Teelucksingh et al., 2003), although Nunnery and Ross (2007) only showed growth in sixth and seventh grades. In a longitudinal study, students in grades 3, 5, and 6 showed a higher level of engagement measured by the number of problems attempted and average correct. The students in the AM classroom gained significantly on standardized tests over students without exposure to AM (Brem, 2003). Springer, Pugalee, and Algozzine (2007) studied high school juniors who failed their state mandated end of course exams in the 10th grade. The students in the experimental group participated in AM interventions, with more than half the students passing the test their junior year compared to only 14% of the control group, and all the students showing improvement on their scores.

AM has also shown success across ability levels. Students in Title I (remedial) math programs across 24 states who participated in AM interventions showed greater
improvements when compared to similar students. In fact the students in non-AM groups showed an average gain of 0.3 normal curve equivalents (NCE) compared to 7.9 NCE using AM (Ysseldyke, Betts, Thill, & Hannigan, 2004). AM classes also exhibited qualitative differences in instructional management. Ysseldyke et al., (2004b) extended the previous study to include students in gifted and talented programs. Gifted students often require more than extra time and opportunity; they require structured intervention and feedback within a challenging opportunity to learn, such as offered with AM. The students were overwhelming more successful in the AM program, with 11.9 NCE units growth. In addition, the AM group students not only obtained a higher percentage of correct practice test score, but also mastered more objectives and attempted more tests.

Ysseldyke and Tardrew (2003, 2007) showed that Accelerated Math is highly successful as a progress monitoring system and a method for differentiating instruction for students. Students in every subgroup, including Title I eligibility, free/reduced lunch programs, and special needs subgroups, scored greater than 85% correct compared to other students. This study also reported qualitative improvements to classrooms. Teachers reported having more time in the day to provide individual instruction and noted that students engaged in lessons more, and students increased their basic math fluency. Students reported enjoying math more and took more responsibility for their work (Ysseldyke & Tardrew, 2007).

Ysseldyke and Bolt (2007) and Bolt, Ysseldyke, and Patterson (2010) furthered the previous studies in a longitudinal examination of a multi-level variance decomposition analysis. They found that AM classes showed significant gains, enabling teachers to make data-driven decision strategies to target necessary interventions. Of
special note, they found that success might not be related to student practice as much as teacher implementation in this technology-enhanced progress-monitoring system.

Most studies have used criterion-referenced tests, such as the STAR test. However, when examining the results of AM on state-mandated testing, similar studies demonstrate incongruous results. Though high school students were more likely to pass their Algebra End of Course Exam (Springer et al., 2007), younger students have not been quite as successful. Stanley (2011) found that fourth graders’ Terra-Nova scores had no significant difference following AM interventions. The study also showed a mixed effect of the relationship between technology and student performance. The greater success was found in the effect that technology had on teacher implementation rather than student scores.

Despite the fact that higher implementation of AM was found to be related to student scores on state assessments, critics of AM claim that the diagnostic tests are nothing more than standardized test practice (Nunnery & Ross, 2007). Each question is set up similar to many state tests, and students increase their test scores by the constant practice. The problem, or critique, lies in the idea that the students are learning facts but not understanding them. In one example, students were able to cite the answer to a problem, but not answer what the problem meant (Nunnery & Ross, 2007). A second critique of AM is that when teachers use AM to replace good instruction, the achievement gap widens; good students achieve more, and poor students fall further behind (Barrow et al., 2007).

AM is designed as an instructional management tool for daily progress monitoring of student growth (Ysseldyke & Bolt, 2007). Ysseldyke and Tardrew (2003,
2007) showed that AM is highly successful as a progress monitoring system and method for differentiating instruction for students. Few studies are available that examine the quantity or level of implementation of the AM program. Ysseldyke and Bolt (2007) found that when AM is implemented as established by Renaissance Learning (2010), students gain considerably more than students with limited or no implementation. Spicuzza et al. (2001) also found significant gains in student achievement in AM classes compared to non-AM classrooms. Brem (2003) found that students in a Title I school gained notably more on the math sections of the SAT-9 test, measured both by the amount of time to complete the test and the number of problems attempted, when presented with high levels of Accelerated Math engagement.

Summary

Research in the area of mathematics interventions and best practices has been inconsistent. Baker et al., (2002) called for math instructors to provide a blend of instruction to best meet the needs of all students. Despite this, many call instruction a pendulum swing, going from one extreme approach to another. In today’s world of higher accountability (IDEA, 2004; NCLB, 2001), teachers need to have a strong arsenal of interventions to draw from as they implement the RtI process. The study can assist teachers and schools as they endeavor to make informed decisions about the effectiveness of mathematics interventions in the RtI process to improve instructional strategies for all students.
CHAPTER THREE: METHODOLOGY

The study sought to answer the question of the effect that increased intensity of RtI programs has on students’ achievement in mathematics. The specific question addressed by the study related to the causal relationship that increased time on Accelerated Math (AM) programs has on student performance in mathematics. An ex post facto causal comparative research design examined the relationship between quantities of time on the AM program and student performances in a whole class RtI program.

Overview

Research has centered on reading instruction for many years. Only recently have studies concentrated on mathematics instruction. Due to the paucity of scientifically based research available, schools lack the arsenal of instructional strategies needed to best meet the needs of all students. Most schools rely on textbooks for math instruction, but continue to find students falling farther behind, requiring additional interventions. Schools then turn to programs such as Renaissance Learning’s Accelerated Math and STAR Math Test to supplement existing instruction as part of the Response to Intervention process.

Design

The research design chosen for the study is correlational to examine the relationships among the variables by forming groups in which the predictor variable is present at several levels. This design is supported in literature for determining whether groups differ on the criterion variable (Gall et al., 2007).
The goal of the study is to examine the relationship between increased time implementing AM and student performance. It also seeks to identify the relationship between the increased AM implementation and student achievement gap. Students already had been identified by the school as at risk and requiring interventions. The study specifically examined if there was a statistically significant relationship in scores for a student who participates in a curriculum with increased AM intervention time, which is individualized to his or her specific intervention needs.

- $H_{01}$: Student achievement is not related to the amount of time dedicated to AM instruction as measured on the STAR Math Test.
- $H_{02}$: The gap between student ability levels is not related to the level of implementation of AM interventions as measured on the STAR Math Test.

**Research Questions**

Research Question 1: *How is student achievement related to the level of implementation when using the AM curriculum?*

Research Question 2: *How is the achievement gap related to the level of implementation when using the AM curriculum?*
Population and Sampling

Study participants were selected using a convenience sampling methodology in the participating school systems in the north central Arkansas area. The intended participants of the study were third to eighth-grade teachers employed at the participating schools. In accordance with federal and state legislation, school procedures attempt to randomize student assignment to classes, using existing school procedures and safeguards to ensure classes are evenly distributed concerning race, disability, gender, socioeconomic status (SES), and ability level (Americans with Disabilities Act, 1990; ADE, 2009). True randomization is not possible for this sampling methodology, but given that most schools use similar procedures to assign classes, it is generalizable to most public schools in the United States.

The school settings serve student populations that are predominantly lower SES, which is commensurate with the surrounding communities.

Each teacher selected to participate used Renaissance Learning’s AM program and the STAR Math Test. This program is designed to help students raise their mathematical skills or address deficit areas by providing lessons tailored to the individual needs of each student (Renaissance Learning, 2010a). A minimum sample size of 30 participants was sought for participation in the study. Notifications requesting permission for participation were provided every participant at the beginning of the study, and only those who returned a permission slip participated in the study. In all, 39 teachers were eligible for the study.
**Setting**

The setting was small independent school districts in the north central Arkansas region. Participating schools included three elementary schools and two middle schools. Participating teachers included only those who taught third through eighth grades. The average class size for participating schools was 20 students per teacher. The surrounding communities are predominantly rural, with outlying farms and ranches.

Regarding the physical environment, the study required the use of both general classrooms and the school computer lab. For the assessment phases, all computers had Internet access to allow access to the Renaissance Learning’s software. General classrooms participating in the study regularly used Renaissance Learning’s AM program as an individualized intervention for students, differing only in time devoted to the intervention. Though the researcher is an employee in one of the districts, in order to ensure validity of the study, her classes were not eligible to participate.

**Instrumentation**

A baseline was established to measure change in math performance by using Renaissance Learning’s STAR Math Test. All students take this assessment at the commencement of the year as a pretest and at the conclusion of the semester as a posttest. STAR Math is a computer-based measurement tool that is used to determine the mathematics achievement level of students in grades 1 to 12. It provides norm-referenced scaled scores and Progress Monitoring Reports (National Center on Response to Intervention, 2011; U.S. Department of Education, 2009). STAR Math uses adaptive assessment strategies to generate each student’s assessment based on responses to previous items. This test does not require direct teacher assistance, as students can log
into their own account and reports are automatically sent to the teacher. The test is given as often as once weekly to determine growth or monitor progress (Renaissance Learning, 2010a), though the participating schools administers it three times per year (August, January, and May).

A bookstore received a shipment of seven different books to put in the new books display. The prices of the books are $29, $17, $31, $18, $26, $18, and $33. What is the median price of the books received in the shipment?

(A) $25
(B) $18
(C) $16
(D) $26

This test item measures:

Determine the median of an odd number of data values.

What is 420,000 in scientific notation?

(A) $4.2 \times 10^{-5}$
(B) $4.2 \times 10^{5}$
(C) $4.2 \times 10^{-4}$
(D) $4.2 \times 10^{6}$

This test item measures:
Convert a whole number greater than 10 to scientific notation

Evaluate: \( n + 6m \) if \( m = -6 \) and \( n = -5 \)

(A) 41
(B) -36
(C) -41
(D) 31

This test item measures:

Evaluate a 2-variable expression, with two or three operations, using integer substitution.

Figure 2. Sample STAR Test Questions.

AM was used to varying levels as a part of the curriculum for all groups based on teacher preference. Teachers were asked to complete a short survey asking how much class time was dedicated to AM practice. AM generates math practice assignments, exercises, or tests tailored to each student’s individual level, and automatically scores all math practice and tests. This instrument also provides ongoing feedback to both the student and the teacher to aid in the instruction process (Renaissance Learning, 2011). AM prints a report, called a TOPS report, for each assignment that lists incorrect responses and average percent correct for all assignments. These reports identify a student’s weak areas and allow the teacher to intervene.

Procedures
Prior to the start of the study, IRB approval was obtained. To maintain confidentiality, all information was kept in a secure location, including locked cabinets, password-protected computers, and password-protected computer programs and files. No personally identifiable information was released. Pseudonyms were used when necessary to ensure the anonymity of the participants.

Further permissions were obtained from the school board and administration of the school setting in full accordance with school policy. Following this, a meeting with all eligible teachers was conducted, and permission was sought from each of the teachers to participate. Administration and teachers were offered a full explanation of the purpose and procedures of the study. Parents were invited to this conference as well. All were given the opportunity to ask questions or express concerns at this time.

Participants were given information regarding informed consent. Only those returning the consent documents were eligible to participate in the study.

All teachers have been trained with the Renaissance Learning’s AM program and the STAR Math Test prior to beginning the study, which ensured that proper procedures were followed during the course of the study.

Teachers eligible for the study provided their students’ 2012-2013 STAR Math Test scores. To ensure confidentiality of the information, teachers were asked to remove all identifying information (name and student ID number) from the report prior to the researcher viewing the report. STAR Math is a computer-based assessment that was presented individually to students following strict procedures for administration. Score reports were gathered for analysis.

Teachers then completed a short survey asking the following questions:
• How long is your math period? Do you use the Accelerated Math program during your class instructional period?
• Have you been trained by the school on the Renaissance Learning’s STAR Math Test and Accelerated Math programs?
• On average, how many minutes do you devote to Accelerated Math?
• How many objectives do you require your students to master per week?
• Do you require different numbers of objectives for students based on their ability? If so, how do you determine that?

Each class or intervention group was categorized according to the amount of time the teacher dedicates to AM. The class schedules consisted of 50, 75 or 80-minute periods, and classes had been in session since August 2012. All interventions took place in the teacher’s regularly scheduled classroom.

The data was then analyzed to determine any significant relationship.

Data Analysis

Dimsdale and Kutner (2004) suggested that quasi-experimental designs such as the current study require advanced statistical procedures when compared to traditional experimental research. Students’ pre and posttest scores on the STAR Math Test were analyzed, as well as the amount of time each teacher spent on AM instruction.

Basic descriptive statistics were run on all data, but additional tests were required as well. Descriptive statistics are used to describe numerical data, and regression analysis enables the researcher to assess the impact that the independent variable has on the dependent variable (Newman, 2003). Descriptive statistics comprised of the mean and standard deviation (SD) were processed to report student performance.
Statistically significant correlations were compared to determine the relationship classroom instructions have on student performance. The variables in the hypothesis were analyzed. Statistical tests were conducted to determine the strength of the relationship between the AM Instruction and STAR Math Test Scores. A Pearson Product-Moment Correlation Coefficient ($r$) test was run to determine the difference in means of the test scores for all groups (Hohmann, 2006). Also known as the bivariate correlation ($r$), it is the score that measures the strength of the association between the independent variable and dependent variable; $r$ square indicates the percentage of variation in the dependent variable that can be explained by the independent variable (Howell, 2011). When simple regression analysis was conducted, $r$ was used to report the strength of the relationship between two variables, the students’ scores on the STAR Math Test and the amount of time spent on the AM Program. Using statistical methods, a control group was simulated, and multiple adjustments were then be made for the outside factors. The use of pretest scores in these statistical measures helped to reduce error variance (Trochim, 2006). In correlational research, $r$ squared defines the degree of association between two variables (Newman, 2003). Specifically, Pearson correlation coefficient ($r$) was used to assess the strength of the relationship between the amounts of time spent on AM instruction and student performance on the STAR Math Test at three implementation levels-minimal, suggested, and maximum.

Hypothesis two examined the achievement gap between the highest and lowest performing students. Descriptive data was collected and analyzed regarding the upper and lower 5% of the students based on their pretest scores. Since the data is correlated and comes from the same set of individuals, a t-test for correlated means was run to
determine the difference scores, which shows the degree of gain or loss between the two scores. Using pre and post testing, a t-test measures whether the means of the two scores are statistically different from each other (Howell, 2011). The t-test requires three basic assumptions: scores must be measured by ratio scale or interval scores, normal distribution of the scores, and score variances are equal (Gall, Gall & Borg, 2007). However, the t-test provides accurate measures of statistical significance even with a slight violation of these assumptions (Howell, 2011).
CHAPTER FOUR: DATA ANALYSIS

The primary goal of the study was to ascertain if a relationship exists between the amount of time spent on the Accelerated Math (AM) program and student performance as part of a comprehensive Response to Intervention program. Secondly, the study sought to determine if the AM program had an influence on the achievement gap.

This was a correlational study. The study employed a design similar to Brem (2003), and centered on student performance in mathematics as measured by the STAR Math Test. Student pretest and posttest scores were evaluated and compared to the amount of class time spent on the AM program. The following Null Hypotheses were investigated in this study: (1) There is no relationship between the amount of time spent on a whole-class RtI program and student achievement in mathematics, and (2) There is no relationship between time spent on a whole-class RtI program and the achievement gap.

The intended participants were all educators who teach third to eighth grade mathematics in school districts in the Arkansas region (n=39). To determine eligibility for the study and to present an overview of the study, a meeting was held with the teachers and administrators. All teachers who participated in this study returned a survey. To be eligible for the study, the teacher had to use the STAR Math Test and Accelerated Math during class time.

During the initial phase of the investigation, the goal was to examine one school district. Eight teachers during this time stated that they do use AM as a supplement to their existing mathematics curriculum, but do not use the STAR Math Test. Two other teachers stated that they do not use either AM or STAR. Consequently, only five
teachers were eligible to participate in the study at that time. The study was then reexamined and the scope was increased to include neighboring school districts to obtain a minimum of 30 participants.

The current study examined the average amount of time spent on AM instruction per week. Some teachers, however, noted that they do not use AM on a daily basis. Table 1 lists the amount of time spent each day on AM instruction and the total amount of time spent per week. Teacher 4 devotes one day per week, while teachers 1 uses AM twice weekly, and teachers 5, 8, 9, 10, 11, and 12 use AM three times per week.
### Table 1

*Minutes of Acc. Math per Day*

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Three neighboring school districts participated in the study, with a total of 39 eligible participants. Following an informational meeting, eligible teachers completed a short survey (see appendix 1). The results of the survey are presented in Tables 1 and 2. Table 1 lists each teacher by grade, and lists their answers to the survey questions. All teacher used AM and had been trained in the AM and STAR Math program.

In all, the average math period was 51.57 minutes, or about 260 minutes per week, though the range was from 30 to 90 minutes daily. As seen in Table 2, all teachers used AM to some extent at least several times per week, but for the purposes of this study, their weekly totals were calculated into minutes per week (mpw) in Table 1. The range of minutes per week spent on AM was 45 to 250, with an average of 77.31 mpw.

In addition, teachers 6, 14, and 15 noted that they also require AM for homework and throughout other times during the day, while teacher 25 uses AM as the sole curriculum.

Each teacher required students to master an average of 1.97 objectives per week. Of the 39 participants, 21 teachers did not require a minimum number of objectives for students to master, but the other teachers ranged from two to eight objectives mastered per week. Fewer teachers differentiated their requirements based on student ability than did not (n=15 compared to n=24). These teachers also noted that they require different objectives or use an easier (younger grade) library for at-risk students based on their STAR scores.
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the amount of time spent on AM instruction, with a focus on the average amount of time
spent by all teachers per week (77.31 mpw). Also noted in Table 3 are the standard
deviation from the mean (49.79) and the range (45 to 250 mpw, range=205 mpw).

Table 3

Minutes per Week

Minutes Per Week Descriptive Statistics

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Following the survey, each teacher presented a STAR Student Summary Report,
which lists all test scores by students. The teacher removed all student identification
information from the reports, and school administration verified student anonymity. The
scores of students not tested in both August and May were excluded from the final report.
Eligible student scores of tests were entered, and are as follows in Table 4.
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<td>88</td>
<td>197</td>
<td>53</td>
<td>128</td>
<td>37</td>
<td>39</td>
<td>553</td>
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<td>17</td>
<td>158</td>
<td>3</td>
<td>111</td>
<td>51</td>
<td>-4</td>
<td></td>
<td></td>
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<td>124</td>
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<td>165</td>
<td>113</td>
<td>325</td>
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<td>-1</td>
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<td>92</td>
<td></td>
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<tr>
<td>127</td>
<td>29</td>
<td>-5</td>
<td>49</td>
<td>43</td>
<td>143</td>
<td>128</td>
<td>11</td>
<td>-54</td>
<td>71</td>
<td>87</td>
<td>33</td>
<td>137</td>
<td>31</td>
<td>-47</td>
<td>4</td>
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<td>57</td>
<td>56</td>
<td>53</td>
<td>27</td>
<td>92</td>
<td>209</td>
<td>91</td>
<td>1</td>
<td>85</td>
<td>21</td>
<td>81</td>
<td>76</td>
<td>89</td>
<td>90</td>
<td>96</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>199</td>
<td>118</td>
<td>193</td>
<td>45</td>
<td>118</td>
<td>50</td>
<td>45</td>
<td>50</td>
<td>116</td>
<td></td>
<td></td>
<td>132</td>
<td>34</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4

Student Scores Change by Teacher
|     | 21  | 22  | 23  | 24  | 25  | 26  | 27  | 28  | 29  | 30  | 31  | 32  | 33  | 34  | 35  | 36  | 37  | 38  | 39  | Teacher |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|---------|
| 53  | -5  | 27  | 95  | 289 | 96  | 84  | 92  | 94  | 96  | 74  | -49 | 175 | 53  | 90  | 102 | 64  | 61  |
| 108 | 28  | 60  | 51  | 22  | 20  | 22  | 38  | 39  | 42  | 49  | 50  | 70  | 61  | 4   | 86  | 25  | 74  | 112 | 110  |
| 107 | -18 | -81 | 236 | 22  | 80  | 38  | 14  | 80  | 179 | 27  | -25 | 70  | 40  | 80  | 27  | 62  | 57  | 37  | 54   |
| 73  | 82  | 31  | 48  | 80  | 32  | 79  | -9  | 3   | 32  | 20  | 30  | -3  | 29  | 74  | 187 | 280 | 155 | 69  |
| 73  | 4   | 103 | 162 | 35  | 81  | 90  | 60  | 60  | -2  | 93  | 65  | 48  | 55  | 163 | 54  | 98  | 57  | -15 |
| 73  | 54  | 81  | -5  | 245 | 12  | 508 | 71  | 0   | 43  | -3  | 8   | 141 | 91  | 127 | -8  | 63  |
| 32  | 57  | 40  | 179 | 12  | 18  | 18  | 22  | 98  | 21  | -54 | 56  | 114 | 149 | 58  | -41 |
| 42  | 51  | 79  | 32  | 65  | 146 | 49  | 25  | -19 | 64  | 89  | 81  | 36  | 6   | 3   | 4   |
| 31  | 25  | 92  | 18  | 194 | 23  | 6   | 38  | 97  | 28  | 60  | 76  | 23  | 153 | 75  | 39  |
| 18  | -79 | 80  | 49  | 130 | 133 | 37  | 39  | 124 | 45  | 137 | -2  | 107 | 1   | 26  | 69  |
| 143 | 91  | 70  | 37  | 42  | 108 | 116 | 70  | 85  | 187 | 69  | -21 | 24  | 44  | 42  | 66  |
| 121 | 110 | 0   | 7   | 29  | 91  | 55  | 28  | 70  | 82  | 58  | 43  | 113 | 58  | 70  | 119 |
| 29  | 44  | 62  | 4   | 6   | 183 | 7   | 49  | 135 | 26  | 25  | 102 | 0   | 116 | 34  | 33  |
| 43  | -47 | 38  | 32  | 23  | 111 | 23  | 22  | 7   | 39  | 67  | 32  | 41 | 122 | 67  | -14 |
| 143 | 31  | 27  | 51  | -51 | -1  | 62  | 27  | 215 | -7  | -70 | 38  | 169 | 187 | -1  | 91  |
| 95  | 152 | 52  | 23  | -18 | 12  | 71  | 78  | 107 | 49  | 38  | 40  | 89  | 159 | -13 | 22  |
| -9  | 94  | 44  | 144 | -28 | 245 | 38  | 50  | 75  | 35  | 183 | 111 | 31  | 179 |
| 34  | 61  | 36  | 174 | 122 | -51 | 79  | 54  | 122 | 28  | -7  | 118 |
| -3  | 80  | 23  | 27  | 14  | 47  | 98  | 92  | 19  |
| 25  | 3   | -5  | -18 | 60  | 63  | 96  | 143 | 258 |
| 44  | 508 | -12 | -9  | 71  | 7   | 140 | -70 | 17  |
| 2   | 133 | 44  | 114 | 90  | 53  | 83  | 116 | 16  |
| 146 | 91  | 100 | 31  | 35  | -57 | 85  | 78  | 131 |

| 53  | 45  | 39  | 72  | 156 | 43  | 84  | 40.6 | 58.1 | 76  | 48  | 40.5 | 79  | 78  | 90  | 76  | 39  | 49  | Average |

79
Preliminary analysis using Microsoft Excel 2007 was performed to determine the descriptive statistics of the data as shown in Table 5. Sample size for each teacher ranged from 1 to 89 student test scores, with a total of 2,578 student test scores among the 39 teachers. It is important to note that teacher 30 was the only seventh grade math teacher for her district, thus the high number of students. The mean sample for each teacher was 20.46 students per teacher. Table 5 also highlights the mean change in test scores among all teachers (69.08), with a range of 33.43 to 127.8.

Table 5

**Student Score Change**

<table>
<thead>
<tr>
<th>Average Student Score Change Descriptive Statistics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AVG Score Change</strong></td>
<td></td>
</tr>
<tr>
<td>count</td>
<td>39</td>
</tr>
<tr>
<td>mean</td>
<td>69.0841</td>
</tr>
<tr>
<td>sample variance</td>
<td>542.9046</td>
</tr>
<tr>
<td>sample standard deviation</td>
<td>23.3003</td>
</tr>
<tr>
<td>minimum</td>
<td>33.43</td>
</tr>
<tr>
<td>maximum</td>
<td>127.8</td>
</tr>
<tr>
<td>range</td>
<td>94.37</td>
</tr>
<tr>
<td>standard error of the mean</td>
<td>3.7310</td>
</tr>
</tbody>
</table>

**Null Hypothesis 1**

A Pearson product-moment correlation coefficient was calculated to evaluate the null hypothesis that there is no relationship between the amount of time spent on a whole-class RtI program and student achievement in mathematics (n=39). Preliminary analysis using Microsoft Excel was used to develop a scatterplot in Figure 4. The scatterplot
marks the two measured variables (time in mpw versus student score change) against each other. In this study, none of the data is independently skewed, and the scatterplot appears to be developed in a linear manner. An inspection of the scatterplot revealed a consistent scatter pattern over most of the range; thus, there were no violations in the assumption homoscedasticity. Any serious violations to normality, linearity, or homoscedasticity may result in overestimating the goodness of fit as measured by the Pearson’s Coefficient ($r$) (Trochman, 2006)

![Scatterplot](image)

*Figure 3. Scatterplot.*

Using IBM Statistical Package for the Social Sciences (SPSS), the data was examined for a correlation and listed in Table 6. The correlation coefficient is a point between -1.00 and +1.00. Stronger relationships between two variables will present with a point closer to either of the two limits (Howell, 2011). The level of significance
determined to minimize the probability of a Type I error was set at a rejection of 0.05 to ensure the null hypothesis is not rejected if, in fact, it is true. In an attempt to prevent a Type II error, a one-tailed test was conducted at the 0.05 level, ensuring the null hypothesis is not falsely accepted. With the average time spent on Accelerated Math instruction of 77.31 minutes per week, and the average change in student performance on the STAR Math Test of 69.08, the Pearson Correlation was found to be statistically significant and positive, $r=+0.722$, with $p<0.05$, thus allowing the rejection of the null hypothesis. Statistical significance is achieved at the $r=0.316$, $p<0.05$ level. Therefore, sufficient statistical significance was found to reject the null hypothesis.

Table 6

*Correlation Data*

<table>
<thead>
<tr>
<th>Correlations</th>
<th>Variable 1</th>
<th>Variable 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Correlation</td>
<td>1</td>
<td><strong>.722</strong></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.000</td>
</tr>
<tr>
<td>Sum of Squares and Cross-products</td>
<td>94192.308</td>
<td>31838.315</td>
</tr>
<tr>
<td>Covariance</td>
<td>2478.745</td>
<td>837.850</td>
</tr>
<tr>
<td>N</td>
<td>39</td>
<td>39</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Correlations</th>
<th>Variable 2</th>
<th>Variable 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Correlation</td>
<td><strong>.722</strong></td>
<td>1</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>Sum of Squares and Cross-products</td>
<td>31838.315</td>
<td>20630.347</td>
</tr>
<tr>
<td>Covariance</td>
<td>837.850</td>
<td>542.904</td>
</tr>
<tr>
<td>N</td>
<td>39</td>
<td>39</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed).
Null Hypothesis 2

The study also examined the null hypothesis that increased time spent in a whole-class intervention would have no effect on the achievement gap. The highest and lowest performing students of each class were collected. Table 7 lists the pretest and posttest scores of all teachers’ highest and lowest performing students. Preliminary analysis of the data was run using Microsoft Excel 2007 to determine the average of each test score, and the differences between each group of students (highest-lowest) were calculated and listed in the table. In addition, the percentage of change on both the high and low achieving students were calculated. During the pretest, the higher performing students scored an average of 778, and the lower performing students scored an average of 492, with a difference of 287. The posttest score averages were, highest: 814, and lowest: 612, with a difference of 201 points. In all, the high-achieving students’ scores increased 4%, with an average 35 point increase. The low achieving students increased 25%, with a 121 average point increase, as depicted in Table 7.

Table 7
Achievement Gap Test Scores

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th></th>
<th></th>
<th>Posttest</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>High</td>
<td>Low</td>
<td>Difference</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Mean</td>
<td>778.03</td>
<td>491.67</td>
<td><strong>287.36</strong></td>
<td>813.62</td>
<td>612.03</td>
<td><strong>200.59</strong></td>
</tr>
<tr>
<td>% Change</td>
<td></td>
<td>4%</td>
<td><strong>25%</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absolute Change</td>
<td></td>
<td>35</td>
<td>121</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The differences between the highest and lowest pretest scores were compared, and then the same students’ posttest score differences were also compared and listed in Table
8, Achievement Gap Differences. Finally, a determination was made whether the differences between the two pretest scores increased or decreased on the posttest. As seen in Table 8, initial examination of the scores revealed differences between the pretest scores and posttest scores (means 287.56 and 200.59). When comparing each teacher’s individual scores, it is noted that 32 teachers had decreased score differences, while six teachers saw some increase in the difference of scores (Table 8). In all, 82% of the teachers decreased the achievement gap on their students’ STAR Math Test scores.

Table 8

*Achievement Gap Differences*

<table>
<thead>
<tr>
<th>Pretest</th>
<th>Posttest</th>
<th>Difference</th>
<th>Increase?</th>
</tr>
</thead>
<tbody>
<tr>
<td>287.359</td>
<td>200.587</td>
<td>86.77</td>
<td>No=32</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>82%</td>
</tr>
</tbody>
</table>

*Figure 5. Achievement Gap Scatterplot*
As shown in Table 8, 82% of the participating teachers saw no increase in the achievement gap. Figure 5 shows a scatterplot of the differences between the pretest and posttest scores by teacher. As shown, there appears to be a positive trend in the score differences.

A t-test was run on the data to determine the sampling distribution. Table 9 shows the t-distribution of the data from the achievement gap. As seen in this table, there was a t value of 1.686. On a one-tailed test, the critical value of $38df=1.684$ at the $p=0.05$ level.

Table 9

<table>
<thead>
<tr>
<th>Achievement Gap T-Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>t-distribution</td>
</tr>
<tr>
<td>$df = 38$</td>
</tr>
<tr>
<td>P(lower)</td>
</tr>
<tr>
<td>.9500</td>
</tr>
</tbody>
</table>

A paired (related) sample t-test was run on the data to compare the achievement gap in the STAR pre and posttests. Paired sample t-tests are appropriate to compare two population means in which the sample means are correlated (Howell, 2011). The following assumptions were met prior to conducting the test: Only matched pairs can be used with equal variances, cases must be independent of each other, and normal distributions are assumed. Table 9 shows the t-distribution of the data from the achievement gap. As seen in this table, there was a t value of 1.686. On a one-tailed test, the critical value of $38df=1.684$ at the $p=0.05$ level. Because the obtained t score (1.686)
is greater than the critical value, there is significant evidence to reject the null hypothesis. Therefore, it is concluded that more time spent on the whole-class intervention does decrease the achievement gap between the highest and lowest performing students.

**Summary**

As part of this dissertation study, the preceding chapter has presented the data derived from classroom teachers who use the Accelerated Math Program and STAR Math Test as part of the Response to Intervention process in a school in Arkansas. The data collected from the participants was presented, including the descriptive data on individual teachers and the group as a whole. Hypothesis 1 examined the relationship between the amount of time spent on the AM program and student achievement using a Pearson’s Correlation to determine the level of correlation between the variables. The results suggested that a significant correlation exists between the level of implementation, or amount of time spent on the AM program, and student performance (r=0.722).

Hypothesis 2 examined the achievement gap between the highest and lowest performing students. A Paired sample t-test was run to determine the relationship between the pre and posttests, and the data further revealed a decrease in the achievement gap between each group’s highest and lowest performing students (t=1.686).

These results indicate a relationship between individualized interventions in a whole class setting and student achievement. They indicate that increased time on these individualized interventions does increase student achievement in the student population as a whole and in the lower achieving students. These results, however, do raise questions about the efficacy of these interventions and higher achieving students’ math achievement.
CHAPTER FIVE: DISCUSSION

To compete in a global society, effective math skills are a necessity. The current approach to mathematics instruction, however, seems to be a guess and check method, causing American students to continue to fall behind other nations in mathematics (NMAP, 2008). Education reform attempts to address this mathematics deficiency of American students. However, research by the NMAP (2008) has demonstrated that these efforts only benefited the higher performing students, often leaving lower performing students behind.

Current legislation, such as NCLB (2001) and IDEA (2004) attempted to answer this discrepancy. NCLB (2001) called for all students to increase academic proficiency and required schools to ensure all students made adequate yearly progress. These laws require schools to provide research-proven, scientifically-based interventions for struggling learners as part of the RtI process (Slavin & Lake, 2007).

RtI is key as an alternative to identification for possible special education referral and as a method to improve procedures associated with prevention and remediation of academic skills (Duhon et al., 2009). RtI is characterized by interventions that increase in intensity as student need increases. Although researchers have begun studying best practices in mathematics instructions and interventions, there is much less available than in other subjects, namely reading and language arts.

Research in reading and language arts shows that when both the quantity and quality of intervention are increased for struggling learners, student achievement is improved (Conner et al., 2009; Duhon et al., 2009). Research in mathematics interventions, however, has failed to identify interventions that address both quantity and
quality. Rather, most literature has focused on math computation or fluency and problem solving (Burns, 1998; Rhoton, 2010). However, Baker et al. (2002) emphasized the importance of balancing instruction for all students.

Citing discrepancies and inconsistencies in state standards, the NCTM identified a key need for national standards. NCTM (2000) outlined specific areas of math learning, but few comprehensive programs are available for teachers to use. Many states are adopting new standards (CCSS), based on the NCTM standards. These new standards have taken a more developmentally appropriate view of learning, allowing students to cement knowledge and learning. Since the quantity of standards has become more streamlined, teachers are more able to concentrate on the quality of student learning, allowing children to become more fully engaged in the lessons (ADE, 2011).

Mathematics standards necessitate specific requirements, according to the Education Alliance (2006), such as the following:

- Lessons created to address explicit standards-based concepts or skills.
- Educational activities must be student centered.
- Lessons based on problem solving and inquiry.
- Knowledge application and critical thinking skills
- Activities presented with sufficient time, space, and resources.
- Assessment procedures are ongoing and rigorous.

Effective mathematics instruction and interventions have four key components, as outlined by the NMAP (2008), as follows: (a) Systematic and explicit lesson is a method where the teacher directs students through specified instructional sequencers; (b) Students regularly apply strategies as they master concepts; (c) Self-instruction is also shown to
improve student learning. In this, students learn the metacognitive strategies to manage their own learning. Peer tutoring is also effective. This method pairs students together to practice specific tasks; (d) Finally, visual representation tools are used to increase achievement. This learning method uses manipulatives, graphics, pictures, number lines, and graphs to represent mathematical concepts.

There are few research-based comparable commercial products to address comprehensive whole-class mathematics interventions. Most research has been conducted on intervention strategies for individual or small-group settings. The What Works Clearinghouse has a comprehensive collection of available commercial curricula or intervention products. A search on their database revealed only nine possible articles, four of which were actual math curriculum, not supplemental. Some of the other available curricula include Odyssey Math, Cognitive Tutor, Accelerated Math, iPass, and Momentum Math (Hanover Research, 2011). Though a qualitative analysis of these interventions has not been conducted, of these choices, AM is the only supplemental intervention that fits the guidelines of this study. It is the only one that uses a combination of CAI and paper-based activities, has ongoing online and face-to-face support, uses a whole-class method of delivery, and is geared for all grades 1-12.

Programs such as Renaissance Learning’s products help streamline the teaching and learning process. The Accelerated Math (AM) program provides students with individualized assignments based on each student’s unique strengths and weaknesses. Students use STAR Math Test to determine growth and retention of skills. AM and STAR Math are both supported in current literature as comprehensive, balanced instructional designs that focus on conceptual understanding, knowledge retention,
problem solving, and application of skills (Slavin & Lake, 2007). This supplemental program also provides consistent and ongoing feedback, which has proven its effectiveness in increasing student achievement (Steeley, Dragoo, Arateh, & Luke, 2008).

**Summary**

This study examined the time spent on a whole-class math intervention and student performance in mathematics to determine if a correlation existed between the two variables. The study employed a design similar to Brem (2003), which centered on student performance as measured by the STAR Math test. In correlational studies, researchers examine these variables for relationships, or correlations. Researchers seek to answer the question, If one variable increases, does the other variable also increase? Three possible results surface in a correlational study: positive correlation, no correlation, or negative correlation. These statistics can range from -1.00 to +1.00, with 0 as no correlation. Though correlational studies cannot prove causation, they can show a direct relationship between the variables. In the case of this study, the relationship between time spent on math interventions and student performance was investigated.

The intervention used was the Accelerated Math program by Renaissance Learning. Using Renaissance Learning’s STAR Math Test, students were administered a pre and posttest, with the math interventions being implemented between August and May in the 2012-2013 school year for a minimum of 50-minute class periods per day. Teachers were asked how much class time they allotted for AM instruction. This time was compared with the difference between students’ pre and posttest scores on the STAR Math Test.
Teachers from the north central Arkansas area who taught third through eighth grades were invited to contribute, with 39 as the total number of participants. All 39 teachers attended an informational meeting outlining the study prior to beginning the study.

It is important to note that of the 39 participants, only two had been trained outside their schools in STAR Math Test and Accelerated Math. Though the other teachers had attended district trainings, only two teachers had attended one hosted by Renaissance Learning. The study sought to establish the validity of two hypotheses: (1) Student achievement is related to the amount of time dedicated to AM instruction, as measured on the STAR Math Test, and (2) The gap between student ability levels is related to the AM intervention, as measured on the STAR Math Test.

**Conclusion**

Hypothesis 1 examined student achievement at it relates to the amount of time dedicated to AM instruction, as measured on the STAR Math Test. Teachers spent an average of 90.7 minutes per week on AM instruction and had an average growth of 66.23 points on the STAR Math Test. To establish this hypothesis, a Pearson’s correlation between the amount of time teachers utilized AM instruction and student achievement was run and uncovered a 0.724 correlation.

This shows a statistically significant correlation, and the null hypothesis was rejected. This shows that more time spent on a whole-class, individualized intervention is positively correlated with student performance. The results of this study supports previous findings of positive trends associated with student performance in interventions...
(Nunnery & Ross, 2007; Springer et al., 2007; Ysseldyke et al., 2003; Ysseldyke & Tardrew, 2003).

The results of the study confirm the idea that whole-class interventions, combined with computer-assisted instruction (CAI), can be used to maximize class time and teacher effectiveness. By using CAI, feedback for both the teacher and the student is immediate. Students know immediately what questions or types of questions they got wrong, and teachers can see patterns in student responses. This allows the teachers to create small groups or provide individualized instruction on those specific skills. Further, the CAI used for AM also sends reports directly to the teachers, highlighting students who are at risk for failing or who have failed and need additional support. The teacher can print intervention activities based on the students’ specific needs.

The second hypothesis examined the gap between student ability levels as it relates to the AM interventions as measured on the STAR Math Test. To study this hypothesis, the highest performing and lowest performing students were compared at the pretest then analyzed for change at the posttest. In all cases, the difference between the students’ performance decreased after the intervention.

The pre and posttest scores of each class's highest and lowest achieving students were collected. The discrepancies between each group of students were compared for change. Analysis of the data shows that the variation between each class's highest and lowest achieving students shows decreases in differences between the pre and posttest scores. The average score difference changed from 287.36 in the pretest to 200.69 on the posttest. In two cases (teachers 29 and 38), the lower achieving students actually performed higher than the higher achieving students (resulting in scores of -135 and -30).
The second null hypothesis was rejected. The study corroborates that the achievement gap does decrease with additional time spent on whole-class interventions.

Research suggests a minimum of 30 participants are required for a good correlational study. Though the sample size of 39 is greater than the minimum of 30, a larger sample size will increase the statistical power of a study’s results (Howell, 2011). In contrast, small sample sizes may cause a Type II error, or a false negative. Sample size will have the greatest effect on descriptive data (mean, median, and mode). It is important in any study for the sample size to be large enough to determine whether a study’s results are the result of chance or not (statistical significance). Accordingly, with smaller sample sizes, it is more difficult for the results to be statistically significant (Howell, 2011).

**Discussion**

The study sought to examine a possible correlation between the amount of time spent on a whole-class math intervention and student performance in mathematics as well as closing the achievement gap. Using Renaissance Learning’s STAR Math Test and Accelerated Math programs, student achievement was examined. The results of the study revealed a statistically significant correlation between the time spent on the program and student scores on the STAR Math Test. Further, it did show a decrease in the achievement gap between the highest and lowest performing students.

**Testing vs. Assessment.**

No Child Left Behind (NCLB) (2001) mandates all districts to test students at least annually in reading, writing, and mathematics. Problems exist in understanding the difference between assessment and testing. Testing is intended to measure a student’s
growth and is usually given at the end of a unit of study or year. Assessment, in contrast, is an ongoing measure of how the student is performing on a daily basis. Renaissance Learning intended the STAR Math to be a test given up to once per week (Renaissance Learning, 2010b). The Accelerated Math program functions as a daily assessment that guides instruction (Renaissance Learning, 2010a). The testing, when assessment is a regular part of the school day, is then only a measure of the effectiveness of the assessment-instruction.

Suswele-Banda (2005) examined the difference between tests and assessments. Teachers sometimes confuse assessment and testing and often think of assessments as tests, thus becoming incapable of understanding the learning abilities in students and the weaknesses experienced by students as part of the learning process. Instead, they strive to cover a minimum number of objectives in a set period rather than concentrate on supporting student learning.

Current legislation requires at least annual testing (NCLB, 2001), but the present trend concentrates on assessment-driven instruction. Hence, both testing and assessment are integral parts of the school experience. A paradigm shift from testing for academic achievement (assessment of learning) to assessing for learning would assist teachers in investigating ways of supporting student learning. Additionally, students investigate their own strengths and weaknesses when classroom assessment is emphasized.

Assessment for learning facilitates the ability to both understand the teaching and learning process and meaningfully support learning. Assessment for learning advises the teachers about students’ strengths and weaknesses. In the present study, the teachers exhibited a limited understanding and use of student assessment and testing. The
confusion on the meaningful use of STAR assessments made it less about documenting student needs and more about documenting student growth in math.

Classroom assessment must be part of the daily instructional process. Assessment should not be viewed as a supplementary activity, as was noted by some researchers (Susuwele-Banda, 2005). Properly managed classroom assessment is likely to empower students to monitor and evaluate their learning, can also facilitate the teaching and learning process, and helps ensure a constructive working relationship between the teacher and the students.

Other factors, including perceptions of classroom assessment, possibly influenced teachers’ classroom assessment practices. Studies reveal that teachers’ flexibility seems to depend on their own academic qualifications. The research conducted by Susuwele-Banda (2005) suggests that other factors, such as class size, teaching, and learning resources, have an effect on classroom assessment.

The participating schools use the Reading First program for reading and writing instruction. Reading First requirements mandate that about 60% of each school day be spent on reading and writing instruction (U.S. Department of Education, 2002). The remaining 40% should be split among lunch, recess, rotation classes (art/music/PE/computer/library), and mathematics. This limits the amount of time allotted for instruction and leaves almost no time for interventions. This lack of time significantly affects student performance. Class size is also an issue in mathematics instruction. In a study by Mosteller (1995), teachers could not finish grading students’ work within the selected mathematics class time because of larger numbers of students. This is likely to affect the teacher’s needed preparation and planning time, specifically
since each student has to be identified and worked with according to his or her ability. This was also true with teaching and learning resources. Further, the assessment-driven instruction model indicates that needs be part of the initial preservice teacher education programs so that it can have a sustained impact on teachers long after graduation.

**Teacher Evaluation and Supervision.**

Teacher evaluation systems, including evaluating math instruction, have been in place for many years. The goal of teacher evaluation is to improve teacher effectiveness. Previous evaluation systems involved highly structured, formal observations. Administrators evaluated veteran teachers in some states only every 5 years or so. The theory behind this system is that teacher effectiveness will reach its maximum level, and then plateau with a few years of teaching experience.

Current research does not support this formal method of evaluation; thus, states are reforming the evaluation process (Cohen & Varghese, 2011). Arkansas is in the process of adopting the Teacher Excellence and Support System (TESS) (ADE, 2012). This system supports high-quality instruction and instructional leadership. TESS encourages administrators to evaluate teachers with multiple measures, including those based on student outcomes, such as student exam scores (ADE, 2012). This method allows administrators and teachers to identify the specific weakness that might be hindering student performance. Teachers can then concentrate on improving that specific issue.

The results of this study revealed a significant gap in the teacher evaluation system at the participating schools. It is important to note that the TESS system is being phased in, beginning in the 2012-2013 school year (ADE, 2012). Currently, teachers are
held to strict standards for reading and writing instruction, as evidenced by the presence of a supervisory reading coach (U.S. Department of Education, 2002). The participating schools use the Reading First program in preschool through fourth grades, which is highly scripted and timed (U.S. Department of Education, 2002). Mathematics instruction, however, has no such accountability in its evaluation.

Concerning the current study, rigorous teacher evaluation, when conducted equitably and annually, can improve mathematics performance in students (Kane, Wooten, Taylor, & Tyler, 2011). Strict supervision in mathematics education, on the other hand, may not be the answer to this issue. A longitudinal study conducted by Taylor and Tyler (2012) showed that it is far more important to determine how the evaluation data will be used to improve teacher effectiveness. They found that evaluation systems, such as TESS, not only improve teacher performance in the year they are evaluated, but continue to affect effectiveness several years after the evaluation. In other words, teacher effectiveness is not fixed in mathematics, as previously thought; rather, it is dynamic. Taylor and Tyler (2012) further found that the greatest student growth was larger for teachers who received evaluation feedback that was more critical and for those who had the most need for improvement.

The curricular emphasis appears to need more cohesiveness among grade levels if administrators are to unite all teachers to improve student performance. The results of the study revealed differing priorities, or a lack of unity, among grade levels. Younger classes tend to stress reading and writing skills. Children are encouraged to learn mathematics, but teachers report that learning to read is more important. Higher grades (fifth to eighth grades, in this study) stress reading to learn, rather than learning to read.
Students are encouraged to apply reading skills to all subjects. This practice is evidenced by a lack of participation in the younger grades, shown by six teachers in third and fourth grades, but 19 in fifth and sixth grades and 13 in seventh and eighth grades.

While united instruction of curricular teaching across grade levels is important to administrators, research shows that their main purpose is to build relationships among the faculty, staff, students, parents, and community (West, 2011). This becomes difficult when the different priorities are taken into account. Previous research has shown that foundational math skills, both problem solving and computation, are imperative to student performance (Baker et al., 2002). This does not appear to be a common priority in the various factions of the participating school. Students who do not have automaticity with basic math facts are unable to function at the higher levels in more difficult math situations of older grades (Gersten et al., 2005). With the need for improved basic math skills for all level students, research supports administrators helping the various groups refocus their emphasis toward mathematical instruction.

**Stereotypes.**

During the course of the study, it was noted that younger grades had a much lower participation than higher grades. It was also observed that as students got older, their growth slowed, especially among the higher performing students. This can be difficult to explain. One possible cause of these issues could be negative stereotypes in math instruction, both from the students and the teachers. Many elementary and middle school teachers report being unprepared, or even uncomfortable, teaching math. In college, some pre-service teachers only take the “math for teachers” course, rather than college algebra because of their discomfort in mathematics (Walker, 2007).
A negative attitude toward math may begin as early as second grade. In fact, 35% of second graders viewed math as difficult when compared to 10% who believed reading was hard (Berch & Mazzacco, 2007, as cited in Gibbs, 2012). Gibbs (2012) also noted several barriers to math development, including the fact that content becomes increasingly more difficult as school progresses. Most of the difference goes back to stereotypes that the children’s parents and teachers had as children. Often parents and students believe they cannot “get it” or note they just “dislike math” (Gibbs, 2012, para 9). Teachers contribute to this stereotype, passing it on to students, resulting in an almost cyclical effect.

Galbreath and Haines (2000) examined the perceived effects of math word problems on student performance. They noted several factors that may contribute to perceived math difficulties, including preconceived perceptions of math ability. Many issues did not even involve mathematics skills; how many problems were on the page, text readability, preconceived ability, and misconceptions about the subject are among some of the factors noted. Additionally, self-efficacy significantly influences problem-solving performance and efficiency. In fact, Hoffman and Spatariu (2008) found self-efficacy has a greater impact than just background knowledge in math skills.

Other research in mathematics instruction has shown a significant difference in student performance between classes taught by teachers with strong math backgrounds and by teachers without strong math backgrounds. Teacher mathematical background, combined with a positive attitude toward mathematics, has a positive impact on student performance (Welder & Simonsen, 2011). In fact, one study attempted to correct this by examining teachers’ backgrounds in mathematics. The school provided $1.5 million in a
two-year professional development geared to improve teachers’ math skills (Schmoker, 2012). Following the study, the average score of the teachers was 75.9% correct. The average score of the control group was only 74.9%. In contrast, ill-tempered math teachers helped create negative attitudes toward math class and mathematical ability in students (Lucas & Fugitt, 2009).

Motivation.

Increasing motivation in the middle grades may be difficult. Ryan and Patrick (2001) found that during the middle grades many students tend to lose interest in mathematics because they feel the math is too difficult or do not see the value of the reward when compared to the amount of effort required. Motivation, or lack of motivation, is most likely to affect mathematics course work compared to other subjects. Ryan and Patrick (2001) support the emphasis of motivation in mathematics, noting that students in middle grades can influence continued success across ages and curricular areas. Further, academic proficiency is imperative for full future participation in society (Long, Monoi, Harper, Knoblauch, & Murphy, 2007). If not motivated to continue in rigorous academic subjects, students may avoid school and later become less likely to take courses directing them toward college readiness (Balfanz, 2007). Balfanz (2007) also stated that students who fail to engage academically in the middle grades are more likely to drop out of high school.

Students come to school with unique perspectives of motivation, and few can be motivated to the same intensity (Hayenga & Corpus, 2010; Meyer, McClure, Walkey, Weir, & McKenzie, 2009). Student motivation, however, continues to be a critical factor
in deciding what and when new learning takes place. Since NCLB (2001), teachers must teach all students, regardless of their level of motivation.

How, then can teachers increase student motivation within the Accelerated Math classroom? Schweinle, Meyer, and Turner (2006) stated that classroom instruction must balance motivation and challenge. Further, Hickey, Moore, and Pellegrino (2001) implied that student motivation is enhanced in student-centered learning environments. Motivation also increases when instruction combines technology with traditional methods (Keller, 2008). Kroesbergen and Van Luit (2003) suggested that new modes of instruction should be used to support student learning and motivation to succeed. Thus, it becomes important for teachers, administrators, and schools to search beyond the curriculum for different ways to motivate students (Crawford & Snider, 2000).

Considering the fact that students of this age are highly social and benefit from social learning (Ryan, & Patrick, 2001), teachers should provide mini lessons with small (or large, when possible) groups of students. Students in this setting would be allowed to interact with each other, thus increasing motivation and student achievement.

Mercer and Miller (1992) cited a correlation between negative attitudes toward mathematics and student motivation. Teachers can help students achieve self-efficacy by assigning tasks that students can complete without frustration and providing adequate scaffolding to help students with new concepts and skills (Basham, Israel, Graden, Poth & Winston, 2010). Teachers can model motivating behavior by rewarding positive attitudes in students, ensuring all lessons build on previously mastered skills, and demonstrating a positive attitude toward mathematics and learning in general (Mercer & Miller, 1992). Students become more engaged as they begin to experience success, see
the value of mathematics, and recognize that their own effort matters. Any effective
math intervention needs to address these issues.

The Education Alliance (2006) suggests that schools focus on specific matters to
increase student motivation and achievement. Classrooms should be safe environments
with clear procedures and routines. Teachers provide both challenging activities and
support for learning using carefully assigned groups and lessons. Regular real-world
connections with an integrated curriculum will provide engaging educational experiences
for students. Finally, students should be encouraged to share their work and successes
with others (Education Alliance, 2006).

Choosing the right intervention.

Interventions are highly personalized processes that require individualized
instruction based on the student's specific needs. Choosing the right interventions,
therefore, is highly dependent on a multitude of factors. The results of this research study
show that the AM intervention may be an effective intervention for some, but possibly
not for everyone. Students who scored the lowest in the beginning of the study had 21%
more growth compared to the higher performing students. This observation implies that
AM instruction may be more effective with students in the lower performing categories
than those in the higher performing categories.

Challenging high-achieving students.

This study showed a decrease in the discrepancy between low-achieving and
high-achieving students. In two instances, the higher achieving students’ scores
decreased. One question that could be raised because of this difference is whether the
intervention truly challenged the higher students. How many students merely answered
the minimum number of questions? The results of the study show that, without proper supervision, higher performing students do not achieve mathematical gains to the best of their ability.

The goal of education, according to national standards, is to increase American students’ competitiveness in the global society. This goal focuses on higher achieving students. In contrast to current legislation, schools focus on the humanitarian edict of NCLB (2001). Thus, lower achieving students get most of the attention in American public schools. When compared to other nations, America is one of the few countries in which education is a right, not a privilege. In fact, many nations do not even test lower students. Hanushek and Woessmann (2011) found a positive correlation between test scores and nations that are more selective about which students continue into secondary education. That is, when education is a right, national test scores should be lower than when education is a privilege. These conflicting goals make educating all students difficult.

Previous research on AM and gifted (high performing) students shows that AM can be effective when implemented correctly. Ysseldyke, Tardrew, Betts, Thill, and Hannigan (2004) noted, however, that though these students were successful with AM, they did not attempt any more practice problems than non-gifted students, though they did get a higher percentage of the problems correct.

Research shows that the new concentration on at-risk students has left many to wonder what happens to the high-achieving and gifted students. In a five-part multiyear study, the Thomas Fordham Institute noted that interventions are greatly successful for lower achieving students, but show minimal gains for higher achieving students (Farkas,
Duffet, & Loveless, 2008). They further noted that teachers are more likely to state that low-achieving students are their top priority. Despite this, as part of this study, the researchers asked the same teachers, "For the public schools to help the U.S. live up to its ideals of justice and equality, do you think it's more important that they focus on..." (Farkas et al., 2008, p 57). Over 80% of the teachers said to treat "all students equally, regardless of their backgrounds or achievement levels" while only 11% of the respondents wanted to focus only on students who struggle academically (Farkas et al., 2008).

To compete in a global society, it is important for all students to make gains, not merely the lower performing and disadvantaged students. It is imperative, therefore, that schools administer interventions that are both excellent and effective to improve the performance of all students.

**Ability grouping.**

Many secondary schools offer ability-grouped classes. Such classes in mathematics might include honors or Advanced Placement math classes for higher achieving and gifted students and remedial classes for lower achieving students. Much research has been conducted in ability grouping for high school students, but little research is available for younger students. Castle, Deniz, and Tortora (2005) showed that flexible grouping with higher needs students significantly improved student performance. This study highlighted the difficulties that teachers have when working with students of different ability levels in one classroom. Perhaps interventions face the same difficulties. Though AM is designed to be an individualized curriculum, the lack of growth by students who performed higher on the pretest is concerning.
Limitations of the Study

Several limitations were revealed during the course of the study. First, the study was initially limited to students in the third through the eighth grades in a single independent school district in north central Arkansas. During the initial phases of the study, 15 teachers were invited to participate. At that time, eight teachers stated that they did use AM as a supplement to their existing mathematics curriculum, but did not use the STAR Math Test. Two other teachers stated that they did not use either STAR Math Test or AM. Consequently, only five teachers were eligible for the study. The study was then reexamined, and the scope was increased to include neighboring school districts to increase the sample size to a minimum of 30 participants.

Despite including additional school districts and teachers, the sample size is still considered to be a limitation of the study. The small sample size may have skewed the results of the study; however, the null hypothesis was rejected. Another limitation to the study was the fact that not all student test scores were eligible, due to the timing of their tests (tests must have been administered in August and May). The teachers or administration for this phenomenon offered no explanation. It is believed that both limitations may improve with both a larger sample size and a requirement that every student be tested.

Also, due to the nature of school systems, a true randomization of the subjects was not possible. Although federal and state legislation mandates that children cannot be discriminated against by race, gender, or disability (ADA, 1990), little research is available on the exact school procedures. Arkansas does have some regulations in place to ensure fair distribution of students (ADE, 2009). In the case of this study, students had
already been identified by school administration and had previously been assigned to a teacher. Further investigation is warranted before determining causation or a true correlation among the variables because of these limitations.

**Implications for Future Research**

Certainly, this study has revealed a gap between research and instruction. Legislation may require frequent and ongoing assessment of student progress; however, experiences in this study’s classrooms reveal otherwise. Researchers might attempt this study with additional schools, but the biggest problem revealed by the study involves the lack of participation.

To correct this problem, several factors need to be addressed. First, a substantial rebalancing of school effort must begin the reform process. Equity in education means that no child really is left behind. This entails supporting all learners. When students are struggling, schools are responsible to remediate them as they catch up. When students are ahead, schools also are charged with providing enrichments to help them reach their potential.

Second, significant professional development programs must be implemented. The study's schools trained teachers in Renaissance Learning’s products, but did not apply this to their implementation of either STAR Math or AM. However, there may be differences noted between teachers who were trained by Renaissance Learning and those trained by their school. Additional training is warranted, and has been cited in literature (O’Brien, 2005). Whether a school chooses to use Renaissance Learning’s products or a different program, effective training is essential to proper implementation. Professional development (PD) programs must concentrate on increased length and intensity, firmly
building on prior teacher knowledge (Scher & O’Reilly, 2009). Follow through of these PD programs is essential, rather than disjointed seminars to further cement teachers’ understanding.

In addition to training on the specific intervention program used by each school, teachers need further training in the differences between assessment and testing as well as how to use both to guide instruction effectively. Furthermore, future research could include teachers’ professional opinions on assessment/testing and student interventions.

This study serves as a call for more research to determine interventions that are effective at varying performance levels. Future research should concentrate on innovative ways to implement these interventions in the classroom setting.

As an extension to the professional development, school administration should increase teacher accountability and evaluation programs to address what level of implementation the teacher is using following a professional development program. At the conclusion of most PD programs, participant input is collected. Future research needs to concentrate on what participants believe works and does not work in PD programs. Rather than approach these PD programs as a basis for evaluation, PD is a form of growth and learning. Nelson and Sasi (2007) supported this idea as they called for school and district administration to support math teachers by attending professional development programs with teachers and observe effective math teachers outside the evaluation system to ensure proper implementation of math programs and PD programs.

Finally, Renaissance Learning is not the only company that provides curriculum to address RtI needs in the school, though it is the only one to fit the parameters of this study. Further evaluation, including a comparison of similar products, is warranted to
determine the most appropriate program for individual schools or specific populations of students.

**Implications for Practitioners.**

Effective research serves several purposes. First, it seeks to answer questions or to find additional information on a topic. Second, it applies the research to the real world. In this study, math interventions were examined in the hopes of streamlining the educational process for teachers and students in the RtI process. As such, several implications have risen as a result of this study.

First, teachers should acknowledge that all children deserve their attention, but priorities must be taken into account. Even in the best situations, teachers cannot provide individual instruction to every student at each lesson. Intervention programs, such as AM, assist with the teaching process as they allow the teacher to concentrate his or her time on those students who most need it. As the teacher endeavors to assist struggling students, it is imperative that he or she not forget those students who may also need positive reinforcement or additional emotional support as they strive to succeed in math.

Secondly, this study highlighted the need for teachers to ensure they have adequate training and background knowledge to teach math. Many teachers, especially in the early grades, become experts at child development, and forget content knowledge. Studies have shown that in order to teach a subject well, the teacher needs to be comfortable with that subject. Building principals and human resources staff need to ensure that teachers are placed not only according to certifications, but also according to ability and comfort. When teachers are placed outside their comfort zone, additional support and professional development programs are warranted.
Finally, administrative faculty and curriculum directors need to evaluate the school system’s current intervention programs for mathematics. Not all students need intensive interventions all the time, but many will need some additional support. It is important that an effective intervention program is in place for all students who may need it. Also, ensure that faculty and staff have been trained in the program and the school policy regarding its use. Doing so will ensure the success of all students during the RtI process.

**Conclusion.**

The results of this study show that AM and STAR Math are effective additions to the existing school day. When implemented correctly, AM provides teachers the support and freedom to teach what needs to be taught to the students who need it most. However, the results also indicate several issues that need to be addressed within the school system. School systems need to make greater attempts to provide students with well-trained, highly qualified math instructors. What works for one school system may not work for all. At a minimum, recruiting effective teachers is important, as well as ensuring that teachers have adequate training and content area knowledge to successfully teach.

Further, school systems should examine learners at all levels. Some legislation requires schools to focus on the lowest achieving students. Other legislation requires schools to succeed on state mandated tests, which places the emphasis on average students. Finally, other national initiatives need the highest achieving students to be most successful. These conflicting requirements can cause problems on differing levels. To address this, school systems need to evaluate the teaching and learning strategies for each group individually.
This study presented a quantitative analysis of the relationship that increased time with the Accelerated Math program has on student performance on the STAR Math Test, published by Renaissance Learning. AM is a scientifically based program designed to supplement quality instruction as part of the Response to Intervention process, which is mandated by No Child Left Behind (2001) and the Individuals with Disabilities Education Act (2004). Using ex post facto data, the study’s results supported two hypotheses: (1) Student achievement is related to the amount of time dedicated to AM instruction, as measured on the STAR Math Test, and (2) The achievement gap between student ability levels is related to the time devoted to AM interventions, as measured on the STAR Math Test.
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APPENDIX

Renaissance Learning Sample Pages, Retrieved from Accelerated Math

The Teacher Assignment Book shows the status of individual students. (Renaissance Learning, 2011, p 62)

Key used for the Teacher Assignment Book. (Renaissance Learning, 2011, p 22)
Status of the Class Report, a printable report that shows which students are ready for tests, additional practices or need interventions.  
(Renaissance Learning, 2011, p 153)
Sample TOPS Report, may be printed when an assignment is graded.
(Renaissance Learning, 2011, p 150)
Practice

Accelerated Math™: Wednesday, February 1, 2012, 10:02 AM

J. Evans
Math 5B
West Middle School

Form Number 3195

Max Bryson

Objectives: (4 of 4 listed)
86. Multiply a decimal number through thousandths by 10, 100, or 1,000
87. WP: Multiply a decimal number through thousandths by 10, 100, or 1,000
65. <Review> Divide a unit fraction by a whole number
66. <Review> Divide a whole number by a fraction, with a whole number quotient using a model

49. Divide: \( \frac{1}{3} \div 12 \) 
   [A] 4  
   [B] \( \frac{1}{36} \)  
   [C] \( \frac{1}{37} \)  
   [D] \( \frac{1}{4} \)

50. To raise money for charity, Duc and his friends rode 22.6 miles in a bike event. As a group, they had a total of $1,000 pledged for each mile they rode. How much money did Duc and his friends raise?
   [A] $226  
   [B] $2,260,000  
   [C] $22,600  
   [D] $226,000

51.  
   \[
   1,000 \times 4.9 
   \]
   [A] 490  
   [B] 4,9000  
   [C] 4,900  
   [D] 49

52.  
   \[
   100 \times 2.7 
   \]
   [A] 2.700  
   [B] 2,700  
   [C] 27  
   [D] 270

53. Use the number line to find \( 6 \div \frac{2}{3} \)
   
   \[
   \frac{2}{3}
   
   0 \quad 1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6
   
   [A] 4  
   [B] \( \frac{1}{9} \)  
   [C] \( \frac{8}{3} \)  
   [D] 9

54. At work, Nico got a raise of $0.75 per hour. He plans to put the money from the raise toward a summer trip. After 1,000 hours, how much money will Nico have put toward the trip?
   [A] $75.00  
   [B] $7.50  
   [C] $750.00  
   [D] $1,000.75

Sample practice assignment  (Renaissance Learning, 2011, p 149)
Each teacher was given the following questionnaire to quantify the amount of time spent on the AM program.

**Teacher Survey**

Directions: Please answer each question as accurately as possible.

1. Have you been trained by the school on the Renaissance Learning’s STAR Math Test and Accelerated Math programs?

2. Do you use the Accelerated Math program during your class instructional period?

3. How long is your math period?

4. On average, how many minutes do you devote to Accelerated Math? Please complete the following chart:

<table>
<thead>
<tr>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Total Minutes per week</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. How many objectives do you require your students to master per week?

   Do you require different numbers of objectives for students based on their ability?

   If so, how do you determine that?
Achievement Gap Pretest and Posttest Scores by Teacher

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Pretest</th>
<th>Posttest</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>657</td>
<td>355</td>
<td>302</td>
</tr>
<tr>
<td>2</td>
<td>554</td>
<td>157</td>
<td>397</td>
</tr>
<tr>
<td>3</td>
<td>658</td>
<td>390</td>
<td>268</td>
</tr>
<tr>
<td>4</td>
<td>552</td>
<td>261</td>
<td>291</td>
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<td>5</td>
<td>544</td>
<td>157</td>
<td>387</td>
</tr>
<tr>
<td>6</td>
<td>773</td>
<td>451</td>
<td>322</td>
</tr>
<tr>
<td>7</td>
<td>758</td>
<td>507</td>
<td>251</td>
</tr>
<tr>
<td>8</td>
<td>808</td>
<td>475</td>
<td>333</td>
</tr>
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<td>9</td>
<td>807</td>
<td>558</td>
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<td>786</td>
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<td>440</td>
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<td>812</td>
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<td>506</td>
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<tr>
<td>15</td>
<td>659</td>
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<td>583</td>
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<td>565</td>
<td>287</td>
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<td>894</td>
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<td>264</td>
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<td>577</td>
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<td>748</td>
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<td>21</td>
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<td>574</td>
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<td>22</td>
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