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A STUDY ABOUT THE EFFECTIVENESS OF THE *ROCKET MATH* PROGRAM TO ACHIEVE MULTIPLICATION FACTS (0-9) FLUENCY, AUTOMATICITY, AND MASTERY

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ABSTRACT

The purpose of this study was to examine if the *Rocket Math: Mastering Math Facts* instructional program (Crawford, 2003) was effective to produce high student growth in multiplication fact (0-9) fluency, automaticity, and mastery for 37 fourth grade students at a medium-sized suburban/rural school district in the Midwest during the 2011/2012 academic year. The research included findings that answered the question: Is there a difference in student mean scores between pre and post student test scores? The data was also analyzed to establish student growth and mastery of multiplication facts. The research was conducted using three-minute timed pre and post- tests of multiplication facts from 0-9. From the data collected, a t-test was completed to compare student growth in multiplication facts (0-9). The findings were analyzed through Microsoft Excel and A Statistical Program (ASP) software. Findings indicated that there was a significant difference between pre and post-test scores. Additionally, analysis revealed that all 37 students in the study demonstrated growth, although at varying percentages, while 11 students or 30% achieved moderate to high mastery. As a result of these findings, the *Rocket Math* program was recommended to be continued in future instructional practices. Furthermore, additional supplemental instructional strategies were recommended to increase the percentage of students who will achieve multiplication fluency, automaticity, and mastery by the end of the fourth grade.

INTRODUCTION

Background, Issues, and Concerns

The study about the effectiveness of the *Rocket Math* program to achieve multiplication facts (0-9) fluency, automaticity, and mastery was conducted in a medium-sized urban/rural elementary school in the Midwest during the 2011/2012 academic year. In 2011, according to the Missouri Department of Elementary and Secondary Education (DESE) website, the district population served 4,742 total students, kindergarten through 12^{th} grade. The elementary school where the study was conducted served 366 students in kindergarten through fourth grade. The free or reduced lunch rate in 2011 for the elementary school was 40.9% with a 95.5% attendance rate (DESE, 2011).

The 2011 school statistics on the DESE website reported that the school's Missouri Assessment Program (MAP) mathematics scores for the 78 fourth grade students in the school were 53.9% proficient and advanced. In 2011, the MAP mathematics scores for the district's fourth grade students was 54.7% proficient and advanced while 50.8% of the overall fourth graders in Missouri scored proficient or advanced. The MAP is a standardized assessment in the State of Missouri that is tied to fulfilling the No Child Left Behind (NCLB) requirements.

DESE (2011) reported that the school achieved Adequate Yearly Progress (AYP) in 2011 based on achievement in mathematics and communication arts MAP scores. Historically, the school was listed with a school-in-improvement status in 2009 and in 2010. In 2011, the school achieved AYP and was no longer listed as a school-in-improvement.

Students in the school were introduced to multiplication facts in the third grade and were expected to master their multiplication facts (0-12) by the end of fourth grade to satisfy the Grade Level Expectations (GLE's) in the State of Missouri. Some students in the school received multiplication concept instruction in second grade if they performed at a high level. An expectation of the teachers was for the students to perform multiplication facts fluency, automaticity, and mastery in the fourth grade in order to achieve at a proficient or advanced level on the district common assessments and on the MAP. Moreover, students were expected to master their multiplication facts of 0-12 by the end of fourth grade in order to perform more complex problem solving such as fractions, functions, and other computations at the middle and high school grades.

To help students achieve the mathematics objectives in fourth grade and to prepare them for mathematics in future grades, effective multiplication facts instruction was deemed necessary. In the 2009/2010 academic year, the principal purchased the *Rocket Math Mastering Math Facts* program by Donald B. Crawford (2003) in order to provide teachers with structured instruction to achieve building and district goals, plus achieve AYP on the MAP. Furthermore, teachers were expected to provide other supplemental instructional practices in addition to Rocket Math which included multiplication fact strategy instruction. This rationale ultimately led the researcher to examine the effectiveness of the *Rocket Math* program in order to achieve student, building, and district goals. The results of this study provided insights into the teaching practices in the classroom and may impact future instructional practices.

Rocket Math was a structural instructional program for sequential practice of math facts including addition, subtraction, multiplication, and division. For the purpose of this study, only the multiplication fact component of *Rocket Math* was researched. The study group selected was 37 fourth grade students who were taught mathematics in a departmentalized setting from one classroom teacher who was part of a two-teacher team.

During the study period from August 2011 to May 2012, the school had four, fourth grade classrooms which were organized in a departmentalized structure. The four teachers were divided into two teams with a total of two teachers who were responsible for mathematics instruction while the other two teachers handled the communication arts instruction. Each team divided their students according to reading level which resulted in a high reading group and a low reading group. The groups were not divided according to mathematical ability levels except during small group differentiated instruction in the classroom. The researcher taught mathematics to the high reading group for 120 minutes in the morning and then taught mathematics to the low reading group for 120 minutes in the afternoon. The 2011/2012 academic year was the first time that a departmentalized structure was used in fourth grade in the school. Science and social studies instruction was a shared responsibility among the four teachers and were expected to be integrated within math and communication arts. This differed from the previous self-contained structure where each teacher taught both mathematics and communication arts.

For the two consecutive years prior to the study period, beginning in the 2009/2010 academic year, teachers from first grade through fourth grade were provided with training and expected from the building principal and district curriculum administration to follow the *Rocket Math* program with fidelity. This included using the program daily in the classroom, following the teacher's manual exactly, and adhering to the daily timings of exactly one minute. The researcher noted that not all teachers in the building used a one-minute time limit for the daily timings which was inconsistent with the teacher's manual and direction from the principal.

Correspondence from the principal was sent home to parents to introduce the program and reinforce practicing facts at home. The researcher also corresponded to parents through a weekly newsletter, meetings, phone calls, and parent/teacher conferences. This communication asked for support of *Rocket Math* and encouraged parents to help their children practice math facts at home. This method of communication continued prior to and during the study.

According to the *Rocket Math* website (Crawford, 2012), the program was a structured curriculum for the sequential practice and mastery of math facts. *Rocket Math* provided instruction for the facts of 0, 1, 2, 4, 5, 6, 7, 8, and 9, but not the facts of 10, 11, and 12. Operations were learned as sets in the sequence of addition, subtraction, multiplication, and division. The *Rocket Math* website (Crawford, 2012) further explained that students learned two facts and their reverses on each worksheet in a carefully controlled sequence which enabled mastery at an individualized pace. Students practiced orally with a partner every day for about four minutes. One-minute paper and pencil timings of 40 problems occurred immediately following daily practice and were immediately assessed.

Moreover, the *Rocket Math* website (Crawford, 2012) reported that the program taught no more than two new facts and their reverses on each practice page (Appendix C). For more difficult facts, the pace was slower by adding only one fact on a page. The program provided differentiated instruction for students of various ability levels. Students worked at their own pace with some students passing a level in one day while others took several days to pass one level.

At the beginning of the school year, teachers in the school modeled to their students how to practice the daily *Rocket Math* facts. Students were given a pocket folder containing the materials (Appendix E, F, G, and H). Students worked with a partner, designated by the teacher, with the practice sheet (Appendix C) in front of them. The problems for practice were in rows at the top half of the page and did not have the answers written on the sheet. As stated on the *Rocket Math* website (2012), the procedure and sequence for practice was as follows:

1. "The learner read each fact (not just the answer) aloud and said the answer.
2. The other student, the 'checker' had the answer key and listened for a hesitation or an error on one of the facts. That is a fact that needed extra practice. So the checker:
3. Told the answer and then,
4. Asked the learner to repeat the problem and the answer three times.
5. Asked the learner to back up three problems and begin again.
6. Students practiced on the top half of the page as many times as they could in the three minutes allotted for practice" (Crawford, 2012, p. 2).

After practicing each day, the students took a one-minute test that was on the bottom of each practice sheet (Appendix C). This test gave students an opportunity daily to show that they learned a set of facts by writing answers as fast as they could write. If students passed the test (the passing criterion was based on the writing speed test on Appendix B), they moved on to the next sheet in the sequence. The students in the researcher's classroom would grade their own daily test with the answer key (Appendix G) while the teacher walked around to monitor and correct student accuracy.

After completion of the daily timing, the students had a short, private conference with the teacher to discuss if they passed or needed more practice because they did not achieve their daily goal. While these conferences occurred, the teacher also checked for accuracy of student grading. This was also the time the student received the next sequence of facts (if passed) or the same set of facts (if needed to practice again). The teacher did not use the word "failed," but instead said "practice" if the students did not pass. This was the procedure used in the researcher's classroom and not necessarily in the other classrooms.

Once students passed a set of facts, they colored in the letter for that set on their *Rocket Chart* (Appendix E) and then moved onto the next practice page. Students who passed were asked to stand up and give a cheer. If students did not pass their daily *Rocket Math* assessment, they were asked to take home their daily practice sheet (Appendix C) and practice with their parents or an older relative. When students passed each operation (addition, subtraction, multiplication, or division), their names would be announced and recognized over the intercom at the end of the school day. During the study, students' names were also placed for recognition on a school-wide bulletin board with student-identified paper rockets showing which operations they passed.

Once a week on Friday, students took a two-minute progress monitoring test of all the facts in the operation that they were practicing (Appendix D). There were 10 total sets of the multiplication facts with 80 questions each. Each student graphed their results on an individual graph (Appendix F) to self-monitor their progress about their fluency of the math facts on multiplication. This graph (Appendix F) was used to demonstrate student learning, for student self-assessment, and for teacher evaluation. The researcher supplemented this activity by having the students play a game to correct their tests.

Materials and suggested methods of student self-assessment and monitoring were included with the *Rocket Math* teacher's manual. At the beginning of the academic school year, students completed the *How Fast Can You Write?* (Appendix B) assessment. The results of this assessment determined the initial daily and weekly goals. Next, the student completed a *Goal Setting Sheet: Standard One-Minute Timing* (Appendix I) based on how fast they could write in one minute. In the fourth grade, the operation of addition was done first and then subtraction. At the beginning of the second quarter, all students whether on addition or subtraction would stop and move onto multiplication. After multiplication was passed, the students would proceed to division and then go back to subtraction. This sequence was not recommended in the manual, but instead was the decision of the district's instructional curriculum facilitator and building principal.

According to the *Rocket Math* teacher's manual, the "student's goal was always to meet or beat his or hers previous best score" (Crawford, 2003, p. 7). The student's goals increased from the initial level as they beat their goals and improved on actual timings. For example, a student may have begun with a goal of 36 correct for the one-minute timing. If the student on a subsequent assessment scored more than 36 correct facts during the one-minute timing (for example, 38), the higher number scored would be the new goal. Therefore, in all upcoming timings the student must answer 38 or more to pass the timing.

If students did not pass a set of facts after six tries, the teacher would try a variety of interventions. Some of the interventions that the manual (Crawford, 2003) suggested were: 1) Model and reteach how to practice, 2) Watch for off-task behavior during timings, 3) Practice with the student and provide feedback, 4) Increase motivation, and 5) Consider having students go back a few levels so that they can pass with success. The researcher used these interventions except for moving back levels because it was observed that students demonstrated math anxiety, less engagement, and motivation when they were moved back levels. Instead, the researcher used manipulatives and other strategies including practicing with the answers first before practicing without answers.

The *Rocket Math* program made the following claims on their website:

- "You can expect results!
- ALL OF YOUR STUDENTS who are expected to move into higher levels of math CAN LEARN MATH FACTS TO AUTOMATICITY (instantly without hesitation).
- When *Rocket Math* is taught with fidelity to the curriculum, students learn one operation of facts to automaticity per semester.
- Students who have mastered math facts show marked improvement in higher order math algorithms including fractions, word problems, long division, multi-digit multiplication, and a host of other areas.
- Even pre-algebra and algebra students find coursework much easier when they successfully complete *Rocket Math* to learn math facts to automaticity.
- TALK TO YOUR COLLEAGUES! Word-of-mouth recommendations from teachers who have experienced successful student outcomes with *Rocket Math* are responsible for the widespread use of the curriculum throughout North America" (Crawford, 2012, p. 6).

The researcher examined the above claims from the *Rocket Math* program during the study and addressed these claims in the literature review and findings section of this study. Concerns during the study were: 1) Did the *Rocket Math* program perform as Crawford (2003) claimed to help students increase fluency, automaticity, and mastery? 2) What were the best practice instructional strategies to teach multiplication facts? 4) Were all students engaged and motivated by *Rocket Math*? and 5) Is *Rocket Math* the best research-based program for teaching multiplication facts for the demographics of the student population of the school?

An additional concern investigated in this study was the claim from the *Rocket Math* website (Crawford, 2012) that this program was a research-based instructional program. Only one professionally-published research study was found about *Rocket Math* (Smith, Marchand-Martella, & Martella, 2001) and was addressed in the literature review section. The study provided on the website, "The third stage of learning multiplication facts: Developing automaticity" by Crawford did not state a published date or a place where Crawford's study was published. The researcher looked through search engines for professional journals (EPSCO Host) and the internet (Google) and could not find any publication in a magazine, book, or professional journal. Moreover, the following statement was listed on the *Rocket Math* website which caused concern:

> "NOTE: While we are waiting for others to conduct and publish research on *Rocket Math*, we make the following offer. If you conduct research comparing *Rocket Math* to some other method of practicing math facts and share your results, we will refund half of the purchase price of the curriculum. If you find some other method is more effective, we will refund 100% of your purchase price. We are certain it is the best math facts practice curriculum available, but we have to wait

for researchers independent of us to confirm that fact" (Crawford, 2012, p. 7).

Practice under Investigation

The practice under investigation is how best to instruct fourth grade students to increase their multiplication facts fluency, automaticity, and mastery.

School Policy to be Informed by the Study

Student growth and achievement in multiplication fact fluency, automaticity, and mastery was important for the students and school on several levels. In order for the United States to compete in the global marketplace, mathematical skills needed to be improved. Manzo & Galley (2003) reported that less than one-third (31%) of fourth grade students in the United States scored at or above the proficiency standard on the 2003 National Assessment of Educational Progress in mathematics (as cited in Burns, 2005). At the national and state levels, proficiency in math is necessary to fulfill the requirements of NCLB.

The desire for high mathematics achievement then reached the district level where each school in the district needed to achieve AYP by performing well on the MAP and achieve accreditation from DESE. Specific GLE's, the MAP tested multiplication fact fluency, automaticity, and mastery. The performance of mathematical skills on district common assessments served as progress monitoring at the district and at the school levels to predict MAP performance plus adjust the curriculum units and pacing guides for teachers. Moreover, this data determined daily instructional practices.

The larger issue of the expectation of mathematical proficiency trickled down next to the school level in the researcher's district where specific instruction and strategies were required in the classrooms to meet School Improvement Plan (SIP) goals.

The principal, teachers, and other school support staff were held accountable for the success of their students to be proficient in mathematics in order to reach goals on the MAP. Multiplication facts 0-12 were one of the GLE's that teachers were required to teach and students were expected to master by the end of fourth grade. According to the DESE website (2012), fourth grade students were expected to demonstrate fluency with basic number relationships (12 X 12) of multiplication and related division facts.

Effective, research-based instruction about multiplication facts was needed in order for teachers to help students become successful. The *Rocket Math* program had been used in the school for the previous two years and was generally well-received by students, teachers, parents, and the administration. Nevertheless, *Rocket Math,* compared to any instruction used with students required data, analysis, and reflection to provide teachers with feedback in order provide the most effective instructional practices. In the researcher's opinion, the common saying, "We've done things this way for a long time, and we are not going to change," does not hold true in the age of educational accountability. This research study was important to examine if *Rocket Math* was the best research-based instruction to achieve national, state, and local standards, plus provide the students with mathematical skills to help them achieve in school and in life.

Conceptual Underpinning

The theoretical framework for this study of the *Rocket Math* program was based on separate, but related key principles and best practices derived from the: 1) Mathematical standards and curriculum focal points from the National Council of Teachers of Mathematics (NCTM, 2012) and DESE (2012) which are aligned with NCLB and 2) Instructional strategies of Robert J. Marzano (2001). The NCTM and

DESE were chosen because of the mathematical standards, principles, and focal points that these associations set forth as guidelines about what and how to teach multiplication. Marzano was chosen due to his extensive research about the best instructional practices that are widely used in classrooms today and were recognized in the researcher's district as best practices. Definitions of multiplication fact fluency, automaticity, and mastery were necessary due to their specific connections to this study. The current research and best instructional practices for these multiplication skills related to the study followed in the literature review section.

Computational fluency was defined by the NCTM website (2012) as "having efficient and accurate methods for computing. Students exhibited computational fluency when they demonstrated flexibility in the computational methods they choose, understood and explained these methods, and produced accurate answers efficiently" (NCTM, 2012, p. 1). Miller & Mercer's study (1997) stated that the NCTM (2000) listed fluent computation as a goal for mathematics instruction, and failure to rapidly recall basic facts was a characteristic often associated with mathematics disabilities (as cited in Burns, 2005). Burns (2005) also referenced the research of Lerner (2003) that in order to be fluent, students should be able to automatically compute mathematical facts. When students exhibited fluency, they demonstrated rapid recall, efficiency, and accuracy.

The definition of automaticity referred to the ease and quickness of recalling multiplication facts. The study by Jensen & Wang (1994) characterized automatic processing of multiplication facts as those not requiring full attention and those which are basically effortless. Automatic processing allows students to deal with relatively large amounts of information and perform operations simultaneously. Jenson & Wang (1994) cited Zutaut's (2002) study that when arithmetic facts are automatically retrieved, they interfere less with working memory. Woodward (2006) reported that information-processing theory supports the view that automaticity in math facts is fundamental to success in many areas of higher mathematics. Woodward (2006) declared that without the ability to retrieve facts directly or automatically, students experienced processing difficulties when they performed complex tasks. These research studies concluded that students who demonstrated automaticity with multiplication facts performed with ease, quickness, and accuracy. Frustrated students who paused to retrieve facts and/or counts on their fingers would not demonstrate automaticity and were slow processors.

The definition of mastery was a full understanding of the concepts and accurate demonstration of the skill. Lee, Stansberry, Kubina, & Wannarka provided an analogy of mastery from Wu (1999): "Practicing and mastering the fundamental components of a skill is a time-tested routine universal in the world of sports. Other skilled performances such as playing a musical instrument also require a student to firmly grasp the basics before attempting more challenging pieces. Mathematics is no different. For example, before applying a mathematical algorithm for solving a complex problem like 234 × 23, a student must master basic multiplication facts" (Lee, Stansberry, Kubina, & Wannarka , 2005, p. 267). In response to this analogy, mastery required extensive practice in sequential steps before achievement of higher levels of performance occurred.

The definitions of multiplication fluency, automaticity, and mastery were related to the district objectives and Missouri GLEs which were based on the standards of mathematics provided by the NCTM. As stated on the NCTM website (2012) a major goal in the early grades, prekindergarten through grade five, was the development of computational fluency with whole numbers. NCTM's statement on their website was "Fluency refers to having efficient, accurate, and generalizable methods (or algorithms) for computing that are based on well understood properties and number relationships. Some of these methods are performed mentally, and others are carried out using paper and pencil to facilitate the recording of thinking" (NCTM, 2012, p. 1). In relation to *Rocket Math*, peers practiced multiplication facts orally without pencil and paper first, and then proceeded to record their thinking with a timed-practice assessment.

Furthermore, the NCTM on their website provided national standards and curriculum focal points relating to specific standards. The standards for grade four related to multiplication were as follows:

"Understand meanings of operations and how they relate to one another

Grades 3–5 Expectations: In grades 3–5 all students should:

- understand various meanings of multiplication and division
- understand the effects of multiplying and dividing whole numbers.

Compute fluently and make reasonable estimates

Grades 3–5 Expectations: In grades 3–5 all students should:

- develop fluency with basic number combinations for multiplication and division and use these combinations to mentally compute related problems, such as 30 × 50;
- develop fluency in adding, subtracting, multiplying, and dividing whole numbers" (NCTM, 2012, p. 1).

The fluency activities used in the *Rocket Math* program displayed both similarities and differences to the standards defined on the NCTM (2012) website. With

Rocket Math, students were developing multiplication fluency with whole numbers which was similar to the NCTM standards. Conversely, the *Rocket Math* program did not include activities that explored "understanding meanings of multiplication and mentally compute related problems" that was listed as a NCTM standard.

According to the NCTM website, the curriculum focal point was as follows: "For grade four, the quick recall of multiplication facts and fluency with efficient procedures, including the standard algorithm, is a focus. Most important is that fluency emerges through understanding of the multiplication process—how multiplication is represented, how properties are used when multiplying, etc. Students become fluent through their understanding of efficient procedures that include the standard algorithm" (NCTM, 2012, p. 1). These NCTM standards and focal point were associated with the *Rocket Math* program where students learned to develop quick recall of multiplication facts and developed multiplication fluency. On the other hand, the NCTM standard of "understanding the meanings of operations and how they directly related to each other" was not referred to in the *Rocket Math* program.

The NCTM established the standards of math instruction, but the question remained about what and how was the best way to teach mathematics. According to the NCTM website: **"**NCTM purposely does not endorse any mathematics curriculum, textbook, or instructional program. There is no one way to teach mathematics. Nor is there only one textbook or program that should be used. However, there are certain prerequisites that teaching materials must meet if they are to move students closer to realizing the goals of the *Standards*. The sequence, timing, developmental appropriateness, and complexity of mathematical tasks described in these materials have a direct impact on the quality of the mathematical content students receive. To evaluate the mathematical content in instructional materials, we should ask the following questions:

- Do the teaching materials ask students to perform at high cognitive levels?
- Do the materials help teachers understand the content for themselves and foster a better understanding of the teaching and learning of mathematics?
- Do the materials integrate assessment into the teaching and learning process?" (NCTM, 2012 , p.1).

In response to the above position about instructional materials from the NCTM (2012) website, there are elements about *Rocket Math* that align with the NCTM's position and others that are contradictory. The *Rocket Math* program did integrate assessment and helped students foster a better understanding the multiplication facts. However, *Rocket Math* did not ask students to perform at high cognitive levels nor fostered a better understanding about the concept of multiplication. Additionally, NCTM's position did not endorse any one program, including *Rocket Math*.

On the website, the DESE (2012) GLEs for multiplication were similar and more specific for fourth grade students in Missouri. The DESE's (2012) objectives related to number and operations were:

- "Compute fluently and make reasonable estimates.
- Develop and demonstrate fluency.
- Demonstrate fluency with basic number relationships (12 X 12) of multiplication and related division facts" (DESE, 2012, p. 1).

The district where this research study occurred adopted the GLE's as a standard for student learning. In the researcher's classroom, the students were expected to demonstrate multiplication fluency of the facts 0-12 by the end of the fourth grade. Since the *Rocket Math* program only taught multiplication facts 0-9, the teachers in the school were expected to provide supplemental instruction for facts 10-12.

Additionally, the instructional strategies of Marzano (2001) provided the principles related to research-based best instructional practices used in this study. The following strategies of Marzano were closely related to several of the components of the *Rocket Math* program. It should be noted that neither Marzano nor the *Rocket Math* program referenced one another in sources found by the researcher. The following similarities from the principles of Marzano (2001) connected to the *Rocket Math* programs were solely related by the researcher.

1) "Have students identify their own learning goals" (Marzano, 2001, p. 23). Marzano (2001) asserted that goal setting was the process of establishing a direction for learning and a skill that successful people used to help them master both short-term and long-term desires. Research demonstrated by Marzano (2001) indicated that setting goals and objectives and providing feedback had a percentile gain of 23. In the *Rocket Math* program, students identified their multiplication fluency goal of how many problems they completed in one and two minutes based on initially how fast they could write. If students reached and exceeded their timing goal, they identified a new, higher goal. This aligned with Marzano's principle of identification of learning goals.

2) "Have student's chart their progress on each learning goal" (Marzano, 2001, p. 25). Marzano (2001) suggested that one useful activity was to have students chart their

own scores for each learning goal on a visual representation that would keep track of their progress. Furthermore, Marzano (2001) claimed that when students charted their own progress, this allowed for powerful conversations about learning goals between the teacher and students. Marzano's instructional strategy was similar to the *Rocket Math* program where students charted their progress and reflected about their progress with the teacher. During the study, the teacher conferenced daily with students about their progress and goals. These discussions were also used with parent correspondence.

Marzano's research (2001) regarding the effectiveness of student feedback was substantiated with research from other sources that were cited in Marzano's studies. Trammel, Schloss, & Alper (1994) indicated that students could effectively monitor their own progress. Lindsley (1972) stated that commonly, this took the form of students' simply keeping track of their performance as learning occurs. For example, students might keep a chart of their accuracy, their speed, or both while learning a new skill. Marzano (2001) contended that the research results for corrective feedback were a 20 percentile gain of 20 of repeat until correct. The *Rocket Math* program offered corrective feedback with peer tutors and student progress monitoring on charts while the students learned multiplication skills.

3) "Recognize and celebrate growth" (Marzano, 2001, p. 26). Marzano (2001) recommended that knowledge gain for each student should be recognized and celebrated in the classroom. Marzano (2001) believed that focusing on knowledge gain, as demonstrated by formative assessments, provided a powerful way to recognize and celebrate, as opposed to reward, success because it allowed students to see their progress over time. Reinforcing effort and providing recognition resulted in a percentile gain of 29

(Marzano, 2001). Furthermore, Marzano (2011) referenced a study by Wiersma (1992) that suggested that providing rewards for the successful attainment of specific performance goals enhanced intrinsic motivation with a percentile gain of 13 for performance. Marzano's principles were reflected in the *Rocket Math* program where students were recognized, celebrated, and reinforced for their efforts and progress through daily formative assessments. The recognition and celebrations in the classroom included daily verbal congratulations from the teacher when *Rocket Math* levels were passed. This extended to school-wide recognitions and celebrations on the *Rocket Math* bulletin board and daily school-wide announcements.

4) "Initially provide structured practices sessions spaced closely together that help develop fluency" (Marzano, 2001, p. 80-81). According to Marzano (2001), structured meant that the practice tasks demonstrated high-quality examples and were addressed and discussed in such a way so students experienced a high rate of success during the practice sessions. Moreover, Marzano contended that "if a procedure was necessary for students' future success in school or in life, enough practice must be provided for students to develop the procedure to a level of fluency" (Marzano, 2001, p. 81). In the *Rocket Math* program, the practice was done on a daily basis in order to develop fluency. As revealed in the literature section, multiplication fact fluency was deemed necessary for students' future success in performing higher-order mathematics.

While similarities existed between Marzano's principles and practices with the *Rocket Math* program, there were also contradictions. Marzano (2001) suggested that when practicing for fluency development, a fairly wide range of exercises should be utilized so students can experience different ways of performing the procedure. To the contrary, the *Rocket Math* practice used the same practice procedure daily except for Fridays when the students took the two-minute timing. Students were trained on one way how to practice the procedure and asked to adhere with fidelity to the method of practice. An additional opposing principle of Marzano to the *Rocket Math* program was Marzano's belief that "the teacher should consider accuracy and speed in these practice sessions along with the further shaping of the procedure" (Marzano, 2001, p. 81). Granted, the researcher considered the accuracy and speed in the *Rocket Math* practice sessions, but the procedure was established and could not be revised. The teacher was expected to adhere to the daily Rocket Math procedure with fidelity.

The theories and practices of the NCTM, DESE, and Robert J. Marzano provided the conceptual underpinning about the "why" and "how" of the *Rocket Math* program. In the researcher's opinion, teachers should understand mathematical concepts of multiplication fact fluency along with providing the best instructional strategies that will help students achieve success. Content knowledge and effective instructional strategies should be interwoven. If either content knowledge or instruction was weak, student achievement may have diminished. A more in-depth presentation and analysis of research-based instructional practices will be provided in the upcoming literature review section.

Statement of the Problem

There are students in fourth grade at the school who do not demonstrate fluency, automaticity, and mastery with multiplication facts with daily work, district common assessments, and the MAP. The research study addressed if the implementation of the *Rocket Math* program made a difference in increasing multiplication facts fluency, automaticity, and mastery for the facts of 0 to 9. The *Rocket Math* program had been used in the school preceding the study. However, there were no pre-test and post-test data plus analysis used to measure if the students mastered multiplication facts other than the *Rocket Math* student self-assessed daily and weekly timings. When students completed and passed each step of the A-W sequential steps of the multiplication program, they had been acknowledged in the school as those who had passed multiplication.

A problem was that once the students passed the multiplication sequence, they moved onto the division component. There was no additional assessment to discover if students retained their multiplication facts after completion of the multiplication *Rocket Math* component. Additionally, even if students did not master their addition facts by the end of the first quarter, they were still expected to start multiplication. The concept of multiplication was a scaffolding skill built upon understanding about addition. Students who did not master addition first were not provided with repeated addition which is the foundation of multiplication.

Purpose of Study

The purpose of the study was to determine if implementation of the *Rocket Math* program produced high student growth in fluency, automaticity, and mastery of the multiplication facts (0-9) for fourth grade students. Subsequently, the purpose of study also involved investigation of the amount of student growth and student achievement of multiplication mastery achieved by utilization of the *Rocket Math* program. Consequently, the purpose of the study extended to an evaluation of the *Rocket Math* program to determine if the program should be used for future instructional practices or if other multiplication instruction would prove to be more beneficial.

Research Question

RQ1: Is there a difference in student mean scores between the pre-test scores and the post-test scores of the multiplication facts (0-9) when the *Rocket Math* program is used in the classroom?

Null Hypotheses

H_{O1}. There is no difference in student mean scores between the pre-test scores and the post-test scores of multiplication facts (0-9) when the *Rocket Math* program is used in the classroom.

Anticipated Benefits of the Study

This study was anticipated to reinforce the continued use of the *Rocket Math* program in the 2012/2013 school academic year as best practices instruction and/or to recommend adjustments for multiplication facts instruction in order to increase student growth on district common assessments, on the MAP, and to meet AYP.

Definition of Terms

AYP: Adequate Yearly Progress

DESE: Missouri Department of Secondary and Elementary Education

GLE: Grade Level Expectations

MAP: Missouri Assessment Performance

NCLB: No Child Left Behind Act of 2001

NAEP: National Assessment of Educational Progress

NCTM: National Council of Teachers of Mathematics

SIP: School Improvement Plan

Summary

Rocket Math: Mastering Math Facts was studied in a fourth grade departmentalized classroom with 37 students at a Midwestern elementary school which was part of a medium-sized suburban/rural school district. To achieve MAP mathematics proficiency and make AYP in order to fulfill NCLB requirements, the district purchased the *Rocket Math* program. The school used *Rocket Math* to instruct students in mathematical fluency in addition, subtraction, multiplication, and division. For the study, only the multiplication component of the program was examined. Teachers were expected to follow the program with fidelity including the daily one-minute timings and weekly two-minute timings. This research investigated with a pre-test and post-test if student growth and mastery in multiplication facts (0-9) was shown during the academic year of 2011/2012. Moreover, the research examined if *Rocket Math* was the best instructional practice in order to help students achieve multiplication fluency, automaticity, and mastery.

REVIEW OF LITERATURE

Teachers in elementary classrooms today have often encountered the daunting challenge of how best to help students become mathematically fluent with automaticity in order to master their multiplication facts, otherwise known as the times tables. In the current climate of high-stakes standardized tests, school accreditation tied to test results, and meeting the requirements of NCLB, competence in mathematics and specifically, multiplication fluency, became crucial to help students develop the expertise needed to perform at a proficient or advanced level on standardized tests. Moreover, mastery of the multiplication tables served as a foundation for higher-order mathematics that will enable students to successfully compete in the United States workforce and in the world. This review of literature was tied to the research question in this study about how best to produce high student growth in multiplication fact fluency, automaticity, and mastery.

There stands little disagreement in the educational community about the central role and importance of mathematical competency in schools to help students in their daily lives now and in their future role as workers. This affirmation was supported by several sources including Hanushek & Kimko (2000) who reported that mathematics was one of the primary academic subjects in a public school curriculum and how students later perform mathematically affects labor quality and national growth (as cited in Linn & Kubina, 2005). Additionally, Ramos-Christian, Schleser, & Varn (2008) noted that competence in mathematics was a crucial goal for early schooling and directly affected the demands of formal schooling, daily activities, employment, labor quality, and national growth (as cited in Smith, Marchand-Martella & Martella, 2011). Furthermore, Smith, Marchand-Martella & Martella (2011) declared that proficiency in arithmetic contributes to students' academic and professional advancement. The competence of students in mathematics today has a direct effect on their future success in school, in life, and on a larger scale, in our nation and world.

This pivotal role of mathematical expertise in the lives of students also extended to the importance of multiplication fluency which was the focus of this study. The literature revealed little controversy about the influential role that multiplication fluency had on mathematical competency. French remarked, "Knowing multiplication tables by heart is an important requirement for success in mathematics and effective ways of learning them should be a key component of any policy for improving standards of numeracy" (French, 2005, p. 8). Whereas Silben, Camine, & Stein (1981) found that the mastery of basic facts was critical if students were to develop fluency in working mathematical problems. To be successful in mathematics problem solving, students needed to demonstrate math facts fluency.

In spite of the common and key goal for students to achieve multiplication fluency, not all students will achieve fluency or the ultimate goal of mastery. Agreement existed among the authors that a prevalent problem in schools today was that many students (specific to this study, fourth graders) do not know their basic math facts and struggle with learning them. Zutaut (2002) declared that the crucial mastery of the basic multiplication facts was not automatic or easy for fourth grade students who often struggled to quickly retrieve facts. Manzo & Galley (2003) reported in Burns (2005) that less than one-third (31%) of fourth grade students in the United States scored at or above the proficiency standard on the 2003 National Assessment of Educational Progress in mathematics. Therefore, the majority of fourth grade students have not shown mastery.

The challenge of mastering multiplication facts in fourth grade can extend to low mathematics achievement in subsequent grades in which multiplication skills are essential for solving fractions, equations, algebra, and higher-order problem solving. Zutaut (2002) noted a study from Campbell & Graham (1985) that found that even after four years of multiplication practice, fifth graders still made errors on at least 12.5% of the trial problems. Moreover, Paulos (1988) noted that “the formal educational system seemed increasingly unsuccessful at educating students to an adequate level of ‘numeracy,’ the mathematical equivalent of literacy” (as cited in Ashcraft, 2002, p. 181). In light of these findings, many fourth grade students who do not know their multiplication facts may be set on a course for failure unless they can overcome their challenges. For special needs students, the problem can become even more intensified and long lasting without intervention that uses effective instructional practices.

In light of the problems in modern-day mathematics education including low student achievement with math facts fluency, an understanding about the history of mathematics education in the United States was necessary. The literature revealed that there have been many changes in the ways that mathematics teachers have instructed students, and there existed oppositional viewpoints about what constituted the best instructional practices. As stated by Haught, Kunce, Pratt, Werneske, & Zemel (2002), mathematics education had been undergoing changes since the 1950’s. The decade of the 1960’s promoted the “new math” and the decade of the 1970’s was the “back to basics” movement. In 1989, the NCTM produced a set of standards for school mathematics in grades K-12 that recommended increased emphasis on using manipulatives and technology while decreasing emphasis on rote memorization. Consequently, Chung

(2004) reported that the NCTM Standards for School Mathematics (NCTM, 2000) advocated that mathematics learning in grades three through five must foster more than students' abilities to make sense of mathematics, which should enhance their problem solving abilities. After the publication of the NCTM standards in 2000, there was criticism that the teaching of mathematics emphasized concept formation over practiced skills. An analogy of a pendulum that swings back and forth was made by the researcher to describe these changes in mathematics education.

Furthermore, this examination of educational history in mathematics involved seeking answers about what instructional practices have been used and the effectiveness of these practices. The review of literature provided three predominant and sometimes, oppositional viewpoints about the best way to learn multiplication facts: 1) Timed-practice drills 2) Concept formation, and 3) An integrated approach using timed-practice drills and strategies tied to concept formation. Each of these positions was examined through the literature review to determine which of these three approaches provided the best research-based approach to achieving the goal of multiplication fluency, automaticity, and mastery. Within the literature examined, there were conflicting opinions about the effectiveness of timed-practice drills and concept formation. The integrated approach appeared to gain the most favorable response from scholars.

The first approach to teach multiplication facts, timed-practice drills, was supported by advocates of traditional-based mathematics instruction. Geist (2010) claimed that mathematics in many classrooms was based on a traditional skills-based model. Smith & Smith (2006) noted that many parents and teachers continued to consider memorizing basic facts as the hallmark and primary goal of school mathematics. Students were expected to learn and memorize their multiplication tables. The expectations about students knowing their facts fluently related to the DESE (2012) objective of developing fluency with the facts of 0-12.

Before analyzing the positive and negative aspects of timed-practice drills, there needed to be a discussion about rote memorization which differed from timed-practice drills but was sometimes viewed as the same practice. On the Multiplication.com website (2007), rote memory was defined as "repeating a concept or idea either orally or written out until students remember it" (as cited in Caron, 2007, p. 279). A survey on the Muliplication.com website (2007) found that 70% of the teachers surveyed felt that rote memory worked well for most students although rote memorization is "one of the least effective ways of memorizing and takes a great deal of time and effort on part of the learner" (as cited in Caron, 2007, p. 279). The literature revealed that rote memorization was not believed to be a best instructional practice even though the practice was widely used in schools today.

The critics of rote memorization argued in agreement that students are simply memorizing the answers but not understanding the concept of multiplication. Geist (2010) reported a study from Cates & Rhymer (2003) who claimed that students were only using memorization and rote recitation skills instead of active concept-based learning. Cornell's (1999) findings concurred with the other studies: "Rote memorization exercises should be de-emphasized. Student's dependence on rote memorization should be viewed as a possible sign of gaps in understanding" (as cited in Geist, 2010, p. 35). In the current school climate that promotes differentiated instruction, rote memorization does not adapt to the needs of students with specific learning styles and needs. Boaler

(1997) declared: “Rote memorization is worse. It is often taught as if all the students are not just similar, but identical in terms of ability, preferred learning style, and pace of working (as cited in Geist, 2010, p.25). Predominately, there was not support in the educational community for rote memorization due to the lack of concept knowledge, provisions for individual student needs, and support of long-term retention.

Even though timed-practice drills had the element of quick recall of facts in common with rote memorization, the approaches were different. There was mixed agreement among educational authorities about the effectiveness of timed-practice drills. The positive opinion of timed-practice drills was supported by several researchers. Caron (2007) noted the research of Hasselbring, Goin, & Bransford (1988) who claimed that automatic recall was best developed through drill and practice. Additionally, Burns (2005) cited the findings of Cohen, Servan-Schreiber, & McCelland (1992) who reported that increasing the speed through practice improved performance, and Chase & Symonds (1992) who asserted that an increase in the amount of drill and practice was often considered to be the most effective approach to improve learning.

Furthermore, Burns (2005) declared that timed-practice drills with incremental rehearsal was an effective method to increase the number of new mathematics facts retained. Incremental rehearsal was defined as practicing and acquiring new information in each practice session in sequential steps. In support of these claims, Burns (2005) explained that some children may lack prerequisite skills for higher-order tasks. They must first master the basic information before movement to higher levels especially since mathematics was hierarchical learning. Burn’s (2005) research discovered that third-grade children identified as learning disabled increased their fluency of multiplication facts with incremental rehearsal. Cooke & Reichard (1996) discussed the findings of Britt & Feldmen, 1982; Hasselbring et al., 1988; Koegel & Keogel, 1986 who found that the planned acquisition of unknown items with the maintenance of known items during drill and practice increased the rate of mastery over drill of all unknown items. This research was relevant to the support of *Rocket Math* since this instructional program used a mix of known and unknown math facts during timed-practice drills.

The effect of the *Rocket Math* program with a student at risk for school failure was researched by Smith, Marchand-Martella, & Martella (2001). This was the only published study found in the literature review that directly referenced the *Rocket Math* program. In the study, John, a student with Attention Deficit Hyperactivity Disorder, improved his mathematical fluency score with an average of 23.1 problems correct of out 40 problems. The results of this study showed that using a fluency-building program may be effective with individuals at-risk for school failure. However, it should be noted that John was a first-grade student who did *Rocket Math* addition, not *Rocket Math* multiplication which was the focus of this study.

Additionally, a similar program to *Rocket Math* called *Minute Math* that used timed-rehearsal drills was studied by Brookhart, Andolina, Zuza, & Furman (2004). The *Minute Math* project involved students who predicted and graphed their test scores on a weekly-timed test of the 0-9 multiplication facts. Students also reflected each week about their progress and the success of their studying and problem-solving strategies. Their study found that "student self-assessment was successful at turning the rote memorization task of learning the times tables into a deeper experience for students about monitoring their own mathematics learning" (Brookhart, Andolina, Zuza, & Furman, 2004, p. 213). *Minute Math* was similar to *Rocket Math* due to the self-assessment of students graphing their progress. Where the studies differed was that *Rocket Math* used timed-practice drills while *Minute Math* applied rote memorization.

In contrast, research was presented that opposed the effectiveness of timed-practice drills. Procedures for learning basic facts have been a matter of debate since the 1930’s. Caron (2007) noted the study of Brownell & Chazal (1934) who found that drill did not guarantee automatic recall, change the students’ slower procedures, nor lead to improved strategic learning of addition facts. Gersten and Chard (1999) declared: “This brute force use of drill and practice can make mathematics unpleasant and uninviting. It is a cumbersome, simplistic procedure, hard on the memory, worse on the mind, and as good as useless for any form of learning” (as cited in Caron, 2007, p. 279). These authors offered the viewpoint that timed-practice drills were neither engaging for students nor effective for learning.

Subsequently, these oppositional opinions against timed-practice drills voiced additional concerns that this learning method did not create understanding about multiplication and in turn, produced math anxiety among students. Smith & Smith (2006) noted the work of O’Brien and Casey (1983a, b) who demonstrated that many children in grades fourth through sixth who had experienced a “back to basics” (drill and practice) curriculum demonstrated algorithmic skill but no mathematical knowledge about the concept of multiplication. Geist (2010) noted the *Minute Madness* study by Williams (2000) who discovered that the early use of high-stress techniques like timed tests instead of more developmentally appropriate and interactive approaches lead to a high incidence of math anxiety. The results of William’s study indicated that there was a significant increase in the number of problems correctly answered on the post-test by the treatment group that used *Multiplication Puzzles* on the computer. The mean scores for the pencil and paper group did not indicate a significant improvement in their multiplication skills. The evidence from this research suggested that students preferred and responded better to less stressful assessments than timed-practice drills.

In light of these research findings and others, the instructional approach of timed-practice drills was challenged in the literature with the second approach of learning multiplication facts which was concept formation. Caron declared: “No one would dispute that learning the basics is important, even necessary; however, students who memorize facts or procedures without understanding are often not sure when or how to use what they know” (Caron, 2007, p. 280). Schifter (2007) suggested that to teach mathematics for conceptual understanding, it should be treated as ideas to be investigated rather than a set of facts, procedures, and definitions. Haught, Kunce, Pratt, Werneske, & Zemel (2002) reported the work of Burns (1999) who acknowledged the important role of memorization in computation where memorization should follow instead of lead instruction. While these authors recognized the role of learning basic facts, they also endorsed the prime importance of understanding the concept of multiplication.

The literature provided support for the method of conceptual understanding or in other words, understanding the concept of multiplication. In their study, Smith & Smith (2006) provided evidence that the traditional third-grade curriculum and instruction that emphasized memorization of multiplication facts produced much less understanding of the basic concepts of multiplication than a standards-based curriculum and instruction that focused on construction of number sense and meaning for operations. Robinson, Smith & Smith (2006) endorsed the study of Robinson & Maceli (2000) who claimed that a focus on computational skills alone worked against the development that learning mathematics was a sense-making activity. Moreover, French (2005) suggested that learning multiplication should involve application of useful strategies to reinforce connections rather than learning a set of isolated facts. French (2005) declared that instead of frequent testing which may be counterproductive because it reinforced failure and did little to improve attitudes and motivation, a problem-solving approach to math that encouraged understanding should be utilized. The consensus gleamed from the literature was that through understanding and problem-solving, students learned their multiplication facts. Reciting isolated facts through recurrent testing did not create meaningful learning and was detrimental to students' attitudes and self esteem.

In the review of literature, there appeared to be no opposition to the conceptual approach except from the proponents of the timed-practice drills. Both instructional approaches have benefits to help students learn their multiplication facts. Under these circumstances, the third and most recent approach to learning multiplication facts, the integrated approach using timed-practice drills and strategies tied to concept formation, appeared to be received positively among the authors. Although *Rocket Math* was a timed-practice drill, utilization of other strategies may supplement the instruction in math facts fluency and evolve the program into more of an integrated approach.

The review of literature suggested that an integrated approach was the best instructional practice to teach multiplication facts. Woodward (2006) indicated that students might benefit from an integration of approaches. Woodward's experimental study contrasted an integrated approach (i.e., strategies and timed practice drills) with timed-practice drills only for teaching multiplication facts. Results from Woodward's study indicated that both approaches were effective in helping students achieve automaticity in multiplication facts. Askew and William (1995) discussed evidence which suggested that "knowing by heart and figuring it out are two complementary aspects of developing students' number sense" (as cited in French, 2005, p. 8.). The integrated approach presented a win/win scenario for students to help them both learn and understand multiplication.

Furthermore, the research of Woodward (2006) indicated that an integrated approach and timed-practice drills are comparable in their effectiveness at helping students move toward automaticity in basic facts. Woodwood's research concurred with Cumming & Elkins' research (1999) that advocated the use of strategy instruction for all students through the end of elementary school. However, the results of Cumming & Elkin's research indicated that instruction in strategies alone does not necessarily lead to automaticity and frequent timed practice was essential. Nevertheless, for an integrated approach to be effective in teaching the multiplication facts, other instructional strategies were needed to be examined and included in this review.

Due to the focus of this literature review on the best practices instruction specifically pertaining to the *Rocket Math* program, all of the possible supplemental strategies were not explained in this study. In the vast amount of literature available, there existed an extensive amount of strategies to teach multiplication facts in addition to the three approaches of timed-practice drills, concept formation, and an integrated approach. Strategies discovered in the literature were providing the answers (Caron, 2007), manipulatives (Chung, 2007), games (French, 2005), cover/copy/compare (Burns, 2005), computers (Smith, Marchand-Martella, & Martella, 2011), self reflection (Wood & Frank, 2000), feedback (Marzano, 2001), rewards/recognition (Marzano, 2001), peer tutoring (Marzano, 2001) , and multiple intelligences (Gardner, 1991, as cited in Willis, 2001). The components of the *Rocket Math* program pertaining to Marzano were examined in the conceptual understanding section. The other instructional strategies were found in the literature to increase student engagement, motivation, and effectiveness.

A review of the literature suggested three approaches to developing fluency, automaticity, and mastery of multiplication facts: 1) timed-practice drills, 2) conceptual knowledge, and 3) integrated approach using strategies, with the third approach viewed as the most effective best practice for instruction of multiplication facts. In relation to the *Rocket Math* program, the research showed that the time-practice drill, which most closely matched *Rocket Math*, increased fluency, but lacked the conceptual understanding that was also necessary to be effective in multiplication learning. Within the *Rocket Math* program were research-based strategies such as student goal setting, peer tutoring, and self-reflection which promoted student achievement. However, there existed other factors that may have affected the student growth of multiplication fluency in the school which was revealed in the literature that were not solely controlled by instructional practices.

The demographics of the school in the study showed a moderately high free and reduced lunch rate of 40.9% (DESE, 2011). In the literature, Jordon, Kaplan, Olah, & Loucuniak (2006) demonstrated that the most consistent risk factor for low achievement in mathematics was family income level which meant that the lower the family income, the lower the achievement (as cited in Geist, 2010). Additionally, Geist (2010) reported a study on the National Assessment of Educational Progress (NAEP) mathematics assessment, where children who were eligible for the USDA's free or reduced cost lunch program, regardless of ethnicity, scored 13 points below the national average and 22 points below those students that did not qualify for the program. This data supported the contention that poverty is a significant risk factor for early mathematics achievement. Furthermore, Miller & Miller (1994) stated: "The effect of high-stakes methods such as timed test on these 'at-risk' groups were just some of the examples of how math anxiety and negative attitudes toward mathematics can affect achievement and progress in mathematics" (as cited in Geist, 2010, p. 28). This final thought from the literature review revealed that there may have been several contributing factors to the effectiveness of the *Rocket Math* program which was beyond the scope of choices of instructional practices and of this study.

RESEARCH METHODS

Research Design

For RQ1, a pre-experimental (pre-test) post-experimental (post-test) one group study research design was used to collect data for this investigative project. The t-Test with a matched pair design was used to determine significance at the 0.10 Alpha level to challenge the null hypothesis. This study compared one group of student mean scores related to a three-minute timed test with 90 questions each. Both the pre-test and the post-test were independent tests taken from the Multiplication.com website (2011) and were not connected with the *Rocket Math* program. The independent variable was the pre-experimental scores, and the dependent variable was the post-experimental scores. Both scores were recorded as raw scores and percentages.

Study Group Description

The study group consisted of 37 fourth graders of varying mathematical abilities from two elementary classrooms in the same school. The 37 students in the study group were comprised of 20 students in the homeroom classroom of the researcher and 17 students from another fourth grade teacher's classroom who were taught in a departmentalized setting. All 37 participants in the study group received the same *Rocket Math* instruction during the 2011/2012 academic year and their participant number was recorded. The classrooms were not subdivided into two groups for the purpose of this study. Students who moved or were enrolled in school between the pre and post-test periods were excluded from the study.

Data Collection and Instrumentation

The data collected for this study was collected from the study participants during the 2011/2012 academic year. All data collection occurred in the researcher's classroom and was monitored by the researcher. The participants took a three-minute timed pre-test and post-test each consisting of 90 multiplication, non-sequential fact problems (Appendix A). The pre-test was administered in August 2011, and the post-test was administered in May 2012.

Before beginning the *Rocket Math* program, participants took a *How Fast Can You Write Test* (Appendix B) to determine their daily and weekly multiplication goals. The participants completed a daily one-minute timed test on every Monday, Tuesday, Wednesday, and Thursday (Appendix C), and a weekly two-minute timed test on Friday (Appendix D). The students did not receive or make up the daily timing if school was not in session, they were absent, there was other math testing that day, or school events occurred during the time block designated for *Rocket Math*. If the participant achieved their daily goal, the participant would advance to the next alphabet letter from A-W and color in the rocket on the student self-assessment recording sheet (Appendix E). Every Friday, or the last day of the school week, the participant would take a two-minute timed test and record results on a graph (Appendix F). If the participant passed all levels of multiplication, the participant would move to the division component of *Rocket Math*.

Fourth grade participants began the academic year with the addition facts and then subtraction. The district curriculum facilitator mandated if the fourth grade student did not pass addition by the end of the first quarter, they would advance to multiplication starting in the second quarter. Those students who passed addition and were on subtraction at the end of the first quarter would also move onto multiplication. Starting in the second quarter, all fourth grade students worked on multiplication, followed by division, and then worked on the subtraction levels.

To move to the next operation (addition, subtraction, multiplication, and division), participants were required to complete all levels. Mastery levels for completion of multiplication level were 100% for (A-W) and less if the participants had not mastered multiplication by the end of the academic year. Individual participant goals varied according to the *How Fast Can You Write* test (Appendix B) and were adjusted with student self-monitored goal sheets (Appendix F). The students also completed the *Rocket Math* graphic organizer showing completion of multiplication levels A-W (Appendix E). On the pre and post-tests, scores of the multiplication facts (0-9) demonstrated high mastery (90% to 100%), moderate mastery (80% to 89%), basic mastery (70% to 79%), or low to non-mastery (69% or less). These levels of mastery were defined by the researcher and were related a standard scale of mastery.

Statistical Analysis Methods

Statistical Package (ASP) software was used to complete the statistical calculations in this study. Descriptive statistics of a t-test were calculated. Additionally, Microsoft Excel was used to compile and analyze totals used in the research. The data was collected from one study group with a matched pair of scores from the same individuals who took the same pre and post tests. The alpha level was set at 0.10.

FINDINGS

To determine if the *Rocket Math* program produced high student growth for fluency, automaticity, and mastery in multiplication facts 0-9, 37 students took a pre-test in August 2011 and a post-test in May 2012. A t-test analysis was conducted to answer the research question: Is there a difference in student mean scores between pre and post student test scores? The results of the t-test were displayed Table 1 which showed the pre-test with a mean score of 26.2, the post-test mean of 58.7, and the mean difference of -32.51. For this study, the alpha level was set at 0.10. The null hypothesis stated: There is no significant difference between the pre and post-test mean scores. Since the p-value of 1.17E-14 was significantly less than the alpha level of 0.10, the null hypothesis was rejected. This finding indicated that there was a significant difference between the pre and post-test mean scores after instruction with the *Rocket Math* program.

Table 1
t-Test Analysis Results Between Pre and Post-Rocket Math Tests

Source	Mean	Mean D	t-Test	df	p-value
Pre	26.2				
Post	58.7	-32.51	-1.50	3.6	1.17E-14
Note: Significant when	p = <0.10				

While it is true that the t-test indicated a significant difference between the pre and post-test scores, the individual student data, shown in Table 2 and in Graph 1 additionally revealed that all students experienced multiplication fluency growth between August 2011 and May 2012. At the bottom of Table 2, the mean, minimum, average, and ranges were provided for the individual student scores. The pre-test scores had a mean of 26 which was 29.10% out of 90 questions and demonstrated non-mastery. The range of the pre-test scores was 75 or 83.33%, with a maximum score of 80 or 88.89%, and a minimum score of 5 or 5.56%. The post-test scores showed a mean of 59 which was 65.23% out of 90 questions which demonstrated non-mastery but did show a significant difference from the pre-test scores. The range of the post-test scores was 66 or 38.56%, with a maximum score of 90 or 100%, and a minimum score of 24 or 26.67%. The difference between the pre and post-test scores reported a mean of 32.5. The range of the difference between the pre and post-test scores was 60 with a maximum difference of 62 and a minimum difference of 2. The overall average of the pre and post-test scores was a mean of 42.45 with a range of 67 with a maximum of 84 and a minimum of 17. As demonstrated by this data, the mean scores were non-mastery on the pre and post-tests.

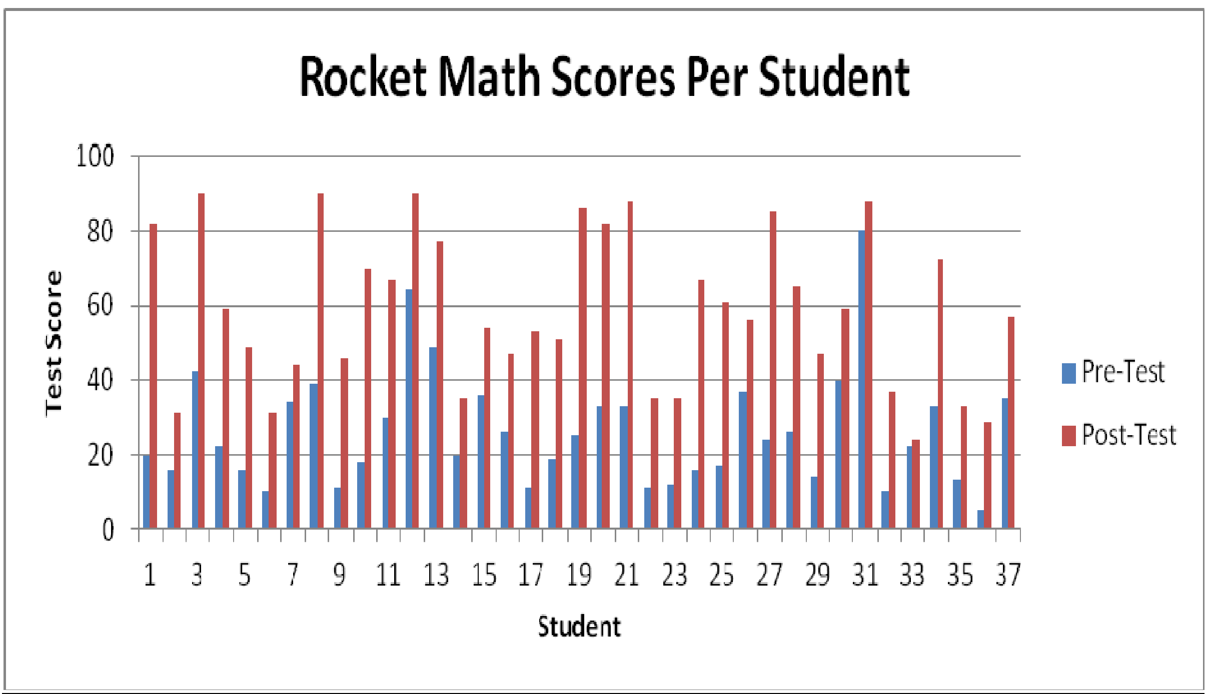
The percentage differences between the pre and post-test scores were displayed in Table 2 and illustrated in Graph 2. A noteworthy statistic from Table 2 and Graph 2 was that 76% or 28 out of the 37 students increased 50% or more from their pre-test to their post-test scores. The breakdown of this data was offered in Table 3 and Graph 3. The data was found to show that nine students scored 90 to 100% accuracy on the post-test. This evidence suggested that these nine students achieved a high mastery level of multiplication fluency. Two students performed at 80 to 89% accuracy on the post-test which indicated a moderate level of mastery. A basic level of mastery of 70 to 79% on the post-test was demonstrated by four students. The total of number of students who reached varying mastery levels above 70 percent on the post-test was 15 or 41% of the 37 total participants in the study. In contrast, 22 students or 59% of the total students in the study scored below 70% of mastery on the post-test. However, on a standard mastery scale, a score of below 80% would indicate low or non-mastery. As supported in the data, only 30% of the students or 11 of the total students in the study performed at a mastery level above 80%. Evidence found that 70% of the students did not achieve mastery of multiplication fluency on the post-test even though there was a significant difference between the pre and post-test scores as indicated with a p-value of 1.17E-14.

Table 2
Student Pre and Post-Test Multiplication (0-9) Scores

Student Number	Pre - Test Score (Out of 90)	Pre-Test %	Post-Test Score (Out of 90)	Post-Test %	Difference of Scores (Pre/Post)	Average of Pre/Post Scores	Percentage Difference of Pre/Post
1	20	22.22%	82	91.11%	62	51	121.57%
2	16	17.78%	31	34.44%	15	23.5	63.83%
3	42	46.67%	90	100%	48	66	72.73%
4	22	24.44%	59	65.56%	37	40.5	91.36%
5	16	17.78%	49	54.44%	33	32.5	101.54%
6	10	11.11%	31	34.44%	21	20.5	102.44%
7	34	37.78%	44	48.89%	10	39	25.64%
8	39	43.33%	90	100%	51	64.5	79.01%
9	11	12.22%	46	51.11%	35	28.5	122.81%
10	18	20.00%	70	77.78 %	52	44	118.18%
11	30	33.33%	67	74.44%	37	48.5	76.29%
12	64	71.11%	90	100%	26	77	33.77%
13	49	54.44%	77	85.56%	28	63	44.44%
14	20	22.22%	35	38.89%	15	27.5	54.55%
15	36	40.00%	54	60.00%	18	45	40.00%
16	26	28.89%	47	52.22%	21	36.5	57.53%
17	11	12.22%	53	58.89%	42	32	131.25%
18	19	21.11%	51	56.67%	32	35	91.43%
19	25	27.78%	86	95.56%	61	55.5	109.91%
20	33	36.67%	82	91.11%	49	57.5	85.22%
21	33	36.67%	88	97.78%	55	60.5	90.91%
22	11	12.22%	35	38.89%	24	23	104.35%
23	12	13.33%	35	38.89%	23	23.5	97.87%
24	16	17.78%	67	74.44%	51	41.5	122.89%
25	17	18.89%	61	67.78%	44	39	112.82%
26	37	41.11%	56	62.22%	19	46.5	40.86%
27	24	26.67%	85	94.44%	61	54.5	111.93%
28	26	28.89%	65	72.22%	39	45.5	85.71%
29	14	15.56%	47	52.22%	33	30.5	108.20%

Student Number	Pre - Test Score (Out of 90)	Pre-Test %	Post-Test Score (Out of 90)	Post-Test %	Difference of Scores (Pre/Post)	Average of Pre/Post Scores	Percentage Difference of Pre/Post
30	40	44.44%	59	65.56%	19	49.5	38.38%
31	80	88.89%	88	97.78%	8	84	9.52%
32	10	11.11%	37	41.11%	27	23.5	114.89%
33	22	24.44%	24	26.67%	2	23	8.70%
34	33	36.67%	72	80%	39	52.5	74.29%
35	13	14.44%	33	36.67%	20	23	86.96%
36	5	5.56%	29	32.22%	24	17	141.18%
37	35	38.89%	57	63.33%	22	46	47.83%
Mean	26	29.10%	59	65.23 %	32.51	42.45	81.64%
Minimum	5	5.56%	24	26.67%	2	17	8.70%
Maximum	80	88.89%	90	100%	62	84	141.18%
Range	75	83.33%	66	38.56%	60	67	132.48%

Graph 1: Rocket Math Scores Per Student (Pre-Test and Post-Test)



Graph 2: Pre and Post-Test Difference by Percentage

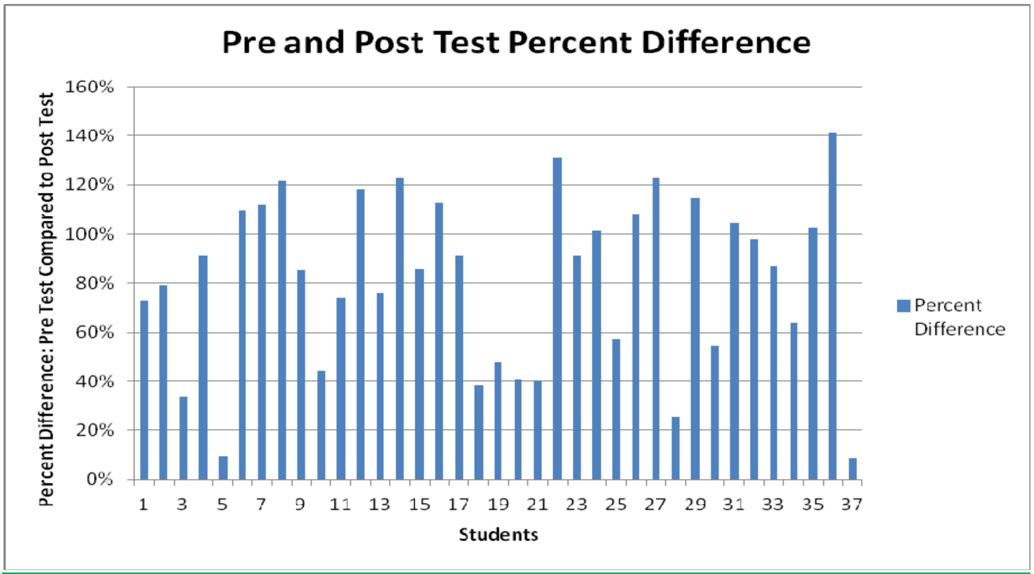
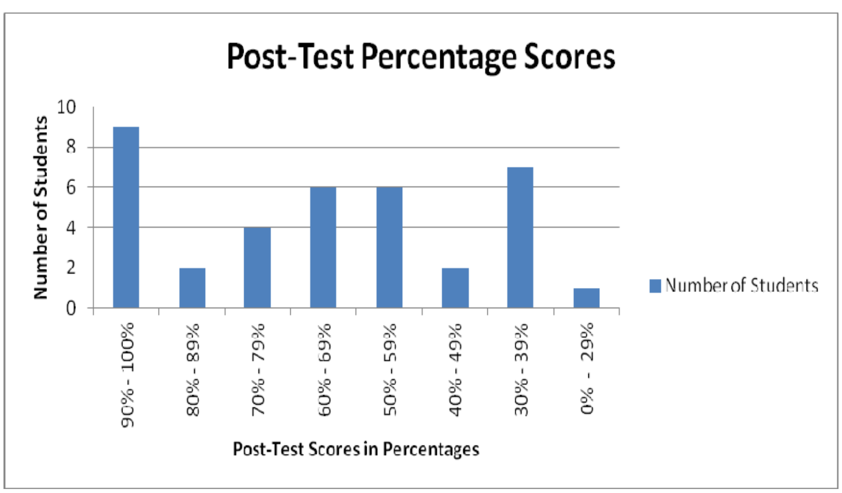


Table 3: Post-Test Percentage Scores Breakdown

Post-Test Percentage Scores Percentages	Number of Students
90% - 100%	9
80% - 89%	2
70% - 79%	4
60% - 69%	6
50% - 59%	6
40% - 49%	2
30% - 39%	7
0% - 29%	1

Graph 3: Post-Test Percentage Scores



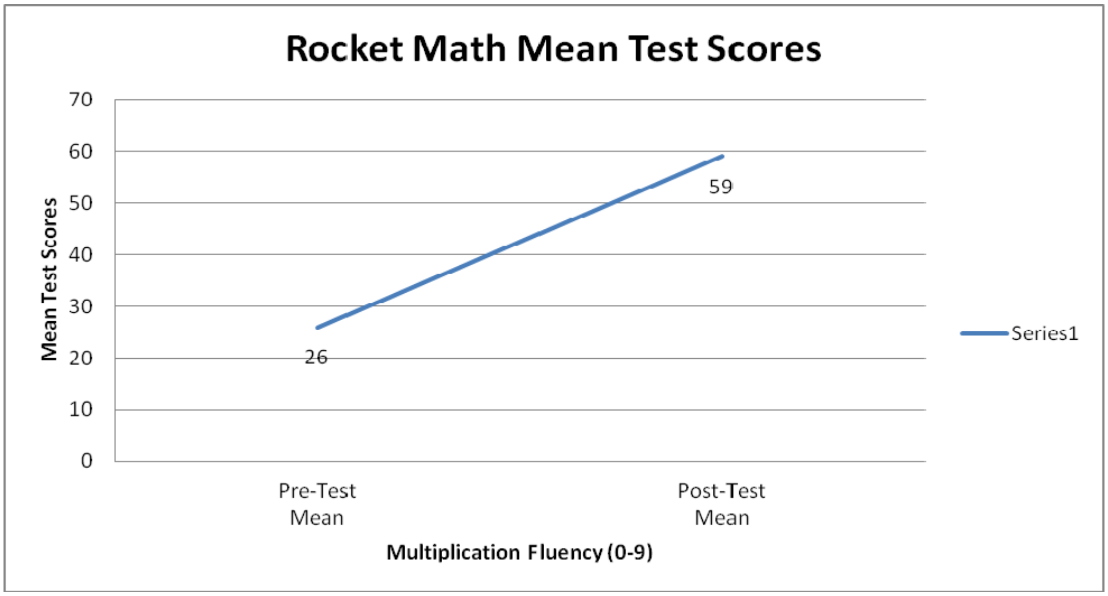
CONCLUSIONS AND RECOMMENDATIONS

The null hypothesis stated that there is no difference in student mean scores between pre and post-student test scores when the *Rocket Math* instructional program was used in the study group of 37 fourth grade students. The results of this study indicated that the null hypothesis was rejected with a p-value of 1.17E-14 which is significantly less than the Alpha value of 0.10. This data supported that there was a significant difference between pre and post-test mean scores. Evidence suggested that the *Rocket Math* program was effective in increasing multiplication fluency in post-test scores. Notwithstanding, the determination of mastery and automaticity of multiplication facts 0-9 required additional analysis in greater depth, especially when the individual growth scores were examined.

As explained in the findings section of this study and illustrated with Graph 4, the quantitative results collected between the pre-test and the post-test showed moderate growth in test scores that increased from a mean of 26 on the pre-test to a final mean of 59 on the post-test. Subsequently, the difference between the pre-test and the mean score of the post-test was a moderate increase of 33 points. There were 90 problems possible on the three-minute timed pre and post-test. A final mean score of 59 represented 65% mastery of multiplication fluency. When compared to the standard benchmark for mastery that is 80% or greater, 65% represented non-mastery of multiplication facts. Under these circumstances, the study group, when observed as a whole, experienced an increase in fluency with the *Rocket Math* program, although at varying percentages.

However, only 11 students or 30% achieved moderate to high mastery and automaticity. Out of the study group, 70% did not achieve mastery of their multiplication facts. The goal of instruction was to achieve mastery of multiplication facts by the end of fourth grade and did not occur for all students.

Graph 4: Rocket Math Mean Test Scores



Nevertheless, individual student growth occurred during the study period. The research shown in Table 3 found that 30% of the students or 11 out of the 37 study participants performed at a moderate or high mastery level at or above 80%, while 15 students or 41% of the students reached a basic mastery level of 70% and above. Furthermore, as depicted in Graph 2, 76% or 28 out of the 37 students increased 50% or more from their pre-test to their post-test score. All student scores increased at varying percentages between the pre-test and the post-test. Students in the study increased their multiplication fluency during their fourth grade year, although not at the increase that was expected or anticipated by the researcher.

Under these circumstances, there are indications that multiplication fluency and automaticity increased in the group of fourth grade students but was not mastered except for 11 students or 30% of the participants. This represented less than one third of the study group who scored at 80% or more on the post-test. The study group appeared to be in the process of increasing their fluency and automaticity rather than achieving mastery.

These findings were related to the conceptual underpinning. Evidence suggested that less than one third of the study group met the objectives set forth by the NCTM, the Missouri GLE's, and the district objectives to demonstrate fluency of the multiplication tables of (0-12). However, the NCTM (2012) standards, according to the website used the key words of "develop fluency" and "understand meanings" rather than "achieved mastery." The researcher interpreted the NCTM standards to signify that the students were learning the process of multiplication rather than demonstrating a perfect performance of multiplication fact knowledge. This can be compared to the growth model used when analyzing MAP scores and related to NCLB. Even though the student may have not achieved a proficient or advanced score, the students demonstrated growth.

Additionally, Marzano's instructional strategies appeared to be evident within the *Rocket Math* program with the components of student goal setting, self reflection, progress monitoring, recognition, and celebrations. The researcher noted that most of the students were observed to take an active part in their own learning by charting their progress, setting goals, and celebrating their achievements. While it is true that students were active participants in the study, there were students who appeared to experience math anxiety about the one and two-minute timings. Often, students would miss their goal with just a few facts and say, "If I just had a little more time because I know the answer." The students who were observed by the researcher to be anxious were the students who were slower processors, counted on their fingers, took several attempts to pass one level, and did not practice their multiplication at home when they did not achieve their daily goal. The researcher found it challenging to get parents to practice with their children at home if the students did not pass their daily timing.

Additional informal observations about the students occurred during the study. Even the students who passed more levels with ease sometimes complained about the daily timings that did not vary in routine. The researcher used other supplemental instructional strategies in the classroom outside of the time block for *Rocket Math* to teach the multiplication facts such as fact strategies, manipulatives, computer websites, games, stories, videos, drawings, discussions, and songs. The students often appeared more engaged in their learning when these supplemental instructional strategies were used and the struggling learners seemed less anxious. As the review of literature revealed, a variety of instructional strategies along with concept understanding indicated best practice. Learning also included differentiated instruction that acknowledged different student learning styles and rates of learning instead of rote memorization of multiplication facts.

The researcher recognized many positive aspects about the *Rocket Math* program. The daily practice and timing procedures were structured and gave students a consistent way to practice their facts throughout the school year. Students understood the daily routine and except for occasional off-task behavior, adhered to the program. Most students enjoyed the opportunity to practice the facts with a partner and showed determination to pass their levels. Additionally, the students were excited to hear their names over the intercom when they passed the operation and celebrate in their own and others’ success. The teachers in the school remarked that the program was easy to follow.

In retrospect, the *Rocket Math* program offered a user-friendly structured instruction for students to learn and develop multiplication fluency. The results demonstrated that students increased their multiplication fluency. However, there are components of the program that were undesirable such as the lack of materials for facts 10-12. The inconsistency of some teachers extending the timing to longer than one minute helped some students in other classrooms to pass more levels, but prevented some students, such as those in the researcher's classroom, to pass levels and sometimes resulted in an increase in student frustration and decrease in motivation.

Contrary to the claims of Crawford (2003) on the *Rocket Math* website, all students did not learn math facts to mastery—only about less than a third of the students. Consequently, fourth grade students appeared to be in the process of learning their multiplication tables through the *Rocket Math* program and through other strategies used in the classroom. In retrospect, the data showed a significant increase in mean scores and individual growth. Compared to the growth model of MAP that is linked to the NCLB, the students in the study showed growth over the academic year. In light of the research that suggested that best practices should include a variety of instructional strategies along with the concept formation of multiplication, the *Rocket Math* program can be considered to be one of many instructional tools to develop fluency. The data suggested that *Rocket Math* should be reinstated in the 2012/2013 academic year but with a concern to use supplemental strategies to help a greater percentage of the students achieve mastery.

The recommendation by the researcher was to retain the *Rocket Math* program in the 2012/2013 academic year but make some revisions including using an integrated approach of instructional strategies and timed-practice drill that was found in the literature review. In addition, the school district should consider purchasing a supplemental program for facts 10-12 since the Missouri GLE's are specific about students demonstrating fluency for facts 0-12, and the Rocket Math program only taught the facts 0-9. Another recommendation would be to adjust the daily timing from one minute to one and a half minutes, due to the school's student population of a moderately high free or reduced lunch rate of 40.9% including the students who displayed math anxiety. Instead of the 40 problems in 60 seconds that is used now, 40 problems could be completed in 90 seconds. This would give students about 2 ¼ seconds to answer each problem compared to about 1 ½ seconds now. Thirty extra seconds or ¾ a second per problem more may increase the student mean scores. The final recommendation would be to allow students who have not mastered addition to complete all of the levels before starting multiplication. Mastering repeated addition before beginning multiplication is a scaffolding skill that would be helpful in learning multiplication.

There are several areas warranting further study including evaluation of the effectiveness of the *Rocket Math* program compared to other mathematical instructional programs. The review of literature showed that other instructional strategies such as practicing with the answers before assessment, conceptual understanding, and using an integrated approach of strategies and timed-practice drill. A possible study could compare a group using the *Rocket Math* program exclusively compared to a group utilizing an integrated approach. Furthermore, a study that showed the effect of students taking multiple attempts on one level would have on student math anxiety, motivation, and achievement would be beneficial.

As previously mentioned, there was a statement on the *Rocket Math* website, “If you find some other method is more effective, we will refund 100% of your purchase price. We are certain it is the best math facts practice curriculum available, but we have to wait for researchers independent of us to confirm that fact” (Crawford, 2012, p. 7). This study revealed that *Rocket Math* instructional program increased multiplication fluency mean scores moderately and student growth at varying percentages. However, since not all students achieved mastery and mean score growth was moderate, this opened the possibility that other instructional practices could be researched to determine the most effective method of teaching multiplication facts.

REFERENCES

Ashcraft, M. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science, 11* (5), 181-185. Retrieved from http://ezproxy.nwmissouri.edu:2063/Library/IPChecking.asp?http://ezproxy.nwmissouri.edu:2065/login.aspx?direct=true&db=a9h&AN=7317059&site=ehost-live

Becker, A., McLaughlin, A., Weber, K., & Gower, J. (2009). The effects of copy, cover and compare with and without additional error drill on multiplication fact fluency and accuracy, *Electronic Journal of Research in Educational Psychology, 7* (2), 747-760. Retrieved from http://ezproxy.nwmissouri.edu:2063/Library/IPChecking.asp?http://ezproxy.nwmissouri.edu:2065/login.aspx?direct=true&db=ehh&AN=44962255&site=ehost-live

Brookhart, S., Adolina, M., Zuza, M., & Furman, R. (2004). Minute math: an action research study of student self-assessment. *Educational Studies in Mathematics, 57* (2), 213-227.doi: 10.1023/B:EDUC.0000049293.55249.d4.

Burns, M. (2005). Using incremental rehearsal to increase fluency of single-digit multiplication facts with children identified as learning disabled in mathematics computation. *Education and Treatment of Children, 28*(3), 237-249. Retrieved from http://vnweb.hwwilsonweb.com/hww/jumpstart.jhtml?recid=0bc05f7a67b1790e9497635a63473613936b63454e46ae7b0aebe4a0c5e63745b3677de35f30f716&fmt=P

Caron, T. (2007). Learning multiplication the easy way. *Clearing House, 80*(6), 278-282. doi: 10.1111/j.1949-8594.2006.tb18171.x

Chung, I. (2004). A comparative assessment of constructivist and traditional approaches to establishing mathematical connections in learning multiplication. *Education*, *125*(2), 217-278. Retrieved from http://ezproxy.nwmissouri.edu:2065/Library/IPChecking.asp?http://ezproxy.nwmissouri.edu:2059/login.aspx?direct=true&db=eft&AN=507953572&site=ehost-live

Cooke, N. (1996). The effects of different interspersal drill ratios on acquisition and generalization of multiplication and division facts, *Education and Treatment of Children, 19*, 124-142. Retrieved from http://ezproxy.nwmissouri.edu:2063/Library/IPChecking.asp?http://ezproxy.nwmissouri.edu:2065/login.aspx?direct=true&db=ehh&AN=9607032850&site=ehost-live

Crawford, D. (2003). Mastering math facts: A structured program of sequential practice. Teacher's Manual. Otter Creek Institute. Eau Claire, WI.

Dempsey, D., & Marshall, J. (2001). Dear Verity: Why are all the dictionaries wrong? *Phi Delta Kappan, 82* (6), 457-459. Retrieved from http://ezproxy.nwmissouri.edu:2063/Library/IPChecking.asp?http://ezproxy.nwmissouri.edu:2065/login.aspx?direct=true&db=ehh&AN=4047325&site=ehost-live

French, D. (2005). Double, double, double. *Mathematics in School*, *34*(5), 8-9. Retrieved from http://vnweb.hwwilsonweb.com/hww/jumpstart.jhtml?recid=0bc05f7a67b1790e9497635a63473613936b63454e46ae7bf8f6a99b588e382868b2f0bafdb5a1b4&fmt=P

Geist, E. (2010). The anti-anxiety curriculum: Combating math anxiety in the classroom, *Journal of Instructional Psychology, 37* (1), 24-31. Retrieved from http://ezproxy.nwmissouri.edu:2063/Library/IPChecking.asp?http://ezproxy.nwmissouri.edu:2065/login.aspx?direct=true&db=ehh&AN=50303275&site=ehost-live

Hawkins, R., Musti-Rio, S., Hughes, C., Berry, L., & McGuire, S. (2009). Applying a randomized interdependent group contingency component to classwide peer tutoring for multiplication fact fluency. *Journal of Behavioral Education, (18)*4, 300-318. doi: 10.1007/s10864-009-9093-6

Koran, L., & McLaughlin, T. (1990). Games or drill: Increasing the multiplication skills of students, *Journal of Instructional Psychology, 17* (4), 222-231. Retrieved from http://ezproxy.nwmissouri.edu:2063/Library/IPChecking.asp?http://ezproxy.nwmissouri.edu:2065/login.aspx?direct=true&db=ehh&AN=9607242164&site=ehost-live

Lee, D., Stansbery, S., Kubina, Jr., R., & Wannarka, R. (2005). Explicit instruction with or without high-p sequences: which is more effective to teach multiplication facts? Journal of Behavioral Education, *(14)*4, 267-281. doi: 10.1007/s10864-005-8650-x

Lin, F., & Kubina, Jr. (2005). A preliminary investigation of the relationship between fluency and application for multiplication, *(14)*2, 73-87.doi: 10.1007/s10864-005-2703-z

Marzano, R., Pickering, D., & Pollock, J. (2001). Classroom instruction that works. Association for Supervision and Curriculum Developmment. Alexandria, VA.

Mattingly, J., & Bott, B. (1990). Teaching multiplication facts to students with learning problems, *(56)*5, 438-449. Retrieved from http://ezproxy.nwmissouri.edu:2063/Library/IPChecking.asp?http://ezproxy.nwmissouri.edu:2065/login.aspx?direct=true&db=ehh&AN=21506319&site=ehost-live

Multiplication.com (2012). Pre and post tests: Multiplication 0-9, http://multiplication.com

National Council of Teachers of Mathematics (2012). Standards for grades 3- 5. http://www.nctm.org/standards/content.aspx?id=24600#3-5

Rocket Math (2012). About Rocket Math. http://www.rocketmath.com/

Schifter, D. (2007). What's right about looking at what's wrong? *Educational Leadership*, *65*(3), 22-27. Retrieved from http://vnweb.hwwilsonweb.com/hww/jumpstart.jhtml?recid=0bc05f7a67b1790e9497635a634736131fe4937ac5c7d83af689dac0ef34d6e7b06b00c85d03b009&fmt=P

Smith, C., Marchand-Martella, N., & Martella, R. (2001). Assessing the effects of the Rocket Math program with a primary elementary school student at risk for school failure: A case study. *Education and Treatment of Children*, *(34)*2, 247-258. Retrieved from http://vnweb.hwwilsonweb.com/hww/jumpstart.jhtml?recid=0bc05f7a67b1790e9497635a6347361373512cead48f9f25496c7efc386d053b6742a65a227b11b9&fmt=P

Smith, S. & Smith, M. (2006). Assessing elementary understanding of multiplication concepts. *School Science and Mathematics. School Science and Mathematics*

Association, Inc., *106*(3), 140-145. doi: 10.1111/j.1949-8594.2006.tb18171.x

Willis, J. & Johnson, A. (2001). Multiply with MI: Using multiple intelligences to master multiplication. *Teaching Children Mathematics*, *7*(5), 260-269. Retrieved from http://vnweb.hwwilsonweb.com/hww/jumpstart.jhtml?recid=0bc05f7a67b1790e9497635a634736131ddc4b26d52794a1cc9db244f047faf7f22a0050929f56a6&fmt=P

Wood, D., & Frank, A. (2000). Using memory-enhancing strategies to learn multiplication facts. *Teaching Exceptional Children*, *(32)*5, 78-82. Retrieved from http://ezproxy.nwmissouri.edu:2063/Library/IPChecking.asp?http://ezproxy.nwmissouri.edu:2065/login.aspx?direct=true&db=eft&AN=507694028&site=ehost-live

Woodward, J. (2006). Developing automaticity in multiplication facts: integrating strategy instruction with timed practice drills. *Learning Disability Quarterly*, *9*(4), 269-289. doi 10.2307/30035554

Appendix A

Multiplication (0-9) Pre-test and Post-Test

Source: http://multiplication.com/quiz

Times Tables - Pre-test: Student Name_______________ Student Number_____

1 2 x 5	2 6 x 2	3 3 x 6	4 7 x 3	5 4 x 8	6 9 x 4	7 6 x 7	8 8 x 6	9 9 x 9	10 1 x 9
11 4 x 2	12 2 x 7	13 5 x 3	14 3 x 8	15 7 x 4	16 5 x 5	17 6 x 6	18 6 x 9	19 9 x 8	20 7 x 0
21 2 x 3	22 8 x 2	23 3 x 4	24 9 x 3	25 4 x 6	26 6 x 5	27 5 x 9	28 7 x 7	29 8 x 8	30 8 x 1
31 2 x 2	32 2 x 9	33 3 x 3	34 4 x 4	35 5 x 4	36 5 x 7	37 8 x 5	38 7 x 8	39 9 x 7	40 1 x 7
41 7 x 7	42 9 x 6	43 4 x 7	44 6 x 4	45 2 x 8	46 2 x 7	47 4 x 1	48 1 x 3	49 1 x 0	50 9 x 9
51 8 x 7	52 6 x 8	53 8 x 4	54 4 x 5	55 9 x 2	56 6 x 2	57 1 x 5	58 2 x 1	59 0 x 2	60 5 x 8

Times Tables - Pre-test: Student Name______________ Student Number____

61 7 x 9	62 6 x 7	63 4 x 9	64 4 x 4	65 3 x 3	66 5 x 2	67 6 x 1	68 1 x 1	69 3 x 0	70 7 x 5
71 8 x 8	72 6 x 6	73 5 x 5	74 3 x 9	75 4 x 3	76 2 x 4	77 1 x 7	78 9 x 0	79 0 x 4	80 3 x 7
81 8 x 9	82 9 x 5	83 5 x 6	84 8 x 3	85 3 x 5	86 3 x 2	87 8 x 1	88 0 x 8	89 5 x 0	90 6 x 3

Times Tables - Post-test: Student Name________________ Student Number_____

1 9 x 9	2 6 x 8	3 7 x 6	4 4 x 9	5 8 x 4	6 3 x 7	7 6 x 3	8 2 x 6	9 5 x 2	10 5 x 1
11 8 x 9	12 9 x 6	13 6 x 6	14 5 x 5	15 4 x 7	16 8 x 3	17 3 x 5	18 7 x 2	19 2 x 4	20 0 x 6
21 8 x 8	22 7 x 7	23 9 x 5	24 5 x 6	25 6 x 4	26 3 x 9	27 4 x 3	28 2 x 8	29 3 x 2	30 7 x 0
31 9 x 7	32 8 x 7	33 5 x 8	34 7 x 5	35 4 x 5	36 4 x 4	37 3 x 3	38 9 x 2	39 2 x 2	40 9 x 1
41 7 x 7	42 6 x 9	43 7 x 4	44 4 x 6	45 8 x 2	46 2 x 7	47 1 x 4	48 3 x 1	49 0 x 1	50 3 x 6
51 7 x 8	52 8 x 6	53 4 x 8	54 5 x 4	55 2 x 9	56 6 x 2	57 5 x 1	58 1 x 2	59 2 x 0	60 7 x 3

Times Tables - Post-test: Student Name________________ Student Number____

61 9 x 7	62 6 x 7	63 9 x 4	64 4 x 4	65 3 x 3	66 2 x 5	67 1 x 6	68 1 x 1	69 0 x 3	70 5 x 7
71 8 x 8	72 6 x 6	73 5 x 5	74 9 x 3	75 3 x 4	76 4 x 2	77 7 x 1	78 0 x 9	79 4 x 0	80 8 x 5
81 9 x 8	82 5 x 9	83 6 x 5	84 3 x 8	85 5 x 3	86 2 x 3	87 1 x 8	88 8 x 0	89 0 x 5	90 9 x 9

Appendix B

"How Fast Can You Write?" *Rocket Math* assessment

Mastering Math Facts xxx Name ___________________________
Assessments

How fast can you write?

Wait for my signal to begin. You will have 1 minute to copy the numbers shown in the corner of each box. Write as quickly as you can. Ready, set, go!

3	72	8	32	9	15	1

7 boxes

94	7	80	2	28	0	63

14 boxes

4	56	6	36	5	45	8

21 boxes

27	3	81	9	55	1	64

28 boxes

2	49	6	18	4	21	7

35 boxes

24	8	48	5	75	3	35

42 boxes

Count how many boxes you completed. ________________

Appendix C

Sample *Rocket Math* Daily Multiplication Practice (Top Half of Page) and Assessment (Bottom Half of Page)

Mastering Math Facts - Multiplication M-5 Name_______________________

Set A [1 x any number, any number x 1] **Practice on facts in Set A**

3	1	1	5	7	1	9	1	1	2
x1	x8	x2	x1	x1	x4	x1	x6	x1	x1
1	4	1	6	1	1	8	5	1	6
x7	x1	x9	x1	x1	x3	x1	x1	x3	x1
8	1	1	1	1	2	9	1	3	5
x1	x4	x1	x5	x7	x1	x1	x8	x1	x1
1	5	1	1	4	7	1	1	9	3
x9	x1	x6	x8	x1	x1	x2	x1	x1	x1

One Minute Timing on facts in Set A

7	1	9	3	1	1	5	1	1	2
x1	x4	x1	x1	x8	x2	x1	x6	x1	x1
1	1	8	1	4	1	6	5	1	6
x1	x3	x1	x7	x1	x9	x1	x1	x3	x1
1	2	9	8	1	1	1	1	3	5
x7	x1	x1	x1	x4	x1	x5	x8	x1	x1
4	7	1	1	5	1	1	1	9	3
x1	x1	x2	x9	x1	x6	x8	x1	x1	x1

1 minute timing goal __________ Number of problems correct_____

Appendix D

Sample *Rocket Math* Weekly Assessment

Mastering Math Facts - Multiplication M-29 Name________________________

Two Minute Multiplication Timing #1 (Do this weekly to see your progress)

6	9	4	3	8	7	2	5	9	7
x 7	x 5	x 8	x 3	x 3	x 6	x 7	x 4	x 9	x 1
8	4	5	6	3	2	8	0	2	9
x 8	x 5	x 8	x 6	x 6	x 4	x 1	x 9	x 8	x 7
8	4	6	9	4	5	7	5	0	9
x 2	x 9	x 2	x 8	x 3	x 1	x 5	x 2	x 4	x 1
7	0	8	4	6	4	5	8	0	8
x 3	x 7	x 7	x 4	x 9	x 2	x 6	x 7	x 8	x 5
6	6	9	8	4	2	7	4	0	3
x 8	x 4	x 3	x 9	x 7	x 9	x 7	x 1	x 6	x 1
3	8	7	8	9	3	6	0	6	5
x 4	x 6	x 2	x 4	x 6	x 8	x 5	x 5	x 1	x 9
9	7	3	0	3	4	2	5	5	0
x 2	x 8	x 7	x 5	x 9	x 6	x 5	x 7	x 5	x 3
3	9	2	2	7	2	7	6	5	5
x 5	x 4	x 2	x 1	x 9	x 6	x 4	x 3	x 3	x 9

Goal _____ Number of problems correct______

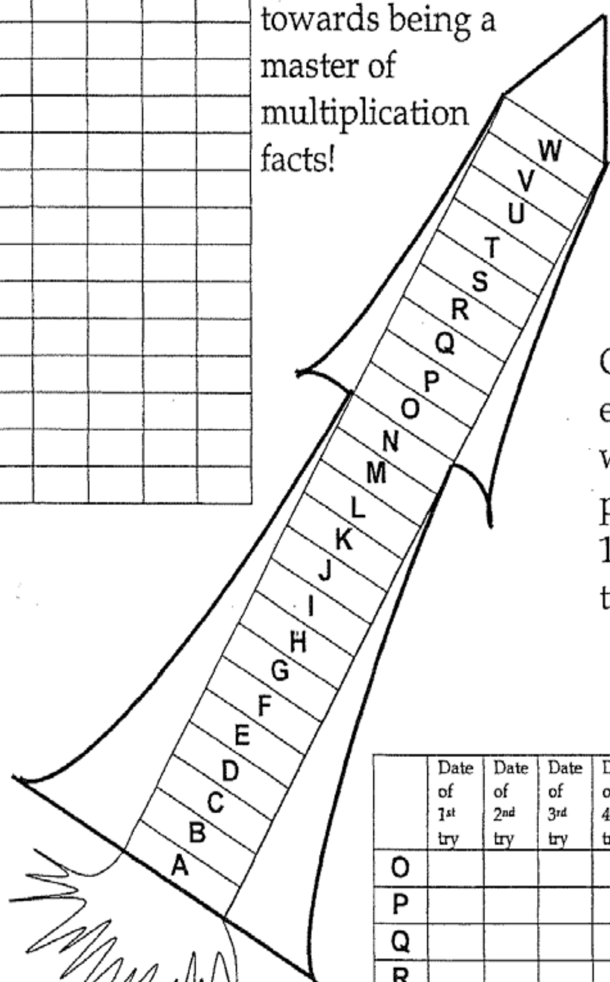
Appendix E

Sample *Rocket Math* Daily Student Self-Assessment Record Sheet

Mastering Math Facts **-** Multiplication M-3 Name________________________

	Date of 1st try	Date of 2nd try	Date of 3rd try	Date of 4th try	Date of 5th try	Date of 6th try
A						
B						
C						
D						
E						
F						
G						
H						
I						
J						
K						
L						
M						
N						

__________ is ROCKETING towards being a master of multiplication facts!

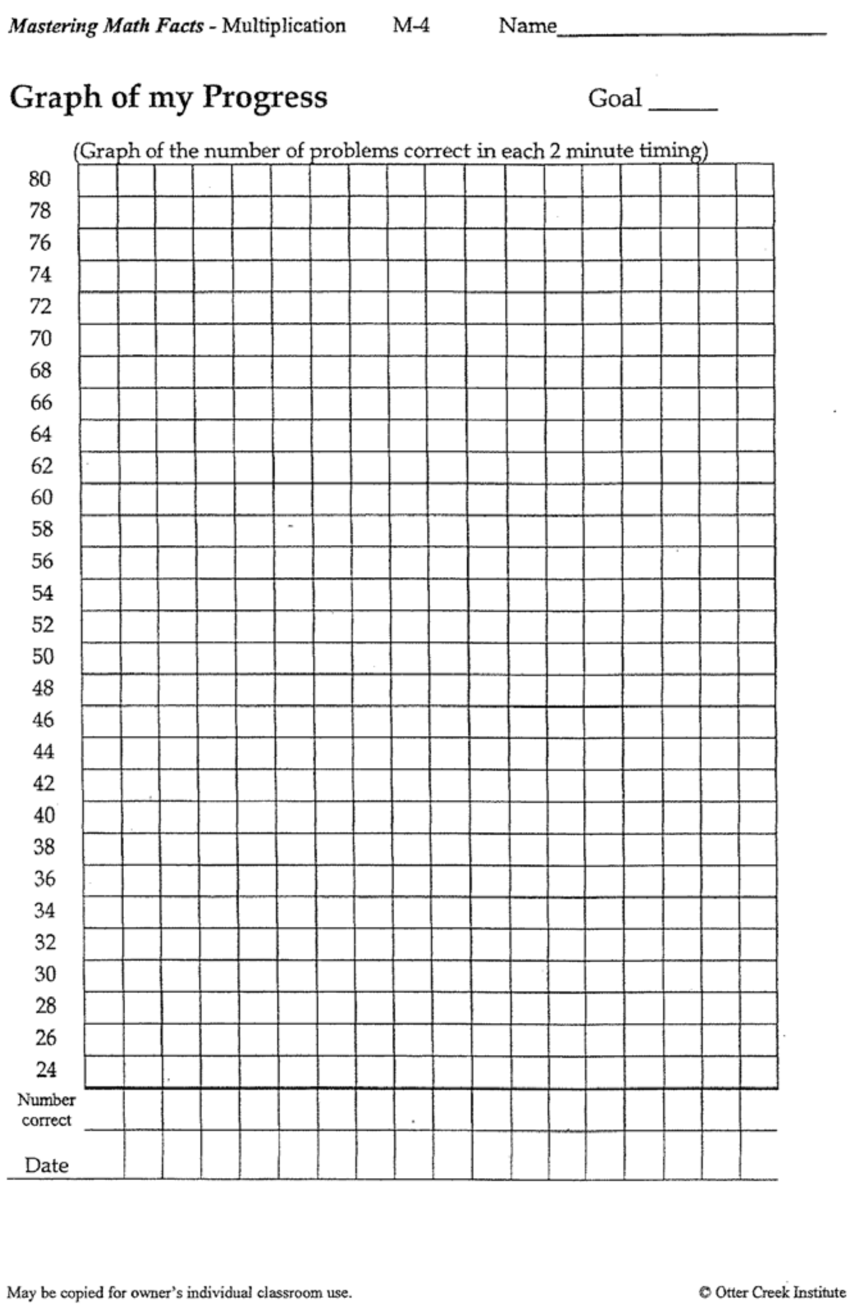


Color in each letter when you pass its 1-minute timing.

	Date of 1st try	Date of 2nd try	Date of 3rd try	Date of 4th try	Date of 5th try	Date of 6th try
O						
P						
Q						
R						
S						
T						
U						
V						
W						

Appendix F

Sample *Rocket Math* Weekly Student Self-Assessment Graph


Mastering Math Facts - Multiplication M-4 Name________________________

Graph of my Progress Goal _____

(Graph of the number of problems correct in each 2 minute timing)

80
78
76
74
72
70
68
66
64
62
60
58
56
54
52
50
48
46
44
42
40
38
36
34
32
30
28
26
24

Number correct

Date

Appendix G

Sample *Rocket Math* Daily Answer Key

Mastering Math Facts –MULTIPLICATION ANSWER KEYS– 41

Set A [1 x any number, any number x 1] Practice on facts in Set A

3	1	1	5	7	1	9	1	1	2
x1	x8	x2	x1	x1	x4	x1	x6	x1	x1
3	8	2	5	7	4	9	6	1	2
1	4	1	6	1	1	8	5	1	6
x7	x1	x9	x1	x1	x3	x1	x1	x3	x1
7	4	9	6	1	3	8	5	3	6
8	1	1	1	1	2	9	1	3	5
x1	x4	x1	x5	x7	x1	x1	x8	x1	x1
8	4	1	5	7	2	9	8	3	5
1	5	1	1	4	7	1	1	9	3
x9	x1	x6	x8	x1	x1	x2	x1	x1	x1
9	5	6	8	4	7	2	1	9	3

One Minute Timing on facts in Set A

7	1	9	3	1	1	5	1	1	2
x1	x4	x1	x1	x8	x2	x1	x6	x1	x1
7	4	9	3	8	2	5	6	1	2
1	1	8	1	4	1	6	5	1	6
x1	x3	x1	x7	x1	x9	x1	x1	x3	x1
1	3	8	7	4	9	6	5	3	6
1	2	9	8	1	1	1	1	3	5
x7	x1	x1	x1	x4	x1	x5	x8	x1	x1
7	2	9	8	4	1	5	8	3	5
4	7	1	1	5	1	1	1	9	3
x1	x1	x2	x9	x1	x6	x8	x1	x1	x1
4	7	2	9	5	6	8	1	9	3

1 minute timing goal ______ Number of problems correct___

Set B [0 x any #, any # x 0] Practice on facts through Set B

7	1	9	3	1	1	5	1	1	2
x0	x4	x0	x0	x8	x2	x0	x6	x0	x1
0	4	0	0	8	2	0	6	0	2
1	0	8	0	4	1	6	5	1	6
x1	x3	x1	x7	x0	x9	x1	x0	x3	x1
1	0	8	0	0	9	6	0	3	6
0	2	9	8	1	1	0	1	3	5
x7	x0	x1	x0	x4	x0	x5	x8	x0	x1
0	0	9	0	4	0	0	8	0	5
4	7	0	1	5	1	1	0	9	3
x1	x1	x2	x9	x0	x6	x8	x1	x1	x0
4	7	0	9	0	6	8	0	9	0

One Minute Timing on facts through Set B

9	3	1	1	7	1	5	1	1	2
x0	x0	x8	x2	x0	x4	x0	x6	x0	x1
0	0	8	2	0	4	0	6	0	2
8	0	4	1	1	0	6	5	1	6
x1	x7	x0	x9	x1	x3	x1	x0	x3	x1
8	0	0	9	1	0	6	0	3	6
9	8	1	1	0	2	0	1	3	5
x1	x0	x4	x0	x7	x0	x5	x8	x0	x1
9	0	4	0	0	0	0	8	0	5
0	1	5	1	4	7	1	0	9	3
x2	x9	x0	x6	x1	x1	x8	x1	x1	x0
0	9	0	6	4	7	8	0	9	0

1 minute timing goal ______ Number of problems correct___

Appendix H

Sample *Rocket Math* Weekly Answer Key

Two Minute Multiplication Timing #1

6	9	4	3	8	7	2	5	9	7
x7	x5	x8	x3	x3	x6	x7	x4	x9	x1
42	**45**	**32**	**9**	**24**	**42**	**14**	**20**	**81**	**7**
8	4	5	6	3	2	8	0	2	9
x8	x5	x8	x6	x6	x4	x1	x9	x8	x7
64	**20**	**40**	**36**	**18**	**8**	**8**	**0**	**16**	**63**
8	4	6	9	4	5	7	5	0	9
x2	x9	x2	x8	x3	x1	x5	x2	x4	x1
16	**36**	**12**	**72**	**12**	**5**	**35**	**10**	**0**	**9**
7	0	8	4	6	4	5	8	0	8
x3	x7	x7	x4	x9	x2	x6	x7	x8	x5
21	**0**	**56**	**16**	**54**	**8**	**30**	**56**	**0**	**40**
6	6	9	8	4	2	7	4	0	3
x8	x4	x3	x9	x7	x9	x7	x1	x6	x1
48	**24**	**27**	**72**	**28**	**18**	**49**	**4**	**0**	**3**
3	8	7	8	9	3	6	0	6	5
x4	x6	x2	x4	x6	x8	x5	x5	x1	x9
12	**48**	**14**	**32**	**54**	**24**	**30**	**0**	**6**	**45**
9	7	3	0	3	4	2	5	5	0
x2	x8	x7	x5	x9	x6	x5	x7	x5	x3
18	**56**	**21**	**0**	**27**	**24**	**10**	**35**	**25**	**0**
3	9	2	2	7	2	7	6	5	5
x5	x4	x2	x1	x9	x6	x4	x3	x3	x9
15	**36**	**4**	**2**	**63**	**12**	**28**	**18**	**15**	**45**

Goal____ Number of problems correct___

Two Minute Multiplication Timing #2

4	6	7	5	8	9	4	5	0	9
x9	x2	x5	x2	x2	x8	x3	x1	x4	x1
36	**12**	**35**	**10**	**16**	**72**	**12**	**5**	**0**	**9**
0	8	5	8	7	4	6	4	0	8
x7	x7	x6	x7	x3	x4	x9	x2	x8	x5
0	**56**	**30**	**56**	**21**	**16**	**54**	**8**	**0**	**40**
6	9	7	4	6	8	4	2	0	3
x4	x3	x7	x1	x8	x9	x7	x9	x6	x1
24	**27**	**49**	**4**	**48**	**72**	**28**	**18**	**0**	**3**
9	4	2	5	6	3	8	7	9	7
x5	x8	x7	x4	x7	x3	x3	x6	x9	x1
45	**32**	**14**	**20**	**42**	**9**	**24**	**42**	**81**	**7**
4	5	8	0	8	6	3	2	2	9
x5	x8	x1	x9	x8	x6	x6	x4	x8	x7
20	**40**	**8**	**0**	**64**	**36**	**18**	**8**	**16**	**63**
8	7	6	0	3	8	9	3	6	5
x6	x2	x5	x5	x4	x4	x6	x8	x1	x9
48	**14**	**30**	**0**	**12**	**32**	**54**	**24**	**6**	**45**
7	3	2	5	9	0	3	4	5	0
x8	x7	x5	x7	x2	x5	x9	x6	x5	x3
56	**21**	**10**	**35**	**18**	**0**	**27**	**24**	**25**	**0**
9	2	7	6	3	2	7	2	5	5
x4	x2	x4	x3	x5	x1	x9	x6	x3	x9
36	**4**	**28**	**18**	**15**	**2**	**63**	**12**	**15**	**45**

Goal____ Number of problems correct___

Appendix I

Goal Setting Sheet: Standard One-Minute Timing

Mastering Math Facts xxxi Name ______________
Assessments

GOAL SHEET—STANDARD ONE- MINUTE TIMING

What is your goal? It's to meet or beat your best score ever, each time.

To find a fair **starting** place find the number of boxes you copied in the column below. To find what your goals are for timings circle that entire row. You'll circle your goal for how many problems correct to pass a 15 second, a 1 minute timing, and an annual goal (how fast you should be when you know all the facts) in a 2 minute timing.

Boxes copied	15 sec. timing	1 minute timing	2 min. annual goal
24 or less	Place into *Mastering Numerals* to improve writing		
25	6	23	46
26	6	24	48
27	6	25	50
28	7	26	52
29	7	27	54
30	7	28	56
31	8	29	58
32	8	30	60
33	8	31	62
34	9	32	64
35	9	33	66
36	9	34	68
37	10	35	70
38	10	36	72
39	10	37	74
40	10	38	76
41	10	39	78
42	10	40	80

Write your STARTING goals here. Remember, whenever you beat your goal, cross it out and write down your new "record score" as your new goal!

How many problems do I need to complete to pass:

a 15– second timing?______________

a 1 minute timing?______________