Assessing the Effects of the *Rocket Math* Program with a Primary Elementary School Student At Risk for School Failure: A Case Study

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Abstract

This study assessed the effects of the *Rocket Math* program on the math fluency skills of a first grade student at risk for school failure. The student received instruction in the *Rocket Math* program over 6 months. He was assessed using a pre- and posttest curriculum-based measurement (CBM) and individualized fluency checkouts within the program. On the CBM pretest, he completed 10 problems correct in 1 minute. On the CBM posttest, he finished 21 problems correct in 1 minute. On the *Rocket Math* fluency checks, the student’s problems correct per minute increased from 19 (Level A on first assessment) to 26 (Level M on third assessment session). He had few errors and averaged 23.1 problems correct per minute on the fluency checks. Implications for further research are discussed.

Keywords: mathematical fluency, automaticity, accuracy, proficiency

Mathematics is one of the core academic subjects taught in U.S. public schools. A substantial amount of time, effort, and money is invested in mathematics education every year. For example, “The U.S. Department of Education Budget Office (2003) estimated it would spend $1 billion dollars over five years for requested mathematics and science partnerships” (Lin & Kubina, 2005, p. 73). Competence in mathematics is a crucial goal for early schooling and directly affects the demands of formal schooling, daily activities, employment, labor quality, and national growth (Ramos-Christian, Schleser, & Varn, 2008).

Unfortunately, the goal of mathematical competence is not being reached in the United States. In 2009, the National Assessment of Educational Progress (NAEP) reported fewer than 30% of students in grades 8 and 12 achieved proficiency in mathematics (Duncan, Easton, & Kerachsky, 2007). Proficiency is identified by the NAEP as representing solid academic performance and demonstrating
competency over challenging subject matter. Further, 39% of students in fourth grade performed at or above the proficient level (Duncan et al.). In Washington State, 43% of fourth graders achieved the proficient level on this national assessment.

Poor U.S. performance in mathematics is also being illustrated internationally. The Trends in International Mathematics and Science Study (TIMSS) 2007 illustrated the poor performance of U.S. students in mathematics compared to international students (Gonzales et al., 2007). The content areas of this study were number, geometric shapes and measures, and data display. The U.S. ranked eleventh out of 36 industrialized countries of fourth-grade students analyzed. Additionally, only 10% of fourth-grade students reached the TIMSS advanced international benchmark, the highest point on the mathematics scale, scoring eighth out of 36 countries analyzed (Provasnik, Gonzales, & Miller, 2007).

The National Council of Teachers of Mathematics (NCTM) identified fluency in computation and knowledge of math facts as integral elements of national math standards (NCTM, 2010). Within these standards is the expectation that by the end of second grade, students should know the basic addition and subtraction combinations and be fluent in adding two-digit numbers. Fluency in basic mathematical skills is essential for the success of students in primary education because it serves as a foundation for mathematical applications such as time, money, and problem solving (Codding, Chan-Iannetta, Palmer, & Lukito, 2009).

There are many reasons to build mathematical fluency. First, fluency of basic facts is essential to master higher-order skills, such as multi-step problems in algebra and calculus. Second, many of these higher-order skills require automatic recall of basic facts (Wong & Evans, 2007). Third, building fluency can increase students’ motivation and effort (Codding et al., 2009). Fourth, students will have more opportunities to respond when given more opportunities to complete problems (Poncy, Skinner, & Jaspers, 2007). Fifth, skills are maintained longer, students are better able to resist distractions, and they are able to stay on task longer (Rhymer, Dittmer, Skinner, & Jackson, 2000). Sixth, students who are responding automatically typically have less anxiety in math due to the lack of effort required and the increased level of success (Poncy et al.). Finally, if basic skills are not fluent, students may rely on time-consuming strategies such as finger counting, preventing them from completing more math problems in an efficient manner (Ramos-Christian et al., 2008).

Unfortunately, there is a lack of focus given to memorization of mathematics facts through fluency building in general education.
Contemporary methods of math instruction have de-emphasized fluency to concentrate on problem solving and concept development (Spear-Swerling, 2006). A paucity of published studies on interventions enhancing computational fluency has been conducted (Codding et al., 2009). For example, Duvall, McLaughlin, and Sederstrom (2003) conducted a study utilizing precision teaching, goal setting, and immediate feedback to increase mathematical fluency with three middle school students with disabilities. Results indicated methods such as precision teaching could increase accuracy and fluency and that skip counting methods such as counting by 5s, 6s, and 8s can also be used to increase accuracy and fluency.

Further, Codding et al. (2009) compared the effects of copy-cover-compare (CCC) and goal setting to increase mathematics fluency with 173 third-grade students. These strategies were used by teaching students to use copy-cover-compare to decrease errors and setting goals to increase fluency. Results showed the combined CCC and goal setting strategy produced higher scores of computational fluency. Average pretest scores were in the frustration range (students were at the beginning stages of fluency building). Posttest scores increased to the instructional range (increased rate of problem completion and reduced errors). Finally, Fuchs et al. (2009) assessed the efficacy of tutoring on fluency of number combinations and word problems with 133 third graders with math difficulties. Participants were tutored on automatic retrieval of simple arithmetic problems and on word problems. Results showed superior improvement of the tutoring conditions compared with the control group. Results also indicated that providing small amounts of timed practice and teaching students an efficient counting strategy could affect comparable outcomes.

In the studies reviewed only one was located that incorporated a published mathematics fluency-building program. Wong and Evans (2007) used two programs to increase mathematics fluency including Back to Basics Math Multiplication (Back to Basics, 1999) and Mathematics Worksheet Factory Lite (Schoolhouse Technologies, 2001). Wong and Evans examined the systematic practice of multiplication facts using computers in comparison to a pencil and paper approach with 64 fifth graders. Participants received multiplication practice on the computer or with worksheets in the classroom. Results illustrated a greater increase of mean scores in the paper and pencil approach.

One mathematics program used in elementary classrooms to increase computational fluency is Rocket Math (Crawford, 2009). This program gives a sequence of learning facts that students master. Prior to the implementation of the program, current level of performance is established using a pretest that evaluates the writing speed of each
student. Twenty-six different worksheets, progressing from simple to more difficult, are provided consisting of four levels of addition, subtraction, multiplication, and division problems. The problems include already mastered problems and a new set of novel problems. Students progress from one level to the next when their pre-determined fluency goal is reached. Interspersion of known and unknown facts is used to increase speed of completing facts. Students cannot progress to the next set of problems until an individualized performance criterion is reached. The program does not introduce more than two new facts at any one time. As students complete the addition level, they continue through the progression of subtraction, multiplication, and division. No published studies could be found assessing the effects of Rocket Math. The purpose of this study was to assess the effects of Rocket Math on a first-grade student at risk for school failure.

Method

Participant

John was a first-grade student at risk for school failure. He was diagnosed with Attention Deficit Hyperactivity Disorder and qualified for special education services under the category of Developmental Delay with social/adaptive deficits. On the district first-grade math assessment, he scored 62%. On the Woodcock-Johnson III: Test of Cognitive Abilities (Woodcock, McGrew, & Mather, 2001), his standard score was 101, placing him in the average range of basic intelligence. On the Behavior Assessment System for Children (BASC) (Reynolds & Kamphaus, 1992), John scored clinically significant in Externalizing Problems (77 standard score) and Behavior Symptoms Index (75 standard score). John was unable to attend to specific math tasks such as completing story problems and had difficulty with math fact fluency. Given these reasons, the student was deemed most in need of support, and thus, became the focus of the intervention. Procedures required by the Institutional Review Board through Eastern Washington University were followed for this project.

Setting

This study took place in a suburban elementary school in eastern Washington. The elementary school (K-6) consisted of 576 students, 90 of whom were in the first grade. Of the school population, 11% qualified for free and reduced price lunch. Sixty students school-wide were served in special education; 23 students qualified for special education in the area of math.

The fluency program occurred 3 days a week from 1:15 p.m. to 1:30 p.m. in the general education classroom; only John’s data were
examined for this project. During the study, a graduate student in special education served as the educator and conducted the Rocket Math program with the entire class of 24 students. She was the general education classroom educator, having been in this position for 5 years. She had a bachelor’s degree in elementary education and endorsements in English and reading and was working toward a master’s degree in special education. This project fulfilled the requirements for her graduate research project.

All students participated in the Rocket Math program at their desks. In addition to this program, the educator taught Math Trailblazers (Wagreich & Kelso, 1997), the standard math curriculum used by the district. Math Trailblazers is a curriculum that emphasizes problem-solving exercises in real world contexts, utilizing whole-class instruction, small-group activities, and individual work. Math Trailblazers was taught for 60 minutes everyday. Lessons were focused on hands-on activities and paper and pencil tasks. Fluency building on math facts was not a part of Math Trailblazers.

Curriculum and Materials

Rocket Math was the math fluency program used for this study. The addition portion of the program was used for this study. There were 26 levels in addition (A-Z); John started at Level A. Materials for this program included a pre- and posttest, 1-minute tests, and a student progress-monitoring chart. Also used during the study were pencils, folders, and a timer. If there was a problem they couldn’t answer, students used a number line at their desks. The 1-minute test consists of one page with practice problems around the outside border in a rectangular shape and the test portion in a rectangular box in the middle of the page.

Dependent Measures

Two dependent measures were selected to measure John’s fluency progress. These measures included scores on Curriculum-Based Measurements (CBM) and Rocket Math fluency checks included in the program.

CBM. The educator used a CBM of addition of whole numbers to assess John before and after the implementation of the fluency program. This CBM was obtained from AIMSweb (Shinn, 2008). John was given 1 minute to answer as many addition problems as possible. The dependent measure was the rate per minute of single-digit addition problems completed correctly.

Rocket Math fluency checks. Timed 1-minute fluency checks were conducted during every lesson. John had to complete as many addition problems as possible on a test set of problems. If John met or
exceeded his individualized goal (see Procedure section), he recorded it on the progress-monitoring chart. Any numerals that were incorrect or reversed were marked as errors. The dependent measure was the rate per minute of single-digit addition problems completed correctly. Attempts to mastery, average errors, and average problems correct were recorded.

Design and Procedures

The research design used for this study was a single-case pre-test posttest noneperimental design (Martella, Nelson, & Marchand-Martella, 1999). *Rocket Math* was delivered over 4 months. The educator followed the program’s guidelines for all students including John. A 1-minute placement test was given to all students to determine how fast they could write numerals. From this test, an individualized goal was determined for each student. From the placement test, it was determined that John’s individualized goal was 26 problems correct; other students’ goals ranged from 15 to 35 problems correct. For each 1-minute timing, students write as many answers as they can to basic addition problems. As students pass their individualized goal for each level, they proceed to the next level (e.g., when they complete level C, they progress to level D). The students received a folder with a progress-monitoring sheet in the shape of a rocket on the front. When students passed a level, the students colored in one section on the rocket. Each level introduces two new addition problems.

Prior to the implementation of the program, the educator taught the steps to each lesson in an explicit fashion. She started each lesson by giving all students their folder with a new test sheet enclosed. Students were instructed to put their finger on the first problem of the outside group of practice problems. The educator said, “On your mark, get set, go” and the students practiced as many problems as possible by whispering the answers for 1 minute. The educator walked around listening to the students’ answers to check for accuracy. The educator conducted this portion of the study this way, rather than having students pair up and work with a partner as noted in the *Rocket Math* program, because the first graders in her class had a difficult time both practicing with each other without becoming distracted and tracking each other’s responses. At the conclusion of 1 minute, the students were instructed to stop. Next, the students were told to get their pencils ready for the same practice set of problems. At the beginning of 1 minute, the educator said, “On your mark, get set, go.” The students completed the same portion of practice problems on the worksheet, writing as many answers to the problems as possible. At the end of 1 minute, the educator said, “Pencils down.”

Finally, the educator followed the same procedure as the
previous practice with the exception that the students were instructed
to complete the inside portion of the worksheet with different addi-
tion problems than the previous set. The students completed as many
problems as possible in 1 minute. At the conclusion of the test por-
tion, the students put their sheet back in their folder and turned in
the folder to the educator. The educator corrected students’ tests after
completion of the lesson. The teacher also checked for errors on the
practice portion on the test. If there were problems that students con-
sistently missed, the students were given additional opportunities for
practice before the next fluency checks were administered. When the
students reached their goal, the educator replaced the test with the
next level sheet. If the students did not reach their goal, the educator
replaced the test with same level sheet. John completed 13 of the 26
levels of the Rocket Math program. The last 3 weeks of implementation
of the program, John was the only student to complete a lesson every
day, in an effort to complete the program. John would complete a les-
son when the other students in the classroom were working on inde-
pendent work. Because of this, John’s environment often had varying
degrees of distraction (e.g, students moving around the classroom,
students talking, students working together).

Treatment Fidelity

To assess treatment fidelity, a 5-item observation form was used;
this form was adapted from one used by Benner, Kinder, Beaudoin,
and Stein (2005). The observation form consisted of five sections: (a)
Educator follows format outlined by the Rocket Math program, (b)
Educator frequently provides positive feedback, (c) Educator moni-
tors student responses, (d) Educator ensures students abide by timing
rules, and (e) Educator ensures students follow steps of the program.

Two of the educator’s university professors and a colleague ob-
served the administration of Rocket Math five times over the course of
the study. The professors had over 20 years of academic experience.
The educator’s colleague was a first-grade teacher who had 11 years of
teaching experience; she taught in the same building as the educator.
The professors observed the educator four times and the colleague
observed the educator twice throughout administration of the pro-
gram. The advisor and colleague reported the educator administered
the program with 100% treatment fidelity during each observation.

Results

CBM

As shown in Figure 1, John completed 10 problems correct in 1
minute on the CBM pretest. He used his number line to complete five
of the problems. On his posttest CBM, he finished 21 problems correctly. John did not use his number line to complete any of the problems. No errors for either the pretest or the posttest were recorded.

Figure 1. Number of corrects and errors across CBM and Rocket Math fluency checks.

Rocket Math Fluency Checks

As shown in Table 1 and Figure 1, John began the program on level A and completed 19 problems correctly in 1 minute. At the conclusion of the program, John ended at Level M and completed 26 problems correctly in 1 minute. When mastery was not achieved on a level, errors were similar; difficulties were noted on problems with 9 as one of the addends. The educator practiced these problems again with John before the next fluency check was administered. On average, John took 2.6 times on each level before he met mastery to continue to the next level.

Discussion

The purpose of this study was to examine the effects of the Rocket Math program for a primary elementary school student at risk for school failure. The CBM showed that John exhibited an increased rate of problems completed correctly per minute from 10 to 21 from the pre- to posttest assessment; he did not exhibit an increase in errors. A score of 21 is considered “mastery” by Shapiro (1996) for digits correct per minute: grades 1-3 should complete 20+ digits correct per minute.
In this study, the student correctly completed 11 digits per minute on the pretest CBM and 29 digits per minute on the posttest CBM. Thus, the student moved from instructional (10-19 digits per minute) to mastery (20+ digits per minute) by the end of the study.

John’s Rocket Math fluency check scores also improved. He averaged 23.1 problems correct throughout the program. On average, John took 2.6 attempts to pass a level. The class average was three attempts to pass a level, with a range of one to six attempts to pass a level across students. At the beginning of the program, when the problems were more familiar (he had practiced them previously), John completed these levels more quickly. As the levels became more difficult, John progressively took more repetitions to meet mastery on each level.

These results show the impact of a fluency-building program for students who are at risk for school failure. This study adds to the limited research base on the efficacy of Rocket Math (Crawford, 2009).
Further studies on this program are needed to address program effectiveness. Further, treatment fidelity was an important aspect of this study. High fidelity noted this program was being implemented as intended. When future studies are conducted, treatment integrity should be assured.

One of the integral elements of national math standards is fluency in computation and knowledge of math facts (NCTM, 2010). Within this standard is the expectation of basic addition fact fluency by the end of second grade. This expectation is crucial for students who struggle in mathematics because if skills are not fluent, students rely on more time-consuming strategies, such as finger counting (Ramos-Christian et al., 2008). Students cannot complete higher-order skills if there is no automatic recall of basic facts (Wong & Evans, 2007). Contemporary methods of math instruction de-emphasize fluency to concentrate on problem solving (Spear-Swerling, 2006). Math fluency is crucial if all students in the United States are going to reach proficient levels in mathematics.

Over the course of this program, there were positive effects noted with John. When it was time for a Rocket Math lesson, John had his pencil ready. He remained on task for the entirety of the lesson. He got out his crayon as soon as he was asked and quickly colored in his goal sheet when he passed his goal.

Despite the positive findings, several caveats were noted. First, no experimental control was demonstrated given that an experimental design was not used. Essentially, this investigation should be considered a case study. Second, this study only examined one student. Future studies should include more participants to show generalizability across a variety of settings. Third, generalizability could not be shown because there was only one instructor. Future studies should include multiple instructors to implement the program with the student instead of having only one instructor. Fourth, history effects should be noted because additional math instruction was occurring during this study that may have positively or negatively affected this study. Fifth, John did not finish the program. Future studies should be conducted so that the student finishes the program. Finally, John was easily distracted. To remediate this, John had a behavior chart to motivate him during the entirety of the study.

Although there were several limitations of this study, the student showed gains in math fluency after the Rocket Math program. John’s fluency of basic addition problems increased as a result of this program. The instructor maintained treatment fidelity. The results of this study show that using a fluency-building program may be effective with individuals at risk for school failure.
References


