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The use of graphing and an effort and achievement rubric to increase students' multiplication fact accuracy and fluency

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THE USE OF GRAPHING AND AN EFFORT AND ACHIEVEMENT RUBRIC TO INCREASE STUDENTS' MULTIPLICATION FACT ACCURACY AND FLUENCY

by
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Dedication

I would like to dedicate this manuscript to Chris and my family and friends for their encouragement and support.

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Abstract

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The purpose of this study was to determine the effects of self-graphing and an effort and achievement rubric on increasing students' multiplication fact accuracy and fluency. The research design was a two-group pretest/posttest research design. Data was collected from student multiplication math fact quizzes. Students were given the same math fact quiz for a month before a new set of facts was introduced the next month. For each month, the first quiz of the month served as baseline data as no interventions were introduced for those quizzes. The second month of quizzes served as the self-graphing alone data, and the last three months served as the self-graphing and effort and achievement rubric data. Students were separated into a group of five low achievers and five high achievers and data was grouped according to grades on the quizzes, the time it took to finish the quizzes, and digits correct per minute. All data was analyzed by finding the mean of the quizzes to eliminate practice-effects of taking the same quiz for a whole month. The results of the study showed that the use of self-graphing alone was most beneficial for increasing math fact accuracy and fluency. This suggests that students should graph their math fact achievement from week to week, but that the addition of an effort and achievement rubric might best be introduced with a different task.

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Introduction

Statement of the Problem

The level of higher order thinking skills required of today's elementary school students demands that students know basic math facts in order to manipulate those facts to perform higher order thinking skills. For example, the Common Core State Standards being implemented in 45 out of 50 states (including New Jersey) require mathematic practices of students including: solving two-step word problems using the four operations, representing these problems using equations with a letter standing for the unknown quantity, and assessing the reasonableness of answers using mental computation and estimation strategies including rounding. Students are also expected to identify arithmetic patterns (including patterns in the addition table or multiplication table), and explain them using properties of operations. In addition, the Standards state that students, by the end of third grade, "know from memory all products of two one-digit numbers" (NGA Center/CCSSO, 2012). Because students are expected to master their multiplication facts, it is desirable to spread out the acquisition of new sets of facts throughout the school year as well as explain to students the importance of knowing their multiplication facts so they will be able to become productive adult members of society in the 21st century.

As math fact fluency is included in the Common Core State Standards, it can be assumed that math facts will be assessed on state tests. These tests have become very high stakes for both students and teachers, so it is important for both parties to understand ways students can best meet math fact acquisition and fluency goals. While it is hard to predict exactly what an assessment of math fact fluency will look like, the good news is, for students struggling with the memorization of math facts, other strategies are often taught to help students find products of single-digit multiplication problems. Students are provided with strategies to answer math facts, mainly so a deeper conceptual understanding is formed, but this also means students have strategies to fall back on when their memories fail them. Now that it has been established that student memorization of math facts is a fundamental mathematics learning block to be built on later, what does current research say is the best way to learn math facts?

Most researchers agree that math facts should not be taught in isolation. Rote memorization of math facts reinforces lower level thinking skills in mathematics and does not allow students to explore strategies for solving these facts that come naturally when given opportunities to practice (Woodward, 2006). Students must understand the conceptual notion that multiplication is groups times the number of objects in each group. When asked what 5 x 6 means, students need to be able to articulate that there are five groups of six rather than just replying with the answer 30. Students should be provided with strategies to solve multiplication problems other than relying solely on the memorization of facts. These strategies include: repeated addition (i.e. 5 x 6 = 6 + 6 + 6 + 6 + 6), manipulating objects into a certain number of groups with objects in each group, using arrays, and finding patterns within multiplication facts.

Significance of the Study

Methods for teaching math facts have changed significantly even in my six years of teaching. When I was first hired at my school district, the mathematics instructional facilitator instructed teachers not to require students to memorize any math facts but that the facts would come as students solved problems involving them. My district now gives fact quizzes every week, and math fact memorization is required by the mathematical standards that drive our math curriculum. The amount of time devoted to rote memorization of math facts versus the building of conceptual understanding has been a debated topic, but why? As I am a third grade teacher, the focus of this research is mainly multiplication facts, but addition and subtraction fact memorization is also closely related as far as the necessity of memorizing such facts and the strategies used to teach and assess accuracy and fluency of these facts. Learning math facts leads to higher order mathematical thinking. Does it not make sense to know what 5 x 6 is before going on to answer a problem such as 35 x 26?

Word problems involving multiplication are also introduced in third grade. When students are asked to solve a word problem they are required to perform complex mental activities such as: read the problem, find the important information needed to solve the problem, decide what operation the word problem is asking them to do, and write an answer in a complete sentence. Because students are asked to decipher all of these steps, it would seem advantageous for students to know their multiplication facts so that their mental faculties can be freed up to figure out those other pieces to the word problem puzzle. In addition, division is often sequentially taught as the inverse to multiplication. It would seem to make sense that students have a very firm grasp of multiplication strategies and fact accuracy and fluency before expecting them to manipulate the numbers to form complex division problems. When less attention is needed to figure out math facts, greater mental capacity is freed up to solve higher-level mathematical computations. Furthermore, research indicates that students who have specific learning disabilities in mathematics often have deficits in fact fluency, that these deficits continue with them, and that a lack of computation fluency may be a telltale sign of mathematics difficulties (Codding, Burns, and Lakito, 2011).

Math fact acquisition is not only a building block for further mathematical thinking, it is also highly relevant to real world skills. And students should be provided with examples of how multiplication will be useful in their day-to-day lives. In my current teaching practice, I show students how I use multiplication facts to figure out their grades. I explain to them how I use multiplication at the grocery store, and how multiplication helps me to plan parties. Math fact fluency is necessary for successful independent living.

Along with building the conceptual framework of multiplication, there are several research-based strategies that teachers can use to help students with the acquisition and fluency of math facts. These strategies include: drill and practice with modeling, incremental practice, cover-copy-compare, taped problems, and flashcards with peer tutoring. But what happens when these strategies are not enough? Some students still struggle with improving their math fact accuracy and fluency. Research suggests that self-monitoring is an effective strategy throughout many school subjects. Can self-monitoring be used as an effective strategy for memorizing multiplication facts?

Purpose of the Study

The purpose of this study is to determine the effects of student self-monitoring on both the acquisition and fluency of multiplication math facts by third grade students in a regular education setting. For the purposes of this study, student self-monitoring will include self-graphing and an effort and achievement rubric. For students initially struggling with fact acquisition after the baseline, self-monitoring techniques of self-graphing and an effort and achievement rubric will be introduced. Math fact acquisition will refer to the number of problems answered correctly. Math fact fluency will refer to if the students are able to answer the problems correctly in a certain amount of time. Data will be collected to see if the students' time decreases thus proving an increase in math fact fluency. This study will be conducted with regular education students in a third grade classroom and the results will be used solely within this classroom to see if the interventions introduced will increase the level of math fact accuracy and fluency with this particular group of students.

The hypothesis for this study is that the students' math fact fluency will increase as students recognize the connection between effort and achievement and become active participants in the monitoring of their progress and learning. This hypothesis is based on previous classroom evidence showing that typically students who study more for assessments are able to perform better on those assessments. Research also states that helping students see the connections between self-management and goal-setting will increase their work productivity thus leading to higher gains in accuracy and fluency as work quality and effort increase (Konrad, Fowler, Walker, Test & Wood, 2007). Self-management refers to changing one's behavior tactics to produce desired behaviors. Self-monitoring is a component of self-management (Joseph& Konrad, 2009).

Students participating in this study are regular education students. None of the students have been classified with a learning disability in the area of mathematics, however, some students received basic skills instruction because they were identified as needing additional support in the area of mathematics. Multiplication math facts includes all products of two one-digit numbers as well as one-digit numbers multiplied by ten. Due to time constraints, only facts zero through six, and 10 will be assessed and used for data collection in this study. Self-graphing is the process by which students will record the number of answers correct out of the 50 total math facts on each quiz. A data table will be filled in for each month with columns for the week number, number sentence, and total correct. The students will self-monitor their progress on each of the quizzes through the use of self-graphing and an effort and achievement rubric.

Examples given to the students of putting effort into remembering their multiplication facts were studying for three to five minutes every night or longer if needed, using flashcards or technology websites if internet access is available, and practicing over and over again until you become the best you can be. An explanation of why effort should be used was also discussed so that students understood the importance of remembering their math facts. This included real world examples of adults using multiplication facts and the explanation that knowing these facts will allow them to free up brain energy to work on more complex problems. Examples provided to students on the achievement they should see from putting effort into studying their facts would be their number correct should improve each week, their grades should go up, and/or the time it takes students to complete the quizzes should decrease.

For students initially struggling with fact acquisition after the baseline, the addition of the self-monitoring techniques of self-graphing and the effort and achievement rubric, should make a difference. For the purposes of this study, math fact acquisition is defined as the number completed correctly. Math fact fluency is defined as meeting the criteria for math fact acquisition in a certain amount of time. Many studies working with math fact fluency use the standard that students must complete problems at a rate of at least 20 digits correct per minute (dc/m) to demonstrate mastery and 10 to 19 dc/m to be at the instructional level. Students with a fluency rate of nine or less dc/m would be at the frustration level (Burns, 2005). In order to meet the criteria for math fact accuracy for the purposes of this study, students must achieve no more than five incorrect answers in ten minutes. Students struggling with math fact fluency will include those students taking longer than five minutes to complete the quiz. Students scores will also be compared to the suggested standard of digits correct per minute. Students struggling with math fact acquisition will refer to those students receiving anything lower than a B, or an 84, on their multiplication quizzes.

Low math achievers and high math achievers will be identified using a rubric of 1-3 for math performance. Both high and low achieving students will be identified using end of the year math test scores from second grade, a rubric of 1-3 for math performance, response to intervention Tier II identification, and baseline data from the first set of multiplication quizzes. The goal of this study is to include a discussion of high math achievers vs. low math achievers when determining if the effects of self-graphing and an effort and achievement rubric increase students' multiplication fact accuracy and fluency by enabling students to answer more problems correctly in an increasingly shorter period of time.

Chapter 2

Literature Review

Introduction

Most educators recognize the need for students to know their math facts in order to perform higher-level math operations. However, educators also realize that the memorization of math facts does not come easily to all students. Math fact acquisition and fluency is a much-researched topic due to the fact that educators are continually searching for the best ways to teach math facts to a diverse student population. They are also searching for strategies to employ when students are not progressing as expected in memorizing math facts. Before looking into research on the best math fact practices, it is important to note that there are differing perspectives on the amount of instructional time that should be spent on allowing students to memorize math facts.

An article written in *The Mathematics Teacher* (Callen, 1994) sums up the ongoing debate between the rote memorization of math facts and the development of conceptual understanding. From teachers' perspectives, students who have not memorized their multiplication facts later struggle with algebra, fractions, division, and other math skills. Rote memorization of facts is a necessary skill or building block for other higher-level math skills, and students who memorize their multiplication facts feel more confident in their math abilities as they have some knowledge to fall back on when learning new processes. On the other hand, some argue that "traditional" mathematics involving rote memorization is no longer necessary. That students can use calculators or learn to remember mathematical facts through discovery learning and that the "traditional" algorithms are no longer the best way to teach mathematics. So how should teachers and students internalize these two very different approaches?

The key is to strike a balance between the rote memorization of facts and activities that allow students to manipulate multiplication facts, look for patterns, and develop their own strategies to solve multiplication problems. While it is understood that the simple memorization of facts does not lead to a deeper conceptual understanding, memorization is still necessary for students, especially students with learning disabilities, to succeed in mathematics instruction (Caron, 2007; Ploger & Hecht, 2012). Thus, teachers should focus on providing students with opportunities to acquire math fact accuracy and fluency.

Current research strongly supports the necessity of math fact accuracy and fluency. Conceptual understanding is obviously the goal, but when the strategies used to develop them take a significant amount of time and effort, they may end up detracting from the development of skill mastery. In addition, cognitive theorists point out that we have a limited amount of cognitive space for tasks that require a great deal of working memory and the processing of information simultaneously (Delazer, Domahs, Bartha, Brenneis, Locky, Treib & Benke, 2003; Poncy, Skinner, and Jaspers, 2006)

Methods for Math Fact Acquisition

There are a variety of research-based strategies for acquiring this necessary math fact fluency and accuracy. The following are a few strategies demonstrated to be effective when working with students to memorize math facts. Most research indicates that direct instruction is necessary for students to be able to gain math fact practice strategies. The strategy of Cover-Copy-Compare (CCC) is a direct approach in which students are asked to look at a correct model, cover the model, respond on their own, then check their accuracy to the model (Poncy, McCallum, Schmitt, 2010; Poncy, Skinner, and Jaspers, 2006). The use of Taped Problems (TP) is similar and takes even less time to implement than CCC. TP involves facts recorded on a tape recorder. The student listens to the fact, records an answer, then hears the correct answer, and crosses out their answer if it is wrong to write the correct answer (Poncy, Skinner, and Jaspers, 2006; Poncy, McCallum, Skinner 2012).

In an alternating treatment study conducted by Poncy, McCallum, and Schmitt (2010), the authors compared the effects of the behavioral intervention of CCC to the constructivist approach of Facts That Last (FTL) on the fluency and automaticity of subtraction facts. The study was conducted with nineteen second-grade students, none of which received special education services in the area of math. CCC and FTL were implemented every day in alternating order. The control was no instruction at all. An assessment packet consisting of forty-eight subtraction problems was also given everyday containing three math probes, one for CCC, one for FTL, and one for the control. During the CCC intervention, the procedures differed from the traditional CCC method in that the model used for correct responding was a fact triangle, not single fact problems. Specifically, students were asked to look at the fact triangle, cover the fact triangle, record the problem and answers to the two related subtraction facts in the spaces provided, and uncover the model and check the accuracy of both problems. In contrast, the FTL strategy consisted of a fact family warm-up and then a more difficult fact family task. During the FTL intervention, teachers asked questions to guide students through fact family exploration, and flashcards were also used to prompt responses. The students used addition to help them figure out the related facts and were permitted to discuss the strategies they used to come up with the fact families and their reasoning behind such strategies. The results indicate that CCC showed an increase in digits correct per minute. Seventeen out of nineteen students had increased digits correct per minute with the CCC strategy. FTL showed fluency levels similar to that of the control. Students also indicated they preferred CCC to FTL when filling out a questionnaire. This study supports that behavioral, direct instruction is favorable over instruction that is more constructivist-oriented in nature when it comes to math facts.

In a second study related to CCC and Taped Problems (TP), Poncy, Skinner, and Jaspers (2006), conducted an alternating treatment study to compare CCC to TP problems with addition facts. This time, the participant was a ten-year-old girl with low cognitive functioning. Each intervention session included a packet consisting of three pages: the CCC or TP sheet, a sprint/practice probe containing the problems of the respective condition, and an assessment probe to collect data on the dependent variables. During the CCC intervention the student read the printed problem and answer, covered the problem and answer, wrote the problem and answer, checked the accuracy of her response by comparing it to the model, and verbalized the correct problem and answer three times. During the TP intervention, the student was given a worksheet and instructed to record the answer before the tape played the answer. If answered incorrectly, the tape was paused so the student could correct the mistake. Immediately after the intervention was implemented, the student's accurate responding to the single digit addition problems increased to 100% on TP problems and remained at this level throughout the study. The student's accuracy on CCC problems immediately increased to 90% and then remained at high levels (89–100%) for the remainder of the study. Because accuracy on the set of control problems remained low, this suggests that both TP and CCC interventions were effective; however, the authors determined TP to be more effective because it took 30% less time for the student to complete problems under that intervention. One notable limitation of this study was, due to the student's low cognitive functioning, only four problems were targeted under each intervention thus causing a ceiling effect.

In a third, alternating treatment study, Poncy, Skinner, and McCallum (2012) compared CCC with TP. During the TP intervention, a group of third grade regular education students listened to a subtraction fact on tape and tried to supply the answer before the tape. The CCC intervention involved students once again consulting triangle flashcards when writing down fact families. The control was no intervention. Students were assessed on a forty-eight problem subtraction quiz every morning (containing twenty-four probe problems from each set) followed immediately by six minutes of either TP or CCC interventions. The students then received a second round of the counterbalanced intervention in the afternoon. Assessment probes were given corresponding to facts from the TP, CCC, and control interventions. Results of the study indicated that the TP intervention was most effective for 16 of the 20 (80%) students. For two students both TP and control showed equal increases. Two other students showed their greatest gains under CCC. In this study, TP worked best overall for the particular group of third grade students assessed, but since some students benefitted from CCC, it is important to note that no strategy is a one-size-fits-all strategy, and not one strategy can be applied to every student in a classroom.

Another strategy that uses direct instruction to drill and practice unknown facts is Incremental Rehearsal (IR). During IR, students are given one unknown fact then given the answer until they can repeat it on their own. Another unknown fact is presented along with the now known fact and so on. Burns (2005) conducted a study to determine the effects of IR on teaching singe-digit multiplication facts to three third-grade students identified as learning disabled in mathematics. Facts were written on index cards and categorized as correct, if answered correctly within two minutes, or unknown. While practicing facts, only ten facts at a time were used using a ration of 10% unknown to 90% known. If a fact was unknown, the answer was verbally supplied, the student repeated the problem and answer, and then continued to rehearse the fact until making that fact a known fact and removing one of the previously known facts to maintain ten total facts. The results indicated both improvements in digits correct per minute performance immediately after the intervention and continuous increases during the intervention. The resulting effect sizes were 17.00 for Student 1, 3.42 for Student 2, and 4.79 for Student 3. The author theorized that the benefits of IR are probably that it contains both an appropriate challenge to increase new learning and increased repetitions. A limitation to this study is that one-on-one intervention was used so it may be considered an intensive intervention.

Peer tutoring using basic multiplication flashcards, when implemented with instruction in tutoring, is also successful in increasing math fact fluency. Hawkins, Musti-Rao, Hughes, Berry & McGuire (2009) researched the use of peer tutoring to teach multiplication facts in a fifth grade classroom. Twenty-six regular education students were involved in this study and were referred based on the fact that they had not mastered multiplication facts and both the assistant principal and classroom teacher felt this was hindering their math performance. The researchers were only able to get eleven of the students' permission to use the data for research purposes. Three target fact sets were obtained during the baseline, and assessment probes were used to gather data on these fact sets. Each probe contained 48 problems. The peer tutoring involved training for the students and a folder containing: flash cards of the targeted math facts during each phase of the study, a Good Tutor Card used to reinforce appropriate tutoring behavior, and a log sheet to record performance after each session, a script outlining the peer tutoring procedures, and a feedback sheet including an enlarged check mark and X symbol to use during testing. Students switched roles between tutor/tutee after five minutes. A flashcard assessment was given at the end of the ten-minute sessions to each of the students by the other student. A group contingency reward was also given for good tutor/tutee behavior. In early sessions students repeated the twelve problems 6-8 times and progressed to 10-15 times in later sessions showing an increase in math fact fluency. For each fact set, there was an immediate increase in digits correct per minute for all eleven students. Data from all three problem sets demonstrated an increasing trend in digits correct per minute. This study is consistent with other research that class wide peer tutoring has a positive effect on mathematics performance.

The inclusion of timed drills in math fact assessment and instruction is necessary to determine math fact fluency, accuracy, and automaticity. Furthermore, students who are asked to memorize multiplication math facts using an integration of both timed drills and direct teaching approaches for fact acquisition are able to maintain math fact acquisition. Woodward (2006) compared an integrated approach of timed practice drills and strategies versus timed practice drills only. Fifty-eight fourth grade students participated in this study, including fifteen students with IEPs in math. Students in both groups were taught for 25 minutes, five days a week, for four consecutive weeks. Students in the timed drill/direct teaching approach were taught research proven strategies such as doubling, derived facts, visual representations, a partial product algorithm, using arrays and number lines etc. The integrated approach group also worked with word problems and was taught a new strategy and asked to relate the new strategy to other strategies. The students in this group were then given a two-minute timed practice drill. They corrected their own work, and when 70% of students achieved 90% success with a strategy, a new strategy was introduced. In the timed practice only group the students gave choral responses to fact sets after the teacher provided the fact and its answer. The students in this group were then given a two-minute timed practice drill. They self-corrected their own work and the teacher moved on using the same percentages listed for the integrated group. The students also completed worksheets using the traditional multiplication algorithm to multiply two-digit by two-digit numbers. Three different assessments were used to measure fluency, automaticity, and accuracy. Results indicated that both approaches were effective, but the integrated approach produced greater gains in maintenance and posttest performance as well as math fact automaticity and performance on extended math fact problems (2 x 1 digit math problems). Both groups improved in their knowledge of harder math facts, or those which students typically have trouble remembering. Unfortunately, the learning disabled students in both groups were still below the mastery level of 90% for common math facts highlighting the need to use different interventions with this group of students.

While there are different means for achieving math fact fluency and accuracy, a well-balanced approach to teaching math facts should include other strategies for learning facts besides just rote memorization. These strategies include the use of arrays, manipulatives to make groups with a certain number of objects in each group, looking for patterns, using count bys (3,6,9…), finding fact families, etc. to help students build their conceptual framework for multiplication (Ford & Usnick, 2010-2011; Greene, 1992; McIntyre, Test, Cooke & Beattie, 1991). The use of computer software to aid in conceptual understanding of math facts is also beneficial in addition to classroom instruction (Chang, Sung, Chen & Huang, 2008). Teaching other strategies and using different techniques can actually aid in the memorization of math facts (Phillips, 2003).

Students with Math Difficulties and Self-monitoring

But what about those students who are still really struggling to memorize their facts even after many research-based strategies have been utilized? The demands of using technology in the 21st century require mathematics proficiency and higher level thinking skills. Mathematics proficiency has been linked to greater ease in finding jobs and higher gains in employment, and mathematical deficits also tend to follow students into adulthood (Burns, 2005). Lower achieving students are less likely to fluently retrieve math facts and fact recall fluency and accuracy problems are typical of students classified with learning disabilities and low overall math achievement (Stickney, Sharp, Kenyon, 2012). How can teachers help these students gain math fact fluency? Will the use of self-graphing and self-monitoring lead to higher math fact acquisition and fluency?

Research supports the use of student self-monitoring and self-graphing to increase student performance across all academic subjects. When self-monitoring procedures are used in conjunction with self-management instruction, an improvement in the performance of students' with disabilities can be seen (McDougall, 1998; Gunter, Miller, Venn, Thomas & House, 2002; Figarola, Gunter, Reffel, Worth, Hummel, & Gerber, 2008) and students using self-management techniques can correct their level of math accuracy as well as improve upon math, reading, and writing goals through the use of self-graphing (Joseph & Konrad, 2009; Kasper- Ferguson & Moxley, 2002).

Self-graphing can be used to improve many academic areas. For example in a study by Kasper-Ferguson & Moxley (2002), fourth grade students used graphing to improve writing fluency when they made bar graphs to show their word counts during five minute free-writing sessions. All students improved their writing rates over the course of the school year, and an improved overall quality of student writing was noted. The study authors suggest that, because fluency is a hallmark of success in many academic areas, graphing fluency data is useful in teacher planning and increased academic performance in other curricular areas.

In addition to self-graphing, other self-management techniques are also effective and relevant to this study. Joseph & Konrad (2009) reported on twenty effective self-management tools. The effectiveness of these tools is reported through evidence from student observations, teacher conversations, and a professional literature review. Through the use of these strategies, the authors contend that students can begin to take control of their academic outcomes. Strategies noted with relevance to math fact fluency include the use of a stopwatch to improve upon the time it takes students to start and finish assignments, using self-evaluation of outcomes to make adjustments based on whether or not goals were met, using a cover-copy-compare method to practice math facts, and recording performance on a graph to compare performance from one session to the next.

Self-management is also very effective for students with disabilities. McDougall, (1998) reviewed studies that included self-management techniques with students with a disability. The author explained that while the large majority of studies done on self-management do not target students with learning disabilities, studies that do include such individuals indicate an improvement in student performance. This descriptive review focused on 14 studies done over the past three decades because they met the following criteria: included at least one individual with a disability or handicap, a setting that included both regular education and students with disabilities at the same time, and quantitative data-based dependent variables rather than only qualitative descriptions. For each study, the participants, setting, dependent variables, measurement technique, independent variables, and research design are indicated. A summary of outcomes is also provided listing intervention efficacy, maintenance, generalization, and social validity. The results indicate that Behavioral Self-Management (BSM), also know as self-determination, is an effective inclusionary technique to enhance the social and academic performance of students with disabilities in the general education setting. BSM includes self-assessment (questioning about one's own behavior or performance), self-recording (a response answering the self-assessment question), self-determination of reinforcement (rewards contingent on behavior or task completion), and self-administration of reinforcement. Out of the 14 studies, two involved self-graphing and five studies measured permanent products such as the percentage of correct responses on spelling or math tasks. The author also notes that most studies, even if they were not included in the

14 studies that were the focus of the article, indicate that BSM produces favorable self-management components including self-instruction, self-reinforcement, and self-monitoring. Self-management components also improve time on-task, homework completion, creative writing, independent performance, spelling performance, and math calculations.

The article *Effects of Self-Graphing and Goal Setting on the Math Fact Fluency of Students with Disabilities* (Figarola, P. M., Gunter, P.L., Reffel, J.M., Worth, S.R., Hummel, J. & Gerber, B.L., 2008) builds upon research supporting the use of self-management techniques to focus solely on math fact fluency. The participants in this study were three first and second graders with mild disabilities. The students were taught how to use Microsoft® Excel to graph their correct responses to timed single-digit math addition fact calculations. Correct digits per minute was the dependent measure and was calculated by dividing the total number of correct digits by the total time required of the student to complete the problems. The instructor inputted data into an Excel spreadsheet for the students and an aim line or goal was established for the students for practice sessions across the school year based on the parameters of an acceptable 70 digits correct per minute. The students were then taught how to enter data themselves and to create graphs showing the rate of correct digits. If student progress was below the aim line for three consecutive sessions, additional modifications were provided including fewer practice problems, only graphing certain practice sessions, and providing a brief free time after desired behaviors were observed; thus, the teacher was able to differentiate instruction based on student need. The results showed that two of the three students nearly always met their aim line or goal for correct calculations while the third student needed further modifications such as the ones listed previously. Anecdotal results also showed that students were motivated by meeting the progress of their aim line and looked forward to showing the teacher when they had met their goal.

The collection of data transformed into a graph, whether done by a student or with the assistance of a teacher, is particularly helpful in the teacher's ability to differentiate instruction to meet the needs of a diverse group of learners. In research by Hojnoski, Gischlar & Missall (2009), the importance of graphing data is further supported. In this article, the authors detail how to make an appropriate graph to show whether targeted behaviors are improving or not. The authors describe basic graphing information such as axes, data collection, and the phase changes for baseline and intervention. They also provide step-by-step instructions for creating graphs using both pencil and paper and computer software. Visual data is crucial in determining progress toward individual student goals whether they be increasing or decreasing occurrences of a targeted behavior. Graphs enable teachers to track progress over time and to monitor progress toward Individualized Education Plan goals. Graphed data also easily allows for comparison to one's peers in the classroom. The effects of instruction and interventions can be seen and information about a student's goal attainment can be easily communicated to others interested in the child's progress. This article's implications for math fact practice indicate that graphing provides teachers with evidence to advise them to provide more direct instruction or math fact practice for those students who need it.

Effort, Achievement, and Metacognition

As far as self-monitoring is concerned, some may question the ability of individuals to perceive the connection between effort and achievement and to accurately report on the amount of effort they put into a task, but college students (Smith, 1999) and even elementary age children are able to accurately report on factors such as the connection between effort and achievement, effort expended, and the prediction of future scores, which is important in setting reasonable goals for future math fact quizzes (La Voie & Hodapp, 1987).

Lisa F. Smith (1999) asked college students to engage in tasks designed to engage them in (1) low difficulty, low required effort, (2) low difficulty, high required effort, (3) high difficulty, low required effort, and (4) high difficulty, high required effort activities. The goal of the study was to manipulate levels of difficulty and effort to see what role these factors play in performance. As expected the results indicated that low difficulty and low required effort equates to higher scores, high difficulty and low required effort equates to moderate scores, and low difficulty and high required effort equates to moderate scores. Of significance for self-monitoring research, one surprise result of this study was that when difficulty was high and required effort was high, fairly high scores were still obtained even though the author hypothesized that these scores would be low. The author's discussion of this unexpected outcome is important to students being able to accurately perceive the connection between effort and achievement. Smith points out that the construct of effort is useful in understanding the motivation students bring to academic tasks because students weigh how much effort will be required to complete successfully what is being asked of them. Therefore, in academic tasks including the memorization of math facts, students have a degree of control over the amount of effort and therefore the level of achievement they bring to the task. Students of younger age need to be explicitly shown this connection between effort and achievement for later academic success.

Furthermore research by La Voie and Hodapp (1987), provides evidence that younger students can accurately rate their effort and performance on a task. This study was conducted to determine the connection of test performance related to the effort students perceived they put into the assessment. This study concluded that a group of 311 fourth, fifth, and sixth grade students were able to accurately rate the level of effort they put into the IOWA Test of Basic Skills. Filling out a questionnaire on the last day of testing attained the students' level of effort. The students rated their performance on each of the subtests as well as their performance on the overall test. In addition to rating their effort, the students were also able to accurately predict, to a certain extent, the scores they would receive on these tests (La Voie & Hodapp, 1987).

Additional research confirms the notion that students are also able to self-administer interventions when it comes to math fact practice, which supports the use of students graphing their own facts rather than having a teacher do it for them. In a study by Hulac, DeJong & Benson, (2012), 11 fourth grade students identified as having deficits in multiplication fact memorization were asked to use a self-administered folding in technique (SAFI) which incorporated a self-managed Cover, Copy, Compare strategy in which the students were asked to mix three unknown facts with seven known facts, write the answers on a whiteboard, check the answers with the back of a flashcard, and continue until all ten facts were mastered. If a fact was wrong the student wrote the fact and answer three times before rehearsing the facts again. The amount of facts the students knew at the end of each week was assessed using a flashcard technique. Study data indicated that the average score increased from 49.9 digits correct per two minutes to 74.2 digits correct per two minutes during the self-administered intervention phase and seven of the 11 participants demonstrated higher slope and level of improvement during the intervention phase than they did during the baseline phase. The student self-administered technique of SAFI was successful. Students averaged 95.9% accuracy when implementing the steps of this self-administered intervention. The students were able to rely on self-monitoring and self-correction rather than adult cueing to improve their math fact fluency.

There are other benefits reaped when students are able to self-monitor academic interventions. Students who are able to self-graph math facts are learning about their own learning, figuring out that they have control over their math learning, and are highly motivated to reach the goal indicated after graphing their fact progress. In a study by Brookhart, Andolina, Zuza, and Furman (2004), 41 third grade students, including students in special education, participated in weekly timed multiplication tests and graphed their test scores to predict future test scores. Researchers hypothesized that using self-graphing and self-monitoring would lead to a greater metacognitive outcome in addition to the rote memorization of multiplication facts. Quizzes of 100 facts (0-9) were given in a five-minute time period over ten weeks. During that time students were provided with math fact strategies using flashcards, student partnering, etc. Students were also asked to complete a self-reflection sheet and prediction exercise after each weekly test. The students predicted how they would do each week by drawing a bar on a graph. They then graphed the actual score next to their prediction on the same graph and so on. The students also completed a reflection sheet to indicate whether they had met their goal from the previous week, what study strategy they used and how well it worked, and what strategy or strategies they planned to use for the next week. While some teachers modified the reflection sheet, all students' reflections included the same basic information. The results indicated that students in both classes were able to predict their scores well, and for the most part, student predictions became more accurate over time. Overall fact assessment score averages also increased gradually over the ten weeks. Students reported that they enjoyed seeing their progression on the graph, and because students were able to report on the strategies they used to acquire math fact accuracy and fluency, students did indeed receive metacognitive benefits from graphing their results, predicting future results, and reflecting on the way they used different strategies to practice math facts.

However, certain areas of self-monitoring techniques and self-graphing efficacy are not so clear. Further research is needed to determine if self-graphing is solely responsible for increasing student achievement. Most studies done indicate that other modifications were used in addition to self-graphing for students still struggling with math fact fluency. For example, one study done with math facts suggests limiting the amount of teacher praise in connection with self-graphing as well as trying to determine exactly which students will benefit from the use of self-graphing (Figarola, Gunter, Reffel, Worth, Hummel, & Gerber, 2008). The current study will only include one additional modification for students still struggling with math facts, the effort and achievement rubric, to try to eliminate the confusion behind exactly what interventions are contributing to the students' success with multiplication facts.

While conceptual understanding is certainly the goal of math instruction, the memorization of multiplication facts is necessary to free up working memory and foster the development of higher level thinking skills. Students with and without disabilities benefit from direct instruction in math facts. There is not one strategy that works for all students, so it is of value for educators to be familiar with a variety of strategies to teach multiplication facts. One proven connection to successful math fact fluency is student self-graphing. Another possible connection to math fact fluency may be to explicitly teach students the link between effort and achievement. While definitions of effort and the means by which it is measured differ, effort is positively related to achievement (Carbonaro, 2005). With the addition of the self-graphing and effort and achievement connection, I am hoping to see a gain in the multiplication fact accuracy and fluency of the students in my third grade classroom.

Chapter 3

Methodology

Context of the Study

The purpose of this study was to determine if students' math fact accuracy, or the number of math facts answered correctly, and fluency, or the time it takes to answer math fact problems correctly, would improve with the addition of student self-monitoring. The students practiced self-monitoring by graphing their results and rating their effort and achievement each week. The research design was a two-group pretest/posttest research design. Each individual student's progress was compared against his or her previous. The performance of low vs. high math achievers was also compared.

Participants

The participants in this study were a group of third grade regular education students in a rural, but increasingly more suburban school setting. Approximately 21% of the students in the school were eligible for free or reduced lunch and 76% of the students were described as Caucasian, 10% Black, 7% Hispanic, and 6% other at the time of the study. In the third grade class involved in this study, there were twelve white, two African American students, and two mixed-race students. Three of the students in the classroom were eligible for free or reduced lunch.

While there were no students classified with a disability, the students were performing at different mathematical ability levels when they entered third grade. A comparison of second grade end of the year teacher ratings showed that 14 students were performing on grade level, and one student was performing below grade level in overall mathematics skills. Two students were new to the district, so no math data was recorded.

Low math achievers and high math achievers were identified by second grade teachers using a rubric of 1-3 for math performance (see Table 3.1). One problematic aspect of the second grade teacher recommendations was that most of second grade math instruction was very teacher-directed and primarily in whole group as compared to third grade math, which is more independent in nature, so some teacher ratings may have been elevated. Second grade end of the year math assessment results yielded five A grades, three B's, three C's, and three D's or below. This demonstrated that while only one student was rated by their second grade teacher as performing below grade level, three students performed below grade level on the independent end of the year assessment.

Table 3.1 Student Academic Performance Rating

(Adopted from the Woodstown-Pilesgrove Regional School District)

Indicators of Student with Support Recommendation of **1**	Indicators of Student with Support Recommendation of **2**	Indicators of Student with Support Recommendation of **3**
- requires maximum academic support to complete class work - requires directions repeated or clarified multiple times - rarely completes homework assignments - rarely contributes to class discussions; responses often unclear, confused or unconnected to topic - watches group activities, adding few contributions to projects or assignments -overall academic performance falls below grade level benchmarks	- requires some academic support to complete class work - may require directions repeated or clarified more than once - usually completes homework assignments - usually contributes to class discussions with thoughtful responses - participates well in group activities, adding some contributions to projects or assignments -overall academic performance meets grade level benchmarks	- requires little or no academic support to complete class work - completes tasks after directions are given once - regularly completes homework assignments - regularly contributes to class discussions with insightful responses - leads group activities AND/OR adds important contributions to projects or assignments -overall academic performance exceeds grade level benchmarks

In selecting students to include for the current study, it was also important to consider third grade math performance of the students during the first marking period. There were five children that had been identified early in the year as needing response to intervention Tier II interventions. These students were identified for Tier II intervention if they met the following criteria: a grade of C or below, a teacher recommendation, and worked unofficially with the Tier II teacher for a period of at least two months. Tier II interventions included working with the support of another teacher during math time three days of the week, also known as basic skills instruction in math. Furthermore baseline data collection indicated that four students were struggling with math fact acquisition. These students received scores of 61, 23, and 61 for an average of four addition and subtraction fact quizzes with one student achieving a 61 on the first round of multiplication quizzes which assessed facts 0-2. These students were included in the number of students needing Tier II intervention. While data was collected for all the students in the classroom, only the students qualifying for Tier II math services were the low-achieving subjects for data comparison in this study. Using the opposite end of the above stated criteria, the subjects were narrowed down to five students for low-achieving data comparison and five students for high-achieving data comparison. The second grade teacher rating mean for the high-achieving group was 2.4 with an average score of 94.6 on the second grade end of the year math test, and the mean second grade teacher rating for the low-achieving group was 1.8 with an average score of 72.8 on the second grade end of the year math test. The third grade teacher rating mean for the high-achieving group was 3.0 with an addition and subtraction fact quiz mean score of 97 and the mean third grade teacher rating for the low-achieving group was 1.6 with an average score of 68.2 on the addition and subtraction fact quizzes.

Procedure

Student math facts were assessed using a randomized selection of 50 math facts answered in a ten-minute time limit. Students were given facts in increments of (0-2), (0-2,5), (0-2,5,10), (0-3,5,10), (0-5,10), (0-6,10) and were given four identical quizzes on the same fact increments every month. An average of all four monthly fact quizzes was obtained. See Table 3.2 for the timeline of math fact quizzes given. Each month's weekly quiz facts are shown.

Table 3.2 Monthly Math Fact Quiz Timeline

	Weekly Quiz
September	All Addition/subtraction
October	Multiplication 0-2
November	0-2, 5, and 10
December	0-3, 5, and 10
January	0-5, and 10
February	0-6, and 10
March	0-7, and 10
April	0-8, and 10
May	All multiplication facts

During the month of October, students were given a multiplication quiz on facts 0-2 every Friday with the exception of quizzes given on Thursdays due to holidays from approximately 8:30 am to 8:40 am. Each quiz contained 50 randomized multiplication facts from 0-2 (Figure 3.1), but the same quiz was given each Friday. The students were given ten minutes to complete each quiz and the time it took for the student to answer each quiz as well as the student's grade was recorded by the teacher in a data table (Table 3.2). The students indicated when all 50 problems were completed by raising their hand silently at their seat. Any student who finished early was still given the full ten minutes if they choose to check their work. The students recorded the number of correctly answered problems in their data tables every Monday, with the exception of days off from school resulting in Tuesday recording (see Table 3.3). These four quizzes served as the baseline for data collection. After all four quizzes were recorded, students graphed their results in a bar graph. The x-axis was labeled with the quiz numbers and the y-axis was labeled with the number correct (see Figure 3.2).

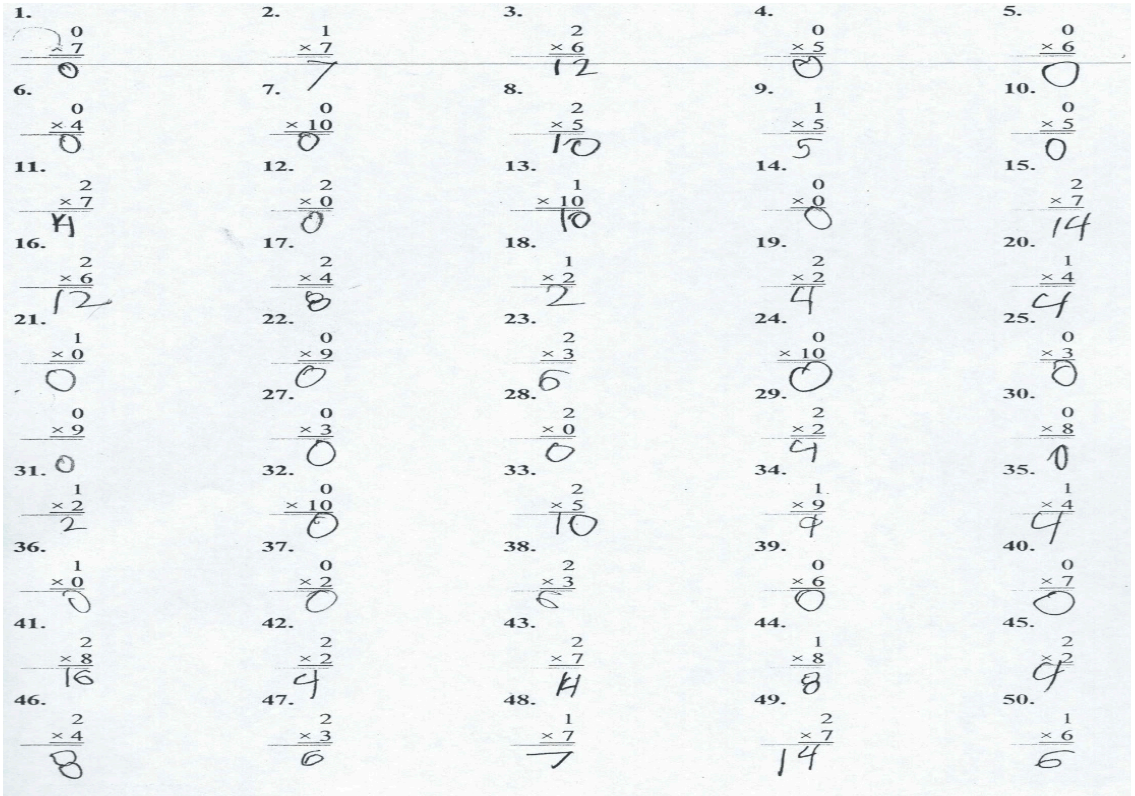


Figure 3.1 Math Fact Quiz for Facts 0-2

Table 3.3 Student Data Table

October

Week	Number Sentence	Number Correct
1	50-0=50	50
2	50-0=50	50
3	50-0=50	50
4	50-1=49	49

Table 3.4 Teacher Data Table

Quiz 1	Quiz 2	Quiz 3	Quiz 4	Average
80 7:40	68 4:21	98 3:08	98 4:22	86
98 5:30	98 3:24	98 2:55	100 3:35	99
90 5:00	96 3:12	98 3:20	96 2:27	95
100 4:37	100 2:20	98 1:40	100 1:25	100
100 5:57	100 3:12	100 2:41	100 2:47	100
96 6:15	100 3:00	92 2:47	100 2:28	97
100 6:50	100 2:55	100 3:00	100 2:13	100
56 7:05	100 4:55	100 2:47	100 2:00	89
100 4:37	100 2:20	98 1:55	100 1:55	100
100 6:38	100 2:39	100 2:55	100 2:20	100
56 6:57	~~absent~~	64 5:40	64 5:30	61
100 4:00	90 2:12	100 2:05	100 1:47	98
98 10:00	100 6:30	98 4:13	100 4:09	99
100 5:50	98 2:48	94 2:21	98 2:12	98
100 4:50	100 2:39	100 2:14	98 2:57	100
100 4:45	100 3:30	100 3:08	100 3:05	100
100 8:37	100 4:04	100 3:18	100 2:48	100

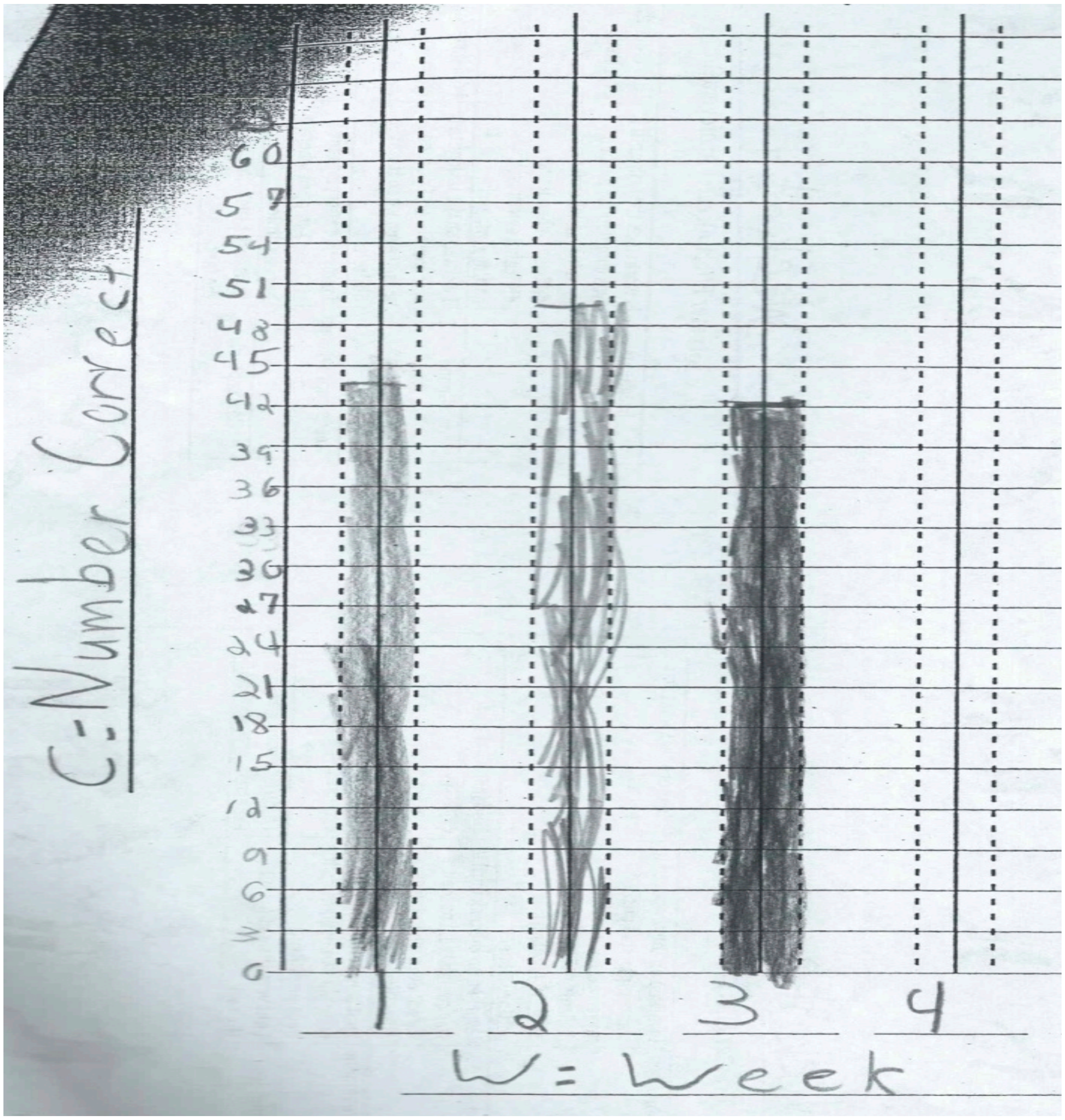


Figure 3.2 Student Graph

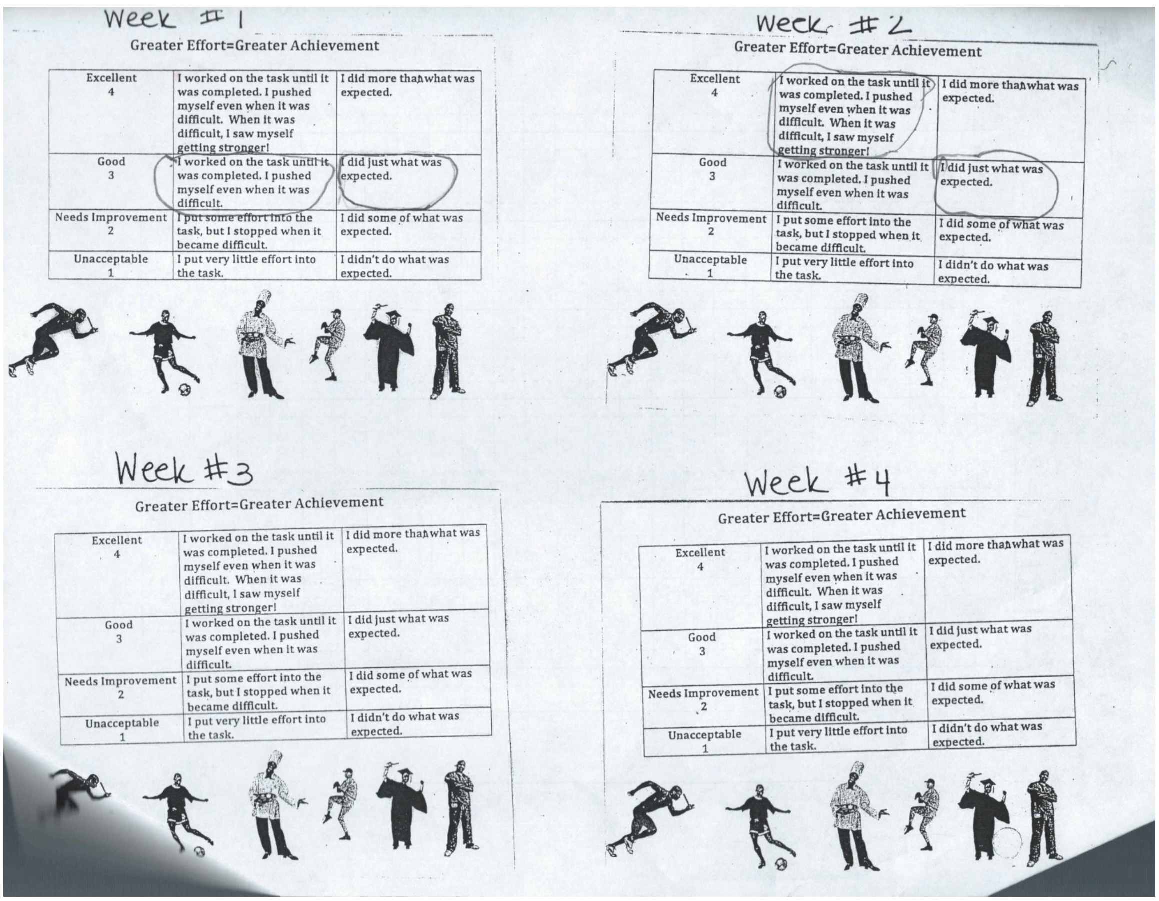
During the month of November, the self-graphing intervention frequency was increased. During this month students were still given four identical quizzes but were assessed on facts 0-2, 5, and 10. The students were given 50 random problems to complete in ten minutes, but the same quiz was used each week. The students took the quiz, recorded their number correct, and graphed the results after each quiz rather than at the end of the month as during the month of October. The goal was for students to be able to see their number correct increase over time. The hypothesis was that self-graphing would lead to improved scores overall. Self-graphing would also decrease the amount of time it takes students to complete their multiplication fact quizzes.

During the month of December and all months following, the students continued to progress through the multiplication times table with a gradual addition of new facts each month (see Table 3.2). They continued to record and graph the number correct after each quiz, however there was also a new intervention in place for December and all months following. This intervention was the addition of an effort and achievement rubric (see Table 3.5). The hypothesis was that the addition of the effort and achievement rubric would allow students still struggling with math fact acquisition to show higher gains in the number of problems answered correctly as the connection between effort and achievement was reinforced through both self-graphing and the effort and achievement rubric. The elements of the rubric were chosen by third grade teachers during a teacher training program based on the effective strategies detailed in *Classroom Instruction that Works: Research-Based Strategies for Increasing Student Achievement* (Dean, 20-34). Third grade teachers took the information presented in the book and tailored it to meet third grade expectations.

Table 3.5 Effort and Achievement Rubric

Greater Effort = Greater Achievement		
Excellent 4	I worked on the task until it was completed. I pushed myself even when it was difficult. When it was difficult, I saw myself getting stronger!	I did more than what was expected.
Good 3	I worked on the task until it was completed. I pushed myself even when it was difficult.	I did just what was expected.
Needs Improvement 2	I put some effort into the task, but I stopped when it became difficult.	I did some of what was expected.
Unacceptable 1	I put very little effort into the task.	I didn't do what was expected.

To assess their effort, students were instructed to count the number of study or test-taking techniques they used to choose the proper effort scale (1-4) and their achievement score (1-4) to correspond to their grade. For example, students practicing seven to eight different fact memorization strategies would circle a 4 for effort, five to six strategies a 3, three to four strategies a 2, and one to two strategies a 1. The strategies included on the list were brainstormed by the students and there was a chart referenced when students rated their effort. The strategies included: studying flashcards two to three minutes every night, making no excuses to study, using online resources, double checking work on the quizzes, taking their time and not rushing, studying for more than three minutes a night if needed, using time right before the quiz to study, and finding a partner to help quiz them if needed. Students with an A (100-93) grade circled a 4 for their achievement, B (92-84) a 3, C (83-77) a 2, and D or F a 1 (76 or below). Students indicated both their effort and achievement score by circling the proper circle next to the corresponding number 1-4 in first the effort column, and then the achievement column. The bar graph and effort and achievement rubric were copied on the same sheet of paper to keep as a record for the entire month (See Figure 3.3).



Week #1

Greater Effort=Greater Achievement

Excellent 4	I worked on the task until it was completed. I pushed myself even when it was difficult. When it was difficult, I saw myself getting stronger!	I did more than what was expected.
Good 3	I worked on the task until it was completed. I pushed myself even when it was difficult.	I did just what was expected.
Needs Improvement 2	I put some effort into the task, but I stopped when it became difficult.	I did some of what was expected.
Unacceptable 1	I put very little effort into the task.	I didn't do what was expected.

Week #2

Greater Effort=Greater Achievement

Excellent 4	I worked on the task until it was completed. I pushed myself even when it was difficult. When it was difficult, I saw myself getting stronger!	I did more than what was expected.
Good 3	I worked on the task until it was completed. I pushed myself even when it was difficult.	I did just what was expected.
Needs Improvement 2	I put some effort into the task, but I stopped when it became difficult.	I did some of what was expected.
Unacceptable 1	I put very little effort into the task.	I didn't do what was expected.

Week #3

Greater Effort=Greater Achievement

Excellent 4	I worked on the task until it was completed. I pushed myself even when it was difficult. When it was difficult, I saw myself getting stronger!	I did more than what was expected.
Good 3	I worked on the task until it was completed. I pushed myself even when it was difficult.	I did just what was expected.
Needs Improvement 2	I put some effort into the task, but I stopped when it became difficult.	I did some of what was expected.
Unacceptable 1	I put very little effort into the task.	I didn't do what was expected.

Week #4

Greater Effort=Greater Achievement

Excellent 4	I worked on the task until it was completed. I pushed myself even when it was difficult. When it was difficult, I saw myself getting stronger!	I did more than what was expected.
Good 3	I worked on the task until it was completed. I pushed myself even when it was difficult.	I did just what was expected.
Needs Improvement 2	I put some effort into the task, but I stopped when it became difficult.	I did some of what was expected.
Unacceptable 1	I put very little effort into the task.	I didn't do what was expected.

Figure 3.3 Student Effort and Achievement Monthly Recording Sheet

The students were also given a survey asking them questions about their perception of how graphing and the effort and achievement rubric affected their performance. The questions for this survey were chosen based on my experience with third grade students and their ability to answer questions honestly and completely independently. The questions were kept simple enough so that students understood the questions and were able to share information that will coincide with the type of evidence collected during the math facts data collection. This survey consisted of five questions. The students were asked the following questions: What strategies do you use to practice for your math fact quizzes?, How often did you practice your math facts? How many things do you do to put effort into your quizzes?, How much did graphing math facts help you?, and How much did rating your effort and achievement each week help you? (See Figure 3.4).

Name: ______________________

Math Fact Quiz Questionnaire

1. What strategies do you use to practice for your math fact quizzes? Check all the strategies that you use.

- I study for 2-3 minutes every night.
- Sometimes I study for more than 2-3 minutes every night.
- I use IXL or other websites to practice.
- I practice my facts after my spelling test.
- I don't make excuses for not studying.
- Other: ______________________

2. How often did you practice your math facts?

I usually practice ____________ days a week, and I usually practice for ____________ minutes each day.

3. How many things do you do to put effort into your quizzes? Check all the things that you do.

- I try to get an A on every quiz.
- I don't rush.
- I double-check my work on my quizzes after I am finished.
- I don't give up even when I am stuck on a fact.
- Other: ______________________

4. How much did graphing math facts help you?

1 = not at all

2 = a little

3 = a lot

Please explain your answer:

____

____

____

5. How much did rating your effort and achievement each week help you?

1 = not at all

2 = a little

3 = a lot

Please explain your answer:

____

____

____

Figure 3.4 Student Questionnaire

Chapter 4: Findings

This study utilized a two group, pretest/posttest research design to determine the effects of using self-graphing and an effort and achievement rubric to improve students' grades, times, and digits correct per minute (DCPM) on multiplication facts. Data was gathered over a period of five months using multiplication quizzes. Students were given the same multiplication quiz over a period of a month and their grades, times, and digits correct per minute were recorded for each quiz. Each month, a new quiz was given as the addition of a new set of facts was memorized. During the first month, students were simply timed to collect baseline data. During the second month, students were timed and they graphed their progress on a bar graph. During the third-fifth months, students were timed, graphed their progress, and rated their effort and achievement for each quiz. Data is presented in the following tables in the form of averages of each student's grade, time, and digits correct per minute as well as overall averages. The tables are split into low-achieving math students and high-achieving math students for comparison.

Table 4.1 Low Group Results

Low Group (1)	Mean Grade			Mean Time			Mean Digits Correct Per Minute		
Student	Baseline	Graphing	Graphing & E vs. A	Baseline	Graphing	Graphing & E vs. A	Baseline	Graphing	Graphing & E vs. A
1	87.6	99	92	6:36	3:58	6:45	4.48	4.95	4.60
6	91	96	93	5:29	4:31	4:25	4.8	4.8	4.70
11	67.3	92	80.7	10:30	7:16	8:43	4.48	4.08	4.07
13	81.6	97	81	9:11	6:31	9:57	4.08	4.85	4.04
15	92	99	93.7	7:12	3:43	7:43	4.6	4.73	4.68
Overall Means	83.9	96.6	88.08	7:47	5:11	7:30	4.64	4.8	4.42

The data in the above chart for the low group shows that from baseline data to self-graphing data, the low group students' overall means for grades improved by 12.7 points, their times went down by 2 minutes and 36 seconds, and their digits correct per minute improved by 0.16 DCPM. However, the addition of the effort and achievement rubric did not improve students' scores from where they were with the self-graphing condition alone. From self-graphing to the addition of the effort and achievement rubric overall grades went down by 8.52 points, times increased by 2 minutes and 19 seconds, and digits correct per minute went down by 0.38 DCPM. With the exception of student 6, whose time was lowered by 6 seconds with the addition of the effort and achievement rubric, the overall scores were better with the effort and achievement rubric than overall baseline scores for grades and time, but not better than self-graphing alone. The addition of the effort and achievement rubric actually produced an overall DCPM mean lower than the baseline overall mean.

Table 4.2 High Group Results

High Group (2)	Mean Grade			Mean Time			Mean Digits Correct Per Minute		
Student	Baseline	Graphing	Graphing & E vs. A	Baseline	Graphing	Graphing & E vs. A	Baseline	Graphing	Graphing & E vs. A
4	99.6	100	99.7	3:01	1:53	2:15	4.98	5.0	4.99
8	89.6	99	99.3	4:55	3:01	4:05	4.48	4.97	4.97
12	98.4	99	98	3:59	2:55	3:53	4.92	4.92	4.89
16	98	100	97.7	5:34	4:49	4:31	4.9	4.98	4.86
17	99.6	99	98.3	5:59	4:22	5:21	4.98	4.95	4.92
Overall Means	97.04	99.4	98.6	4:41	3:24	4:01	4.98	4.96	4.93

The data in the above chart for the high group shows that from baseline data to self-graphing data, the high group students' overall means for grades improved by 2.36 points, and their times went down by 1 minute and 20 seconds, but their digits correct per minute went down by 0.02 DCPM. Like the low group, the addition of the effort and achievement rubric also made students' scores fall from where they were with the self-graphing intervention alone. From self-graphing to the addition of the effort and achievement rubric overall grades went down by 0.8 points, times increased by 37 seconds, and digits correct per minute went down by .03 DCPM. With a few exceptions such as student 8's grade increasing by .03 points and student 16's time decreasing by 18 seconds, the overall scores were better with the effort and achievement rubric than overall baseline scores for grades and time, but not better than self-graphing alone. The addition of the effort and achievement rubric actually produced an overall DCPM mean lower than the baseline overall mean.

Students' opinions of using self-graphing and the effort and achievement rubric were also collected using a student questionnaire. The questionnaire consisted of five questions asking students what strategies they use to study their facts, how long they typically practice each week for fact quizzes, what things they do to put effort into their quizzes, how much did graphing help, and how much did rating effort and achievement help. The most popular strategies for practicing math facts were reviewing facts right before the quiz, not making excuses for not studying, visiting websites to practice, and studying for at least two to three minutes every night. The most popular means of putting effort into their quizzes were double checking work, trying to get an A, not rushing, and not giving up. Most students indicated that they practiced facts three to five days a week and anywhere between two to ten minutes a night.

The last two questions of the survey, how much did graphing and the effort and achievement rubric help, are of particular value for the variable tested in this study. Three students from the low group said that graphing their math facts helped them a lot while two students from the low group said graphing helped them a little. Students said that graphing math facts helped them: to understand what their grade was, see what they can do better, and know how they are doing in math. No students from the low group thought that graphing did not help them at all. On the other hand, one student from the high group felt that graphing did not help at all because they always got 49 or 50 out of

50 correct, two felt it helped a little with one student responding that it tells them to try harder, and two felt it helped a lot with one responding that it helped set goals for the next week. Overall, both groups of students seemed to see value in graphing their math fact progress.

Students' opinions of the effort and achievement rubric were different in that the low group seemed to value rating their effort and achievement more so than the high group. Four of the students from the low group said rating their effort and achievement helped them a lot while one student said it helped a little, and no students said it did not help at all. Students said rating their effort and achievement helped them: see what they did and to see that they can do better on the next quiz, see what they got wrong, grade themselves, and see how much they practiced and if they needed to practice more. In the high group, two students said rating their effort and achievement helped a lot, because it helped them see how many strategies they've been using and it made them practice more, but three students said it did not help at all because they know a lot of their facts, already know how much effort they put in, got an A or B on every quiz, or were really good and already practiced a lot. Interestingly, those students in the high group who seemed to see little value in rating their effort and achievement are the same students who seemed to need to put forth little effort into math fact memorization.

The results indicate that self-graphing showed an improvement for all students on multiplication quiz grades, times, and digits correct per minute. However, the addition of the effort and achievement rating, did not further improve grades, times, or digits correct per minute. Although many students in the low-achieving group seemed to see value in self-graphing as well as rating their effort and achievement, the addition of the effort vs. achievement rubric lowered student scores from self-graphing alone.

Chapter 5: Summary, Conclusions, and Recommendations

This study examined the effects of self-graphing and an effort and achievement rubric in increasing students' multiplication fact accuracy and fluency by enabling students to answer more problems correctly in an increasingly shorter period of time. Results are shown as a comparison between high and low achievers on baseline data, self-graphing alone data, and self-graphing plus an effort and achievement rubric data. These means were calculated for student grades, times, and digits correct per minute (DCPM). The results show that, when using self-graphing, all students showed a performance level increase in grade, time and DCPM, but the effort and achievement rubric intervention did not lead to a further increase. A higher level of performance than baseline performance was attained through the use of self-graphing and the effort and achievement rubric for grades and time, but not for DCPM and not higher than just self-graphing alone. Reinforcing effort and achievement through math facts with a rubric was not highly effective, but demonstrating the connection between effort and achievement with self-graphing math facts was effective with this group of students. This indicates that teaching the connection between effort and achievement through self-graphing can increase math fact accuracy and fluency.

Although previous research indicates that behavioral self-management techniques such as self-assessment (questioning about one's own behavior or performance) are effective technique for increasing the academic performance of students with disabilities in the regular education classroom (McDougall, 1998), the connection between effort and achievement and math fact fluency improvement was not demonstrated through the use of an effort and achievement rubric in this study. Rating effort and achievement on multiplication math fact quizzes was not as beneficial as self-graphing alone. Self-graphing proved to be a better means for improving math fact accuracy and fluency. As previous research indicates, fluency is a hallmark of success in many academic areas, and graphing fluency data is useful in increasing academic performance (Kasper-Ferguson & Moxley 2002). Self-evaluation and recording performance on a graph to compare performance from one session to the next are effective self-management tools in taking control of academic outcomes (Joseph & Konrad 2009.) The results of the current study are similar to the study by Figarola, Gunter, Reffel, Worth, Hummel, and Gerber (2008) where an improvement in students digits correct per minute was noted when students graphed correct responses to timed addition fact calculations as well as a study conducted by Brookhart, Andolina, Zuza, and Furman (2004) in which students graphed and correctly predicted multiplication quiz scores. The Brookhart et al (2004) study and the results of this study suggest that self-graphing can improve math fact fluency and accuracy. Both previous studies and this study indicate that students are motivated by seeing their progress and look forward to performing better to meet their goals. Since the effort and achievement rubric did not increase scores in this particular multiplication math fact accuracy and fluency study, suggestions for further research would be to modify the effort and achievement rubric or to use it with a different task rather than graphing math facts.

While the effort and achievement method did not prove helpful in increasing math fact fluency and accuracy with this particular group of students, it may prove beneficial to others due to the limitations of this study. Limitations included the time available to collect data. Due to the requirements of this thesis course, only six months of data were collected with a small data set for the self-graphing alone phase. If more data were collected for self-graphing alone, the addition of the effort vs. achievement rubric may have shown more of a stabilizing effect rather than a reduction in performance. The number of students involved in this study was also a limitation. Besides it being a small participant sample, the students chosen to be included as the low achieving group were chosen only because they were receiving extra support in math instruction not because they were students with a disability in math. Further research using students with documented math disabilities may prove the effort and achievement rubric to be more helpful. Some limitations that were very specific to this study included student absences limiting data collection in an already small pool of data, students forgetting to raise their hand when done their quiz to record the time it took them to finish, a student who lost their self-graphing and effort and achievement rubric paper for a whole month's worth of data collection, and the time it took to get the students acquainted with using the effort and achievement rubric before they could effectively rate their effort and achievement. Had the students been more acquainted with using the effort and achievement rubric before using it to graph math facts, perhaps facility in using the rubric would have allowed students to better focus on adapting their performance. Another big limitation of this study was the quizzes that needed to be given as part of the third grade curriculum. Because the same fact quiz was repeated four times each month, it gave the students more time to study, and data had to be analyzed in a way that tried to alleviate the practice effect.

Some factors were out of the researchers' control and should be considered if further research were conducted. One major factor is that the quizzes were exactly the same every week, so students have more time to study for subsequent quizzes. Another factor was the amount of time the students studied at home as well as the level of help they received when studying at home impacted their grades. Some factors that influenced data collection relating to fluency were students forgetting to raise their hand when they completed the quiz. One student even raised their hand to indicate they were done when they had not completed all of the problems. Careful teacher monitoring eliminated that problem. Other factors influencing data collection include student absences, and one student lost their graphing paper. Teacher collection of materials in between quizzes eliminated this problem. Another factor that had an influence on the students accurately predicting their effort and achievement was giving the students ample time to adjust to using the effort and achievement rating scales and criteria. All of these extraneous variables affected the results of this study, although some were eliminated with careful teacher monitoring and forethought. While some concerns were raised during the collection of data, the data collected is still very valuable in determining if student self-monitoring can improve student math fact performance.

The results of this study have implications for classroom instruction. The implications are that classroom teachers can use self-graphing as a tool for teaching the connection between effort and achievement. Self-graphing allows students a means for visualizing their improvement over a period of time and allows them to set goals and to monitor their progress so that adjustments can be made that will improve performance. This study indicates that areas assessing fluency, especially math fact fluency, are areas that should utilize self-graphing. When teachers want to use self-graphing they should consider what exactly the students will try to improve and choose one aspect of improvement for the student to graph. For example, in the current study, students tried to improve their number correct each week, so that is what the students graphed. Teachers should also select a period of time that self-graphing will need to take place in order for students to understand why they are graphing and to allow for them to see progress. Teachers should take into consideration whether the student is able to self-graph independently or whether they should graph for the students, what kind of graph is most appropriate (usually a bar graph), and what sort of rewards can be given for students who meet their goals. Teachers should explicitly verbalize the reasons for graphing and praise students who put effort into the graphing process and improving their performance. This way, students are able to begin seeing the connection between the effort they put into tasks and the level of achievement that is attained as a result. The concrete application of effort and achievement through self-graphing is an important stepping-stone for later internalization of the connection between effort and achievement.

In this study I looked at the effects of self-graphing and an effort and achievement rubric on increasing students' multiplication fact accuracy and fluency. Data was collected from student multiplication math fact quizzes. Students were given the same math fact quiz for a month before a new set of facts was introduced the next month. For each month, the first quiz of the month served as baseline data as no interventions were introduced for those quizzes. The second month of quizzes served as the self-graphing alone data, and the last three months served as the self-graphing and effort vs. achievement rubric data. Students were separated into a group of five low achievers and five high achievers and data was grouped according to grades on the quizzes, the time it took to finish the quizzes, and digits correct per minute. All data was analyzed by finding the mean of the quizzes to eliminate practice-effects of taking the same quiz for a whole month. I found that the use of self-graphing alone was most beneficial for increasing math fact accuracy and fluency. This means that students should graph their math fact achievement from week to week, but that the addition of an effort and achievement rubric might best be introduced with a different task.

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