

The Effects of Participation in a Math Fact Fluency Intervention on Curriculum Based
Mathematics Assessments

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Abstract

The purpose of this study was to determine whether participation in a math fact fluency intervention would impact student performance on curriculum-based mathematics assessments for selected fourth grade students in Anne Arundel County Public Schools (AACPS). The measurement tool used was AACPS grade four District Assessment 1 and Mid-Year Assessment. This study utilized a pretest/posttest design to compare data from September 2014 to January 2015. Although participating students did not demonstrate gains in score from pre to post testing, these students did demonstrate statistically significant growth in proficiency levels described as basic, proficient, and advanced. Further research is needed to determine if student participation in a math fact fluency program will increase math achievement.

CHAPTER I

INTRODUCTION

High school graduation requirements across the nation reflect the need for the mastery of advanced level mathematics. In order to successfully complete the advanced level mathematics courses, students must have mastered the foundational skills required for high level computation.

Overview

One introductory skill that is paramount in advancing through mathematics skills is the computation of basic math facts (Poncy, McCallum, & Schmitt, 2010). The ability to compute basic facts is required in almost all areas of mathematics including advanced level mathematics; competence in mathematics allows students to be more competent in the world of technology (United States Department of Education, 2004).

According to the Common Core State Standards (CCSS), students in second grade are expected to fluently add and subtract within the number 20, students in third grade are expected to multiply and divide fluently within the number 100, and students in grade four are expected to fluently add and subtract multi-digit numbers. For children to be fluent in computation and to be able to do math mentally, they must become fluent in basic arithmetic facts (Cates & Rhymer, 2003). These abilities are crucial foundations for learning algebra. The CCSS identifies the need for speed and accuracy in calculation. In order to be proficient, students need to have repeated practice and flexibility with basic facts; therefore, mathematical fluency must be addressed within the classroom. As students progress through grade levels, less instructional time is devoted to basic fact fluency because the incorrect assumption is that students have already mastered these skills. When students have not mastered these skills, it is imperative they be given opportunities for instruction that is succinct and targeted.

Statement of Problem

The purpose of this study is to determine if participation in a math fact intervention will affect student achievement on curriculum- based assessments.

Hypothesis

By using *FASTT Math* fact intervention, students in grade 4 will not demonstrate increased student achievement on curriculum- based assessment questions targeting multiplication fluency.

Operational Definitions

This study will compare the results of two curriculum based assessments including the overall achievement score and scores on questions targeting a multiplication standard. The independent variable used in this study is participation in the *FASTT Math* intervention. The dependent variable is the score of the post assessment. The change in score will determine if the student has shown growth as a result of participation in the intervention which is operationally defined as the student's score on the post assessment.

CHAPTER II

REVIEW OF THE LITERATURE

As pressure increases for American education to increase proficiency on high stakes testing, schools are scrambling to understand the discrepancies in performance among students. This literature review seeks to explore the importance of mathematics basic fact fluency. The first section of this literature review examines the importance of basic facts in mathematics. Section two explores math fluency as it relates to computational proficiency. Section three discusses the importance of math interventions. Section four provides a summary.

Mathematics Basic Facts

In 2004, the United States Department of Education reported concerns regarding the need to increase the proficiency of students' mathematical skills - particularly because of the belief that competence in mathematics allows students to be more competent in the world of technology. As students progress in their education, those who are performing below grade level are less likely to meet proficiency standards in mathematics, therefore impeding their abilities to achieve proficiency on high stakes tests. A 2008 report published by the National Mathematics Advisory Panel (NMAP) suggests that students in the United States are failing to demonstrate proficiency in a variety of key skills in mathematics including recognition and recall of basic facts. Difficulties with whole numbers can be an obstacle to learning fractions, and difficulties with fractions lead to failure in algebra (NMAP, 2008).

Students in kindergarten through grade five are expected to achieve mastery in arithmetic: addition, subtraction, multiplication, and division; as well as develop a strong conceptual understanding and procedural skills with fractions. These abilities are critical foundations for learning algebra. Basic mathematical facts are single-digit problems for addition

and multiplication in which both addends or factors are less than 10 and subtraction and division correspond to the inverse problems and answers from the addition and multiplication (Poncy, McCallum, & Schmitt, 2010). The ability to compute basic facts is a skill required of nearly all mathematics, but especially higher level mathematics.

A fundamental skill in the progression of math ability is the computation of basic math facts (Poncy, McCallum & Schmitt, 2010). Research conducted by Skinner and others two decades ago, show that fluency with math facts allows students to more accurately complete subsequent math tasks (Skinner, Fletcher & Hennington, 1996). Research also shows that basic math fluency is a critical skill needed to acquire higher-order math skills (Hartnedy, Mozzoni, & Fahoum, 2005). When the human brain is able to focus attention towards the more complex matters, rather than focusing on recall of basic facts, it is able to concentrate on more complex matters such as problem-solving, fractions, and algebraic thinking (Baroody, Bajwa & Eiland, 2009). Practicing skills in order to automatize them is an important condition for reducing working memory load (Tronsky & Royer, 2002), which is in turn necessary for the construction of new conceptual knowledge (Sweller, 1988). Nearly all mathematics builds upon the knowledge of fluency while solving basic facts. Students who are not proficient in basic facts and skills may demonstrate a multitude of misconceptions as they relate to higher level computation skills (Marchand-Martella, Slocum, & Martella, 2004). With a solid base of conceptual knowledge, students can in turn invent their own procedures, ultimately resulting in the ability to be more flexible mathematically and better transfer this information to unique problems (Carpenter, Franke, Jacobs, Fennema, & Epon, S., 1997).

Impact of Mathematics Fluency

With the implementation of the Common Core State Standards (CCSS), the level of rigor in mathematics has increased. According to CCSS (2010), students in second grade are expected to fluently add and subtract within the number 20, using mental strategies; while students in grade three are expected to multiply and divide within 100. By the end of third grade, students should know from memory, all products of one digit numbers. Fluency in mathematics can be defined as the ability to swiftly and accurately complete a task. Deficits in fluency can hinder math performance, as students spend more time and energy completing a low level task; therefore, they are unable to move on to the next task, presumably a higher level task. For children to be fluent in computation and to be able to do math mentally, they must become fluent in the basic arithmetic facts (Cates & Rhymer, 2003).

An essential component of automaticity with facts is that the answer must come from direct retrieval, rather than following a procedure. This situation implies students who rely on counting while using their fingers have not yet mastered the facts. Although correct answers can be found using procedural knowledge, the process is slow. They appear to interfere with learning and understanding higher level math concepts (Crawford, n.d.). Students who put forth great effort to solve the computation have greater difficulty understanding the concept.

Baroody et al. (2009) discusses a common example of fluency impacting deeper understanding which is taken from reading skills. If children are unable to read from sight, they must devote excessive attention to sounding out the words using each phoneme. Because of the attention devoted to the lower level skill of word recognition, the higher level skills of word meaning and comprehension are compromised, making it increasingly difficult to understand what has been read. The same model can be applied to computational fluency. If students have to

constantly compute the basic facts, less of those students' thinking can be devoted to higher level concepts. If children have to utilize massive effort to subtract or multiply during the division process, they are unable to monitor or attend to the higher level division problem. This effort results in students failing to grasp the concepts in multiple-digit division.

In their 2003 study investigating error rates in fluency of basic mathematical operations among college level students, Cates and Rhymer explain that compared to dysfluent students, fluent students tend to find complex math problems less frustrating and experience decreased levels of math anxiety. The students who demonstrate high levels of math-related anxiety have significantly lower fluency rates. Additionally, students who lack fluency are more likely to avoid assigned math tasks because the tasks are perceived as too difficult to complete independently (Skinner, Pappas, & Davis, 2005).

When students lack the ability to accurately and efficiently complete basic math facts, it may hinder their ability to perform well on a wide variety of math activities. This lack may translate to being identified for special education, increased math anxiety, and poor performance on higher level math activities (Cates & Rhymer, 2003). In addition to impacting academic performance, individuals who lack fluency in math skills may experience difficulties outside of the classroom such as exclusion from vocational and career opportunities (Sante, McLaughlin, & Weber, 2001). There are many other areas of life that require the use of math facts, including balancing a checkbook, making change, and measuring.

Mathematics Interventions

Even with appropriate instruction, some students continue to require additional support, or intervention. Some students may require direct instruction in using strategies that their peers may not (Gersten, Jordan & Flojo, 2005). Mathematics difficulties are cumulative and worsen

with time. It is imperative that interventions be available to efficiently increase important math skills (Poncy, et al., 2010). The major goals of early math intervention are development of fluency with basic facts and accurate and efficient use of strategies (Gersten, et al., 2005). That is, students should be fluent with their facts and be able to apply strategies when immediate fact retrieval is not likely. It is critical for students to engage in intervention at an early point in their education in order to provide the foundations for future learning. In many cases, early identification and intervention can prevent children who are at-risk from being identified or labeled as “learning disabled” (Fuchs & Fuchs, 2001). With intervention, these students are given the opportunity to catch up to their peers and perform at a higher level in mathematics.

Through special-resource interventions, students are engaged in additional instruction which is: individualized, intensive, and skills-based. Decisions regarding intervention should be focused on the students’ individual needs, while continually monitoring and adjusting instruction, as necessary (Crawford, n.d.). In addition, the intervention should include a way to motivate students. The intervention should occur regularly over a period of time and include high response rates, appropriate instruction, high levels of support with a gradual release model, and immediate feedback. Skills- based instruction refers to providing students with opportunities to apply the skills learned within generalized, non-isolated contexts. Students are learning the skills with contextual applications (Fuchs & Fuchs, 2001). Embedding the teaching of concepts within student work appears to allow the students to more easily generalize the information (Gersten, et al., 2005).

Students receiving mathematics intervention may already have a low tolerance for math activities including math anxiety. Therefore, intervention should serve to provide students with strategies to engage them in activities that are reinforcing and age appropriate (Gersten, et al.,

2005). Using peers to engage students in this instruction may serve to provide a route to teaching using alternative strategies. Regardless of the curriculum and strategies used, it is important for educators to understand the importance of early intervention and provide students with individualized programs. This intervention may allow students the opportunity to apply their skills on a regular basis, not simply in isolation. Interventions, such as curriculum-based instruction, should be monitored regularly in order to ensure effectiveness.

Summary

Within today's global society it becomes even more important than previously thought to be fluent in basic mathematical performance. Research conducted by the United States Department of Education cites ties between mathematical competency and competency in technology. The use of various mathematical interventions may positively impact all academic performance and lead to proficiency in higher education and job performance as well.

CHAPTER III

METHODS

This study examined the relationship between participation in a fact fluency intervention and performance on curriculum-based assessments.

Design

This study used a quasi-experimental pretest posttest design. The study was planned to determine if participation in a computer-based mathematics fact fluency intervention caused increased achievement on a district-wide curriculum-based assessment, the posttest.

Participants

Students were chosen for participation in the computer-based math fact fluency intervention based on performance on the pretest. The 20 participants were 4th grade students in a co-taught math classroom. Of those 20 participants, 11 students accessed a computer based fact fluency intervention program from October 1, 2014, through January 15, 2015. These students completed the intervention program a minimum of three times per week for 12 weeks, excluding scheduled school breaks. The students in this study were 9-10 years old. Included in the group were 12 boys and 8 girls. Of the 20 students, five of them were identified as students with disabilities. Of the five students with disabilities, three of them received special education services for mathematics inside the general education setting for a minimum of two and a half hours per week.

The participants attended school in a suburban setting, within ten miles of a major metropolitan city. Approximately 52% of the students attending this school were students who came from low-income families and were identified as Free and Reduced Meal students (FARMS). On state-wide assessments, the school typically performs better in reading than mathematics and has met state guidelines for adequate yearly progress for the past three years.

Instrument

The instrument used for this experiment was the Anne Arundel County Public Schools (AACPS) grade four District Assessment 1 and Mid-Year Assessment. These assessments were developed by AACPS. The assessments were designed to provide information regarding student progress on grade level standards. The questions on the assessments were written to reflect the types of problems students might encounter on the Partnership for Assessment of Readiness for College and Career (PARCC). The questions on the assessments were designed to assess student knowledge of the Common Core State Standards. Student proficiency levels were determined by performance on the assessment. For the purpose of this study, the proficiency level was used in addition to determining performance on individual standards. For scoring purposes, students received a score of one, two, or three depending on their level of proficiency on the given assessment, based on cut scores determined by Anne Arundel County Public Schools.

Procedure

The administration of the pre-assessment took place September 26, 2014, and the post-assessment was given January 15, 2015. Students who were identified as students with disabilities, who qualified for special education services, were given the assessments with the appropriate accommodations as identified on their Individualized Education Plan. Students were given one class period to complete the assessment.

After students completed the pretest, they began using the computer based math fact fluency intervention. The first session of the intervention was a pre-assessment used to determine the mathematical facts students did not have committed to memory. The program provided this assessment then analyzed the answers for correctness and length of time it took to respond. The program then targeted facts the student needed to practice, as well as facts that required

additional instruction. Instruction was provided a minimum of three times a week, for twenty minutes each session. After twelve weeks of instruction, students were given the posttest.

CHAPTER IV

RESULTS

The purpose of this study was to determine if participation in a math fact intervention would affect student achievement on curriculum-based assessments. Data gathered both on students in the intervention and those students not in the intervention are depicted in Table 1. Data were gathered using a school system's pre and post measures for a given mathematical instructional unit. Raw data for both pre and post tests are included in the table as well as treatment (yes) or non-treatment conditions (no). Additionally, the school system in which the study was conducted categorizes certain raw scores as basic, proficient, or advanced. Furthermore, on both the pre and posttest there were three items of particular interest that related directly to the intervention, and the number correct out of those three items on the pre and post tests are shown as decimals in Table 1. Gain scores were computed by subtracting the pretest scores from the post scores.

Various other data analyses were performed to see what, if any, impact the intervention had on student performance. Those analyses, displayed in Tables 2, 3, and 4 included:

1. An independent t-test of the gain scores of the intervention students versus the non-intervention students. That analysis is displayed in Table 2 and shows no statistically significant findings.
2. An independent t-test analysis of the gain score obtained by subtracting the sub-items in the pre and posttests that were particularly related to the intervention. That analysis is displayed in Table 3 and no statistically significant findings were obtained.

3. A cross tabulation of the intervention versus non-intervention students on the entire pre measure and the entire post measure categories was also done. This analysis is displayed in Table 4 and, contrary to the other analysis, this analysis indicated a significant difference in the number of students in the categories of the pretest to the number of students in the categories of the posttest. This result is displayed in Table 4.

Table 1

Data Related to the Intervention or Non-Intervention

Student #	Intervention Participation	AACPS Math Gr 4 District Assess 14-15	Pre test Proficiency Category	Pre test Categories on 3 Point Scale	Pre Sub Item Score	AACPS Math Gr 4 Mid Year Assess 14-15	Post test Proficiency Category	Post test Categories on 3 Point Scale	Post Sub Item Score	Gain score pre to post on entire Assessment	Gain Sub Item Score
1	yes	48	Basic	1	0	57	Proficient	2	0.33	9.00	0.33
2	yes	52	Basic	1	0.33	52	Proficient	2	0.67	0.00	0.34
3	yes	60	Basic	1	0	62	Proficient	2	0.67	2.00	0.67
4	yes	40	Basic	1	0	48	Basic	1	0.33	8.00	0.33
5	yes	60	Basic	1	0.33	81	Advanced	3	0.67	21.00	0.34
6	yes	64	Basic	1	0.33	76	Advanced	3	1.00	12.00	0.67
7	yes	60	Basic	1	0.33	52	Proficient	2	0.67	-8.00	0.34
8	yes	36	Basic	1	0	19	Basic	1	0.33	-17.00	0.33
9	yes	44	Basic	1	0.33	43	Basic	1	0.33	-1.00	0.00
10	yes	0	Basic	1	0	48	Basic	1	0.00	48.00	0.00
11	yes	68	Basic	1	0.33	52	Proficient	2	0.67	-16.00	0.34
12	no	84	Proficient	2	0.33	81	Advanced	3	1.00	-3.00	0.67
13	no	88	Proficient	2	0.67	81	Advanced	3	0.67	-7.00	0.00
14	no	92	Advanced	3	1	95	Advanced	3	0.67	3.00	-0.33
15	no	80	Proficient	2	0.67	76	Advanced	3	0.67	-4.00	0.00
16	no	72	Proficient	2	0.67	81	Advanced	3	1.00	9.00	0.33
17	no	68	Basic	1	0.67	100	Advanced	3	0.67	32.00	0.00
18	no	76	Proficient	2	0.67	76	Advanced	3	1.00	0.00	0.33
19	no	76	Proficient	2	0.67	81	Advanced	3	1.00	5.00	0.33
20	no	80	Proficient	2	0.67	57	Proficient	2	0.67	-23.00	0.00

Table 2

An independent t-test of the gain scores of the intervention versus the non-intervention students

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Gain score pre to post on entire Assessment	Equal variances assumed	.417	.526	.522	18	.608	3.939	7.542
	Equal variances not assumed			.534	17.999	.600	3.939	7.373

Table 3

An independent t-test analysis of the gain score obtained by subtracting the sub-items in the pre and posttests that were particularly related to the intervention

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Gain Sub Item Score	Equal variances assumed	2.629	.122	1.671	18	.112	.188855218855219	.113043585603596
	Equal variances not assumed			1.615	14.126	.129	.188855218855219	.116966870503893

Table 4

A cross tabulation of the intervention versus non-intervention students on the categories on the entire pre measure and the entire post measure with statistical analysis

		Posttest Categories on 3 Point Scale			Total
		1	2	3	
Intervention Participation	no	0	1	8	9
	yes	4	5	2	11
Total		4	6	10	20

Chi-Square Tests	Value	Degrees of freedom	Significance level
Pearson Chi-Square	10.168 ^a	2	.006

These results are mixed with some non-statistically significant findings and one statistically significant finding. This will be discussed further in Chapter V.

CHAPTER V

DISCUSSION

The results of this study retained the hypothesis that by using *FASTT Math* fact intervention, students in grade 4 will not demonstrate increased student achievement on curriculum based assessment questions which target multiplication fluency in terms of gain scores from pre to post testing and in terms of the sub item gain scores from pre to post testing. However, in terms of growth in categories described as basic, proficient, and advanced, there was a statistically significant change favoring an increase in positive categories.

Implications of the Study

While the students in the intervention group of this study did not demonstrate statistically significant gains on the posttest, it is important to note that nine out of eleven of the students who received the intervention demonstrated gains on the three questions related to fact fluency, and seven of the eleven students increased their proficiency level from the pre-test to the posttest. The results indicate that fact fluency intervention can have a positive impact on achievement on curriculum-based assessments. Additionally, it is important to note the importance of pre-assessing students prior to beginning instruction, as the curricular content may not be enough to increase students' understanding of complex topics. By pre-assessing students, a teacher is able to determine which students may benefit from repeated practice on a given topic.

Threats to Validity

In conducting this study, the internal validity may have been threatened by the instrumentation itself. The pre- and posttests did not assess the same standards, other than the three questions related to the fluency standard. It is difficult to discern if one test was more difficult than another, or if the topics themselves were less difficult for the participants. As a

result, the two tests are difficult to compare, making it difficult to determine if the treatment had an impact on the assessment scores.

The selection of the students for the treatment group may have also interfered with the internal validity of this study. The participants in the experimental and control groups had different characteristics that may have affected the dependent variable differently. The students chosen for the experimental group were chosen because of their poor scores on the pre-tests, while the control group was the remainder of the class. In addition to this selection method, students who composed the control group continued to receive instruction on grade level content, while the students in the treatment group were given instruction on basic facts. As a result, the students who remained in the classroom may have been exposed to additional content that the control group was not.

The statistically significant finding relating to the categories could have arisen from instrumentation problems. The researcher cannot know whether the pre and post instruments were vertically scaled and thus permitting subtraction of pre from post. Further, how the item categories of basic, proficient, and advanced cut scores were defined may not have been the result of statistical analyses but the result of professional judgment. Thus, the conflict in the findings could be due to instrumentation validity problems in terms of establishing vertical scaling and cut scores.

The external validity of this study may have been threatened by the small sample size and the convenience sample, rather than a random sample. The students chosen for this study were students contained in one co-taught classroom rather than a sample across the grade level. Students were chosen for the co-taught classroom due to previous scores on mathematics assessment, or because of the need for special education services. An additional threat to external

validity is the high number of students with disabilities in the treatment group. Four out of the eleven students in the treatment group were identified as students with a disability, which would mean these students have identified weaknesses in mathematics for which they require additional specialized instruction.

Connections to Previous Studies and Existing Literature

There is extensive research in the field that discusses the acquisition of basic facts, while identifying the need for basic fact retrieval to be immediate and accurate; however, less research focuses on the relationship between math fact fluency and improved mathematics achievement. Research completed in 2005 by Kanive, Nelson, Burns, & Ysseldyke demonstrates that computer-based intervention on fact fluency may be more effective for increasing computational skills. When compared to peers who participated in only small group instruction focusing on conceptual knowledge, the students in the fact fluency intervention outperformed their peers on assessments focusing on computational skills. This research demonstrates the importance of fact fluency in mathematics instruction, particularly for struggling learners. It is important to note that this research did not find a correlation between participation in the intervention and problem-solving skills, which was measured through separate assessments, unlike the curriculum-based assessment used in this study, which measured grade level standards.

Implications for Further Research

Given the emphasis placed on computational fluency, much work is needed to further the understanding of increasing fact fluency and generalization of these skills across all math domains. Further research should attempt to eliminate the aforementioned threats to validity. In order to eliminate some of these threats, researchers may want to first begin with larger, heterogeneous groups as samples, rather than homogenous convenience samples. Additionally,

researchers may want to use different instrumentation in order to attempt to control for the differences in assessment questions and to control for the cut scores.

Conclusions

The purpose of this study was to determine if participation in a math fact intervention would affect student achievement on curriculum-based assessments. Although it was found that students who participated in this brief intervention did not demonstrate increased achievement in terms of overall scores between the pre and post-test, the findings did demonstrate increased proficiency scores after receiving the intervention.

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