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FASTT MATH®

A Preliminary Evaluation in Citrus County, Florida

IMPACT STUDY

FASTT Math:
A Preliminary Evaluation in Citrus County, Florida

2010

Table of Contents

Executive Summary

In partnership with the Citrus County School District in Florida, Scholastic conducted preliminary research focusing on the impact of *FASTT Math*, a technology-based intervention program, on the math achievement of students in Grades 2–8. The goal of the *FASTT Math* program is to develop in students the ability to retrieve the answers to basic math facts from memory, both accurately and fluently. The primary purpose of the study was to examine student growth in math fact fluency during the 2008–2009 school year, as demonstrated by the *FASTT Math* software data (as measured by the number of lessons each student completed on the program and his or her number of fluent facts over time).

Teachers were instructed to use the program three to five times a week for 10 to 15 minutes a session. Data were collected from 11 elementary schools (Grades 2–5) and four middle schools (Grades 6–8) from Fall 2008 through Spring 2009.

Quantitative findings from the study revealed the following:

- Elementary and middle school students who used *FASTT Math* showed significant gains in their number of fluent math facts in both addition and multiplication. The number of fluent or near fluent students, defined as achieving fluency in at least 80% of the math facts, significantly increased after *FASTT Math* usage.
- There was a strong relationship between implementation and students' fact fluency. Students who used the program on-model gained significantly more fluent facts than those who used the program off-model.
- *FASTT Math* program usage was also significantly related to student outcomes. Students who completed more lessons on the *FASTT Math* software gained significantly more fluent math facts than did students who completed fewer lessons.

FASTT Math Program Overview

FASTT Math is an intervention program that uses adaptive software to help students in Grades 2 and higher develop fluency with basic math facts. *FASTT Math* uses the FASTT system (Fluency and Automaticity through Systematic Teaching with Technology), based on nearly two decades of research on the development of mathematical fluency in math-delayed and non-math-delayed children. *FASTT Math* embodies several unique design features to help develop these relationships. These features include:

- **Identification of fluent and non-fluent facts:** *FASTT Math* begins with a computer-based assessment that presents all the basic facts in an operation and records the amount of time that the child takes to answer each fact correctly. By measuring the latencies of student responses, the program can accurately determine the facts that are being recalled from memory and those that are solved using a counting strategy.

- **Restricted presentation of non-fluent information:** The program expands the student's declarative knowledge network by building on existing knowledge. As a general rule, the program selects facts to be automatized based upon the size of the minimum addend. For example, once all facts with a minimum addend of 1 have been automatized, *FASTT Math* begins to select facts with a minimum addend of 2, and so on, until all the 2s have been automatized.

- **Student generation of problem/answer pairs:** *FASTT Math* explicitly requires students to type each newly introduced fact. By generating the problem/answer pair, students connect the two elements together. And when students falter in holding that connection in memory, the program demands that they retype the fact to reestablish the relationship.

- **Use of controlled response times:** Once a problem/answer relationship is established, *FASTT Math* uses controlled response times to reinforce the memory connection and inhibit the use of counting or other nonautomatic strategies. A controlled response time is the amount of time allotted to retrieve and provide the answer to the fact. *FASTT Math* begins with a controlled response time of 1.25 seconds, forcing students to abandon inefficient strategies and to retrieve answers rapidly from the declarative knowledge network. If the controlled response time lapses before the child can respond, or if the student answers incorrectly, the program provides corrective feedback by presenting the problem/answer relationship again. This continues until the child gives the correct answer within the controlled response time.

- **Spaced presentation of nonfluent information:** *FASTT Math* develops a declarative knowledge network by interspersing the two new "target" facts with other already automatized facts in a pre-specified, expanding order. Each time the target fact is presented, another automatized fact is added as a "spacer" so that the amount of time between presentations of the target fact is expanded. This "expanding recall" model requires the student to retrieve the correct answers to the target facts over longer and longer periods.

- **Appropriate use of drill and practice:** Only after a student is consistently able to retrieve the answer to a target fact within the controlled response time is that fact added to the child's set of drill and practice facts. Drill and practice has been shown to be effective only with facts that are already being retrieved from memory. *FASTT Math* systematically builds a memory relationship before it reinforces speed of recall with appropriate drill and practice activities.

FASTT Math provides a unique, individualized learning experience, building fluency at the pace and level adapted specifically for that student. The software provides placement assessment, adaptive instruction, and independent practice, leading to operation mastery.

FASTT Math Elements

1. Placement Assessment

FASTT Math *establishes a baseline of math fact fluency, identifying exactly which facts need to be targeted for intervention.*

2. Adaptive Instruction

FASTT Math *provides 10-minute daily instruction sessions focused on a student's non-fluent facts.*

3. Independent Practice

FASTT Math *offers a series of engaging and motivating games in which students gain fluency —and confidence—by practicing their learned and fluent facts.*

4. Operation Mastery

FASTT Math *ensures that all students, regardless of their initial fluency level, can build the long-lasting fluency that they will need to tackle more complex math.*

FASTT Math also provides supplemental noncomputer-based materials. A *Fact Fluency Foundations Guide* assists teachers in providing instruction to students who lack foundational number concepts, such as counting skills and the ability to link number facts. To help reinforce what students learned on the computer, an individualized practice sheet generator allows teachers to print custom practice sheets for each student. This provides an opportunity for transfer of the facts students are learning in the software to paper-and-pencil format. The practice sheets draw on each student's fluent facts, allowing students to extend their fluency to another medium. Teachers can generate reports that track student math growth and performance through a data management system, the *Scholastic Achievement Manager*.

Study Introduction

Nearly two-thirds of eighth-grade students score at or below basic level, as measured by the National Assessment of Educational Progress Mathematics test (2009). This low performance in math achievement may be attributed to curricula that quickly move students through extensive math content in the early grades before they have mastered foundational skills, including fact fluency.

The ability to solve basic math facts (e.g., 16 ÷ 2) by memory rather than by following a procedure has been shown to be a strong predictor of performance on mathematics achievement tests (Royer, Tronsky, Chan, Jackson, & Marchant, 1999). Studies have found that the inability to rapidly retrieve math facts can impede participation in math class discussions (Woodward & Baxter, 1997) and successful mathematics problem solving (Pellegrino & Goldman, 1987). Although correct answers can be obtained through procedural knowledge, such as finger counting, it is an effortful and slow procedure that can interfere with learning and understanding higher-order concepts (Hasselbring, Goin, & Bransford, 1988). The mental effort involved in figuring out facts often disrupts the thinking about the larger problem in which facts are used. Games, particularly computer and video games, have been tapped as a potentially powerful way to motivate students in the classroom, due to their engaging and interactive nature. Jenkins (2005) pointed out that games can further accelerate student achievement by engaging students, lowering the threat of failure, linking learning to goals and rules, and utilizing multimodal media.

A student who does not have basic math facts memorized is similar to one who cannot recognize words by sight. While reading, the student must devote excessive attention to sounding out each word, phoneme by phoneme. This process leaves little room for attention to higher-level processes such as thinking about the meaning of words or sentences. Likewise, in math, if too much energy goes into figuring out what 16 divided by 2 equals, little is left to figure out more complex long division concepts.

Cognitive psychologists have discovered that students have fixed limits on the attention and memory that can be used to process information. One way around these limits is to overlearn certain components of a task so that they become automatic (Whitehurst, 2003). In line with this research, the National Mathematics Advisory Panel (2008), charged with providing guidance on how to improve mathematics achievement for all students, released a report that recommends “computer-assisted instruction drill and practice . . . as a useful tool in developing students’ automaticity (i.e., fast, accurate, and effortless performance on computation), freeing working memory so that attention can be directed to the more complicated aspects of complex tasks.”

FASTT Math was developed to address the learning challenges that many students face. The program guides students to have ready in memory the answers to a set of addition, subtraction, multiplication, and division problems. *FASTT Math* offers a series of engaging and motivating games in which students gain fluency by practicing their learned and fluent facts. Each day, students play a game that is tailored to their level of fluency. The games reinforce fluent facts and provide practice on facts students are working to master. The games adjust dynamically to each student's performance. If a student is doing well, the games present more difficult facts at a faster pace; if a student is struggling, the games slow down and present less difficult problems.

During the 2008–2009 school year, the Citrus County School District used *FASTT Math* as a targeted intervention to its math program to improve student fact fluency in 15 of its elementary and middle schools. In partnership with the district, researchers examined the growth in fluency level of addition and multiplication facts for students in Grades 2 through 8. Scholastic also investigated the relationship between *FASTT Math* implementation and student outcomes.

The Setting and Sample

The Citrus County School District (CCSD) in Inverness, Florida, is located about 85 miles northwest of Orlando, Florida. The K–12 district enrolls more than 16,000 students in 23 schools: 84 percent of the population is Caucasian, 4 percent is African American, 5 percent is Hispanic, and 2 percent is Asian. English language learners make up 1.5 percent of the overall population. 16 percent of students have learning disabilities and approximately 41 percent qualify for free or reduced-price meals.

CCSD adopted *FASTT Math* to address district concerns that students lacked fluency in math facts. Initially, *FASTT Math* was used to assess all students' math fact fluency in the classrooms included in this study. Students who performed well on the initial placement often did not continue to use the program. At the middle schools, *FASTT Math* was most commonly used in intervention classes. The intervention classes included students who scored in Level 1 or Level 2 (out of 5) on the math section of the Florida Comprehension Assessment Test, meaning they showed "little" to "limited" success with the content of the state standards.

The Setting and Sample (cont.)

Eleven elementary and four middle schools used *FASTT Math*. The elementary schools included Central Ridge, Citrus Springs, Crystal River, Floral City, Forest Ridge, Hernando, Homosassa, Inverness, Lecanto, Pleasant Grove, and Rock Crusher. The middle schools included Citrus Springs, Crystal River, Inverness, and Lecanto.

A total of 4,172 students participating in the *FASTT Math* program during the 2008–2009 school year composed the sample described in this report. Students in this study used the program for an average of about 20 weeks for each operation. All *FASTT Math* students in this study completed a minimum of 10 *FASTT Math* lessons and participated in the program for at least four weeks. Students were enrolled in addition, subtraction, multiplication, and/or division operations. At the elementary school level, 1,860 students were enrolled in addition operations, and 1,323 students were enrolled in multiplication operations. At the middle school level, 177 students were enrolled in addition operations, and 1,256 students were enrolled in multiplication operations. There were 444 students enrolled in both addition and multiplication.

This report focuses on addition and multiplication because those are the primary operations and the ones in which students had completed the most lessons. In line with the district's scope and sequence, *FASTT Math* students completed addition before subtraction, and multiplication before division. Therefore, many of the students had not completed lessons in subtraction and division at the time of this study. Students were enrolled in facts either from 0–9 (e.g., up to 9 x 9 = 81) or from 0–12 (e.g., up to 12 x 12 = 144) based on teacher preference, which was often influenced by their students' initial math performance. In the 0–9 program, students were learning 100 facts, whereas in the 0–12 program, students were learning 169 facts. Tables 1 and 2 present the sample sizes by grade and operation for this study.

Table 1
Citrus County School District *FASTT Math* Students in Addition, 2008–2009
Characteristics of Students Included in the Study (N=2,037)

Elementary School Sample: Grade	Number of Students	Middle School Sample: Grade	Number of Students
2	725	**6**	129
3	615	**7**	30
4	255	**8**	18
5	265		
Elementary Total	**1,860**	**Middle School Total**	**177**

Table 2 Citrus County School District *FASTT Math* Students in Multiplication, 2008–2009 Characteristics of Students Included in the Study (N=2,579)			
Elementary School Sample: Grade	**Number of Students**	**Middle School Sample: Grade**	**Number of Students**
2	7	**6**	468
3	333	**7**	418
4	479	**8**	370
5	504		
Elementary Total	**1,323**	**Middle School Total**	**1,256**

FASTT Math tracks each student's start date, the most recent date a lesson was completed, and the total number of lessons completed between these two time points. The recommended usage for the program is three to five times a week. Tables 3 and 4 present the usage data for the students in this study.

Table 3 Citrus County School District *FASTT Math* Students in Addition, 2008–2009 Usage Data of Students Included in the Study (N=2,037)		
	Elementary School (N = 1,860)	**Middle School (N = 177)**
Average Number of Weeks in Program	21 (range 4–35)	18 (range 4–35)
Average Number of Lessons	33 (range 10–145)	33 (range 10–81)
Average Number of Lessons per Week	1.6 (range 0.3–5.6)	2.3 (range 0.6–7.0)

Table 4 Citrus County School District *FASTT Math* Students in Multiplication, 2008–2009 Usage Data of Students Included in the Study (N=2,579)		
	Elementary School (N = 1,323)	**Middle School (N = 1,256)**
Average Number of Weeks in Program	18 (range 4–35)	23 (range 4–36)
Average Number of Lessons	33 (range 10–118)	33 (range 10–135)
Average Number of Lessons per Week	1.9 (range 0.4–7.5)	1.5 (range 0.3–5.9)

Research Questions

The primary purpose of this study was to examine student growth in math fact fluency during the 2008–2009 school year, as demonstrated by software data. A secondary purpose was to better understand *FASTT Math* implementation and its impact on student outcomes. The evaluation focused on three research questions:

1. **Did the *FASTT Math* sample as a whole make improvements in fact fluency, as measured by the software?**
2. **How did differences in implementation, on-model versus off-model, impact student outcomes in the *FASTT Math* program?**
3. **How did the number of lessons students completed on the *FASTT Math* software relate to student growth in fact fluency, as measured by the software?**

Research Measures

To address the central research questions, evaluators obtained export data from the *FASTT Math* program.

FASTT Math Program Data

Through placement assessment, *FASTT Math* establishes a baseline of math fact fluency, identifying exactly which facts need to be targeted for intervention for each student. *FASTT Math* begins with a placement assessment that identifies which facts a student can retrieve automatically from memory (in less than a second) and which facts are either inaccurate or being processed nonautomatically using a strategy, like adding on or skip counting. By focusing on response latency (the difference between the length of time it takes a student to type, for example, the number 21 versus the time it takes to answer the math fact 7 x 3), the *FASTT Math* software is able to determine whether a student doesn't know the fact at all, is automatically retrieving the fact, or is using procedural knowledge.

Based on the placement assessment, *FASTT Math* determines an intervention path for each student to build fluency. Students receive an individualized assignment each day they use *FASTT Math*. Instructional sessions are carefully tailored to the specific facts a student needs to learn, and these facts are presented systematically and in increasing order of difficulty.

This study collected data on the number of lessons each student completed on the software as well as the number of fluent facts at the placement and final assessments.

Implementation

During the 2008–2009 school year, CCSD began implementing *FASTT Math* as an intervention to improve math fluency among its struggling students.

Teachers were instructed to use *FASTT Math* with each student as a supplement to their regular math curriculum for 10 minutes each day. *FASTT Math* supplemented McGraw-Hill's *Everyday Mathematics* (Grades 2–5) and *Glencoe Mathematics: Applications and Concepts* (Grades 6–8) for the students in the sample. The majority of the classrooms had two to four computers that students rotated through before school, during the school day, or after school.

Scholastic provided full-day training sessions for teachers and half-day training sessions for administrators. The teacher training introduced the background and research behind the program. Scholastic representatives explained the instructional sequence of the software, demonstrated the software, and allowed teachers to experience being a *FASTT Math* student through a program simulation. The teachers also received an introduction to the teacher management system, which includes resources for managing class rosters and accessing reports.

All the students in this study used the software, fewer than 5 percent used the practice sheets, and few to none required lessons from the Fact Fluency Foundations Guide. Teachers used the fact fluency reports generated by *FASTT Math* as a tool to help them determine how to differentiate instruction in the classroom. Some schools sent the fact fluency reports home to parents as part of their progress reports.

Analyses and Results

This section presents results from the analysis of student outcome data.

Research Question #1:

Did the *FASTT Math* sample as a whole make improvements in fact fluency, as measured by the software?

To answer this first question, the data were examined separately for both the elementary school and the middle school groups, as well as for both addition and multiplication operations.

Overall Growth in Fluent Math Facts

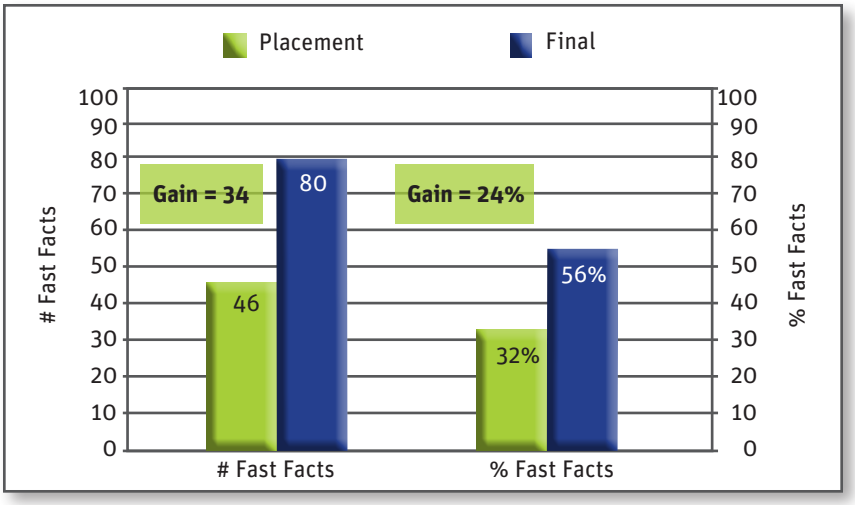
Growth was examined on two dimensions: number of fast facts gained and percentage of fast facts gained. Number of fast facts, which is recorded at both the placement assessment and the final assessment of the study period, represents a student's fluent facts, that is, the number of facts a student retrieved in less than one second. Final assessment refers to the last collection of data during the study period. The growth in fluent math facts presented in this report is preliminary, as many students continued to use the program. Fast fact gain was calculated by subtracting each student's initial number of fast facts from his or her final number of fast facts and averaging these gains for all students. In addition to number of fast facts, the percentage of fast facts was also calculated. Since some students were enrolled in the 0–9 program, and others in the 0–12 program, it was important to consider student performance in terms of "possible" performance. Thus, percentage of fast facts represents the percentage of facts on which a student was fluent out of the total number of facts on which the student was tested. For example, if a student demonstrated fluency on 30 addition facts and was enrolled in the addition 0–9 program, the student would have 30 percent fluency (or 30 fluent facts out of 100 possible). Conversely, if a student demonstrated fluency on 30 addition facts and was enrolled in the addition 0–12 program, the student would have 18 percent fluency (or 30 fluent facts out of 169 possible). Here again, gain was calculated by subtracting each student's initial percentage of fast facts from his or her final percentage of fast facts.

Graphs 1 and 2 show the growth in fact fluency for both addition and multiplication operations for elementary school students in Grades 2–5.

Graph 1

Citrus County School District, *FASTT Math* Students (N=1,860), 2008–2009

Number and Percentage of Addition Fast Facts Retrieved by Elementary School Students

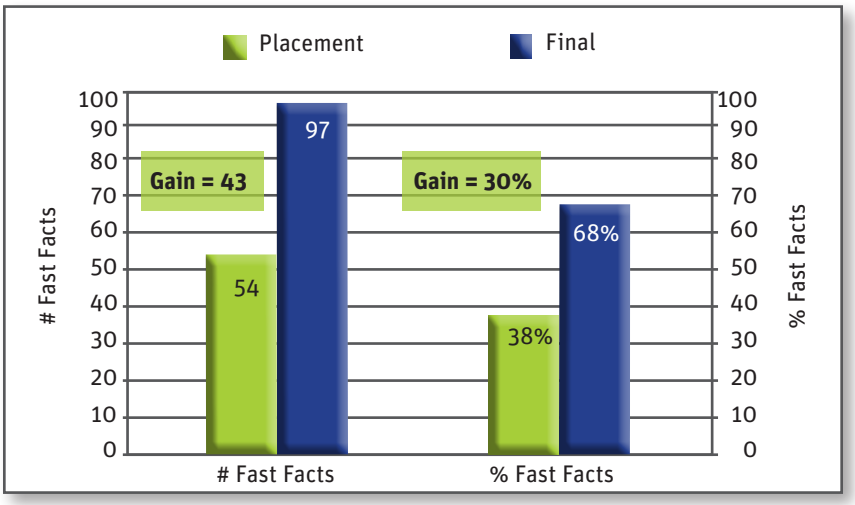


Note: Dependent t-tests show that the gains in the number of fast facts and in the percentage of fast facts were significant for the full sample (number of fast facts: t=59.07, p <.01; percentage of fast facts: t=65.04, p <.01).

Graph 2

Citrus County School District, *FASTT Math* Students (N=1,323), 2008–2009

Number and Percentage of Multiplication Fast Facts Retrieved by Elementary School Students



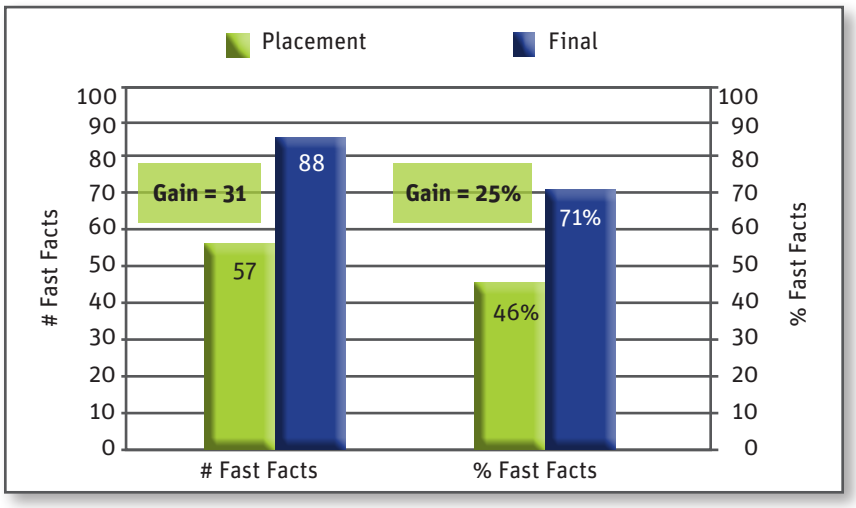
Note: Dependent t-tests show that the gains in the number of fast facts and in the percentage of fast facts were significant for the full sample (number of fast facts: t=56.87, p <.01; percentage of fast facts: t=61.47, p <.01).

Analyses and Results (cont.)

Research Question #1 (continued):

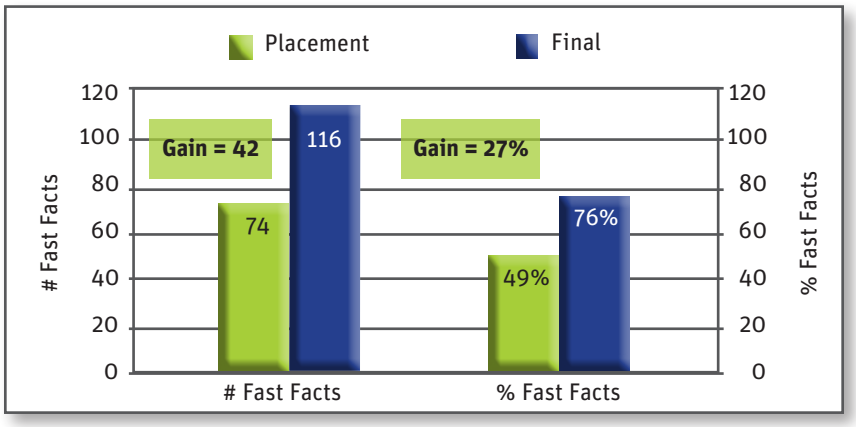
Graphs 3 and 4 show the growth in fact fluency for both addition and multiplication operations for middle school students in Grades 6–8.

Graph 3
Citrus County School District, *FASTT Math* Students (N=177), 2008–2009
Number and Percentage of Addition Fast Facts Retrieved by Middle School Students



Note: Dependent t-tests show that the gains in the number of fast facts and in the percentage of fast facts were significant for the full sample (number of fast facts: t=16.41, p <.01; percentage of fast facts: t=19.54, p <.01).

Graph 4
Citrus County School District, *FASTT Math* Students (N=1,256), 2008–2009
Number and Percentage of Multiplication Fast Facts Retrieved by Middle School Students



Note: Dependent t-tests show that the gains in the number of fast facts and in the percentage of fast facts were significant for the full sample (number of fast facts: t=52.16, p <.01; percentage of fast facts: t=56.66, p <.01).

Dependent t-tests indicated that both the elementary and middle school groups made significant gains in the number of fluent math facts for both the addition and multiplication operations. The greatest improvement was shown for multiplication, with gains of 43 (elementary school) and 42 (middle school) fluent facts between the placement assessment and the final assessment of the study period.

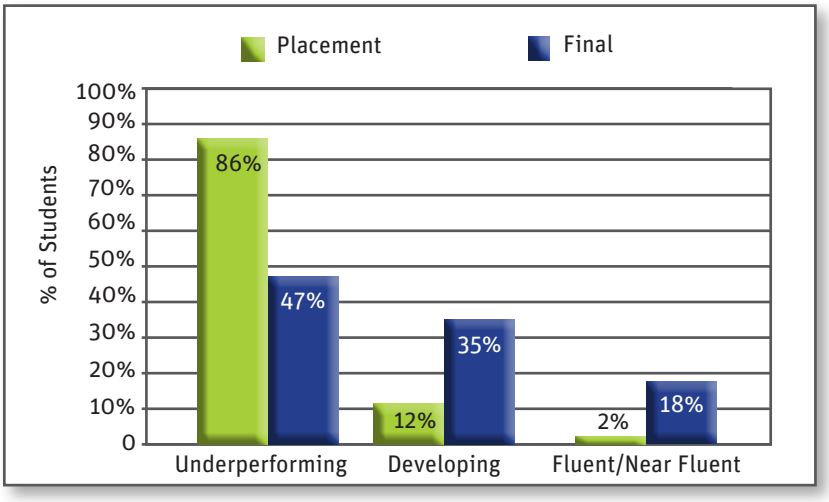
Improvements in Fluency Levels

FASTT Math categorizes students into one of four fluency levels based on their math facts recall performance. The fluency levels are defined by the program as follows:

- Underperforming: fluency with fewer than 50% of facts
- Developing: fluency with 50% to 79% of facts
- Near fluent: fluency with 80% to 96% of facts
- Fluent: fluency with 97% to 100% of facts

Graphs 5 through 8 show the percentage of students performing at each fluency level in addition and multiplication at the placement assessment and the final assessment of the study period.

Graph 5
Citrus County School District, *FASTT Math* Students (N=1,860), 2008–2009
Percentage of Elementary School Students in Each Performance Level of Addition Fact Fluency

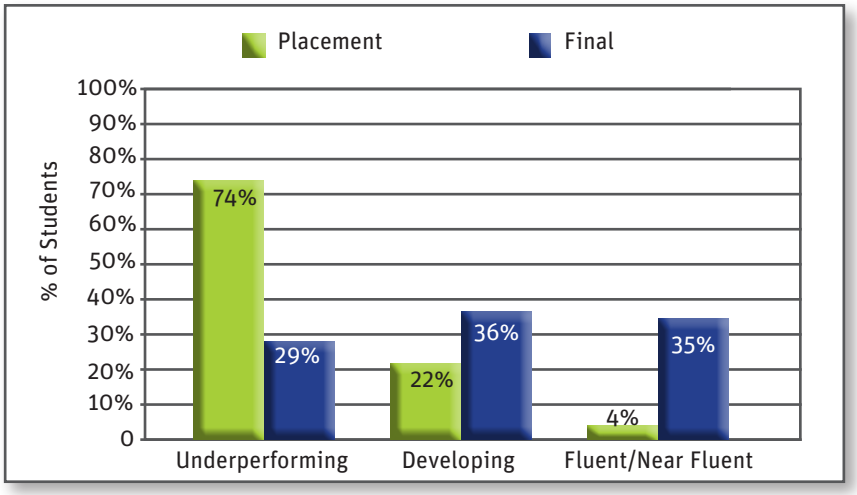


Note: Dependent t-test shows that there was a significant increase in the number of students performing at the fluent or near fluent levels between placement assessment and the final assessment of the study period, increasing from 2% to 18% ($t=18.98$, $p < .01$).

Research Question #1 (continued):

Graph 6

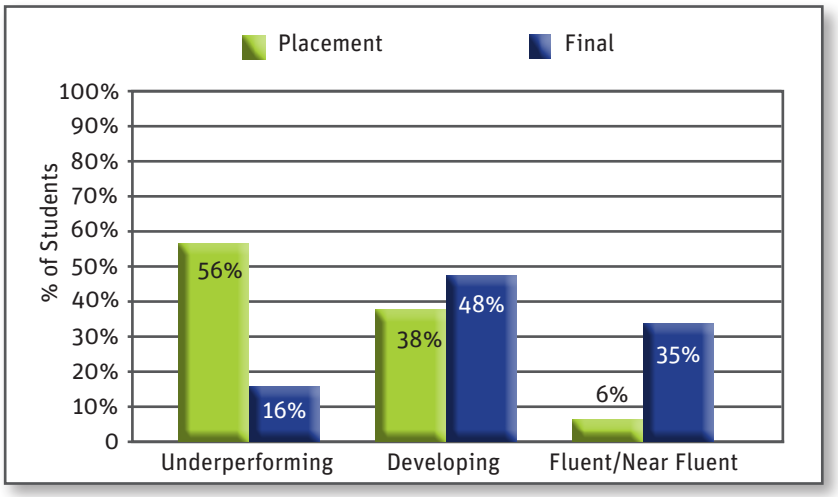
Citrus County School District, *FASTT Math* Students (N=1,323), 2008–2009
Percentage of Elementary School Students in Each Performance Level of Multiplication Fact Fluency



Note: Dependent t-test shows that there was a significant increase in the number of students performing at the fluent or near fluent levels between placement assessment and the final assessment of the study period, increasing from 4% to 35% (t=24.54, p <.01).

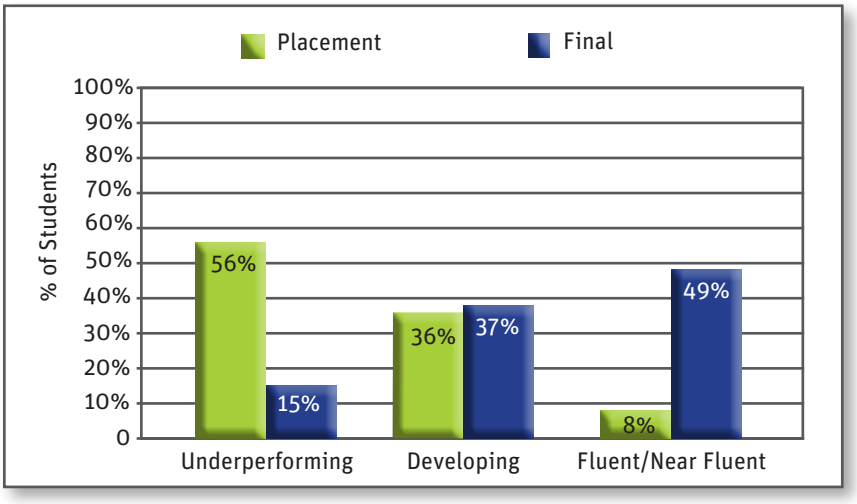
Graph 7

Citrus County School District, *FASTT Math* Students (N=177), 2008–2009
Percentage of Middle School Students in Each Performance Level of Addition Fact Fluency



Note: Dependent t-test shows that there was a significant increase in the number of students performing at the fluent or near fluent levels between placement assessment and the final assessment of the study period, increasing from 6% to 35% (t=8.67, p <.01).

Graph 8
Citrus County School District, *FASTT Math* Students (N=1,256), 2008–2009
Percentage of Middle School Students in Each Performance Level of Multiplication Fact Fluency



Note: Dependent t-test shows that there was a significant increase in the number of students performing at the fluent or near fluent levels between placement assessment and the final assessment of the study period, increasing from 8% to 49% ($t=29.39$, $p < .01$).

Dependent t-tests confirmed that there was a statistically significant increase in the number of fluent or near fluent students in addition and multiplication. The number of fluent or near fluent elementary school students increased significantly from 2% to 18% for addition and from 4% to 35% for multiplication. The number of fluent or near fluent middle school students increased significantly from 6% to 35% for addition and from 8% to 49% for multiplication.

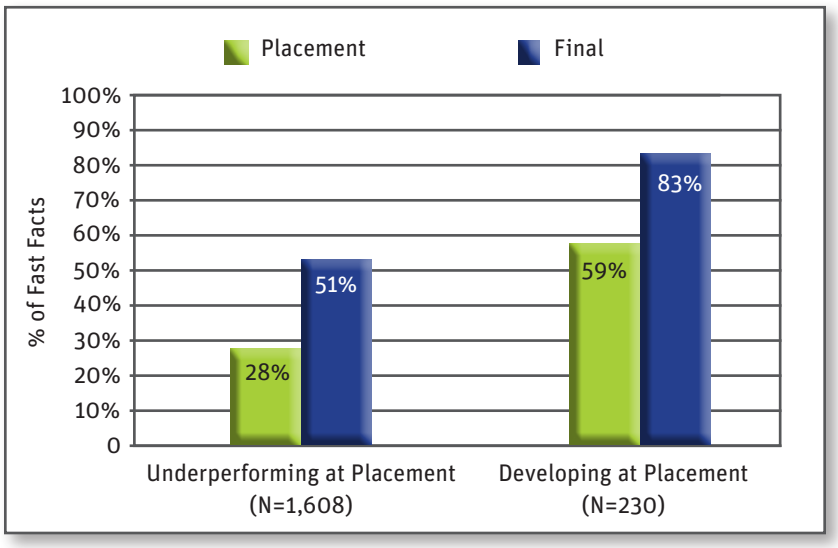
Furthermore, results showed that at the placement assessment, the majority of the elementary and middle school students were underperforming in both addition and multiplication operations. Following *FASTT Math* usage, the percentage of underperforming students was less than half for both operations at the elementary and middle school levels. The biggest reduction in the number of underperforming students came for elementary school students in multiplication; 74% were underperforming at the placement assessment but only 29% were underperforming at their final assessment of the study period.

Research Question #1 (continued):

How the Most-Struggling Students Performed

Graphs 9 through 12 illustrate the impact of *FASTT Math* specifically on students who struggled most with fact fluency, scoring at the underperforming or developing level during their placement assessment; that is, they had mastered fewer than 80% (developing) or fewer than 50% (underperforming) of their math facts.

Graph 9
Citrus County School District, *FASTT Math* Students (N=1,838), 2008–2009
Addition Fact Fluency Growth by Initial Performance Level in Elementary School Students

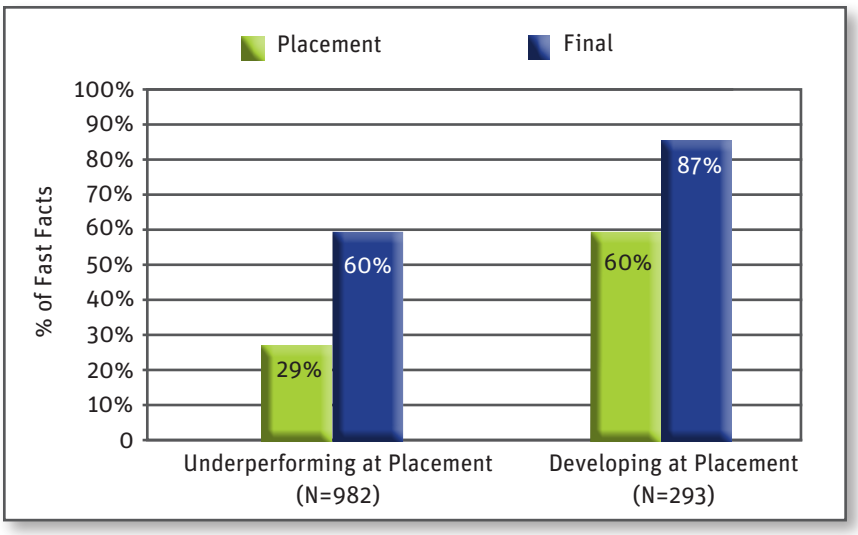


Note: Dependent t-tests show that the gain in the percentage of addition fast facts was significant for both the underperforming ($t=59.47$, $p < .01$) and developing ($t=27.55$, $p < .01$) elementary school groups.

Graph 10

Citrus County School District, *FASTT Math* Students (N=1,275), 2008–2009

Multiplication Fact Fluency Growth by Initial Performance Level in Elementary School Students

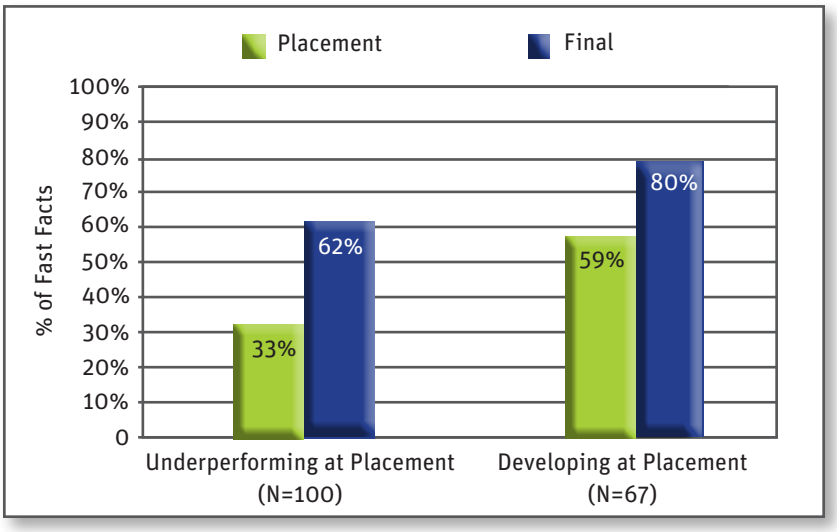


Note: Dependent t-tests show that the gain in the percentage of multiplication fast facts was significant for both the underperforming (t=52.69, p <.01) and Developing (t=34.25, p <.01) elementary school groups.

Graph 11

Citrus County School District, *FASTT Math* Students (N=167), 2008–2009

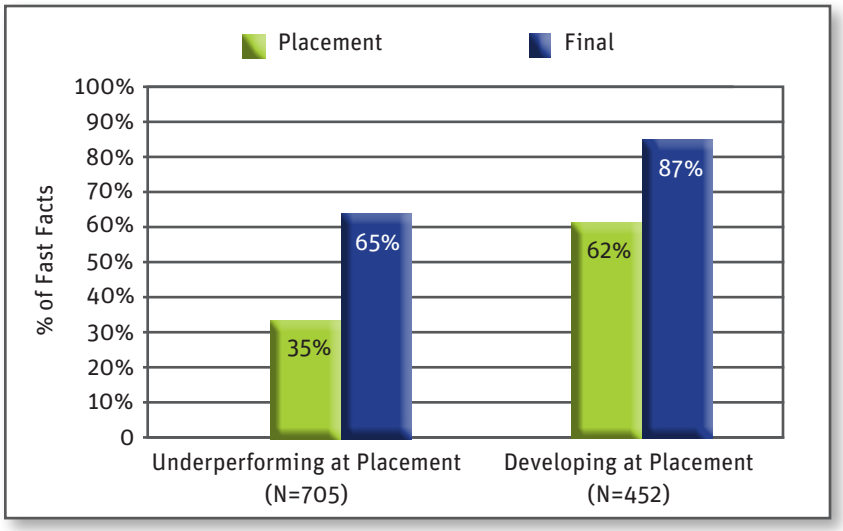
Addition Fact Fluency Growth by Initial Performance Level in Middle School Students



Note: Dependent t-tests show that the gain in the percentage of addition fast facts was significant for both the Underperforming (t=15.41, p <.01) and developing (t=13.00, p <.01) middle school groups.

Research Question #1 (continued):

Graph 12
Citrus County School District, *FASTT Math* Students (N=1,157), 2008–2009
Multiplication Fact Fluency Growth by Initial Performance Level in Middle School Students



Note: Dependent t-tests show that the gain in the percentage of multiplication fast facts was significant for both the underperforming ($t=41.95$, $p < .01$) and developing ($t=41.88$, $p < .01$) middle school groups.

Dependent t-tests confirmed significant gains in fact fluency for the most struggling students, those scoring at either the underperforming or developing level at placement. The group of students who placed at the underperforming level at the start of the program improved, on average, one performance level to the developing level by the final assessment of the study period. In other words, students who were fluent in fewer than half the math facts at the start of the program averaged fluency on 50% to 79% of the facts by the final assessment of the study period.

Similarly, students who placed at the developing level at the start of the program improved, on average, one performance level to the near fluent level (fluent in 80% to 96% of math facts) by the final assessment of the study period. This pattern of results was seen in both the elementary and middle school groups and with both addition and multiplication operations.

Research Question #2:

How did differences in implementation, on-model versus off-model, impact student outcomes in the *FASTT Math* program?

The recommended classroom usage for *FASTT Math* is three to five times per week. For reporting purposes, the software computes on-model usage as an average of 2.25 times a week or more over the course of the program. This is to account for missed weeks during school holidays and vacations. Tables 5 and 6 describe the characteristics of the on-model and off-model students in elementary and middle school. Graphs 13 through 16 compare the percentage of on-model students with the percentage of off-model students who were fluent or near fluent in math facts at the final assessment of the study period.

Table 5
Citrus County School District *FASTT Math* Students, 2008–2009
Characteristics of On- and Off-Model Elementary School Students

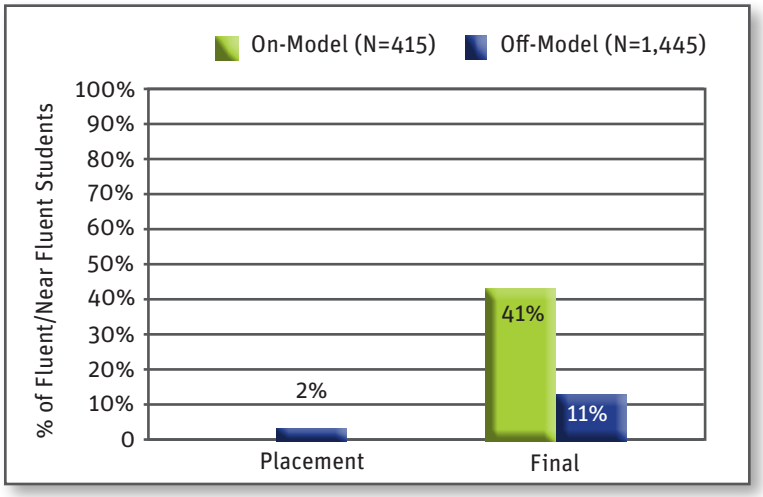
	Addition (N=1,860)		Multiplication (N=1,323)	
	Off-Model (N=1,445; 78% of sample)	On-Model (N=415; 22% of sample)	Off-Model (N=891; 67% of sample)	On-Model (N=432; 33% of sample
Percentage of Fast Facts at Placement	32%	34%	38%	39%
Percentage of Final Fast Facts*	51%	72%	63%	78%
Number of Lessons per Week	1.2	3.0	1.4	3.1
Number of Weeks	22	20	20	15
Number of Lessons	25	58	27	45

*On-model vs. off-model difference in Final Fast Facts: Addition ANCOVA, $F=662.09$, $p < .01$; Multiplication ANCOVA, $F=259.38$, $p < .01$.

Research Question #2 (continued):

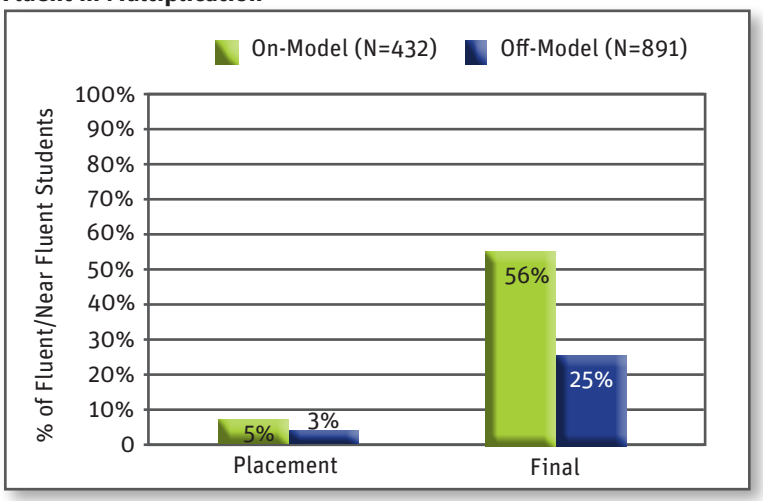
Elementary school students who were on-model recalled significantly more fast facts at the last assessment of the study period than their off-model peers in both the addition and multiplication groups. Graphs 13 and 14 show that there were also significantly more fluent or near fluent students in the on-model group than in the off-model group at the final assessment of the study period.

Graph 13
Citrus County School District, *FASTT Math* Students (N=1,860), 2008–2009
Percentage of On-Model and Off-Model Elementary School Students Fluent or Near Fluent in Addition



Note: The difference in the percentage of on- vs. off-model students achieving fluency or near fluency levels at their final assessment of the study period is significant (ANCOVA: DV=% Fluent/Near Fluent Final, IV: On- or Off-Model, CV: % Fluent/Near Fluent Placement, F=272.17, p <.01).

Graph 14
Citrus County School District, *FASTT Math* Students (N=1,323), 2008–2009
Percentage of On-Model and Off-Model Elementary School Students Fluent or Near Fluent in Multiplication



Note: The difference in the percentage of on- vs. off-model students achieving fluency or near fluency levels at their final assessment of the study period is significant (ANCOVA: DV=% Fluent/Near Fluent Final, IV: On- or Off-Model, CV: % Fluent/Near Fluent Placement, F=136.41, p <.01).

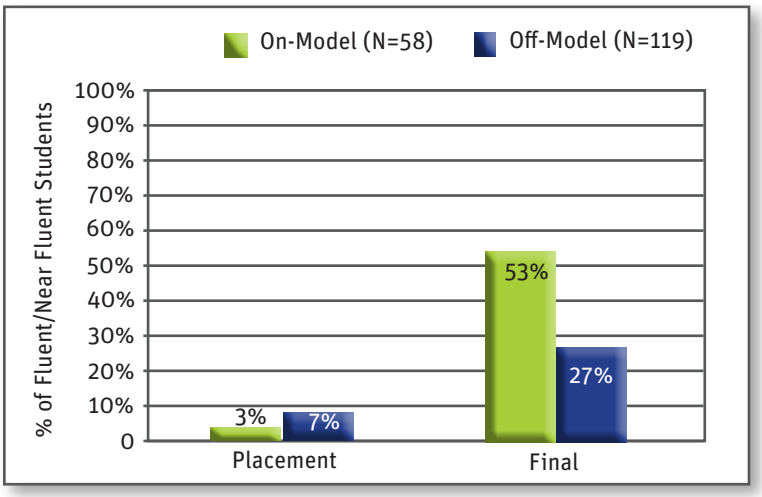
Table 6
Citrus County School District *FASTT Math* Students, 2008–2009
Characteristics of On- and Off-Model Middle School Students

	Addition (N=177)		Multiplication (N=1,256)	
	Off-Model (N=119; 67% of sample)	On-Model (N=58; 33% of sample)	Off-Model (N=1,049; 84% of sample)	On-Model (N=207; 16% of sample)
Percentage of Fast Facts at Placement	47%	44%	49%	47%
Percentage of Final Fast Facts*	68%	78%	73%	90%
Number of Lessons per Week	1.4	4.1	1.2	3.3
Number of Weeks	21	11	25	17
Number of Lessons	28	43	29	53

* On-model vs. off-model difference in Final Fast Facts: Addition ANCOVA, F=22.72, p <.01; Multiplication ANCOVA, F=282.68, p <.01.

Middle school students who were on-model recalled significantly more fast facts at the last assessment of the study period than their off-model peers in both the addition and multiplication groups. Graphs 15 and 16 show that there were also significantly more fluent or near fluent students in the on-model group than in the off-model group at the final assessment of the study period.

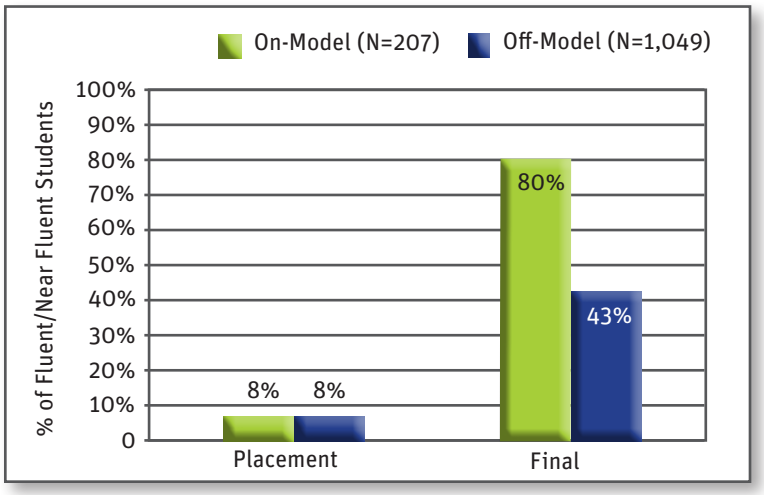
Graph 15
Citrus County School District, *FASTT Math* Students (N=177), 2008–2009
Percentage of On-Model and Off-Model Middle School Students Fluent or Near Fluent in Addition



Note: The difference in the percentage of on- vs. off-model students achieving fluency or near fluency levels at their final assessment of the study period is significant (ANCOVA: DV=% Fluent/Near Fluent Final, IV: On- or Off-Model, CV: % Fluent/Near Fluent Placement, F=17.16, p <.01).

Research Question #2 (continued):

Graph 16
Citrus County School District, *FASTT Math* Students (N=1,256), 2008–2009
Percentage of On-Model and Off-Model Middle School Students Fluent or Near Fluent in Multiplication



Note: The difference in the percentage of on- vs. off-model students achieving fluency or near fluency levels at their final assessment of the study period is significant (ANCOVA: DV=% Fluent/Near Fluent Final, IV: On- or Off-Model, CV: % Fluent/Near Fluent Placement, $F=115.28$, $p < .01$).

These results show that students who used the program on-model were fluent in significantly more math facts at their final assessment of the study period than were those students who used the program off-model. This advantage for on-model students was demonstrated for both elementary and middle school grades and for both addition and multiplication operations.

The greatest difference between the performance of on-model and off-model students existed at the elementary school level in the addition operation. Nearly four times as many on-model students were fluent or near fluent in addition as compared with their off-model peers.

Research Question #3:

How did the number of lessons students completed on the *FASTT Math* software relate to student growth in fact fluency, as measured by the software?

To investigate the relationship between the amount of exposure students received to the *FASTT Math* program and outcomes, the correlation between the number of lessons completed and gain in fast facts was calculated. Tables 7 and 8 show significant positive correlations between the number of completed lessons and gain in fluent math facts. Thus, a greater number of completed lessons was associated with a larger gain in fluent math facts.

Table 7
Citrus County School District *FASTT Math* Students, 2008–2009
Correlations Between Gains in Addition Fast Facts and Number of Lessons

	Elementary School (N=1,860)	Middle School (N=177)
	# of Lessons	# of Lessons
Gain in Addition Fast Facts	.74*	.69*

*p < .05

Table 8
Citrus County School District *FASTT Math* Students, 2008–2009
Correlations Between Gains in Multiplication Fast Facts and Number of Lessons

	Elementary School (N=1,323)	Middle School (N=1,256)
	# of Lessons	# of Lessons
Gain in Multiplication Fast Facts	.79*	.80*

*p < .05

Research Question #3 (continued):

To further explore this relationship between software dosage and student outcomes, the performance of students falling into each of three dosage categories—(1) Low: fewer than 20 lessons; (2) Medium: 20–39 lessons; and (3) High: 40 or more lessons—was examined. The difference in usage among students during the 2008–2009 school year was affected by the date at which each student started the program, the length of time students remained in the program, and the amount of time per week each classroom allotted for program use. Tables 9 and 10 show the number of students in each dosage category for addition and multiplication.

Table 9
Citrus County School District *FASTT Math* Students, 2008–2009
Number (Percentage) of Addition Students in Each Dosage Category

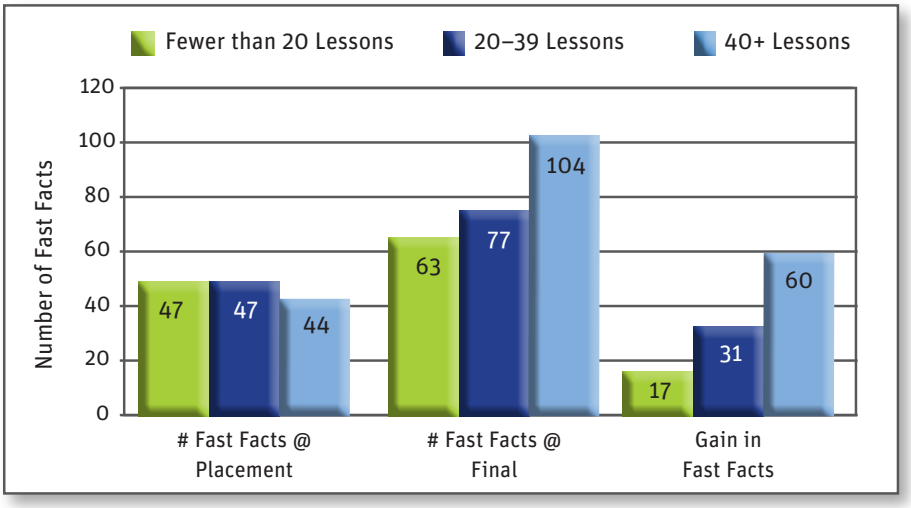
Dosage Category	Elementary School (N=1,860)	Middle School (N=177)
Low (Fewer than 20 Lessons)	677 (36%)	57 (32%)
Medium (20–39 Lessons)	667 (37%)	60 (34%)
High (40+ Lessons)	513 (28%)	60 (34%)

Table 10
Citrus County School District *FASTT Math* Students, 2008–2009
Number (Percentage) of Multiplication Students in Each Dosage Category

Dosage Category	Elementary School (N=1,323)	Middle School (N=1,256)
Low (Fewer than 20 Lessons)	401 (30%)	348 (28%)
Medium (20–39 Lessons)	523 (40%)	534 (43%)
High (40+ Lessons)	399 (30%)	374 (30%)

Graphs 17 through 20 show the effects of *FASTT Math* dosage—number of lessons completed—on the number of final fast facts and the gain in fast facts. Statistical tests demonstrated a significant relationship between the number of *FASTT Math* lessons a student completed and his or her gain in fluent facts, as well as the number of fluent facts at the final assessment of the study period. A greater number of completed lessons was associated with a greater gain in fluent facts between the placement assessment and the final assessment of the study period, as well as with a higher number of final fluent facts.

Graph 17
Citrus County School District, *FASTT Math* Students (N=1,860), 2008–2009
Dosage Effects on Elementary School Student Outcomes in Addition Fluency

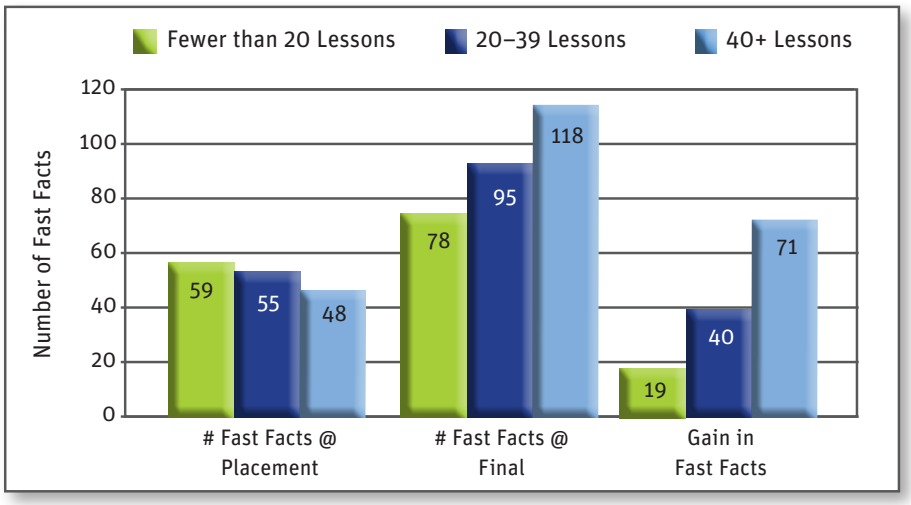


Note: There were significant differences in the gain in fluent math facts shown by the three dosage groups (ANOVA, F=879.52, p <.01). There were also significant differences in the number of fluent math facts at the final assessment of the study period (ANCOVA, DV: # Fast Facts Final, IV: Dosage Group, CV: # Fast Facts Placement, F=908.79, p <.01).

Research Question #3 (continued):

Graph 18

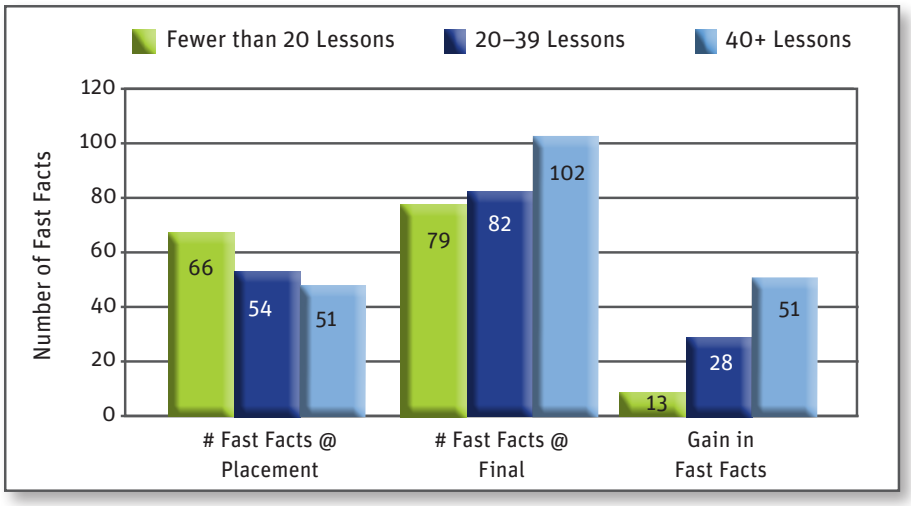
Citrus County School District, *FASTT Math* Students (N=1,323), 2008–2009
Dosage Effects on Elementary School Student Outcomes in Multiplication Fluency



Note: There were significant differences in the gain in fluent math facts shown by the three dosage groups (ANOVA, F=782.97, p <.01). There were also significant differences in the number of fluent math facts at the final assessment of the study period (ANCOVA, DV: # Fast Facts Final, IV: Dosage Group, CV: # Fast Facts Placement, F=781.32, p <.01).

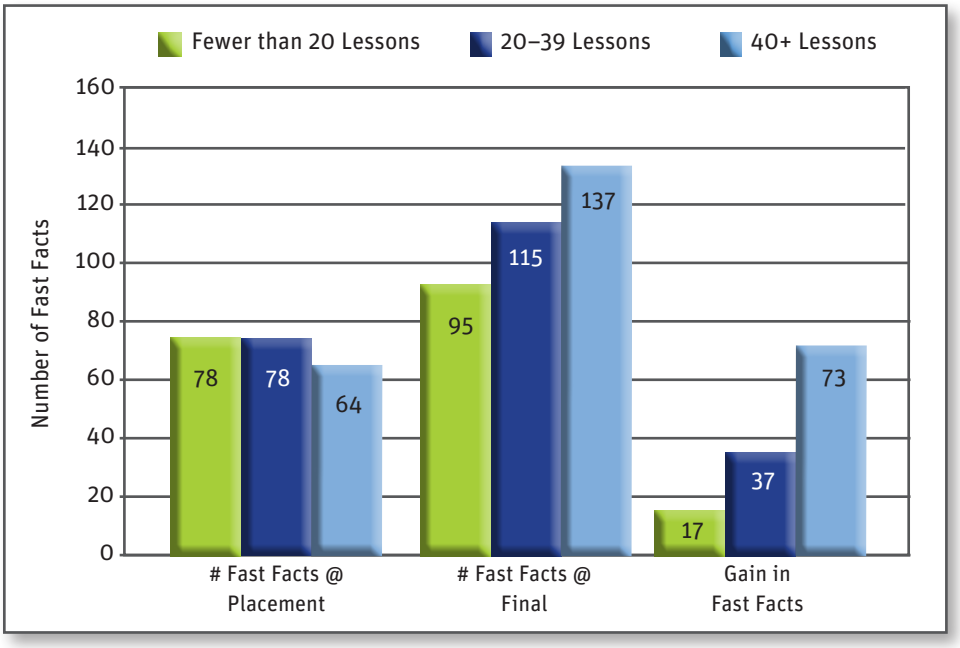
Graph 19

Citrus County School District, *FASTT Math* Students (N=177), 2008–2009
Dosage Effects on Middle School Student Outcomes in Addition Fluency



Note: There were significant differences in the gain in fluent math facts shown by the three dosage groups (ANOVA, F=54.32, p <.01). There were also significant differences in the number of fluent math facts at the final assessment of the study period (ANCOVA, DV: # Fast Facts Final, IV: Dosage Group, CV: # Fast Facts Placement, F=61.29, p <.01).

Graph 20
Citrus County School District, *FASTT Math* Students (N=1,256), 2008–2009
Dosage Effects on Middle School Student Outcomes in Multiplication Fluency



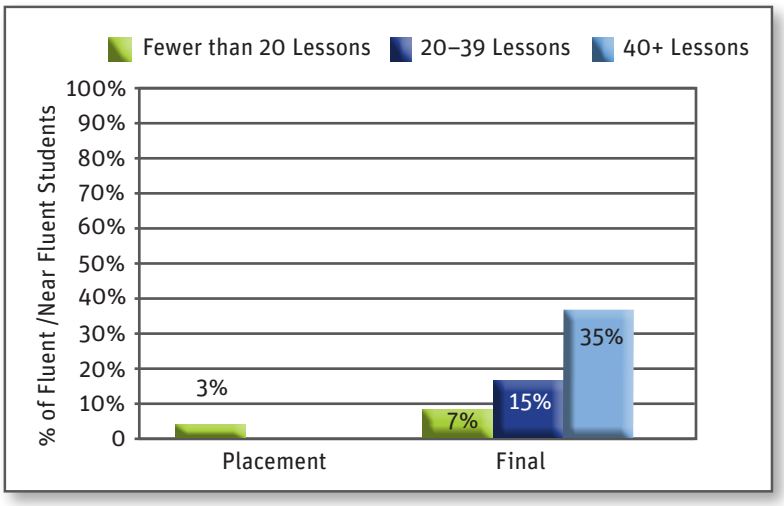
Note: There were significant differences in the gain in fluent math facts shown by the three dosage groups (ANOVA, F=811.86, p <.01). There were also significant differences in the number of fluent math facts at the final assessment of the study period (ANCOVA, DV: # Fast Facts Final, IV: Dosage Group, CV: # Fast Facts Placement, F=787.83, p <.01).

Results showed that students who completed 40 or more lessons demonstrated significantly greater gains in fluent facts than students who completed fewer lessons. Both elementary and middle school students experienced the largest usage differences in multiplication fact gains. Elementary school students completing 40 or more lessons gained an average of 71 multiplication facts compared with gains of only an average of 19 multiplication facts for students completing fewer than 20 lessons. Middle school students completing 40 or more lessons gained an average of 73 multiplication facts compared with gains of only an average of 17 multiplication facts for students completing fewer than 20 lessons.

Research Question #3 (continued):

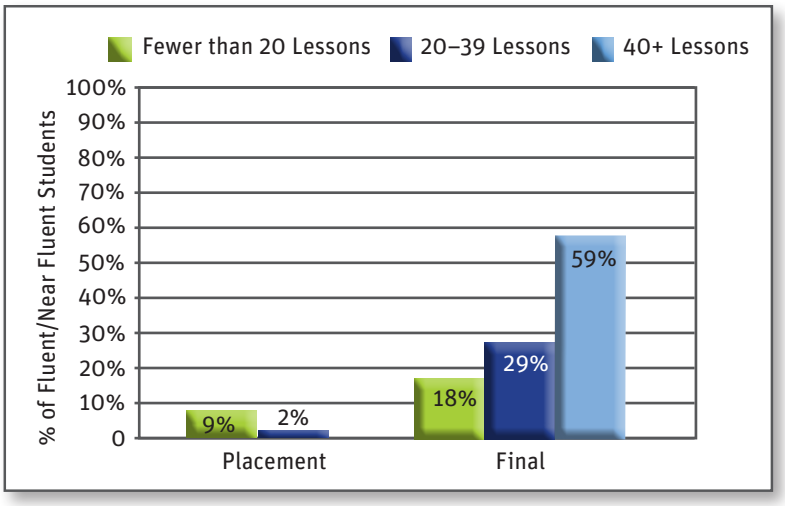
Graphs 21 through 24 show the relationship between the number of completed lessons and the percentage of fluent or near fluent students.

Graph 21
Citrus County School District, *FASTT Math* Students (N=1,860), 2008–2009
Relationship Between Dosage and Number of Fluent or Near Fluent Elementary School Students in Addition



Note: The difference in the percentages of students achieving fluency or near fluency at the final assessment of the study period among the three dosage groups is significant (ANCOVA: DV=% Fluent/Near Fluent Final, IV: Dosage Group, CV: % Fluent/Near Fluent Placement, F=115.56, p <.01).

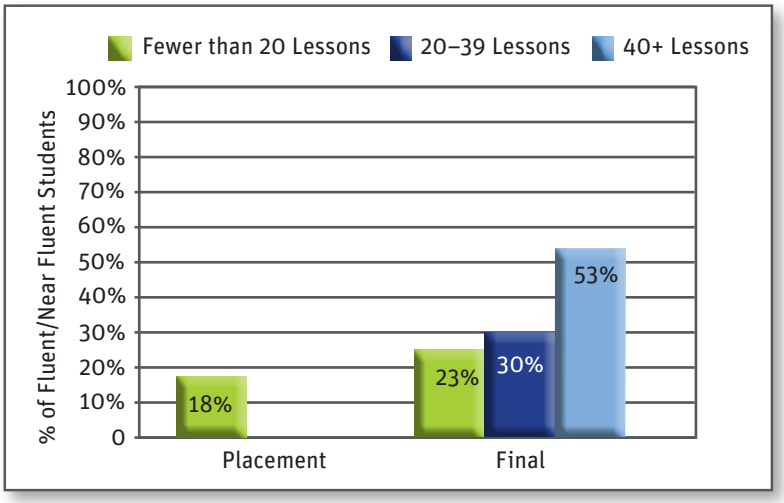
Graph 22
Citrus County School District, *FASTT Math* Students (N=1,323), 2008–2009
Relationship Between Dosage and Number of Fluent or Near Fluent Elementary School Students in Multiplication



Note: The difference in the percentages of students achieving fluency or near fluency at the final assessment of the study period among the three dosage groups is significant (ANCOVA: DV=% Fluent/Near Fluent Final, IV: Dosage Group, CV: % Fluent/Near Fluent Placement, F=129.75, p <.01).

Graph 23

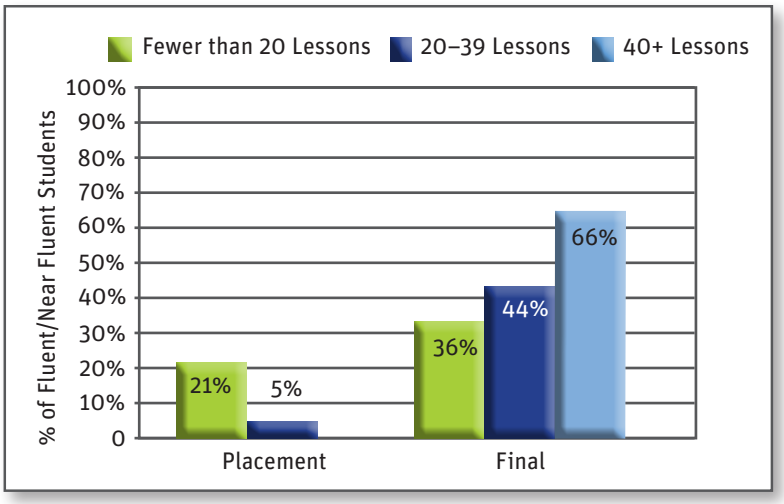
Citrus County School District, *FASTT Math* Students (N=177), 2008–2009 Relationship Between Dosage and Number of Fluent or Near Fluent Middle School Students in Addition



Note: The difference in the percentages of students achieving fluency or near fluency at the final assessment of the study period among the three dosage groups is significant (ANCOVA: DV=% Fluent/Near Fluent Final, IV: Dosage Group, CV: % Fluent/Near Fluent Placement, F=16.64, p <.01).

Graph 24

Citrus County School District, *FASTT Math* Students (N=1,256), 2008–2009 Relationship Between Dosage and Number of Fluent or Near Fluent Middle School Students in Multiplication



Note: The difference in the percentages of students achieving fluency or near fluency at the final assessment of the study period among the three dosage groups is significant (ANCOVA: DV=% Fluent/Near Fluent Final, IV: Dosage Group, CV: % Fluent/Near Fluent Placement, F=85.19, p <.01).

Analyses and Results (cont.)

A significantly greater percentage of students who completed 40 or more lessons reached near fluency or fluency by the final assessment of the study period as compared with students who completed fewer lessons. This finding applied to the elementary and middle school groups and to the addition and multiplication operations.

In each case, the percentage of high dosage (40+ lessons) students reaching fluency or near fluency far outpaced the average for all students. That is, in the elementary school group as a whole (refer to Graphs 5 and 6), 18% of addition students and 35% of multiplication students achieved fluent or near fluent levels, and students in the high dosage group showed fluent or near fluent rates of 35% (addition) and 59% (multiplication). Likewise, in the middle school group as a whole (refer to Graphs 7 and 8), 36% of addition students and 49% of multiplication students achieved fluent or near fluent levels, and students in the high dosage group showed fluent or near fluent rates of 53% (addition) and 66% (multiplication). Thus, these results illustrate the enhanced math fluency rates obtained at higher levels of *FASTT Math* usage.

Summary of Results

General *FASTT Math* outcomes

- Overall, this sample of elementary and middle school students demonstrated significant gains in fluent math facts during the 2008–2009 school year.
- Elementary and middle school students using *FASTT Math* addition or multiplication showed statistically significant gains in the number of fluent facts from the start to the end of the study period. The average gain in addition facts was 34 for elementary school students and 31 for middle school students. The average gain in multiplication facts was 43 for elementary school students and 42 for middle school students.
- There were statistically significant increases in the percentage of students performing at the fluent or near fluent levels (80%–100% fluency) from the start to the end of the study period.
- Results showed that, on average, students who placed in the underperforming level (less than 50% fluency) at the initial assessment moved up one performance level to developing (50%–79% fluency) over the course of this study. Likewise, on average, students placing in the developing level at the initial assessment moved up one performance level to near fluent (80%–97% fluency) over the course of this study. This was consistent for both elementary and middle school students and for both the addition and multiplication operations.

Findings Related to Implementation Factors

- Program implementation was strongly related to student outcomes. Results showed that students who used the program on-model had significantly more fluent facts at the final assessment of the study period than did their peers who used the program off-model.
- Additionally, significantly more on-model students achieved fluency or near fluency by the final assessment of the study period, as compared with their off-model peers.
- There was also a significant relationship between the number of *FASTT Math* lessons a student completed and his or her gain in fluent facts. A greater number of completed lessons was associated with a greater gain in fluent facts between the placement assessment and final assessment of the study period.
- A significantly greater percentage of students who completed 40 or more lessons reached fluency or near fluency by the final assessment of the study period, as compared with students who completed fewer lessons.

Conclusions

The three overarching questions addressed in this evaluation were: 1) Did elementary and middle school students participating in the *FASTT Math* program improve their math fact fluency? 2) Did variations in program implementation and usage relate to growth in fact fluency? and 3) How did the number of student lessons completed on the *FASTT Math* software relate to student growth in fact fluency?

Findings indicated that this sample of students using *FASTT Math* evidenced a significant gain in the percentage of math fact fluent students. Students at both the elementary and middle school levels in both the addition and multiplication operations showed significant gains in the number of fluent math facts from the start to the end of program usage during the study period.

Further, study data showed that there was a strong relationship between *FASTT Math* implementation and student outcomes. Results demonstrated a clear advantage for students who met the on-model usage recommendations. Elementary and middle school students who were on-model recalled significantly more fast facts at the final assessment of the study period than their off-model peers in both the addition and multiplication groups. Moreover, significantly higher percentages of on-model students reached fluency or near fluency by the end of the study period. In addition, there was a statistically significant relationship between the number of completed *FASTT Math* software lessons and gains in fact fluency, such that the more lessons completed, the larger the gain in fluent facts.

While this was not a randomized controlled study, this preliminary research suggests that *FASTT Math* is having a positive impact on student math fluency. During the 2008–2009 school year, students in this study used the program for an average of about 20 weeks for each operation. The following year, more than 800 of those students continued to use the software to further improve their fact fluency. Longitudinal research with a control group will deepen our understanding of the effect of *FASTT Math* on math achievement.

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Notes

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