DC public schools Math Outcomes Analysis 2013/14

Grade Levels: 3, 4, 5
ST Math Program: Gen-4
Analysis Type: Two-Year
Treatment-Year: 2013/14
Baseline-Year: 2011/12

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Abstract

This analysis covers all grades using ST Math in DC public schools in 2012/13 and 2013/14. It identifies those grades with nominal or better implementation of the ST Math program, and matches them to similar math-performance, comparison grades. The nominal ST Math users are an aggregation of 32 grades 3, 4, and 5 at 17 schools. They were compared to 75 control grades at 37 schools never using ST Math. Grade-wise growth in math proficiency was evaluated (i.e. growth in same grade, same school, from 2011/12 to 2013/14) on the DCAS proficiency levels. Grades 3, 4, and 5 aggregated showed a significant 19 points of growth in DCAS Proficient or Advanced for ST Math users, compared to 5.2 points for comparison grades.

Contents

List of Figures

List of Tables

1 Introduction

1.1 Background

This is a quasi-experimental analysis at the grade-mean level. Entire grades represent the units of analysis, and outcome measures are the 2-year changes in grade-mean DCAS Proficient or Advanced percentages. The treatment grades used the ST Math program for 2 years, beginning in the 2012/13 school year. The control grades were selected to have similar math attributes to the treatment grades during the baseline year (2011/12), and did not use ST Math in 2013/14. The treatment grades' selection pool was all schools using ST Math in grades 3, 4, and 5 in DC public schools. The control grades' pool was all schools not using ST Math in grades 3, 4, and 5 in DC public schools.

1.2 Program Description

The ST Math program is a supplemental math program covering grade-level DC public schools math standards. The ST Math content consists of visual representations of math standards, concepts, and procedures, presented to students as "Puzzles" of virtual manipulatives, with which they interact to pose solutions. Each time the student poses a solution, the computer visually animates the Puzzle, diagram, or symbols to show why the posed solution correctly solves, or why it does not solve, the math problem (puzzle). The Puzzles are arranged into sequential groups, called "Levels". To proceed to the next Level in sequence, the student needs to master his/her current Level. Mastering a Level requires solving 100% of the math problems, or Puzzles correctly. In this way, the program is self-paced. Students must correctly solve approximately 4-12 Puzzles, with only 1 failure and retry allowed, to proceed. Levels are sequenced together into Games and, again, the student must master each Game to get to the next Game in sequence. Games are sequenced into "Learning Objectives" (e.g. 'Fractions Concepts'). The ST Math curriculum of approximately 20-25 Learning Objectives can be rearranged in a year-long, grade-level syllabus to match district math pacing through the school year.

The Puzzles typically start with concrete representations of the math, without abstract symbols, math vocabulary, or even English words. Gradually, through subsequent Levels or Games, abstractions are introduced. For example, a Puzzle might start with "n" green blocks on the screen, and then at a subsequent Level may represent the quantity with the numeral for "n" (no green blocks anymore). In this way, three things are accomplished: i) language proficiency prerequisites to engage with the program are minimal, ii) non-mathematical distractions (e.g. back-stories for word problems) are minimized or eliminated – thereby reducing load on working memory, and iii) the actual math in the problem can be represented clearly, simply, and unambiguously.

Besides the self-paced progress made by students in their one-to-one environment, the program is designed to be referenced by teachers during their regular math instruction. It is supplemental to core or basal math instruction and instructional materials. As the great majority of grade-level math standards are covered in the ST Math digital curriculum, completion of 100% of the entire ST Math curriculum (i.e. completing every Game) is required to cover all grade-level math standards.

To achieve nominal progress through the program, there is a time-on-task requirement. MIND Research Institute has found that application of adequate time-on-task is generally sufficient to get virtually all students to make sufficient progress through the program. Students are recommended to use the program in school for at least two 45-minute sessions per week, or 90 minutes per week, over about 35 weeks. Analyses of ST Math usage have shown that consistently following this schedule throughout the school year is usually sufficient to achieve 50% or more Progress through

ST Math content. Progress is a percentage of ST Math content coverage, and is defined as Levels completed by the student, divided by the total number of Levels in the curriculum. In addition, MIND's historical analyses have shown that it is necessary to complete at least 50% of the program in order to expect significantly higher performance compared to non-users.

2 Data Collection

Since this analysis uses grades as the unit of analysis, and states publish grade-mean state standardized test scores, the data for student math outcomes was requested from the state education agency's research files. The treatment students use ST Math student accounts served by MIND. Student ST Math usage data is aggregated to grade-level means by MIND.

2.1 Proficiency Levels Definition

The following (Table 1) are DC public schools's proficiency level descriptions:

Proficiency Level	State Proficiency Level Name
L1	Below Basic
L2	Basic
L3	Proficient
L4	Advanced

Table 1: Proficiency Level Naming

2.2 Treatment Grades Pool and Selection

The Treatment grades pool originated with all schools and grades using ST Math in DC public schools. From these schools, every grade that had used the ST Math program for the years 2012/13 and 2013/14 was identified. The resultant set comprised both low-performance, defined as $\leq$ 75% math proficient or better, and higher-performing grades. The analysis evaluates only those lower-performing grades which started the baseline year, 2011/12, with $\leq$75% of students Proficient or better in math. They comprise the Treatment grades pool for this evaluation of 2 year usage.

Because the analysis uses grade-mean data, such as grade-mean proficiency level percentages, it is necessary that the program also be a grade-wide treatment, with the great majority of students in treatment. Otherwise, the grade-means reported by the state of 100% of *tested* students would not be valid measures of a smaller fraction of *treatment* students. MIND's site implementation requirement is that an entire grade, including all teachers and all classes within that grade, use the ST Math program. We validate how closely this is the case for each individual treatment grade by comparing the number of ST Math student accounts at a grade level to the DC public schools's reported enrollment at that grade level. We discard from the Treatment pool any grade with a ratio of ST Math student accounts to reported grade enrollment lower than 85%.

Furthermore, the outcomes measure is a summative year-end test, i.e. DC public schools's standardized math assessment (DCAS). The math assessment thus covers all the math standards for that entire grade level. Meanwhile, the ST Math program curriculum (arranged into Learning Objectives) is also aligned to DC public schools math standards. To infer that the ST Math content

is having a valid effect on student outcomes on the summative assessment, we discard any grade with grade-mean of ST Math Progress for its students lower than 50% by year-end.

Progress is a percentage, and is defined as Levels completed by the student, divided by the total number of Levels in the grade-level curriculum. Note that student achievement of at least 50% progress in ST Math is accomplished primarily by teacher assignment of computer session time to students. With sufficient time on task, students make progress. The program helps them self-pace through providing real-time informative feedback for each puzzle.

2.3 Control Grades Pool and Selection

The control grades are all grades 3, 4, or 5 in DC public schools not using ST Math in 2012/13 or 2013/14 and which started at $\leq$ 75% Proficient or better in the baseline year 2011/12.

3 Data Analysis

The set of all initially low-performing schools and grades using ST Math in DC public schools is evaluated for Enrollment percentage and Progress percentage parameters. A filtered Treatment set (TRT) of all ST Math grades with $\geq$ 85% Enrollment and $\geq$ 50% Progress is identified. State math assessment data is tabulated.

Changes in math performance, i.e. the difference in math performance of a grade from a baseline year to the final year, are evaluated and tabulated. Statistical tests of the significance of the difference in math performance changes between Treatment grades and Control grades are performed. Finally, after all this analysis has been performed on a grade-aggregated basis, a grade-by-grade disaggregation is performed.

3.1 Final Treatment and Control

3.1.1 ST Math Grade-Aggregated Implementation ($\geq$ 85% Enrollment Grades Only)

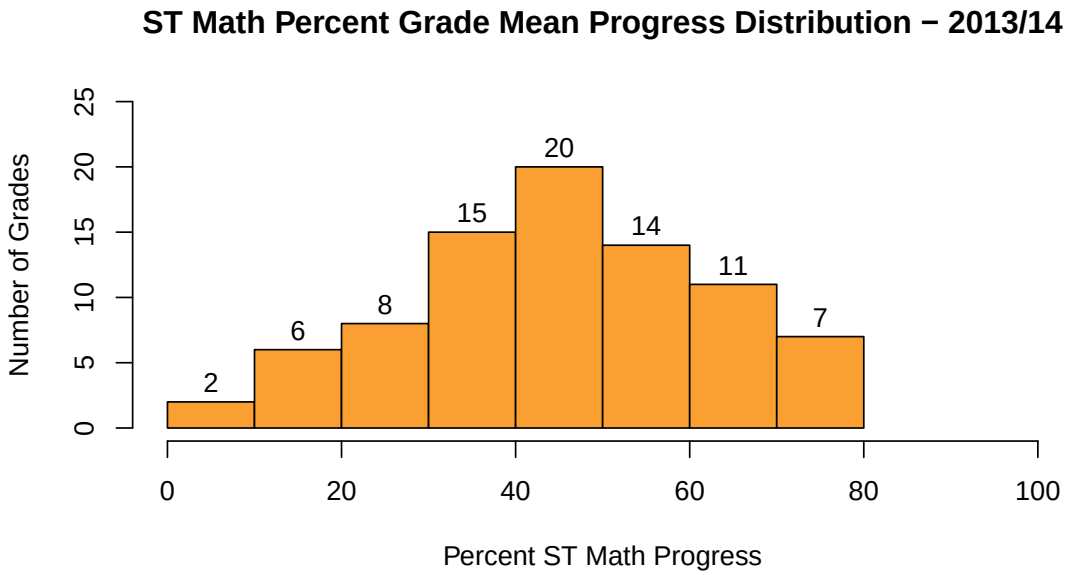

Figure 1: Histogram of ST Math Percent Progress for $\geq$ 85% Enrollment Grades 2013/14

For all ST Math grades with Enrollment $\geq$ 85%, Figure 1 shows the frequency distribution of grade-average Progress percentage through the program. Note that we will only be using grades with $\geq$ 50% Progress as the Treatment Group.

Table 2 provides some descriptive statistics of the Progress distribution. Table 3 shows the number of remaining treatment grades after applying enrollment and progress filters.

	Min.	Max.	Average	S.D.
ST Math % Progress	4.9	78.9	45.8	17.9

Table 2: Descriptive Statistics of ST Math Percent Progress for >= 85 percent Enrollment Grades

Grades with >= 85% Enrollment:	83
Grades with in addition >= 50% Progress:	32

Table 3: Number of ST Math Grades with >= 85 percent Enrollment and with >= 50 percent progress

3.1.2 Filtering Treatment and Controls

Table 4 shows the total number of grades in the Treatment pool, the number of grades that exceeded the 85% Enrollment figure, and also the 50% Progress filter. Other rows in the table indicate counts of numbers of students (2013/14 from state testing count) and counts of number of schools represented. The number of matched Control (CTRL) grades, students, and schools is also shown.

	Grade 3	Grade 4	Grade 5	Total
ST Math Using Grades	29	28	26	83
ST Math Using Schools	29	28	26	30
ST Math Students	1073	1071	923	3067
ST Math Grades (Enroll >= 85%)	29	28	26	83
TRT Grades (Enroll >= 85% & Prog >= 50%)	10	11	11	32
TRT Schools (Enroll >= 85% & Prog >= 50%)	10	11	11	17
TRT Students (Enroll >= 85% & Prog >= 50%)	335	416	384	1135
CTRL Grades	29	22	24	75
CTRL Schools	29	22	24	37
CTRL Students	1263	747	673	2683

Table 4: Treatment Pool Filtering and Controls: Counts of Grades, Schools, and Students

3.1.3 Match of Controls to Treatment

Figure 2 shows the density plot of the baseline DCAS percent students at DCAS Proficient or Advanced for treatment grades overlayed on control grades , showing the closeness of the match obtained between Treatment and Control sets of grades in the baseline year, 2011/12.

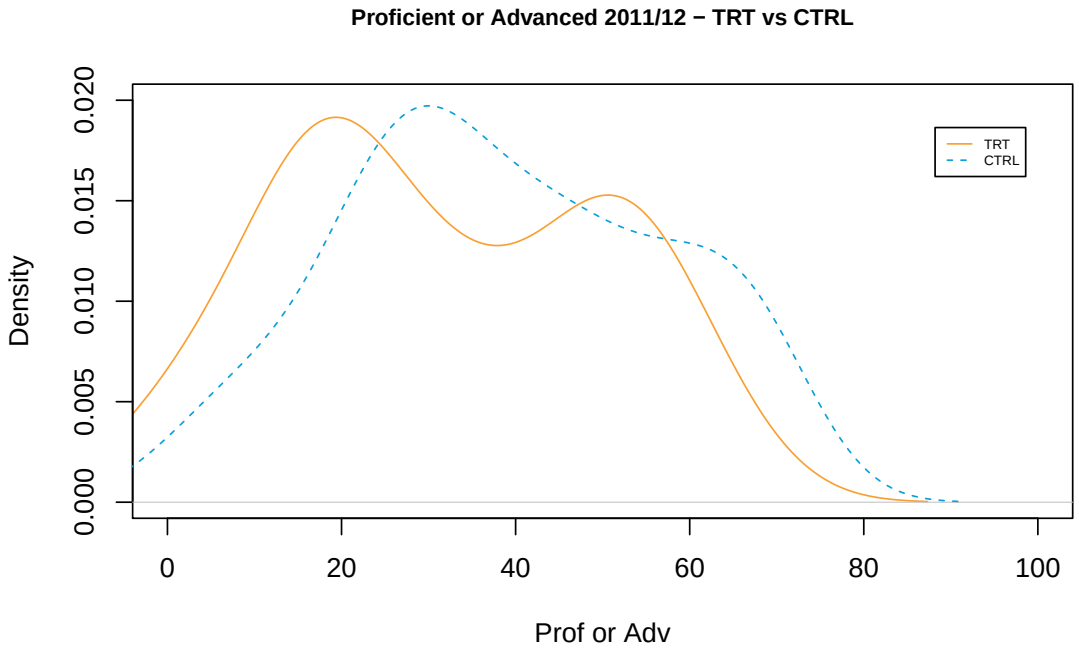

Figure 2: Baseline Year Density Plot Showing Match between TRT and CTRL - 2011/12

3.2 Grade-Aggregated Analysis

Table 5 below shows for both the Treatment (TRT) and Control (CTRL) sets of grades the aggregation across grades and proficiency level distributions. The far right column also shows the average ST Math Progress for the TRT set.

	# Grades	# Schools	# Students	L1	L2	L3	L4	Prof_or_Adv	ST Math Per Prog.
TRT.11.12	32	17	1094	27.79	40.65	25.69	5.87	31.56	–
TRT.12.13	–	–	1118	21.18	39.78	29.02	10.03	39.06	33.81
TRT.13.14	–	–	1135	17.77	31.66	36.33	14.23	50.57	63.68
TRT.Delta	–	–	–	-10.02	-8.99	10.64	8.37	19.01	–
CTRL.11.12	75	37	2594	20.37	40.95	31.29	7.39	38.68	–
CTRL.12.13	–	–	2411	20.03	36.75	30.93	12.30	43.23	–
CTRL.13.14	–	–	2683	19.56	36.53	32.00	11.91	43.91	–
CTRL.Delta	–	–	–	-0.81	-4.42	0.71	4.52	5.23	–

Table 5: All Grades Together Growth

The following chart (Figure 3) shows the changes in percentage of students at each math proficiency level for the grade-aggregated Treatment and Control sets (TRT.delta and CTRL.delta).

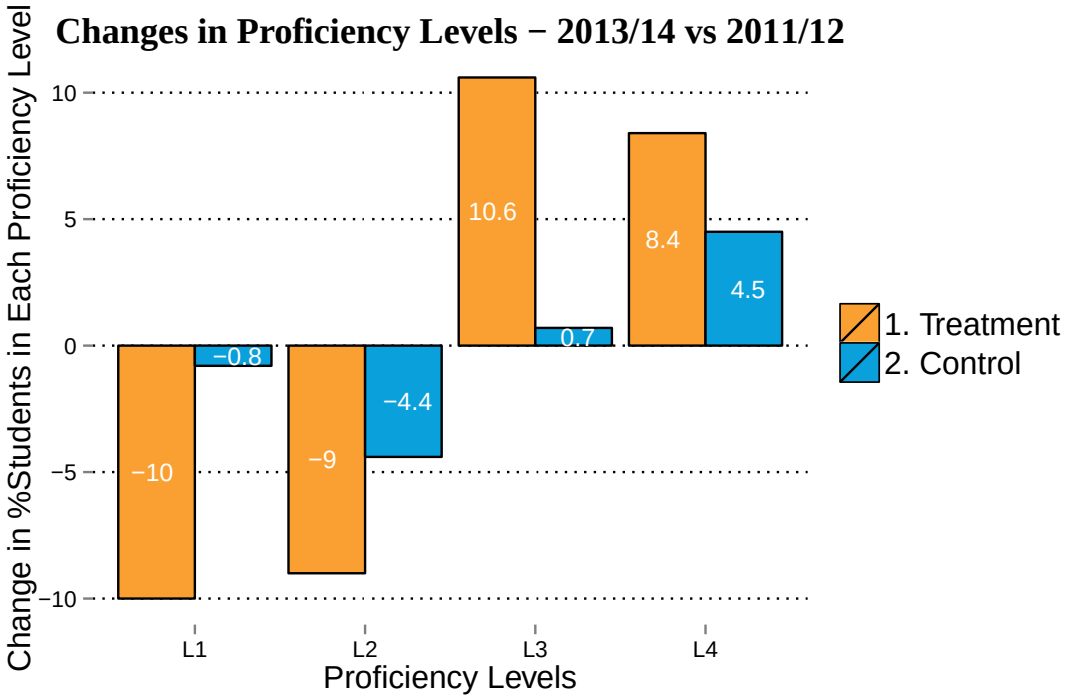

Figure 3: Change between 2011/12 and 2013/14 at each Proficiency Level for Grade-Aggregated TRT and CTRL Datasets

The following chart (Figure 4) shows the chronological changes in average % students at Proficient or Advanced from the 2011/12 baseline year to the current year (2013/14).

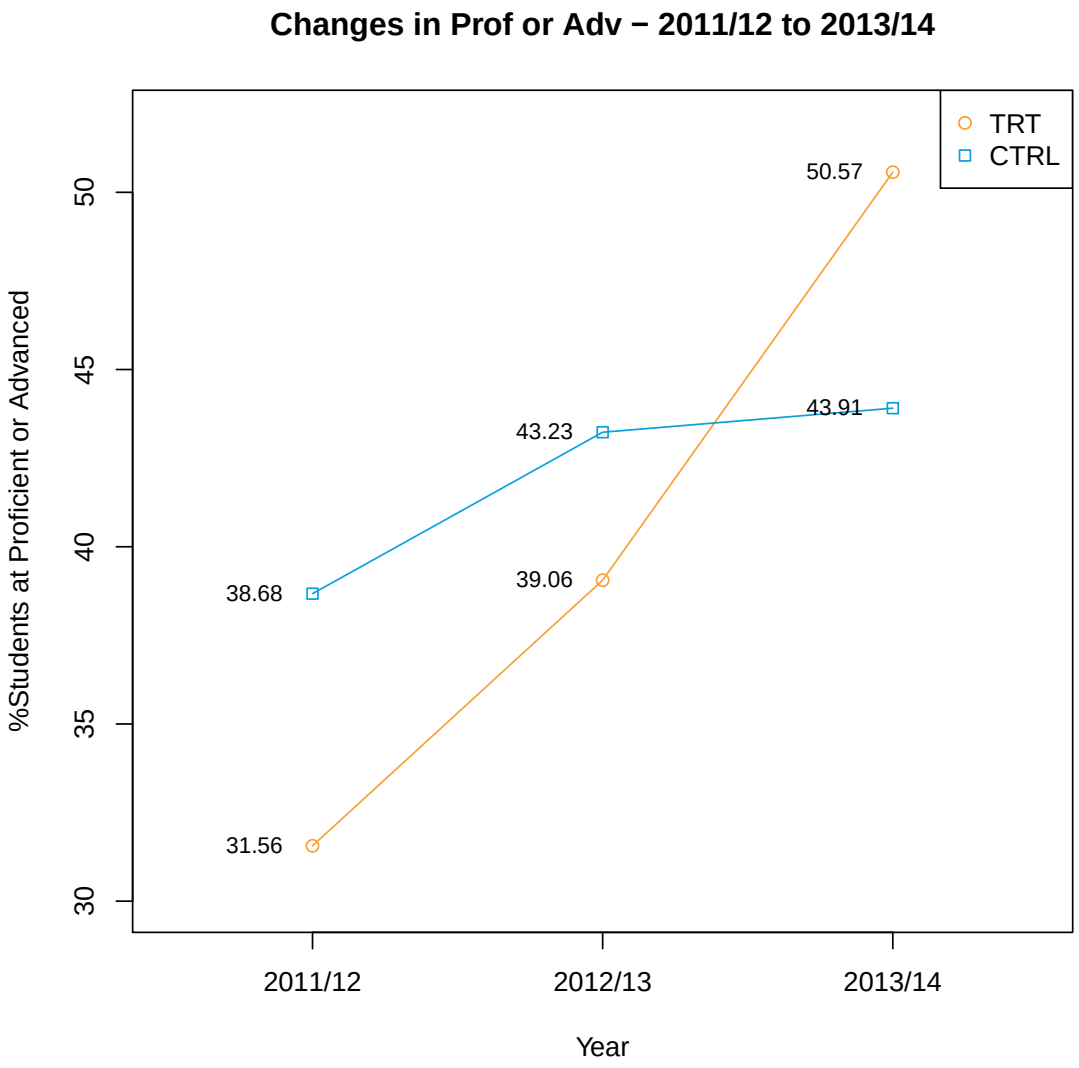

Figure 4: Yearly changes in DCAS Percent Students at Proficient or Advanced for grade aggregated TRT and CTRL datasets between 2011/12 and 2013/14

Finally, Figure 5 shows the two-year changes in percent of students at DCAS Proficient or Advanced for the grade-aggregated Treatment and Control sets.

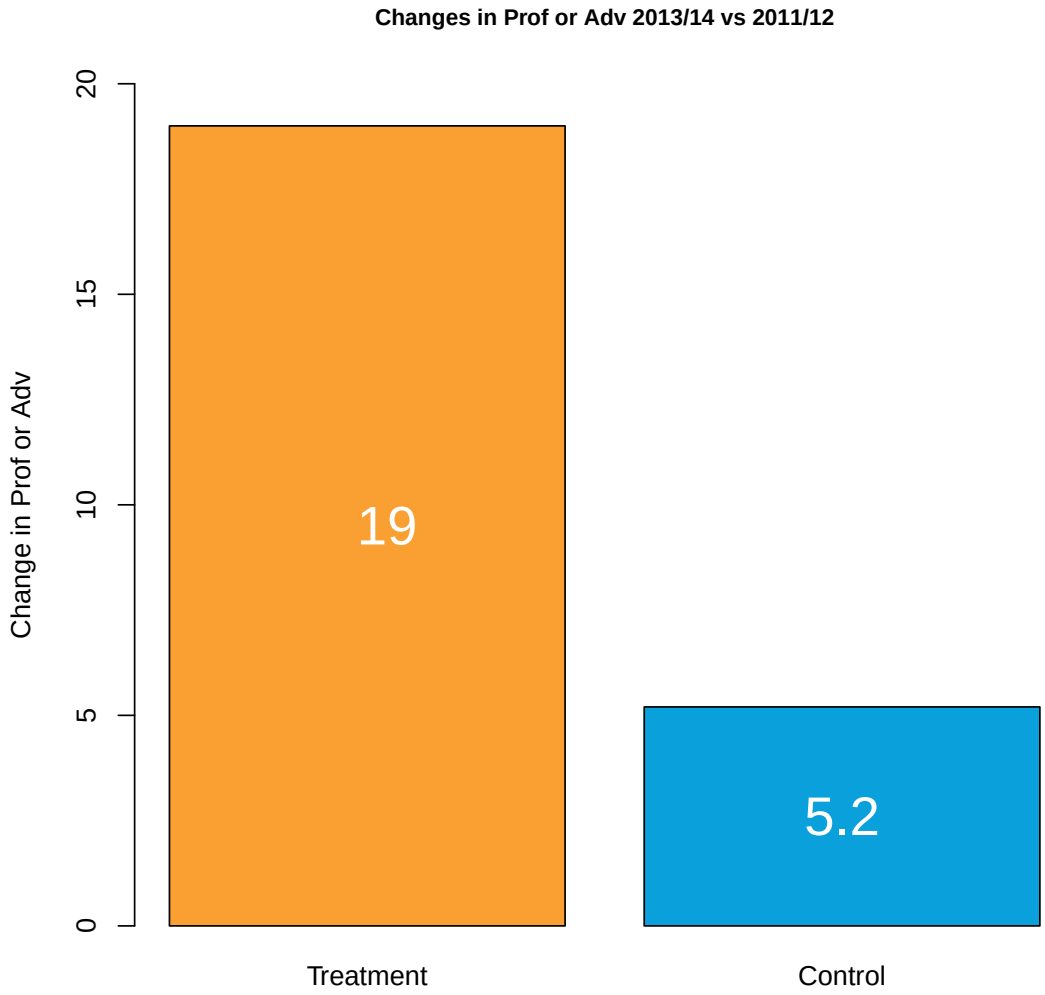

Figure 5: Changes in DCAS Proficient or Advanced for Grade-Aggregated TRT and CTRL datasets between 2011/12 and 2013/14

Finally, Table 6 shows the statistics for the *differences* in changes between TRT and CTRL (Treatment - Control) for these same DCAS math proficiency changes as in the above figures.

	Estimate	P-Value	Int.Low	Int.High
Prof_or_Adv	13.77	0.00	6.46	21.08
L1	-9.21	0.02	-16.75	-1.68
L2	-4.58	0.16	-10.93	1.78
L3	9.93	0.00	4.57	15.28
L4	3.85	0.12	-1.03	8.73

Table 6: Statistics for the Differential Changes in Math Scores Growth (TRT - CTRL)

3.3 Grade-Level Analysis

3.3.1 Grade Level Result Tables

The following tables (Table 7, 8, and 9) present a disaggregation of results by grade level. The far right column in each table also shows the average ST Math Progress for the TRT set.

	# Grades	# Schools	# Students	L1	L2	L3	L4	Prof_or_Adv	ST Math Per Prog.
TRT.11.12	10	10	346	29.58	41.18	24.37	4.87	29.24	–
TRT.12.13	–	–	348	21.97	44.90	24.90	8.25	33.15	28.04
TRT.13.14	–	–	335	14.90	33.47	35.96	15.69	51.65	59.61
TRT.Delta	–	–	–	-14.68	-7.71	11.59	10.82	22.41	–
CTRL.11.12	29	29	1043	21.64	42.97	28.80	6.58	35.38	–
CTRL.12.13	–	–	951	21.71	36.93	28.04	13.30	41.35	–
CTRL.13.14	–	–	1263	17.67	38.13	29.83	14.39	44.22	–
CTRL.Delta	–	–	–	-3.97	-4.84	1.03	7.80	8.84	–

Table 7: Grade 3 - Yearly Math Performance and Counts for TRT and CTRL Datasets

	# Grades	# Schools	# Students	L1	L2	L3	L4	Prof_or_Adv	ST Math Per Prog.
TRT.11.12	11	11	326	21.57	43.18	28.65	6.61	35.26	–
TRT.12.13	–	–	410	22.60	31.56	34.31	11.55	45.85	38.35
TRT.13.14	–	–	416	17.06	27.87	40.15	14.91	55.06	64.12
TRT.Delta	–	–	–	-4.51	-15.31	11.50	8.30	19.80	–
CTRL.11.12	22	22	848	20.34	37.18	34.64	7.83	42.47	–
CTRL.12.13	–	–	770	21.22	30.21	38.74	9.85	48.60	–
CTRL.13.14	–	–	747	20.89	29.77	37.70	11.60	49.31	–
CTRL.Delta	–	–	–	0.55	-7.41	3.06	3.77	6.84	–

Table 8: Grade 4 - Yearly Math Performance and Counts for TRT and CTRL Datasets

	# Grades	# Schools	# Students	L1	L2	L3	L4	Prof_or_Adv	ST Math Per Prog.
TRT.11.12	11	11	422	32.39	37.64	23.94	6.04	29.97	–
TRT.12.13	–	–	360	19.05	43.35	27.48	10.15	37.63	34.51
TRT.13.14	–	–	384	21.10	33.79	32.85	12.24	45.09	66.96
TRT.Delta	–	–	–	-11.29	-3.85	8.92	6.20	15.12	–
CTRL.11.12	24	24	703	18.86	41.96	31.23	7.95	39.18	–
CTRL.12.13	–	–	690	16.90	42.52	27.25	13.34	40.59	–
CTRL.13.14	–	–	673	20.63	40.79	29.40	9.18	38.59	–
CTRL.Delta	–	–	–	1.77	-1.17	-1.83	1.23	-0.59	–

Table 9: Grade 5 - Yearly Math Performance and Counts for TRT and CTRL Datasets

3.3.2 Grade-Level Analysis of Changes in DCAS Math Proficient or Advanced

Figure 6 shows the difference in the growth of percentages of students at DCAS math Proficient or Advanced, for the TRT and CTRL datasets, disaggregated by grade:

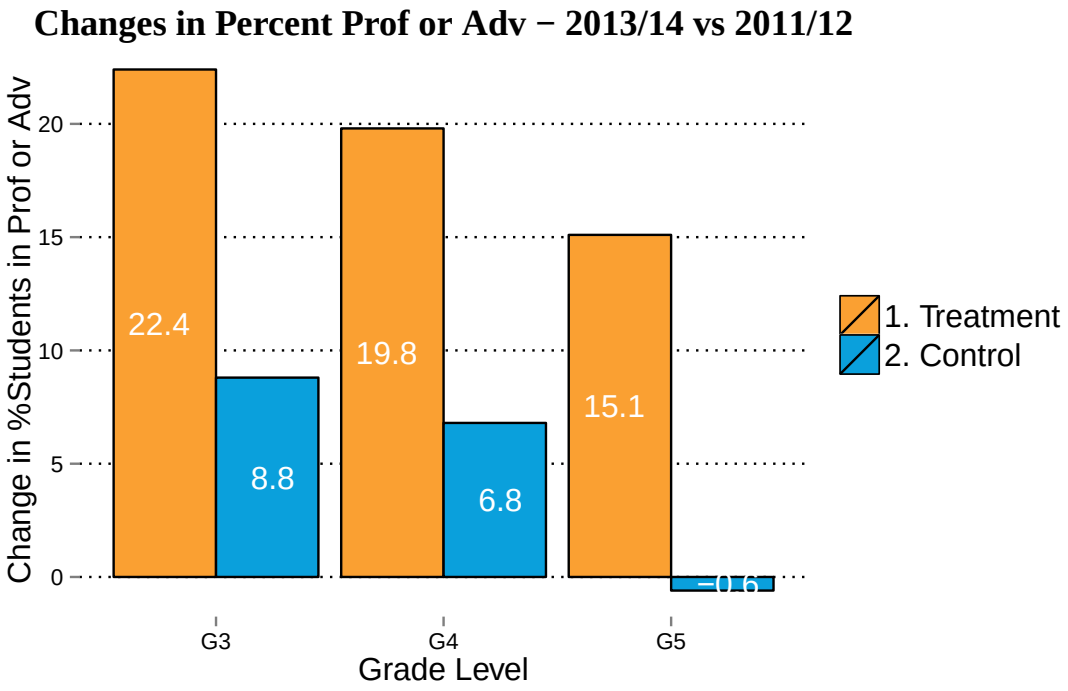

Figure 6: Changes in Percent of Students at DCAS Prof or Adv for TRT and CTRL Datasets between 2011/12 and 2013/14

Table 10 shows the statistics for the *differences* in changes between TRT and CTRL (Treatment - Control) for these same DCAS Proficient or Advanced math proficiency changes as shown in Figure 6.

	Estimate	P-Value	Int.Low	Int.High
Grade 3	13.57	0.03	1.37	25.78
Grade 4	12.96	0.07	-1.26	27.18
Grade 5	15.71	0.02	3.30	28.12

Table 10: Statistics for the Differential Changes in DCAS Prof or Adv , TRT - CTRL

4 Findings Summary

DCPS grades 3, 4, and 5 using ST Math for two years, 2012/13 and 2013/14, and starting in the baseline year, 2011/12, at ≤75% math Proficient or better, averaged 45.8% ST Math Progress in 2013/14. 32/83 grades (38.6%) averaged covering more than 50% of ST Math content (see Table 4). These 32 grades comprise the treatment (TRT) dataset.

All other grades 3,4, and 5 in DCPS which started the baseline year, 2011/12, at ≤75% math Proficient or better served as the control dataset. The resulting match of TRT vs. CTRL distributions of Proficient or better percentages was close, see Figure 2.

These ST Math grades (aggregated) increased their percentages of students at DCAS Proficient or better by 13.8 points more than did the comparison grades (see Figure 5 and Table 6). Focusing just on the Below Basic level, the ST Math grades also significantly outperformed the comparison grades, decreasing the percentages of students at this lower proficiency level by 9.2 points more than did comparison grades (see Figure 3 and Table 6).

Evaluation of disaggregated, individual grade-levels, with "n" ranging from 10 to 11 (see Tables 7, 8 and 9) showed significantly better math growth in Proficient or better at Grades 3 and 5 (see Figures 6 and Tables 10).

5 Reference Tables Grouped By School Year

The following tables show grade-level details, grouped by school year and for treatment (Table 11) and controls (Table 12) separately.

	# Grades	# Schools	# Students	L1	L2	L3	L4	Prof_or_Adv	ST Math Per Prog.
Grade 3 (11.12)	10	10	346	29.58	41.18	24.37	4.87	29.24	–
Grade 4 (11.12)	11	11	326	21.57	43.18	28.65	6.61	35.26	–
Grade 5 (11.12)	11	11	422	32.39	37.64	23.94	6.04	29.97	–
All Grades (11.12)	32	17	1094	27.79	40.65	25.69	5.87	31.56	–
Grade 3 (12.13)	10	10	348	21.97	44.90	24.90	8.25	33.15	28.04
Grade 4 (12.13)	11	11	410	22.60	31.56	34.31	11.55	45.85	38.35
Grade 5 (12.13)	11	11	360	19.05	43.35	27.48	10.15	37.63	34.51
All Grades (12.13)	32	17	1118	21.18	39.78	29.02	10.03	39.06	33.81
Grade 3 (13.14)	10	10	335	14.90	33.47	35.96	15.69	51.65	59.61
Grade 4 (13.14)	11	11	416	17.06	27.87	40.15	14.91	55.06	64.12
Grade 5 (13.14)	11	11	384	21.10	33.79	32.85	12.24	45.09	66.96
All Grades (13.14)	32	17	1135	17.77	31.66	36.33	14.23	50.57	63.68

Table 11: TRT Grades Detail Sorted by Year

	# Grades	# Schools	# Students	L1	L2	L3	L4	Prof_or_Adv	ST Math Per Prog.
Grade 3 (11.12)	29	29	1043	21.64	42.97	28.80	6.58	35.38	–
Grade 4 (11.12)	22	22	848	20.34	37.18	34.64	7.83	42.47	–
Grade 5 (11.12)	24	24	703	18.86	41.96	31.23	7.95	39.18	–
All Grades (11.12)	75	37	2594	20.37	40.95	31.29	7.39	38.68	–
Grade 3 (12.13)	29	29	951	21.71	36.93	28.04	13.30	41.35	–
Grade 4 (12.13)	22	22	770	21.22	30.21	38.74	9.85	48.60	–
Grade 5 (12.13)	24	24	690	16.90	42.52	27.25	13.34	40.59	–
All Grades (12.13)	75	37	2411	20.03	36.75	30.93	12.30	43.23	–
Grade 3 (13.14)	29	29	1263	17.67	38.13	29.83	14.39	44.22	–
Grade 4 (13.14)	22	22	747	20.89	29.77	37.70	11.60	49.31	–
Grade 5 (13.14)	24	24	673	20.63	40.79	29.40	9.18	38.59	–
All Grades (13.14)	75	37	2683	19.56	36.53	32.00	11.91	43.91	–

Table 12: CTRL Grades Detail Sorted by Year

6 Lists of Schools

6.1 Treatment Schools

Table 13 shows the list of treatment schools and grades (after 85% enrollment and 50% progress filtering) used in the analysis.

	District	School Name	GRADE
1	DCPS	Amidon-Bowen ES	3, 4, 5
2	DCPS	Bancroft ES	3, 5
3	DCPS	Brightwood EC	4, 5
4	DCPS	Drew ES	3, 4, 5
5	DCPS	H.D. Cooke ES	3, 4, 5
6	DCPS	Hearst ES	3, 4
7	DCPS	Hendley ES	4
8	DCPS	Ketcham ES	5
9	DCPS	Langley EC	4, 5
10	DCPS	LaSalle-Backus EC	3, 5
11	DCPS	Leckie ES	4
12	DCPS	Ludlow-Taylor ES	3
13	DCPS	Miner ES	4
14	DCPS	Nalle ES	4, 5
15	DCPS	Raymond EC	3, 5
16	DCPS	Shepherd ES	3
17	DCPS	Truesdell EC	3, 4, 5

Table 13: Treatment Schools (TRT Dataset)

6.2 Control Schools

Table 14 shows the control schools and grades (matched control grades to treatment grades) used in the analysis.

	District	School Name	GRADE
1	DCPS	Aiton ES	3, 4, 5
2	DCPS	Barnard ES	3
3	DCPS	Barnard ES (Lincoln Hill)	4
4	DCPS	Brent ES	5
5	DCPS	Burroughs EC	3, 5
6	DCPS	Cleveland ES	5
7	DCPS	Garrison ES	3, 4, 5
8	DCPS	Hyde-Addison ES	3
9	DCPS	Langdon EC	4, 5
10	DCPS	Maury ES	3, 4, 5
11	DCPS	Marie Reed ES	3, 4, 5
12	DCPS	Moten ES at Wilkinson	3, 4, 5
13	DCPS	Noyes EC	3, 4, 5
14	DCPS	Orr ES	3, 4, 5
15	DCPS	Oyster-Adams Bilingual EC	3
16	DCPS	Payne ES	3, 4, 5
17	DCPS	Bruce-Monroe ES @ Park View	3
18	DCPS	Bruce-Monroe ES at Park View	4, 5
19	DCPS	Plummer ES	3, 5
20	DCPS	Ross ES	3
21	DCPS	Seaton ES	3, 4, 5
22	DCPS	Sharpe Health School	3
23	DCPS	Smothers ES	3, 4, 5
24	DCPS	Tubman ES	3
25	DCPS	Tyler ES	3, 4, 5
26	DCPS	Walker-Jones EC	3, 4, 5
27	DCPS	Watkins ES (Capitol Hill Clus)	3, 4
28	DCPS	Wheatley EC	3, 4, 5
29	DCPS	West EC	3, 4, 5
30	DCPS	Whittier EC	3, 4, 5
31	DCPS	J.O. Wilson ES	3
32	DCPS	Wilson, J.O. ES	4
33	DCPS	King, M.L ES	3, 5
34	DCPS	King, M.L. ES	4
35	DCPS	Montessori School @ Logan	3, 5
36	DCPS	Francis - Stevens EC	3, 4
37	DCPS	Francis-Stevens EC	5

Table 14: Control Schools (CTRL Dataset)