

Iowa Math Outcomes Analysis 2014/15

Grade Levels: 3, 4, 5
ST Math Program: Gen-5
Analysis Type: Two-Year
Treatment-Year: 2014/15
Baseline-Year: 2012/13

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Abstract

This analysis covers all grades using ST Math in Iowa for two years, from 2013/14 to 2014/15. It identifies those grades with nominal or better implementation of the ST Math program, and matches them to randomly selected, similar math-performance, comparison grades. The nominal ST Math users are an aggregation of 20 grades 3, 4, and 5 at 10 schools. They were matched to 20 similar, randomly selected control grades at 19 schools never using ST Math. Grade-wise growth in math proficiency was evaluated (i.e. growth in same grade, same school, from 2012/13 to 2014/15) on the NSS proficiency levels and scale scores. Grades 3, 4, and 5 aggregated showed a significant ST Math effect of 6.06 scale score points and 7.81 points at the Proficient or Advanced proficiency levels.

Contents

1	Introduction	5
1.1	Background	5
1.2	Program Description	5
2	Data Collection	6
2.1	Proficiency Levels Definition	6
2.2	Treatment Grades Pool and Selection	6
2.3	Control Grades Pool and Selection	7
3	Data Analysis	7
3.1	Final Treatment and Control	8
3.1.1	ST Math Grade-Aggregated Implementation ($\geq 85\%$ Enrollment Grades Only)	8
3.1.2	Filtering Treatment and Controls	9
3.1.3	Match of Controls to Treatment	10
3.2	Grade-Aggregated Analysis	11
3.3	Grade-Level Analysis	13
3.3.1	Grade Level Result Tables	13
3.3.2	Grade-Level Analysis of Changes in NSS Math Level 2 or above	15
3.3.3	Grade-Level Analysis of Changes in NSS Math Scale Scores	17
4	Findings Summary	18
5	Reference Tables Grouped By School Year	19
6	Lists of Schools	20
6.1	Treatment Schools	20
6.2	Control Schools	21

List of Figures

1	Histogram of ST Math Percent Progress for $\geq 85\%$ Enrollment Grades 2014/15	8
2	Baseline Year Density Plot Showing Match between TRT and CTRL - 2012/13	10
3	Change between 2012/13 and 2014/15 at each Proficiency Level for Grade-Aggregated TRT and CTRL Datasets	11
4	Changes in NSS Math Scale Scores and Level 2 or above for Grade-Aggregated TRT and CTRL datasets between 2012/13 and 2014/15	12
5	Changes in Percent of Students at NSS L2 or above for TRT and CTRL Datasets between 2012/13 and 2014/15	15
6	Changes in Grade-Mean NSS Math Scale Score for TRT and CTRL Datasets between 2012/13 and 2014/15	17

List of Tables

1	Proficiency Level Naming	6
2	Descriptive Statistics of ST Math Percent Progress for ≥ 85 percent Enrollment Grades	8
3	Number of ST Math Grades with ≥ 85 percent Enrollment and with ≥ 50 percent progress	8
4	Treatment Pool Filtering and Controls: Counts of Grades, Schools, and Students	9
5	Yearly Math Proficiency and Counts for TRT and CTRL Grade-Aggregated Datasets	11
6	Statistics for the Differential Changes in Math Scores Growth (TRT - CTRL) .	13
7	Grade 3 - Yearly Math Performance and Counts for TRT and CTRL Datasets	13
8	Grade 4 - Yearly Math Performance and Counts for TRT and CTRL Datasets	13
9	Grade 5 - Yearly Math Performance and Counts for TRT and CTRL Datasets	14
10	Statistics for the Differential Changes in NSS L2 or above, TRT - CTRL	16
11	Statistics for the Differential Changes in NSS Math Scale Scores Growth, TRT - CTRL	18
12	TRT Grades Detail Sorted by Year	19
13	CTRL Grades Detail Sorted by Year	19
14	Treatment Schools (TRT Dataset)	20
15	Matched Control Schools (CTRL Dataset)	21

1 Introduction

1.1 Background

This is a quasi-experimental analysis at the grade level. Entire grades represent the units of analysis, and outcome measures are the 2-year changes in grade-mean NSS Level 2 or above percentages. The treatment grades used the ST Math program for 2 years, beginning in the 2013/14 school year. The control grades were selected to have similar math attributes to the treatment grades during the baseline year (2012/13), and did not use ST Math in 2013/14 or 2014/15. The treatment grades' selection pool was all schools using ST Math in grades 3, 4, and 5 in Iowa. The control grades' pool was all schools not using ST Math in grades 3, 4, and 5 in Iowa.

1.2 Program Description

The ST Math program is a supplemental math program covering grade-level Iowa 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 and math proficiency distributions, the data for student math outcomes is collected from each state education agency’s research files (retrieved from state websites). The treatment students use ST Math student accounts served by MIND. Student ST Math usage data is aggregated to grade-level metrics by MIND.

2.1 Proficiency Levels Definition

The following (Table 1) are Iowa’s proficiency level descriptions:

Proficiency Level	State Proficiency Level Name
L1	Not Proficient
L2	Proficient
L3	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 Iowa. From these schools, every grade that had used the ST Math program for the years 2013/14 and 2014/15 was identified. They comprise the Treatment grades pool for this evaluation of 2 year usage.

Because the analysis uses grade-mean data, such as grade-mean scale scores or 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 if there existed a significantly 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 Iowa’s reported enrollment at that grade level. We discard from the Treatment pool any grade with a ratio of ST Math student accounts to state reported grade enrollment lower than 85%.

Furthermore, the outcomes measure is a summative year-end test, i.e. Iowa’s standardized math assessment (NSS). The math assessment thus covers all the math standards for the entire grade level. Meanwhile, the ST Math program curriculum (arranged into Learning Objectives) is also aligned to Iowa math standards. To infer that the ST Math grade-level content is having a valid effect on student outcomes on the grade-level 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 randomly selected from a control pool of schools in Iowa. Though they are randomly selected, they are also matched to be similar to the Treatment grades' math attributes during the baseline 2012/13 year. The matched math attributes include scale score and student percentages at each math proficiency level, for each grade.

In order to mitigate the risk of randomly picking an unusually favorable or unfavorable set of Control grades, a Monte Carlo approach is used to perform many random picks. The control pool's size is large enough that there are many possible "picks" of closely matched Control grades.

Dozens, or up to hundreds, of randomly matched picks are made and sets of matched control grades are generated. For each set, the differential math growth is evaluated. Some picked sets have high average math growth, some have low average math growth. From the set of all picks, a median pick is chosen. This avoids either an unlikely overestimate, or underestimate, of the Control grades' differential growth.

3 Data Analysis

The set of all schools and grades using ST Math in Iowa 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. A matching set of Control grades based on baseline year state math assessment is identified.

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)

ST Math Percent Grade Mean Progress Distribution – 2014/15

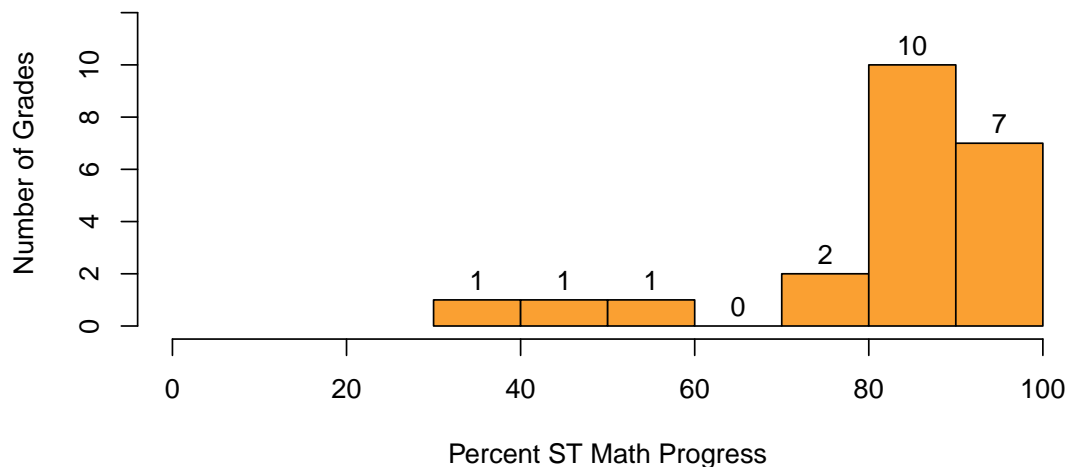


Figure 1: Histogram of ST Math Percent Progress for $\geq 85\%$ Enrollment Grades 2014/15

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	30.8	97.1	81.3	16.9

Table 2: Descriptive Statistics of ST Math Percent Progress for $\geq 85\%$ Enrollment Grades

Grades with $\geq 85\%$ Enrollment:	21
Grades with in addition $\geq 50\%$ Progress:	20

Table 3: Number of ST Math Grades with $\geq 85\%$ Enrollment and with $\geq 50\%$ 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 (2014/15 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	9	8	5	22
ST Math Using Schools	9	8	5	11
ST Math Students	557	477	266	1300
ST Math Grades (Enroll \geq 85%)	9	7	5	21
TRT Grades (Enroll \geq 85% & Prog \geq 50%)	8	7	5	20
TRT Schools (Enroll \geq 85% & Prog \geq 50%)	8	7	5	10
TRT Students (Enroll \geq 85% & Prog \geq 50%)	516	436	266	1218
CTRL Grades	8	7	5	20
CTRL Schools	8	7	5	19
CTRL Students	447	395	354	1196

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 NSS Math scale scores (left plot) and baseline percent students at NSS Level 2 or above (right plot) for treatment grades overlaid on control grades, showing the closeness of the match obtained between Treatment and Control sets of grades in the baseline year, 2012/13. It is important to keep in mind that we only have a small number of treatment and control grades (20) and that the Control set was arrived at through a Monte Carlo process (see Section 2.3) rather than a closest math performance match.

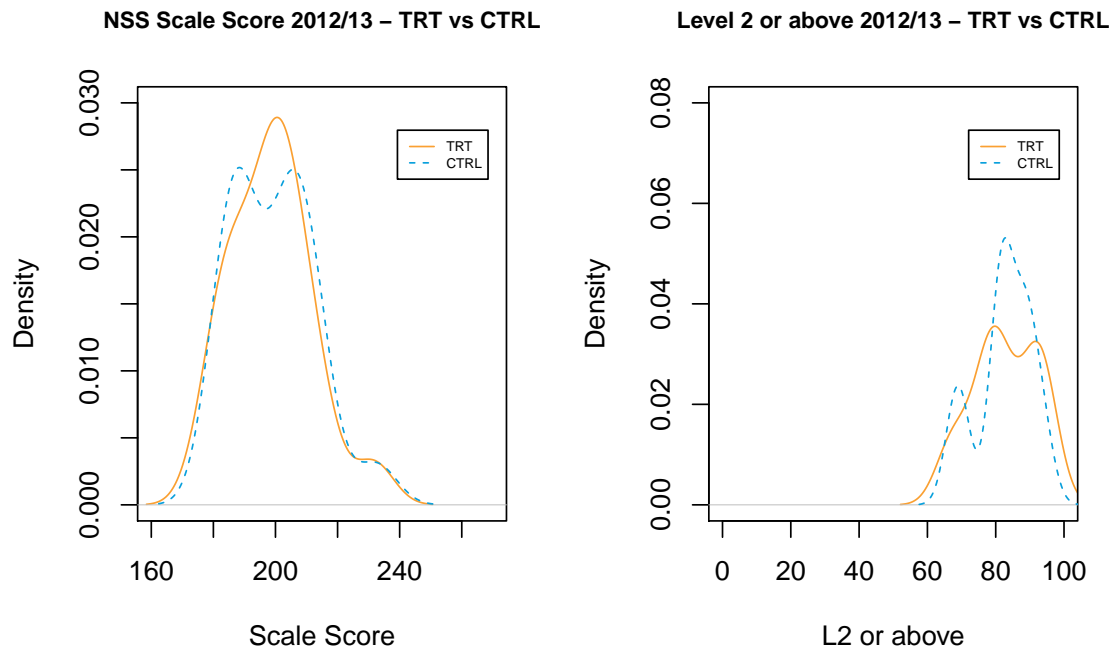


Figure 2: Baseline Year Density Plot Showing Match between TRT and CTRL - 2012/13

3.2 Grade-Aggregated Analysis

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

	# Grades	# Schools	# Students	Scale Score	L1	L2	L3	L2_or_above	ST Math Per Prog.
TRT.12.13	20	10	1318	198.6	17.29	52.73	29.98	82.71	-
TRT.13.14	20	10	1224	203.2	12.40	48.55	39.05	87.60	69.28
TRT.14.15	20	10	1218	206.2	10.68	46.90	42.42	89.32	85.83
TRT.Delta	-	-	-	7.5	-6.61	-5.83	12.44	6.61	-
CTRL.12.13	20	19	1167	199.3	17.50	53.17	29.32	82.50	-
CTRL.13.14	20	19	1200	200.6	19.50	48.60	31.90	80.50	-
CTRL.14.15	20	19	1196	200.8	18.71	50.13	31.16	81.29	-
CTRL.Delta	-	-	-	1.4	1.20	-3.04	1.84	-1.20	-

Table 5: Yearly Math Proficiency and Counts for TRT and CTRL Grade-Aggregated Datasets

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).

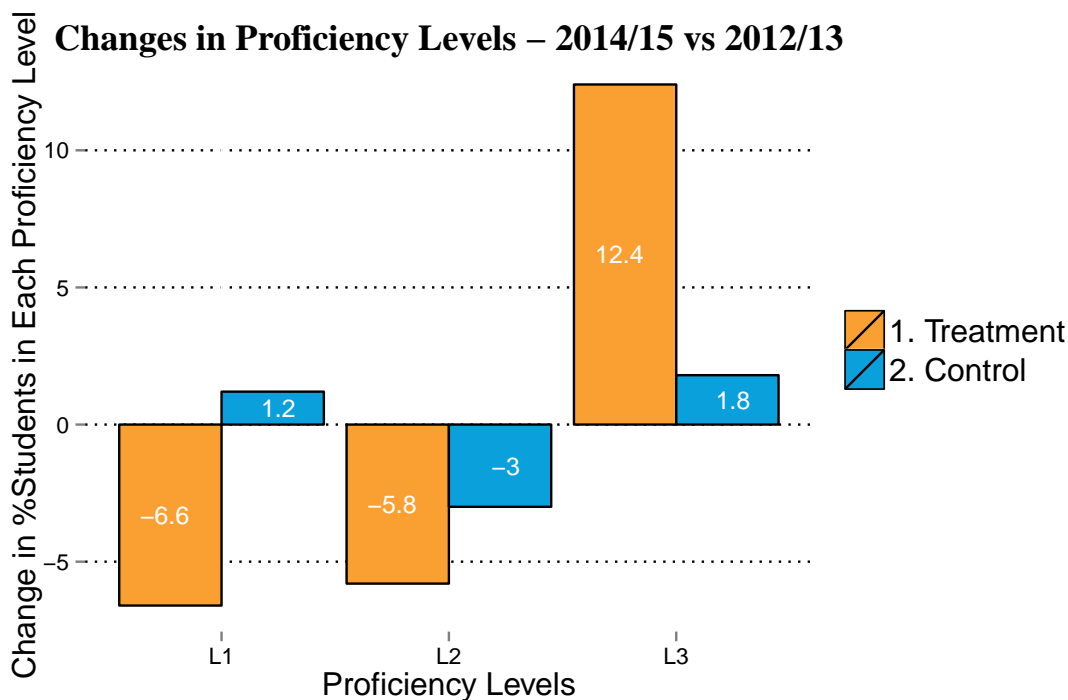


Figure 3: Change between 2012/13 and 2014/15 at each Proficiency Level for Grade-Aggregated TRT and CTRL Datasets

Similarly, Figure 4 shows the changes in NSS Math Scale Scores and changes in percent of students at NSS Level 2 or above for the grade-aggregated Treatment and Control sets.

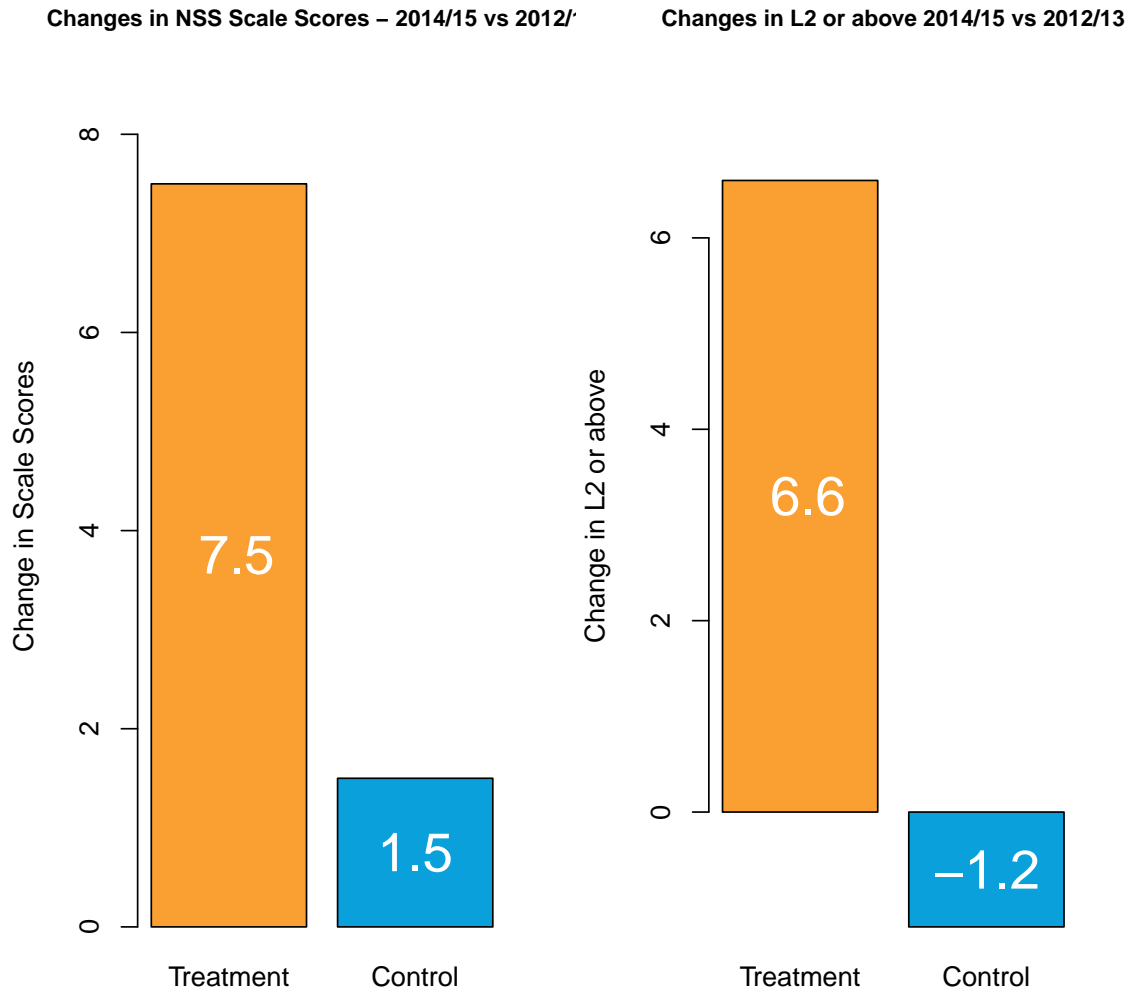


Figure 4: Changes in NSS Math Scale Scores and Level 2 or above for Grade-Aggregated TRT and CTRL datasets between 2012/13 and 2014/15

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

	Estimate	P-Value	Int.Low	Int.High
L2_or_above	7.81	0.00*	2.76	12.86
Scale Score	6.06	0.00*	2.67	9.45
L1	-7.81	0.00*	-12.86	-2.76
L2	-2.79	0.42	-9.68	4.10
L3	10.60	0.01*	3.22	17.98

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	Scale Score	L1	L2	L3	L2_or_above	ST Math Per Prog.
TRT.12.13	8	8	518	188.9	13.15	50.06	36.79	86.85	-
TRT.13.14	8	8	495	192.9	7.67	44.61	47.72	92.33	65.6
TRT.14.15	8	8	516	192.8	9.99	45.18	44.83	90.01	79.26
TRT.Delta	-	-	-	4.0	-3.16	-4.88	8.04	3.16	-
CTRL.12.13	8	8	408	187.0	14.68	52.44	32.88	85.32	-
CTRL.13.14	8	8	448	187.7	14.22	49.11	36.67	85.78	-
CTRL.14.15	8	8	447	188.4	13.97	50.16	35.87	86.03	-
CTRL.Delta	-	-	-	1.4	-0.71	-2.28	2.99	0.71	-

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

	# Grades	# Schools	# Students	Scale Score	L1	L2	L3	L2_or_above	ST Math Per Prog.
TRT.12.13	7	7	468	201.8	17.76	53.44	28.80	82.24	-
TRT.13.14	7	7	418	205.7	13.11	51.09	35.80	86.89	63.09
TRT.14.15	7	7	436	210.6	9.14	47.60	43.26	90.86	90.43
TRT.Delta	-	-	-	8.8	-8.62	-5.84	14.46	8.62	-
CTRL.12.13	7	7	395	203.4	17.47	51.56	30.97	82.53	-
CTRL.13.14	7	7	360	205.9	17.28	49.14	33.58	82.72	-
CTRL.14.15	7	7	395	205.7	16.70	51.01	32.29	83.30	-
CTRL.Delta	-	-	-	2.3	-0.77	-0.55	1.32	0.77	-

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

	# Grades	# Schools	# Students	Scale Score	L1	L2	L3	L2_or_above	ST Math Per Prog.
TRT.12.13	5	5	332	209.8	23.24	56.02	20.74	76.76	-
TRT.13.14	5	5	311	216.0	18.99	51.30	29.71	81.01	83.84
TRT.14.15	5	5	266	221.3	13.95	48.65	37.40	86.05	89.91
TRT.Delta	-	-	-	11.5	-9.30	-7.36	16.66	9.30	-
CTRL.12.13	5	5	364	213.3	22.07	56.61	21.31	77.93	-
CTRL.13.14	5	5	392	213.8	31.05	47.05	21.90	68.95	-
CTRL.14.15	5	5	354	213.7	29.11	48.85	22.05	70.89	-
CTRL.Delta	-	-	-	0.3	7.03	-7.77	0.73	-7.03	-

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

3.3.2 Grade-Level Analysis of Changes in NSS Math Level 2 or above

Figure 5 shows the difference in the growth of percentages of students at NSS math Level 2 or above, for the TRT and CTRL datasets, disaggregated by grade:

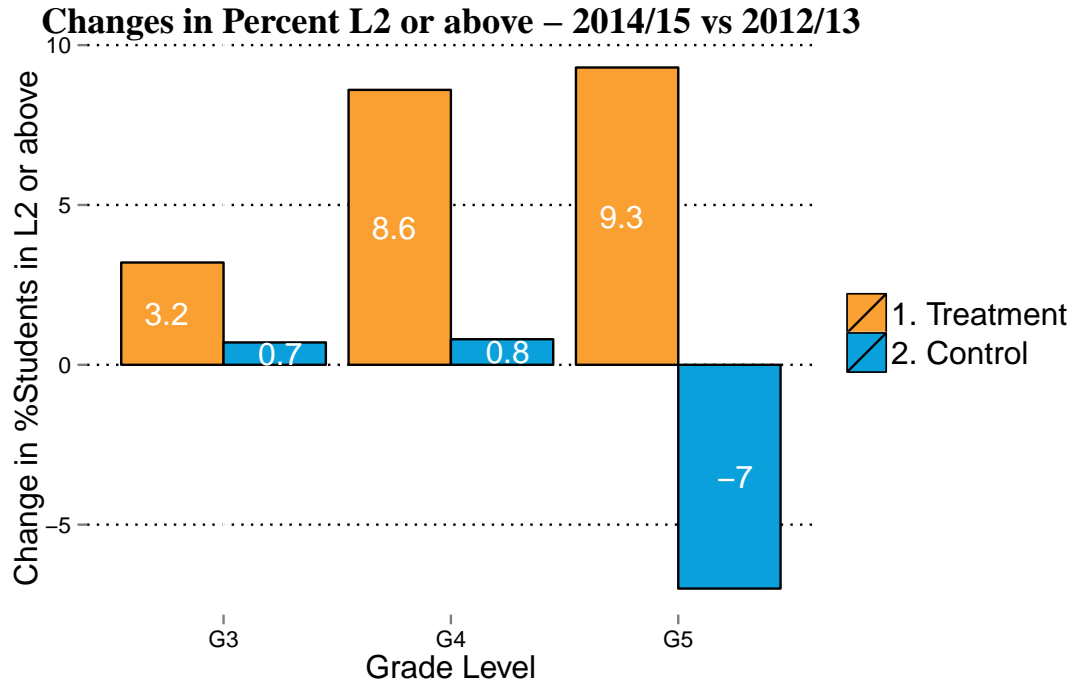


Figure 5: Changes in Percent of Students at NSS L2 or above for TRT and CTRL Datasets between 2012/13 and 2014/15

Table 10 shows the statistics for the *differences* in changes between TRT and CTRL (Treatment - Control) for these same NSS Level 2 or above math proficiency changes as shown in Figure 5.

	Estimate	P-Value	Int.Low	Int.High
Grade 3	2.45	0.36	-3.20	8.10
Grade 4	7.85	0.15	-3.21	18.91
Grade 5	16.33	0.01*	4.29	28.37

Table 10: Statistics for the Differential Changes in NSS L2 or above, TRT - CTRL

3.3.3 Grade-Level Analysis of Changes in NSS Math Scale Scores

Figure 6 shows the changes in the grade-mean math scale scores of students for the TRT and CTRL datasets, disaggregated by grade:

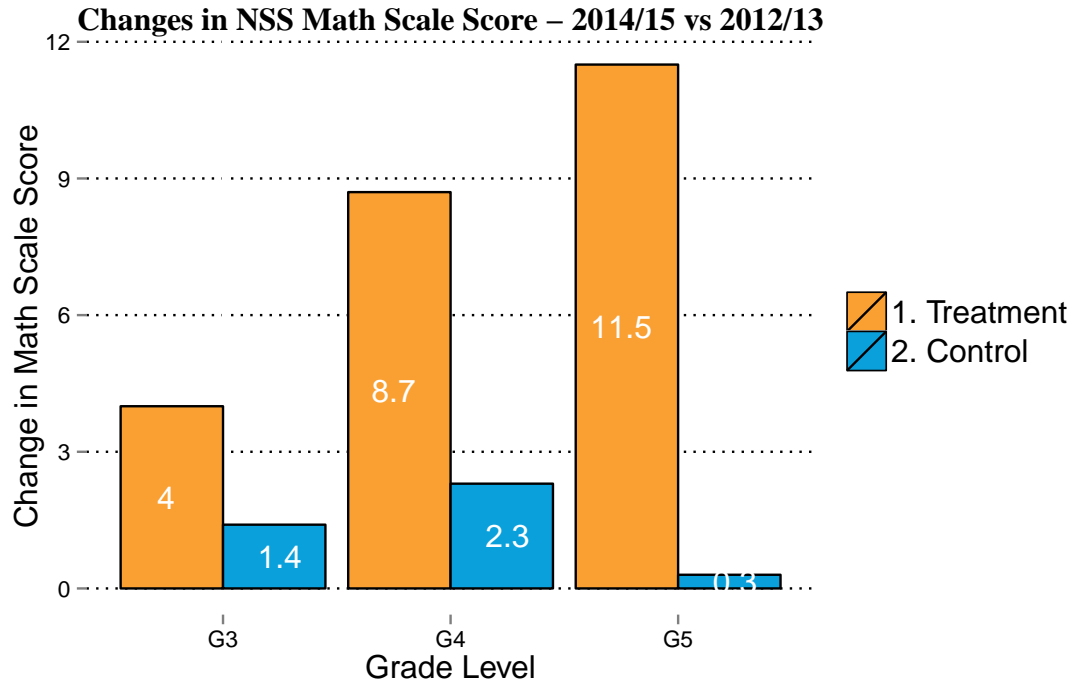


Figure 6: Changes in Grade-Mean NSS Math Scale Score for TRT and CTRL Datasets between 2012/13 and 2014/15

Table 11 shows the statistics for the differences between TRT and CTRL (Treatment - Control) for these same NSS math scale score changes as shown in Figure 6.

	Estimate	P-Value	Int.Low	Int.High
Grade 3	3.62	0.19	-1.45	6.57
Grade 4	8.41	0.07	-0.78	13.66
Grade 5	11.14	0.01*	3.04	19.25

Table 11: Statistics for the Differential Changes in NSS Math Scale Scores Growth, TRT - CTRL

4 Findings Summary

Iowa grades 3, 4, and 5 using ST Math in 2014/15 averaged 81.3% ST Math Progress. 20/22 grades (91%) averaged covering more than 50% of ST Math content. Statistically significant differences were found in this analysis for both grade-aggregated and individual grade levels. Looking at table 6, a statistically significant difference was found for grade-aggregated scale score, with an estimate of 6.06 points favorable for the ST Math treatment set, as well as for grade-aggregated proficiency L2 or above, with a 7.81 point favorable differential for the ST Math treatment set. Similarly, looking at table 10, a statistically significant difference was found for grade 5 proficiency L2 or above, with an estimate of 16.33 in favor of ST Math treatment set. Finally, looking at table 11, the grade 5 ST math treatment set outperformed their matched controls on NSS scale scores with a statistically significant difference of 11.14.

5 Reference Tables Grouped By School Year

The following tables show grade-level details, grouped by school year and for treatment (Table 12) and controls (Table 13) separately.

	# Grades	# Schools	# Students	Scale Score	L1	L2	L3	L2_or_above	ST Math Per Prog.
Grade 3 (12.13)	8	8	518	188.9	13.15	50.06	36.79	86.85	-
Grade 4 (12.13)	7	7	468	201.8	17.76	53.44	28.80	82.24	-
Grade 5 (12.13)	5	5	332	209.8	23.24	56.02	20.74	76.76	-
All Grades (12.13)	20	10	1318	198.6	17.29	52.73	29.98	82.71	-
Grade 3 (13.14)	8	8	495	192.9	7.67	44.61	47.72	92.33	65.6
Grade 4 (13.14)	7	7	418	205.7	13.11	51.09	35.80	86.89	63.09
Grade 5 (13.14)	5	5	311	216.0	18.99	51.30	29.71	81.01	83.84
All Grades (13.14)	20	10	1224	203.2	12.40	48.55	39.05	87.60	69.28
Grade 3 (14.15)	8	8	516	192.8	9.99	45.18	44.83	90.01	79.26
Grade 4 (14.15)	7	7	436	210.6	9.14	47.60	43.26	90.86	90.43
Grade 5 (14.15)	5	5	266	221.3	13.95	48.65	37.40	86.05	89.91
All Grades (14.15)	20	10	1218	206.2	10.68	46.90	42.42	89.32	85.83

Table 12: TRT Grades Detail Sorted by Year

	# Grades	# Schools	# Students	Scale Score	L1	L2	L3	L2_or_above	ST Math Per Prog.
Grade 3 (12.13)	8	8	408	187.0	14.68	52.44	32.88	85.32	-
Grade 4 (12.13)	7	7	395	203.4	17.47	51.56	30.97	82.53	-
Grade 5 (12.13)	5	5	364	213.3	22.07	56.61	21.31	77.93	-
All Grades (12.13)	20	19	1167	199.3	17.50	53.17	29.32	82.50	-
Grade 3 (13.14)	8	8	448	187.7	14.22	49.11	36.67	85.78	-
Grade 4 (13.14)	7	7	360	205.9	17.28	49.14	33.58	82.72	-
Grade 5 (13.14)	5	5	392	213.8	31.05	47.05	21.90	68.95	-
All Grades (13.14)	20	19	1200	200.6	19.50	48.60	31.90	80.50	-
Grade 3 (14.15)	8	8	447	188.4	13.97	50.16	35.87	86.03	-
Grade 4 (14.15)	7	7	395	205.7	16.70	51.01	32.29	83.30	-
Grade 5 (14.15)	5	5	354	213.7	29.11	48.85	22.05	70.89	-
All Grades (14.15)	20	19	1196	200.8	18.71	50.13	31.16	81.29	-

Table 13: CTRL Grades Detail Sorted by Year

6 Lists of Schools

6.1 Treatment Schools

Table 14 shows the list of treatment schools and grades (after 85% enrollment and 50% progress filtering) used in the analysis.

	District	School Name	GRADE
1	BELLEVUE COMM SCHOOL DISTRICT	Bellevue Elementary School	3, 4, 5
2	CLINTON COMM SCHOOL DISTRICT	Bluff Elementary School	3, 4, 5
3	CLINTON COMM SCHOOL DISTRICT	Eagle Heights Elementary School	3, 4, 5
4	BETTENDORF COMM SCHOOL DISTRICT	Grant Wood Elementary School	4
5	BETTENDORF COMM SCHOOL DISTRICT	Herbert Hoover Elementary School	3
6	CLINTON COMM SCHOOL DISTRICT	Jefferson Elementary School	3, 4, 5
7	BETTENDORF COMM SCHOOL DISTRICT	Paul Norton Elementary School	3
8	Non-NCES Schools 3028	Riverdale Heights Elem School	3, 4
9	BETTENDORF COMM SCHOOL DISTRICT	Thomas Jefferson Elementary School	3
10	CLINTON COMM SCHOOL DISTRICT	Whittier Elementary School - Clinton	4, 5

Table 14: Treatment Schools (TRT Dataset)

6.2 Control Schools

Tables 15 show the control schools and grades (matched control grades to treatment grades) used in the analysis.

	District	School Name	GRADE
1	Waukee Community School District	Walnut Hills Elementary	3
2	West Des Moines Community School District	Fairmeadows Elementary School	4
3	Ankeny Community School District	Ashland Ridge Elementary	5
4	Mount Pleasant Community School District	Harlan Elementary School	3
5	Lisbon Community School District	Lisbon Elementary School	4
6	Des Moines Independent Community School District	Garton Elementary	5
7	Benton Community School District	Atkins Elementary School	3, 4
8	Clarinda Community School District	Garfield Elementary School	4
9	Dubuque Community School District	Sageville Elementary School	5
10	Iowa City Community School District	Herbert Hoover Elementary School	4
11	Ankeny Community School District	Northwest Elementary School	3
12	Dubuque Community School District	Irving Elementary School	3
13	Dubuque Community School District	Hoover Elementary School	4
14	Council Bluffs Community School District	Edison Elementary School	5
15	Iowa City Community School District	Bohumil Shimek Elementary School	3
16	Central Springs Community School District	Central Springs Elementary School - Nora Springs	3
17	North Scott Community School District	John Glenn Elementary School	3
18	Muscatine Community School District	Colorado Elementary School	4
19	West Liberty Community School District	West Liberty Elementary School	5

Table 15: Matched Control Schools (CTRL Dataset)