

THE
EFFECTIVENESS
OF IMAGINE
MATH FOR
IMPROVING
STUDENT MATH
SKILLS

February 2019

 **SEGMEASUREMENT**
BUILDING BETTER ASSESSMENTS / EVALUATING PRODUCT EFFECTIVENESS

The Effectiveness of Imagine Math for Improving Student Math Skills

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Executive Summary

Overview

During the 2017-2018 school year, SEG Measurement conducted a study of the effectiveness of Imagine Math, an Imagine Learning program that provides online individualized adaptive instruction and breaks down skills into component parts to help students develop math skills.

The study examined the effectiveness of Imagine Math for improving the math skills of fourth, fifth and sixth grade students. The study was conducted in five school districts in California and investigated the impact of Imagine Math use on Smarter Balanced Assessment Consortium (SBAC) Mathematics Summative Assessment performance. SBAC Mathematics scores among students using Imagine Math (treatment group) were compared to SBAC Mathematics scores among students who did not use Imagine Math (control group).

Context and Background

All participating school districts were located in California within the same geographic region. School districts were selected to participate based on whether they were willing to adopt and implement Imagine Math with students in grades 4-6. All students in grades 4-6 within the selected districts participated in the research study.

The purpose for this research was to describe program impact for fourth, fifth and sixth-grade students in California who used Imagine Math as supplemental math instruction.

Study Design

The study employed a quasi-experimental design with matched groups to compare math skill performance between those students who used Imagine Math as a supplemental part of their math instruction (treatment group) and comparable students who did not use Imagine Math as a supplemental part of their math instruction (control group). Mathematics performance was assessed using scores on the SBAC Mathematics Summative Assessment. Students' Spring 2017 SBAC Mathematics scores served as the pretest and Spring 2018 SBAC Mathematics scores served as the posttest.

Treatment and control group participants were statistically matched using propensity score matching. The students in each grade were matched based on prior math skill, gender, and ethnicity. For each student who used Imagine Math, a similar student who did not use Imagine Math was determined, where available. Only those matched students who took the posttest were included in the analysis. This statistical matching provided increased rigor in the analyses and controlled for factors beyond product use that may have influenced students' performance. After creating matched groups of students who used Imagine Math and students who did not use Imagine Math, 464 fourth grade students, 226 fifth grade and 220 sixth grade students were selected for the matched groups in the study.

Spring 2018 SBAC Mathematics scores in the treatment group and the control group were compared statistically using analysis of covariance (ANCOVA). ANCOVA provides a comparison between the treatment and control group students while adjusting for any potential differences in students' initial ability even though they were controlled for in the propensity score matching process. Specifically, we examined the difference in the Spring 2018 Math SBAC scores (dependent variable) between the treatment and control

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groups (independent variable) while controlling for the initial ability of the students from Spring 2017 Math SBAC Scores (covariate).

Study Results

Students who used Imagine Math showed greater performance on the Spring 2018 Math SBAC Mathematics Summative assessment than comparable students who did not use Imagine Math. Fourth grade students using Imagine Math achieved about 6 more points on the assessment, or .07 standard deviations ($ES=.07$), than fourth graders not using Imagine Math. However, the results failed to reach the traditional .05 level of significance. Fifth graders achieved about 19 more points on the assessment, or .22 standard deviations ($ES=.22$), than did nonusers. This difference was statistically significant. Sixth grade students achieved 28 more points on the assessment, or .29 standard deviations ($ES=.29$), than did nonusers. This difference was also statistically significant. The results indicate that Imagine Math is effective for improving math skills among fourth, fifth and sixth grade students who used the program.

Introduction

Overview

This study examines the effectiveness of Imagine Math for improving the math skills of fourth, fifth and sixth grade students. The year-long study (2017-2018 school year), conducted in five school districts in California, investigated the impact of Imagine Math use among matched groups of fourth, fifth and sixth grade students using and not using the product. Math skill among students using Imagine Math (treatment group) was compared to math skill among students who did not use Imagine Math (control group). End-of-year SBAC Mathematics scores from the 2017-2018 school year were used to compare math skill for the treatment and control group students, accounting for the initial math level of students using the previous year SBAC Mathematics scores.

Imagine Math is a supplemental mathematics curriculum designed to provide differentiated and adaptive mathematics instruction from third grade through geometry skills. Students work independently in a computer-based platform to complete mathematics activities with visual cues and live virtual support from U.S. Certified Mathematics teachers as needed. Embedded within the curriculum are formative and benchmark assessments that inform placement and progress within the program. As students progress through the program, it adapts to the needs of each student to maintain learning in the zone of proximal development. Additionally, various levels of motivation are included (e.g., contests, games, performance points) to support strong student engagement.

In previous studies, teachers reported using Imagine Math for acceleration, supplementing instruction, and remediation. Results across state and district evaluations indicate that Imagine Math can effectively be used as supplemental instruction for students in grades 3-8. Results in Texas indicated that students who used the program outperformed non-users on State of Texas Assessments of Academic Readiness Mathematics (Garland, Shields, Booth, Shaw, and Samii-Shore, 2014). Across two years of evaluations, Utah students in grades 3-8 are three-times more likely to be proficient on the Student Assessment of growth and Excellence than students who did not use Imagine Math (Snyder, 2016).

Although results showed positive impact for Imagine Math users, research has not been conducted using California's Assessment of Student Performance and Progress (CAASPP) as an outcome measure. The current research was designed to provide evidence that Imagine Math is effective for students in California who are assessed using the CAASPP Smarter Balanced Assessment Consortium's (SBAC) Mathematics assessment.

Methods and Procedures

Research Questions

The primary research question addressed by this study is: "Is Imagine Math effective in improving students' math skills?" The specific operational questions addressed to answer this are:

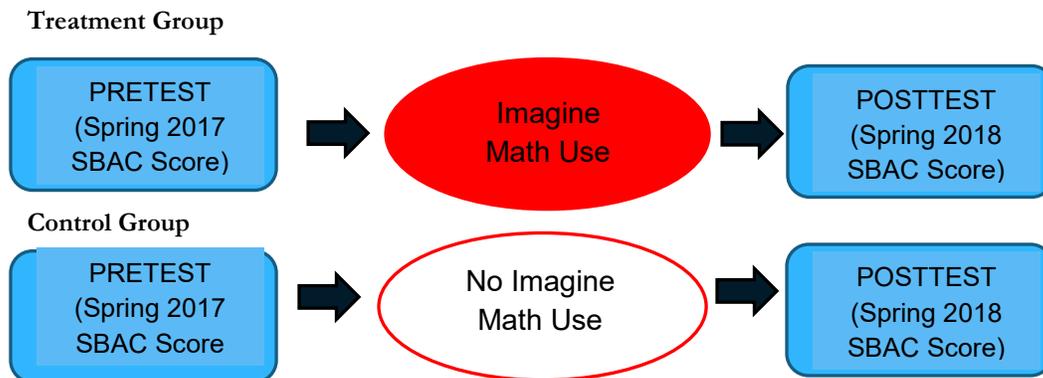
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- Do students in fourth grade who receive supplemental instruction using Imagine Math show larger gains in math skills than comparable students who do not receive instruction using Imagine Math?
- Do students in fifth grade who receive supplemental instruction using Imagine Math show larger gains in math skills than comparable students who do not receive instruction using Imagine Math?
- Do students in sixth grade who receive supplemental instruction using Imagine Math show larger gains in math skills than comparable students who do not receive instruction using Imagine Math?

Study Design

The study employed a quasi-experimental design. A treatment group of students (students who used Imagine Math) was compared to a control group of students (who did not use Imagine Math) based on the end-of-year statewide SBAC Mathematics scores (posttest) adjusting for gender, ethnicity, and initial math ability of the students assessed using the prior year's SBAC Mathematics scores (pretest). The treatment group students received core mathematics instruction and used Imagine Math as supplemental instruction. The control group students received core mathematics instruction and did not have access to Imagine Math. The study design is depicted in Figure 1. Students were not randomly assigned to experimental groups; they were matched with respect to demographic characteristics and ability as described below.

Figure 1: Study Design



Program Implementation

Students included in the study began using Imagine Math in early October 2017. To support local implementations, Imagine Learning offered five key supports for school personnel including: (1) access to Imagine University with online training materials; (2) training provided by Customer Success Managers; (3) access to Imagine Learning's Teacher Care call center; (4) onsite visits by Customer Success Managers; and (5) technical support as needed. These supports are typical supports offered to all Imagine Math customers.

For this study, teachers received initial onsite training lasting 2-3 hours and follow-up training and support provided by local Customer Success Managers. All teachers were given access to Imagine University training videos, which are available on demand and accessible through the teacher portal. Teacher Care, which is a phone support system dedicated to answering teachers' questions about product features and functions, was available during the business hours for participating teachers.

School administrators and teachers determined models for implementing Imagine Math at their sites. Implementation models varied across the study depending on local infrastructure and access to devices.

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Generally, students who used Imagine Math used the program during lab rotations or during station rotations within their classrooms. The program was used as supplemental instruction and did not replace students' core mathematics instruction. Imagine Math users averaged 22 hours on the program for the durations of the school year. Students who did not receive access to Imagine Math participated in mathematics programs available at their schools.

Instrumentation

The measure of mathematical skills used to assess student growth in mathematics was the Smarter Balanced Assessment Consortium's Mathematics test (SBAC). The Spring 2017 SBAC Mathematics scores were used as the pretest; the Spring 2018 SBAC Mathematics scores were used as the posttest.

According to the SBAC's description of tests (www.smarterbalanced.org), "the Smarter Balanced Assessment system is a valid, fair, and reliable approach to student assessment that provides educators, students and parents meaningful results with actionable data to help students succeed." Indeed, substantial research has been conducted to establish the validity and reliability of the SBAC assessment. Specifically, the most recent SBAC technical report substantiates the claim that the assessment is valid (including content and internal validity) and reliable for students in grades 3-8 (Smarter Balanced Assessment Consortium, 2017). The assessment system is aligned to the Common Core state standards.

Population

Recruitment of the study occurred at the district level. School districts were recruited to participate as treatment or control districts. All students in grades 4-6 at participating districts were included in the study. Two of the five school districts recruited served as treatment districts (using Imagine Math) and three school districts provided control group students (not using Imagine Math). The treatment school districts provided program access to all elementary schools serving grades 4-6.

A total of twenty-two schools participated in the study. Students in 66 fourth-grade classes participated, 35 of which were in the treatment group and 31 were in the control group. Students in 63 fifth-grade classrooms participated in the study, 23 of which were in the treatment group and 40 were in the control group. Students in 49 sixth-grade classrooms participated in the study, 23 of which were in the treatment group and 26 were in the control group.

The largest participating district provided instruction for about 10,000 students in 11 schools. Three of the participating districts serviced approximately 3,000 to 5,000 students enrolled in five to nine elementary schools. The smallest participating district enrolled 1,300 students in two schools.

The initial population was defined as those students in grades four, five and six who took the SBAC Mathematics in spring 2017 for whom we received records from the districts. The Spring 2017 SBAC Mathematics scores served as the pretest as well as a definition of initial math ability (along with background characteristics) for matching treatment and control group students.

A total of 4,475 student records were provided to SEG Measurement by the treatment and control districts. Students varied in ability level and background; however, the large number of students provided a basis for selecting matched treatment and control groups with strong matching criteria as described below. For fourth grade, there was a total of 1,663 student records available for matching (treatment N=889; control =774) with a mean ability difference of 21 points (treatment ability=2471; control ability=2492). For fifth grade, there was a total of 1,586 student records available for matching (treatment N=1018; control =568) with a mean

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ability difference of 59 points (treatment ability=2495; control ability=2436). For sixth grade, there was a total of 1,226 students available for matching (treatment N=660; control =566) with a mean ability difference of 84 points (treatment ability=2575; control ability=2491).

Data Collection

At the outset of the study, SEG Measurement acquired data files from the five participating districts. During August and September of 2017, SEG Measurement provided specifications to the districts for providing a data export that included necessary data elements for establishing baseline mathematics ability and matching treatment and control groups. Participating districts were asked to provide identifying information for each participating student along with their Spring 2017 SBAC Mathematics scores and demographic information on student gender and ethnicity. Each district provided SEG Measurement with de-identified SBAC Mathematics performance data for spring 2017 and demographic information for each participating student. Each student was identified with a unique identifying number to both preserve confidentiality and to allow for later linking to the 2018 SBAC Mathematics scores (post test data).

In the spring of 2018, SEG Measurement requested end-of-year data from each district. All participating districts provided SEG Measurement with the spring 2018 SBAC Mathematics scores along with the unique identifying numbers used to provide the first set of data files for treatment and control students, to facilitate merging of the data. Data were received during June and July 2018. Imagine Learning provided usage data (time in program) to SEG Measurement to facilitate separate analyses examining outcomes with all students in the matched groups and for only those students who used the product.

Matched Sample

A multi-step process was used to select comparable groups for the study. Propensity score matching was used to help ensure comparability of the two study groups. Propensity score matching is widely recognized as effective in achieving group equivalence in the absence of randomization (Guo and Frazer, 1999). This technique identifies for each member of the treatment group, a corresponding member of the control group that is matched on ability and background. Propensity score matching was executed using logistic regression without replacement. To be eligible for matching the treatment control match needed to be within .05 (on a 0 to 1 Propensity score scale).

SEG Measurement used the data received from districts to identify the group membership of each participating student (treatment or control). Students from the schools identified as control schools served as the source for creating a comparable control group. Where a suitable match could be found, for each student in the treatment group, a comparable student from the control group districts was selected to be included in the control group. Treatment students and comparable control students were matched such that each treatment student had a matching control student with similar characteristics including initial math ability level (determined by spring 2017 SBAC Mathematics scores), gender, and ethnicity. Matching was done separately by grade.

Suitable matches were identified for 910 students across grades four, five, and six. Of the 889 grade four treatment group students, the propensity score matching identified matches for 464 students. Of the 1,018 grade five treatment group students, the propensity score matching identified matches for 226 students. Of the 661 grade six treatment group students, the propensity score matching identified matches for 220 students. While the districts recruited for this study were located within the same geographical region of the state of California, considerable variation in the demographic make-up of the treatment and control districts,

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including socioeconomic status and ethnicity, likely contributed to the reduced likelihood of obtaining suitable matches between treatment and control students.

Within the analytic matched sample, students were reasonably well matched on initial ability. However, Analysis of Covariance (ANCOVA) was also used to ensure that students were placed on a common baseline of initial starting math skill. Using ANCOVA, we examined the difference in the posttest scores (dependent variables) between the treatment and control groups (independent variable) controlling for the initial skill level of the students (covariate). The spring 2017 SBAC Mathematics scores were used as the covariate to place students in the treatment group and the control group on the same baseline. These analyses were run separately for each grade.

Table 1:
Comparison of Initial Ability (Mean Pretest Scores)

	Treatment	Control
Grade 4	2486 (SD=98.82)	2446 (SD=85.69)
Grade 5	2453 (SD=76.60)	2455 (SD=73.86)
Grade 6	2454 (SD=93.72)	2438 (SD=73.29)

Table 2:
Profile of Matched Samples

	Treatment	Control	TOTAL
GRADE 4			
Gender			
Female	109	109	218
Male	123	123	246
TOTAL	232	232	464
Ethnicity			
White or Caucasian	205	201	406
Hispanic or Latino	1	1	2
Black or African American	0	5	5
Asian or Pacific Islander	22	17	39
Mixed Race or Other	4	8	12
TOTAL	232	232	464
GRADE 5			
Gender			
Female	54	45	99
Male	59	68	127
TOTAL	113	113	226
Ethnicity			
White or Caucasian	104	101	205
Hispanic or Latino	3	2	5
Black or African American	0	0	0
Asian or Pacific Islander	0	2	2

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Mixed Race or Other	6	8	14
	113	113	226
GRADE 6 Gender			
Female	56	51	107
Male	54	59	113
TOTAL	110	110	220
Ethnicity			
White or Caucasian	93	87	180
Hispanic or Latino	0	0	0
Black or African American	12	15	27
Asian or Pacific Islander	5	8	13
Mixed Race or Other	0	0	0
TOTAL	110	110	220

Data Analysis

The effectiveness of Imagine Math was evaluated using ANCOVA. ANCOVA can be used to examine the differences in outcomes between a treatment and control group, while adjusting for any differences in initial ability. ANCOVA was used to examine the differences in math growth (2018 SBAC Mathematics scores; dependent variable) between the treatment and control groups (independent variable) while adjusting for the initial math ability of the students (2017 SBAC Mathematics scores). Separate analyses were executed for each of the three grade levels included in the study.

Results

Two hundred and twenty-four fourth grade treatment students and 223 fourth grade control students were included in the analyses. For fifth grade, 103 fifth grade treatment students and 112 fifth grade control group students were included in the analyses. One hundred and one sixth-grade treatment students and 105 sixth-grade control group students were included in the analyses.

As illustrated in tables three and four below, the two groups were well matched, nearly the same with respect to ability, gender and ethnicity. The treatment and control groups for both grades were similar in ability. The fourth-grade treatment group was of somewhat higher ability, 37 points (.37 SD) greater than the control group. The fifth-grade study groups were comparable in ability, within 2 points (.03 SD) of the control group. The sixth-grade study groups were comparable in ability; with the treatment and control groups within 17 points (.18 SD) of each other on the spring 2017 SBAC Mathematics. Any observed differences in scores prior to analysis were adjusted for using ANCOVA.

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Table 3:
Comparison of Initial Ability (Mean Pretest Scores)

	Treatment	Control
Grade 4	2484 (SD=98.97)	2447 (SD=85.91)
Grade 5	2457 (SD=76.16)	2455 (SD=74.18)
Grade 6	2458 (SD=93.44)	2441 (SD=72.87)

Table 4:
Profile of Students Included in the Analysis

	Treatment	Control	TOTAL
GRADE 4			
Gender			
Female	107	106	213
Male	117	117	234
TOTAL	224	223	447
Ethnicity			
White or Caucasian	198	193	391
Hispanic or Latino	1	1	2
Black or African American	0	5	5
Asian or Pacific Islander	21	16	37
Mixed Race or Other	4	8	12
TOTAL	224	223	447
GRADE 5			
Gender			
Female	47	44	91
Male	56	68	124
TOTAL	103	112	215
Ethnicity			
White or Caucasian	95	100	195
Hispanic or Latino	2	2	4
Black or African American	0	0	0
Asian or Pacific Islander	0	2	2
Mixed Race or Other	6	8	14
TOTAL	103	112	215
GRADE 6			
Gender			
Female	51	50	107
Male	50	55	113
TOTAL	101	105	206
Ethnicity			
White or Caucasian	85	83	168

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Hispanic or Latino	0	0	0
Black or African American	11	14	25
Asian or Pacific Islander	5	8	13
Mixed Race or Other	0	0	0
TOTAL	101	105	206

Attrition

Attrition from the study was minimal. About 4%-6% of the matched students were not included in the final analysis because they did not have a posttest score. The demographic profile for the fourth, fifth and sixth grade groups was comparable after attrition.

For the fourth-grade sample, 17 students (4%) did not have posttest scores and were lost from the initial matched sample of 464 students. For the fifth-grade sample, 11 students (5%) did not have posttest scores and were lost from the initial matched sample of 226 students. For the sixth-grade sample, 14 students (6%) did not have posttest scores and were lost from the initial matched sample of 220 students.

Grade 4 Math Skills Results

For fourth grade students, the results showed an effect size of .07 (Cohen's D) for the 2018 SBAC Mathematics performance. Fourth grade students who used Imagine Math achieved higher scores on the 2018 SBAC Mathematics than students who did not use Imagine Math, however the results failed to reach the conventional level of statistical significance ($F = .670$, $df=2/446$; $p=.413$). The results are summarized in Tables 5 and 6 and Figure 1 below.

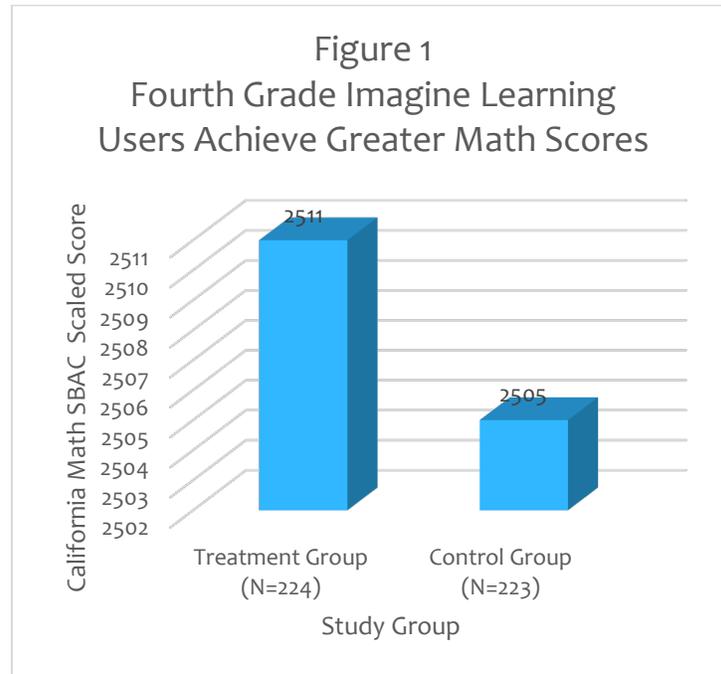
Table 5: ANCOVA of the Treatment and Control Group 4th Grade Posttest Scores

Source	Type III Sum of Squares	df	Mean Square	F	Significance
Corrected Model	1306437.247	2	653218.623	119.604	<.001
Intercept	778130.819	1	778130.819	142.475	<.001
Pretest	1224269.605	1	1224269.605	224.163	<.001
Study Group	3661.025	1	3661.025	.670	.413
Error	2424909.993	444	5461.509		
Total	2816679215.000	447			
Corrected Total	3731347.239	446			

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Table 6: Descriptive Comparison of the Treatment and Control Group 4th Grade Posttest Scores (Adjusted for Pretest Performance)

Group	Number of Students	Posttest Scores	
		Mean	Standard Deviation
Treatment	224	2511.49	106.30
Control	223	2505.65	71.33
Total	447	2508.58	91.47



Grade 5 Math Skills Results

For fifth grade, the results showed an effect size of .22 for the 2018 SBAC Mathematics performance. Fifth grade students who used Imagine Math achieved significantly higher scores on the 2018 SBAC Mathematics than students who did not use Imagine Math ($F = 4.449$, $df=2/214$; $p = .036$). The results are summarized in Tables 7 and 8 and Figure 2 below.

Table 7: ANCOVA of the Treatment and Control Group 5th Grade Posttest Scores

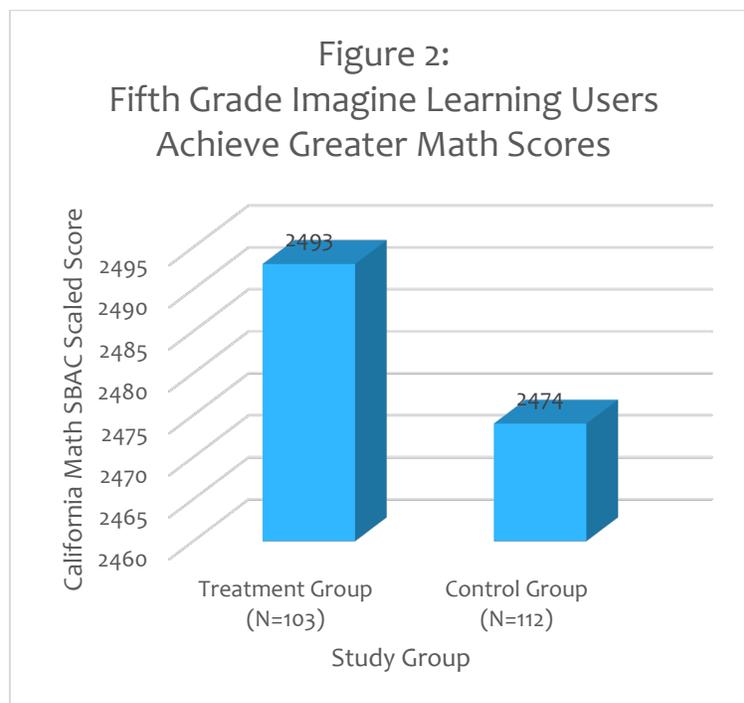
Source	Type III Sum of Squares	df	Mean Square	F	Significance
Corrected Model	641572.649	2	320786.325	71.826	<.001
Intercept	104240.317	1	104240.317	23.340	<.001
Pretest	617619.650	1	617619.650	138.288	<.001
Study Group	19869.088	1	19869.088	4.449	.036
Error	946831.583	212	4466.187		

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Total	1327522849.000	215			
Corrected Total	1588404.233	214			

Table 8: Descriptive Comparison of the Treatment and Control Group 5th Grade Posttest Scores (Adjusted for Pretest Performance)

Group	Number of Students	Posttest Scores	
		Mean	Standard Deviation
Treatment	103	2493.40	93.23
Control	112	2474.15	78.14
Total	215	2483.78	86.15



Grade 6 Math Skills Results

For sixth grade, the results showed an effect size of .29 for the 2018 SBAC Mathematics performance. Sixth grade students who used Imagine Math achieved significantly higher scores on the 2018 SBAC Mathematics than students who did not use Imagine Math ($F = 14.892$, $df=2/205$; $p < .001$). The results are summarized in Tables 9 and 10 below.

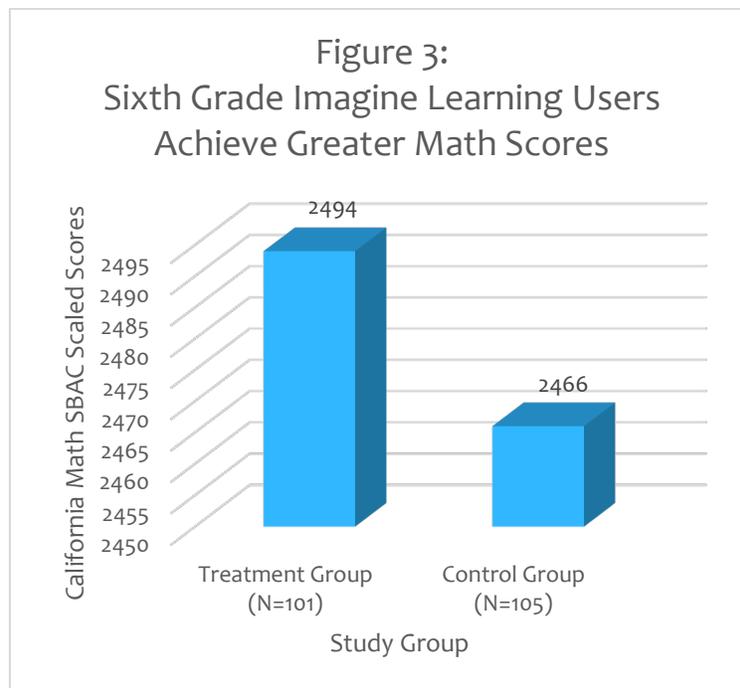
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Table 9: ANCOVA of the Treatment and Control Group 6th Grade Posttest Scores

Source	Type III Sum of Squares	df	Mean Square	F	Significance
Corrected Model	1392681.856	2	696340.928	250.605	<.000
Intercept	5183.371	1	5183.371	1.865	.174
Pretest	1292278.908	1	1292278.908	465.076	<.000
Study Group	41380.634	1	41380.634	14.892	<.000
Error	564063.644	203	2778.639		
Total	1268428317.000	206			
Corrected Total	1956745.500	205			

Table 10: Descriptive Comparison of the Treatment and Control Group 6th Grade Posttest Scores (Adjusted for Pretest Performance)

Group	Number of Students	Posttest Scores	
		Mean	Standard Deviation
Treatment	101	2494.02	108.73
Control	105	2465.53	80.52
Total	206	2479.78	97.70



Conclusion

The results observed in this study indicate that Imagine Math is an effective tool for improving math skills among students at the fourth, fifth and sixth grade. Students who used Imagine Math showed greater growth in Math skills than comparable students who did not use Imagine Math. Fourth grade students using Imagine Math showed about 6 points more growth on the assessment, or .07 standard deviations ($ES=.07$), than did fourth graders not using Imagine Math. However, the results failed to reach the traditional .05 level of significance. Fifth graders showed about 19 points more statistically significant growth on the assessment, or .22 standard deviations ($ES=.22$), than did nonusers. Sixth grade students showed about 28 points more statistically significant growth on the assessment, or .29 standard deviations ($ES=.29$), than did nonusers.

The .29 effect size found in sixth grade and the .22 effect size at the fifth-grade level strongly support the efficacy of Imagine Math. While the .07 effect size observed at the fourth-grade level also points in this direction, this effect failed to reach the conventional .05 level of significance. The fifth and sixth grade findings compare favorably with research comparing the effects of educational technology applications and traditional methods (Cheung and Slavin, 2013; Lipsey et al., 2012).

As with all research, this study is characterized by limitations and strengths that should be considered when interpreting the results of this study. For example, in quasi-experimental research designs, assignment to treatment and control conditions is not random. However, through the use of propensity score matching and the implementation of controlling variables, we can be more certain Imagine Math is responsible for the observed effects. Further, these statistical methodologies ensure that the treatment and control groups are truly comparable based on baseline characteristics. Indeed, despite some minor attrition in both the treatment and control groups, baseline equivalence was achieved for the final analytic sample.

In summary, the findings of this study demonstrate that the Imagine Math program is effective in improving fourth, fifth and sixth grade students' math skills.

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