



Legends of Learning: Math Basecamp

Math Basecamp Use and Math Achievement in Rialto Unified School District

Prepared by McREL for Legends of Learning

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Executive Summary

As the number of sessions of Legends of Learning’s Math Basecamp increases, achievement on California’s Smarter Balanced Mathematics assessment increases significantly.

Completing at least 24 sessions of Legends of Learning’s Math Basecamp significantly increases student scores on California’s Smarter Balanced Mathematics assessment.

Cohen’s D computed for these relationships indicate a medium, significant effect of Math Basecamp on math achievement.

Legends of Learning designs game-based learning programs for teachers, students, and families that are intended to align with school curricula and that leverage fun student activities intended to foster deeper engagement and understanding of the material. Math Basecamp, specifically, was designed to facilitate students’ development of mathematics fluency, including counting, deriving, mastery, and application of mathematical concepts.

McREL International conducted a study of how variation in student use of Math Basecamp in the 2022–2023 school year related to student math achievement on the Smarter Balanced Assessment in Mathematics, in Rialto Unified School District in California.

A total of 3,273 third, fourth, and fifth grade students were included in the analytic sample of this report. Approximately 50% of students in the sample were female. Half of the students were in fourth grade, 24.4% were in third grade, and 25.6% were in fifth grade.¹

We used Ordinary Least Squares (OLS) regression to examine the association between Math Basecamp use and math achievement. This allowed us to account for variables including student gender, special education status, race, grade level, English language proficiency, attendance, and prior performance on the state math assessment (Johnson & Wichern 2023). Next, we used propensity score matching to estimate the average treatment effect of completing the developer’s suggested number of sessions in Math Basecamp (Rosenbaum & Rubin 1983; Raudenbush & Bryk 2002).

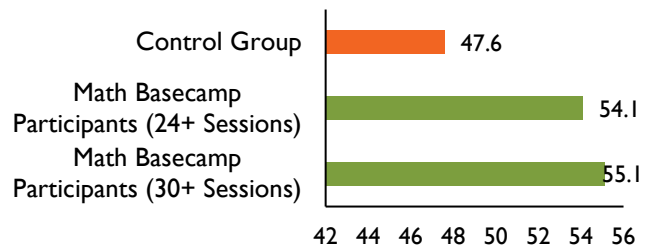


Figure 1. Predicted Percentile of Standardized Student Performance on Smarter Balanced Math Assessments by Treatment Group

OLS results indicated that **as the number of completed sessions increases, math achievement scores also increase significantly.**

Propensity-score matching results indicated that compared to students with zero sessions, completing the recommended number of sessions significantly increases students’ math achievement scores (see Figure 1).

¹ As detailed in the report, we standardized students’ scores by grade level to allow for comparison of achievement across the analytic sample, and then calculated achievement percentiles.

Introduction

The purpose of this study was to examine the relationship between students' engagement with Legends of Learning's Math Basecamp (MBC) and students' math achievement at the elementary school level in Rialto Unified School District (RUSD) in California.

Legends of Learning

Legends of Learning designs game-based learning programs for teachers, students, and families (legendsoflearning.com). The Legends of Learning platform comprises three products that facilitate math and science learning: the Learning Universe, Awakening, and Math Basecamp. Each one of these products centers on different components of math and science learning. The game-based instruction draws upon existing research to provide a variety of challenge levels for a variety of students, while integrating research-based learning experiences (legendsoflearning.com).

Math Basecamp

Math Basecamp was designed to facilitate students' development of mathematics fluency, including counting, deriving, mastery, and application of mathematical concepts (<https://legendsoflearning.com/math-basecamp/>). Math Basecamp employs a three-tiered approach, including: 1) fluency foundation, 2) math fact mastery, and 3) fluency application. In the fluency foundation stage, students gain essential understanding through completing research- and standards-backed lesson plans that involve hands-on activities and digital mini-games. In the math fact mastery stage, students follow a character on a story-based math adventure that requires them to employ their newly-gained math fluency to progress through the adventure while encountering research-backed challenges that build fact mastery and retention. In the fluency application stage, students can play a variety of mini-games that utilize fact mastery and require them to solve complex problems in order to progress.

Research Questions

In this report, we explore two primary research questions:

RQ1: Is there a significant and positive association between participation in Legends of Learning's Math Basecamp and math performance?

RQ2: Is there a causal relationship between participation in Legends of Learning's Math Basecamp at the recommended level of usage and improved math performance?

Although the two research questions both examine the relationship between the intervention and student outcomes, importantly, RQ2 offers a more rigorous analysis of the impact of MBC on student outcomes. As detailed herein, the RQs required different analytic approaches and different student samples.

Analytic Samples

RUSD serves approximately 25,500 students, with approximately 11,170 of these enrolled in the district’s 19 elementary schools. Schools within the district implemented MBC in August 2022 when it was released to schools. De-identified data on student use of Math Basecamp and math achievement scores were provided to McREL by Legends of Learning staff in collaboration with RUSD.

The analytic sample for the first research question (RQ1) in this report includes a total of 3,273 RUSD students (see Table 1). Of these students, 1,829 participated in the intervention, and 1,444 did not. The population was almost equal parts male and female (50.1% and 49.9%, respectively). All students were in primary school, in grades 3 (24.4%), 4 (50.0%), and 5 (25.6%). A large majority of students were Hispanic (87.6%), while 7.4% were black, 2.1% were white, and 2.9% were another race. Over 20% of the analytic sample were designated as English language learners (21.6%).

Table 1. Analytic Sample Characteristics

<i>Characteristic</i>	<i>Mean/Percent</i>	<i>Treatment</i>	<i>Control</i>
Average Math Achievement Percentile 2021-2022	49.8	54.4	48.0
Race/Ethnicity			
Hispanic	87.6%	90.3%	86.4%
Black	7.4%	6.5%	7.7%
White	2.1%	0.7%	2.7%
Other	2.9%	2.5%	3.1%
Grade Level			
4	50.0%	62.4%	45.5%
5	25.6%	37.6%	54.5%
English Language Learners	21.6%	27.4%	21.9%
Special Education	18.9%	14.4%	20.2%

To answer the second research question (RQ2) we created an analytic sample of 402 treatment and 1,206 comparison students with statistically similar characteristics using a propensity score matching algorithm. Table 2 presents the same demographic information presented in Table 1 for the second analytic sample, demonstrating baseline equivalence between the treatment and control groups. There were no statistically significant differences on covariates in the matched sample.

Table 2. Matched Sample Characteristics

<i>Characteristic</i>	<i>Treatment</i>	<i>Control</i>
Average Math Achievement Percentile 2021-2022	50.8	48.4

Race/Ethnicity		
Hispanic	90.3%	89.3%
Black	6.4%	7.3%
White	1.0%	1.0%
Other	2.5%	2.7%
Grade Level		
4	62.4%	45.7%
5	37.6%	54.3%
English Language Learners	24.5%	22.6%
Special Education	15.4%	17.5%

Evaluation

Measures

Smarter Balanced Math Assessment. At the end of each school year, students in grades 3 through 8, and grade 11, take the online Smarter Balanced Summative Assessments for English language arts/literacy and mathematics in California. The assessment is based on Common Core State Standards. For grade 3, scores on this assessment range from 2,190 to 2,660. Grade 4 scores range from 2,205 to 2,700, and grade 5 scores range from 2,220 to 2,740. We standardized students' scores by grade level to allow for comparison of achievement across the analytic sample, and then calculated achievement percentiles. Observed student percentile achievement on this assessment is summarized in Table 3.

Table 3. Average Percentile on Smarter Balanced Math Assessments by Math Basecamp Usage

Treatment	2021–2022 Average Percentile	2022–2023 Average Percentile
Math Basecamp Participants	50.8	51.3
Control Group	48.4	47.9

MBC Use. Legends of Learning recommends that schools that implement MBC should aim to have students complete three to five sessions of the game per week. Three sessions a week, for four weeks, over a period of two months is a total of 24 sessions to meet the minimum threshold for recommended usage.

Most students had either no usage (42.4%) or had fewer than 12 sessions (35.5%). About 9 percent (9.4%) of students had between 12 and 23 sessions, and 12.6% achieved recommended usage or greater (24+ sessions).

Analysis

RQ1: Is there a significant and positive association between participation in Legends of Learning's Math Basecamp and math performance?

We used Ordinary Least Squares Regression (OLS) to model the association between math achievement scores at the end of the 2022–2023 school year and the number of Math Basecamp sessions, controlling for prior math achievement, gender, special education program participation, grade level, race, English Language Learner status, and attendance. Regression models were estimated in the RStudio program using the *lm* package. Percentile of standardized math achievement is the outcome measure in the OLS model, controlling for the demographic and prior achievement measures stated above. OLS models the linear relationship between number of Math Basecamp sessions and math achievement. As a result, the coefficient produced for number of sessions displays the average change in standardized math achievement percentile for each additional session completed by students. Robust standard errors are reported to account for violations of OLS assumptions.

RQ2: Is there a causal relationship between participation in Legends of Learning’s Math Basecamp at the recommended level and improved math performance?

We employed a quasi-experimental design using propensity score matching (PSM) to estimate the average treatment effect (ATE) of recommended usage (24+ sessions) on percentile of standardized math achievement scores at the end of the 2022–2023 school year. Initially, propensity scores were estimated using logistic regression, incorporating treatment-covariate interactions for each student in the analytic sample, facilitated by the *MatchIt* package in R. After matching, we assessed covariate balance between the treated and control groups to ensure the validity of the matching method and baseline equivalence between treatment and control groups. The *MatchIt* package assigned sample weights based on the propensity scores, which were subsequently used in ordinary least squares (OLS) model estimation. To determine the ATE, we utilized the *marginalEffects* package in R. Finally, we calculated *Cohen’s d* to measure the effect size, quantifying the impact of recommended use on percentile of standardized math achievement scores.

Results

As previously mentioned, McREL used two analytic approaches to measure the extent to which participation in MBC was associated with changes in performance on a standardized math assessment.

RQ1: OLS Analysis

Results of the first OLS regression model indicated that as the number of sessions increases, average math achievement in the 2022–2023 school year increases. In other words, **as use of MBC increases, math achievement scores increase. This increase is statistically significant.**

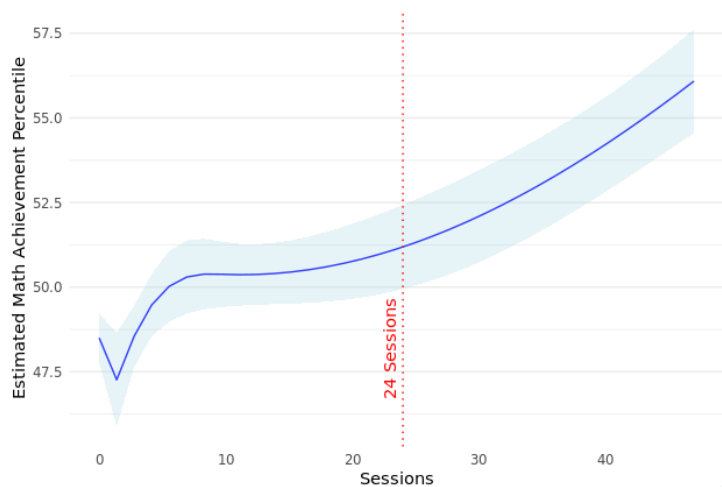


Figure 2. Estimated Percentile of Math Achievement by Sessions.

It is important to note that there is a small decrease in scores at less than five sessions. This may be a result of inconsistent implementation, distracting students from normal instruction, rather than supplementing instruction. Significant gains in math achievement become particularly salient at 30 sessions of Math Basecamp, where increases in math achievement surpass the 52nd percentile of math achievement when compared to students with zero sessions.

RQ2: Propensity-score Matching Analysis

Propensity-score matched regression results indicated that students who complete at least 24 sessions of Math Basecamp, on average, gained a 6.49 percentile advantage over students who did not participate. As shown in Figure 2, the predicted percentile of math achievement for students who completed at least 24 sessions was 54.1, compared to 47.6 for students who did not participate. This predicted score represents the 6.49 percentile-point advantage gained by completing 24+ sessions. The effect size computed for this relationship is 0.22, suggesting a medium significant

effect of Math Basecamp participation on math achievement scores (Kraft 2019). Additional propensity-score matched regression results indicate an even greater gain in math achievement for students who complete at least 30 sessions.² On average, students who complete at least 30 sessions of Math Basecamp gained a 7.46 percentile advantage over students who did not participate (see Figure 2). The effect size for this relationship is 0.28, suggesting a medium significant effect of Math Basecamp participation on math achievement scores (Kraft 2019). **These effects indicate a statistically significant gain in math achievement when the recommended number of sessions are completed.**

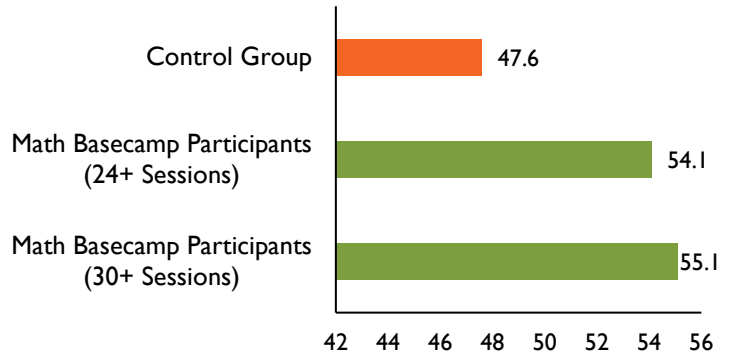


Figure 3. Predicted Percentile of Standardized Student Performance on Smarter Balanced Math Assessments by Treatment Group

Limitations

There are some limitations of this study. This examination relies on usage data collected by the Legends of Learning platform, rather than data directly reported by participating schools. As a result, we do not have insights into the specifics of program implementation at the systems level within each school, including training and support provided to teachers, integration of the program into existing curriculum, and variations in implementation fidelity. Without these data, we cannot be certain there are not additional contextual factors that may influence outcomes observed in this analysis.

² An additional matched sample was created for this analysis. Characteristics of this sample are nearly identical to the first matched sample.

Conclusions

Results of this study indicate an encouraging causal association between Legends of Learning’s Math Basecamp and math achievement. As the number of sessions of Legends of Learning’s Math Basecamp increases, achievement on California’s Smarter Balanced Mathematics assessment increases significantly. Completing at least 24 sessions of Legends of Learning’s Math Basecamp significantly increases student scores on this mathematics assessment.

This study also provides evidence for Legends of Learning’s recommended usage of at least three to five sessions of the game per week for at least two months. Students who complete the recommended number of sessions throughout the school year achieve significantly higher scores on standardized math tests as a result.

Further research is needed to confirm a causal relationship between participation in Math Basecamp and math achievement, which could be done in a Randomized Controlled Trial (RCT) or a robust quasi-experimental design (QED). Expanding future studies to include additional populations and settings, as well as additional analytic approaches can confirm the robustness of these findings and the generalizability of Math Basecamp’s impact.