RESEARCH BRIEF
APRIL 2020

My Math Academy™ Significantly Accelerates Early Elementary Children's Math Skills and Fosters Greater Engagement in Math:

A Replication of a Randomized Control Trial

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Key Findings

- Kindergarteners, first graders, and second graders using My Math Academy made significant learning gains in math, replicating the findings of a randomized control trial on an earlier version of the program.
- Teachers reported that in comparison to other educational technology, My Math Academy had a significantly positive impact on student learning, indicating that students who used My Math Academy were more engaged, motivated, and confident in learning math.
- The more skills students mastered in My Math Academy, the greater the learning gains they experienced.
- Greatest impacts were found where there was more room for growth: (a) among students with lower levels of math knowledge and (b) on the most difficult skills.
- Teachers found My Math Academy easy to use in their classrooms and recognized it as a valuable learning resource for students.

An extensive body of empirical evidence shows that math skills at school entry are the strongest predictor of later academic success and educational attainment,[1,2] but many children lack the opportunity to build the math skills needed for future success. Children who begin school with relatively low levels of math knowledge are at risk of falling behind, and 60% of fourth graders in the U.S. are not proficient in math.[3] As many children enter school unprepared for math,[4] teachers face challenges in appropriately personalizing and individualizing learning for each student in their class.[5] Educational technology can help teachers seeking to provide tailored learning experiences for students, and game-based digital curricula that involve play can promote motivation and learning.[6] To understand the impact of one such program, Age of Learning, Inc.'s, My Math Academy, in developing early elementary children's math skills and replicate a 2017 study on an earlier version of the program, Age of Learning partnered with WestEd to conduct a randomized control trial. For this study, WestEd researchers led the data collection and collaborated with Age of Learning researchers to analyze and interpret the data.

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1 Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., Pagani, L. S., Feinstein, L., Engel, M., Brooks-Gunn, J., Sexton, H., Duckworth, K., & Japel, C. (2007). School readiness and later achievement. Developmental Psychology, 43(6), 1428–46. https://doi.org/10.1037/0012-1649.43.6.1428

2 Entwisle, D. R., Alexander, K. L., & Olson, L. S. (2005). First grade and educational attainment by age 22: A new story. American Journal of Sociology, 110(5), 1458–1502. https://doi.org/10.1086/428444

3 National Assessment of Educational Progress. (2019). NAEP Report Card: Mathematics. The Nation's Report Card. https://www.nationsreportcard.gov/mathematics?grade=4

4 National Research Council. (2009). Mathematics learning in early childhood: Paths toward excellence and equity. Washington DC: The National Academies Press. https://doi.org/10.17226/12519

5 Dixon, F. A., Yssel, N., McConnell, J. M., & Hardin, T. (2014). Differentiated instruction, professional development, and teacher efficacy. Journal for the Education of the Gifted, 37(2), 111–127. https://doi.org/10.1177/0162353214529042; Goddard, Y., Goddard, R., & Kim, M. (2015). School instructional climate and student achievement: An examination of group norms for differentiated instruction. American Journal of Education, 122(1), 111–131. https://doi.org/10.1086/683293

6 Barab, S., Thomas, M., Dodge, T., Carteaux, R., & Tuzun, H. (2005). Making learning fun: Quest Atlantis, a game without guns. Educational Technology Research and Development, 53(1), 86–107. https://doi.org/10.1007/BF02504859

Program Overview

My Math Academy is an adaptive game-based learning program designed to help children build a strong understanding of fundamental number sense and operations. It differs from many other programs in its ability to determine gaps in each child's learning through embedded formative and summative assessments that are fun and organically integrated into gameplay.[7] Through more than 130 game-based activities aligned to learning objectives, My Math Academy covers 96 concepts and skills for prekindergarten through second grade and is supported by an interactive instructional level, as well as several layers of scaffolding and formative feedback.

As a data-driven system, My Math Academy integrates core principles of evidence-centered design,[8] which aligns learning goals with evidence of learning and game mechanics (i.e., balanced design[9]). Each learning activity is built on evidence-based learning progressions. When a student first begins My Math Academy, she takes game-based pretests, her performance on which determines where she is placed within the game. As a student continues her progress in My Math Academy, a Personalized Mastery Learning System™[10] uses assessment data to provide appropriate scaffolding, adjust difficulty, and customize learning pathways. The system uses cohesive narrative and interactive characters to support student engagement with the learning world. A story context fosters engagement and facilitates instruction, as understanding the context of a math problem allows students to make concepts and operations more meaningful and provides a framework for understanding what the student is expected to do and why.[11]

Each game in My Math Academy includes up to six learning activities at various difficulty levels, including a pretest and an in-game mastery check called the "boss" level. Figure 1 is a screenshot of a pretest of a game addressing the "fact families" learning objective, i.e., that addition and subtraction number sentences (facts) can be generated from a number family. Figure 2 is a screenshot of a boss level of the game addressing the same learning objective. In this level, students are asked to help the Adventurer "Shapey" (characters and manipulatives in the game) explore the pyramid of a given number family and make each fact in the family one by one to find keys to discover the artifact room. Students must drag the number tiles to allow Adventurer Shapey to get across the chasm and make the artifacts in the fact family, one by one. After all four keys are collected, Adventurer Shapey unlocks the door to the next room; by the end of the activity, Adventurer Shapey finds the lost artifact.

Data collected as students use the activities fuel in-system adaptive support and/or in-classroom educator intervention via other My Math Academy learning activities or small-group instruction. Teachers have real-time visibility into their students' progress and performance

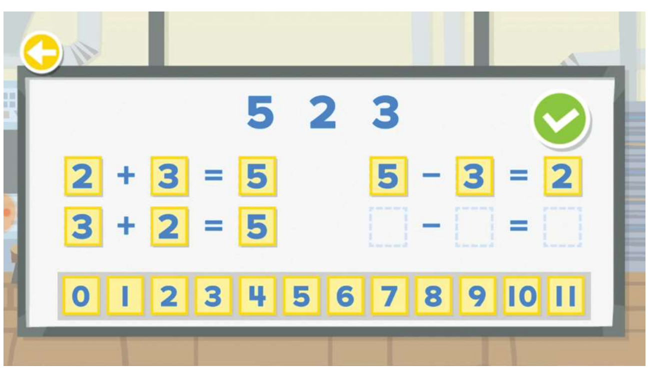

Figure 1. Sample pretest

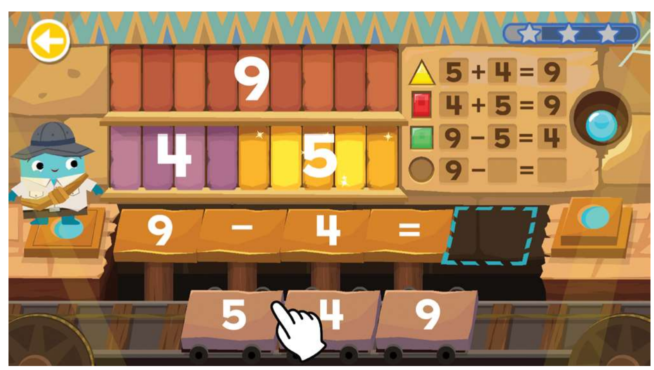

Figure 2. Sample "boss" level

7 Shute, V. J. (2011). Stealth assessment in computer-based games to support learning. In S. Tobias & J. D. Fletcher (Eds.), Computer games and instruction (pp. 503–523). Information Age Publishers.

8 Mislevy, R. J., Almond, R. G., & Lukas, J. F. (2003). A brief introduction to evidence-centered design. Educational Testing Service. https://www.ets.org/Media/Research/pdf/RR-03-16.pdf

9 Learning Games Network, MIT Education Arcade (2015). Better learning in games: A balanced design lens for a new generation of learning games. http://education.mit.edu/wp-content/uploads/2018/10/BalancedDesignGuide2015.pdf

10 Dohring, D., Hendry, D., Gunderia, S., Hughes, D., Owen, V. E., Jacobs, D.E., Betts, A., & Salak, W. (2019). U.S. Patent No. 20190236967 A1. Washington, DC: U.S. Patent and Trademark Office.

11 Sullivan, P., Zevenbergen, R., & Mousley, J. (2003). The contexts of mathematics tasks and the context of the classroom: Are we including all students? Mathematics Education Research Journal, 15(2), 107–121. https://doi.org/10.1007/BF03217373; Betts, A. (2019). Mastery learning of early childhood mathematics through adaptive technologies. In IAFOR (Eds.), The IAFOR International Conference on Education – Hawaii 2019 official conference proceedings (pp. 51–63). The International Academic Forum; Owen, V. E., & Hughes, D. (2019). Bridging two worlds: Principled game-based assessment in industry for playful learning at scale. In Ifenthaler, D., & Kim, Y. J. (Eds.) Game-based assessment revisited (pp. 229–256). Springer.

in My Math Academy through the teacher dashboard, which enables them to gain an overview of the variability of student levels within their class and track individual students' degrees of mastery on specific skills (cf., Learner Variability Project, https://lvp.digitalpromiseglobal.org/).

Participants

A total of 988 students (51% male, 90% Hispanic) in 41 kindergarten, first grade, and combination kindergarten/first and first/second classrooms across 11 high-need elementary schools in two Southern California school districts participated in the study. The 41 classrooms were divided into 16 blocks depending on their grade levels and school locations (two to five classrooms per block), and within each block, the classrooms were randomly assigned to the treatment or the control condition. Five hundred seven students were enrolled in the treatment classrooms, and 481 students were enrolled in the control classrooms. The final analytic sample included all students who completed both the pretest and posttest, which consisted of 886 students, of whom 501 were kindergarteners (57%) and 385 were first graders (43%). There were no statistically significant group differences in baseline performance or attrition.

Design and Procedure

The study took place between February and May 2019. Treatment classrooms had full access to the My Math Academy app and were asked to ensure that each student used the app for at least 60 minutes per week. Control classrooms conducted business-as-usual instruction.

Prior to the study, treatment teachers participated in a two-hour training on using My Math Academy as a supplement to their core math curriculum. All teachers in both conditions completed a survey at the beginning and end of the study in which they reported their previous experiences with implementing new math initiatives and using technology to support their teaching. During the implementation period, treatment teachers participated in a webinar to gain a more in-depth understanding of how to use the teacher dashboard; had one to two visits from Age of Learning staff, who provided support to facilitate program usage; and received weekly usage reports to help ensure that each student met the usage target.

The primary measure of students' mathematics knowledge was an assessment constructed from a repository of high-quality, standards-based items selected from the Certica assessment item bank. The assessment was administered on an electronic platform managed by one of Certica's partners, LinkIt! (https://www1.linkit.com/). The assessment items targeted specific learning objectives students are expected to achieve while using My Math Academy. All assessment items were aligned to the California Common Core State Standards for kindergarten, first, or second grade. A factor analysis conducted on the pretest and posttest scores showed that there is one dominant factor (math knowledge) in each assessment. The reliability coefficient, a measure of the assessment's degree of internal consistency, was 0.89 for pretest and 0.90 for posttest, indicating that the items on each assessment collectively are a good measure of the same underlying construct.

Trained assessors who were not informed of students' condition assignment facilitated the assessment administration in small groups (five to six students). The pretest included 31 multiple-choice items. The posttest included seven additional items targeting second grade standards, as observational visits in May indicated that many students had progressed within My Math Academy well into second grade curriculum.

Treatment students spent 14.79 hours on average (SD = 5.05 hours)—between 74 and 81 minutes per week—on My Math Academy, completing 163 Learning Activities on average (SD = 67.12). Overall, students mastered on average 61 skills (SD = 21.4 skills), and 68 students (15%) completed the entire game, demonstrating mastery on all 96 skills in the program. Among kindergarteners, 40.4% mastered at least 80% of grade-level skills, and 54.2% mastered at least 50% of first grade skills. Among first graders, 55.3% mastered at least 80% of grade-level skills, and 42.5% mastered at least 80% of second grade skills.

Results

To examine the impact of My Math Academy on student outcomes, we used a two-level hierarchical linear model (HLM) that accounts for the nested structure of the data—students nested within classrooms. We also took into account differences in students' pretest scores and their demographic characteristics (grade level, gender, ethnicity, free or reduced-price lunch status).

Finding 1. Students using My Math Academy made significant learning gains in their math skills, replicating the results of a randomized control trial on an earlier version of the program.

My Math Academy produced significantly higher gains in children's mathematics knowledge and skills than business-as-usual instruction. The treatment group outperformed the control group by 2.18 percentage points at posttest, and this difference was statistically significant after controlling for differences in pretest ($p < .05$; effect size = 0.11, see Table 1). Figure 3 displays the percent gain experienced between pretest and posttest by experimental condition. This is a moderate effect size, noteworthy for a program that was used as a supplementary curriculum for only 11 to 12 weeks, and the control group teachers were also using a number of digital math programs, some of which have features similar to My Math Academy.[12] Further analyses[13] to test the validity of our finding indicated that a substantial proportion (22.3%) of the estimated effect of the My Math Academy program on students' performance would have to be due to bias to invalidate the inference of the program's effect on math performance, indicating the practical significance of the effect size.[14]

Table 1. Baseline and Impact Analysis of Student Outcome Measures

	Adjusted Mean Percent Correct		Adjusted Mean Percent Difference[b] (T-C)	*P-Value*	*Effect Size*
	Treatment[a]	Control[a]			
Pretest % Correct	49.66	49.96	-0.3	0.8	0.01[c]
Posttest % Correct	54.46	52.28	2.18	0.02	0.11[d]

a Treatment n =452, Control n = 434.
b No statistically significant difference between groups was observed at baseline.
c Effect size was calculated by dividing the adjusted mean percent difference by the full sample unadjusted standard deviation of the pretest.
d Effect size was calculated by dividing impact estimate by the full sample unadjusted standard deviation of the outcome variable. The impact was significant at p < .05.

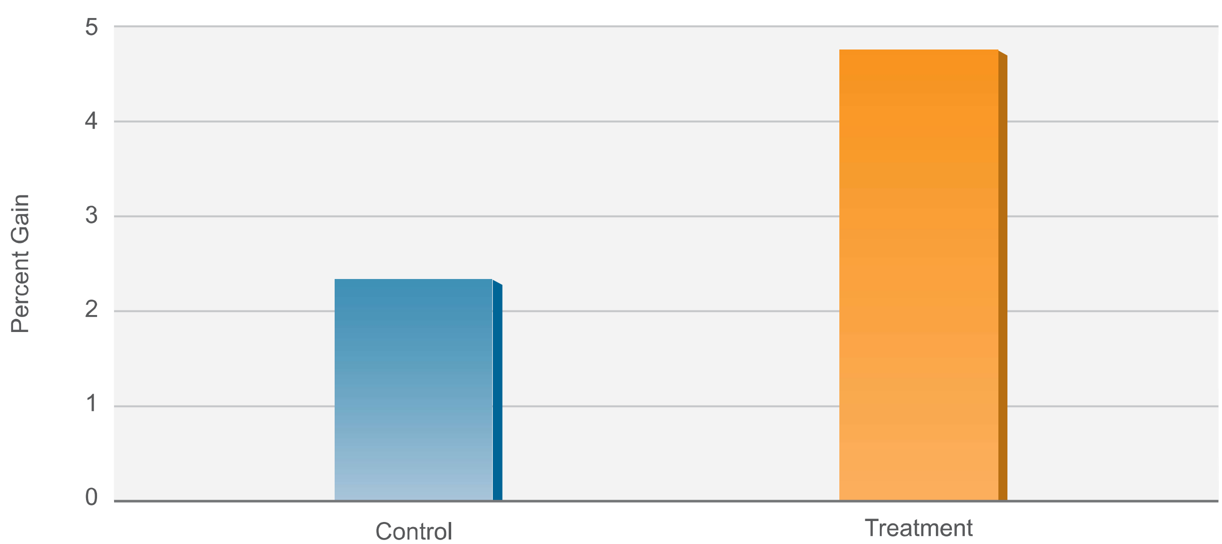

Figure 3. Average percent gain in math scores for treatment (n = 452) and control group students (n = 434); $p < .05$, effect size = 0.11.

12 Kraft, M.A. (2018). Interpreting Effect Sizes of Education Interventions. *Brown University Working Paper*; 17 of 20 control group teachers reported using one or more instructional software programs to teach math during the study period (e.g., Starfall, ST Math, My Math). Additionally, even though treatment teachers were requested to use only My Math Academy in their math instruction, 17 of the 21 teachers used at least one other instructional software program.

13 Frank, K. A., Maroulis, S. J., Duong, M. Q., & Kelcey, B. M. (2013). What would it take to change an inference? Using Rubin's causal model to interpret the robustness of causal inferences. Educational Evaluation and Policy Analysis, 35(4), 437–460. https://doi.org/10.3102/0162373713493129

14 The effect size of .11 is also comparable to or better than most other elementary math interventions incorporating technology (cf. Pellegrini, M., Lake, C., Inns, A., Slavin, R. (2018). Effective programs in elementary mathematics: A best-evidence synthesis. Retrieved from http://www.bestevidence.org/word/elem_math_Oct_8_2018.pdf.)

Finding 2. Teachers reported that in comparison to other educational technology, My Math Academy had a significantly positive impact on student learning, indicating that students who used My Math Academy were more engaged, motivated, and confident in learning math.

My Math Academy's impact on students' learning and engagement was further highlighted in analyses of survey, interview, and observation data. On post-implementation surveys, teachers indicated the extent to which the educational technology they used had a positive impact on their students' math skills. As shown in Figure 4, teachers reported that in comparison to other educational technology used in control classrooms, My Math Academy had a significantly positive impact on students' math skills, as well as on their interest and self-confidence in learning math.

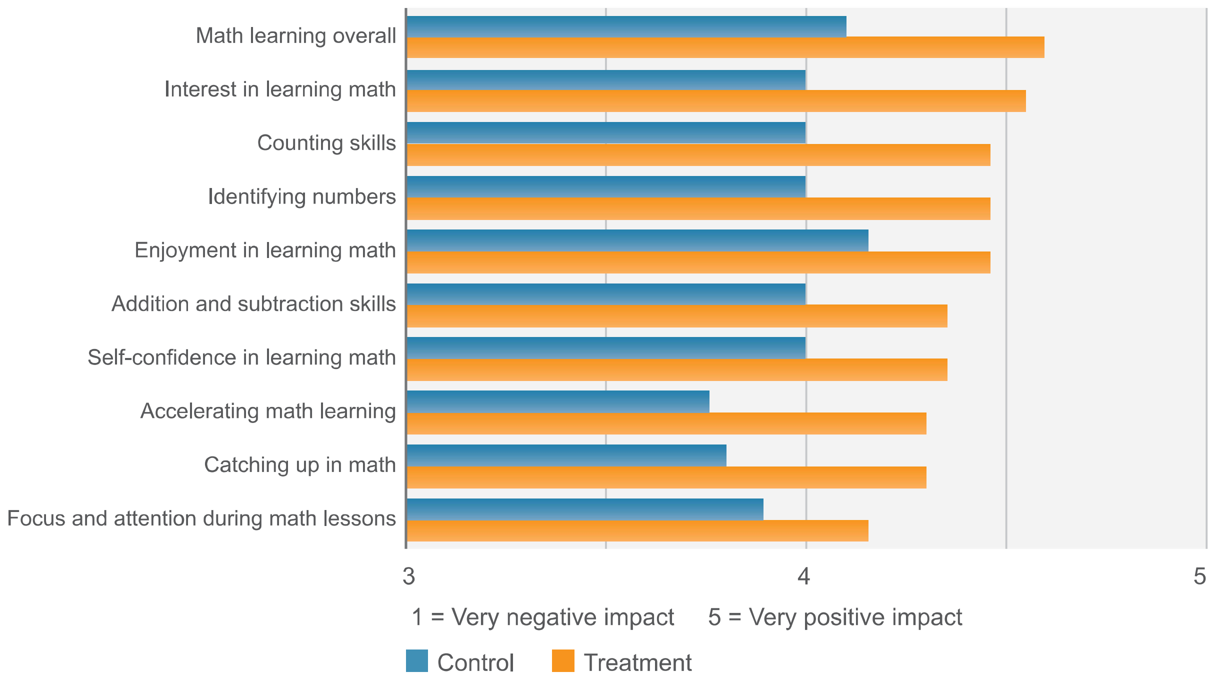

Figure 4. Average teacher survey ratings on the impact of educational technology on their students' math learning skills (treatment $n = 20$, control $n = 20$), listed in order of the magnitude of the difference between the two groups' average ratings, with exception of "Math learning overall." All differences between treatment and control group averages are statistically significant ($p < .05$) except Enjoyment in learning math ($p < .10$) and Focus and attention during math ($p = .26$). Effect sizes range from Cohen's $d = 0.6$ to 1.05).

Additionally, all eight interviewed teachers described how engaged their students were while using My Math Academy. Their positive perception of My Math Academy was attributed to the program's ability to provide personalized instruction for each student and the way in which it helped motivate students when facing new, challenging concepts.

"[When on My Math Academy] I can hear them singing, I can hear them counting, I can hear them really engaging in whatever it is that they're doing. I don't think I've had anybody who gets tired or gets bored of the program yet. We've been using it for a while . . . I hear a lot of conversations with each other. . . . They're having these awesome conversations about their math experiences."

"I have a kindergartener in my class who is very advanced, and . . . I love it that [My Math Academy] is giving him more than what I can give him in the classroom setting. And then I also have people who are working below grade level, and I feel it's going in and helping them fill in those gaps [with] number ordering, double digits, [and] stuff they didn't catch towards the beginning of the year . . ."

Treatment teachers also found My Math Academy easy to use in their classrooms and recognized it as a valuable learning resource.

Among treatment group teachers

- One hundred percent of teachers surveyed reported that their students, as well as they themselves, enjoyed using My Math Academy.
- One hundred percent of teachers observed an increase in students' interest in learning math and reported that they want to continue using My Math Academy in their classrooms.
- Ninety-five percent of teachers recognized My Math Academy as a valuable math learning resource that was very easy to use and user-friendly for their students.

Finding 3. The more skills students mastered in My Math Academy, the greater their learning gains.

To determine whether progress within My Math Academy was related to growth in math skills as measured by the assessment, we examined the relationship between the number of skills mastered in the program and students' performance on the posttest. The correlation between post-assessment test score and cumulative number of skills mastered on My Math Academy was strong at $r = 0.73$ (see Figure 5 below).

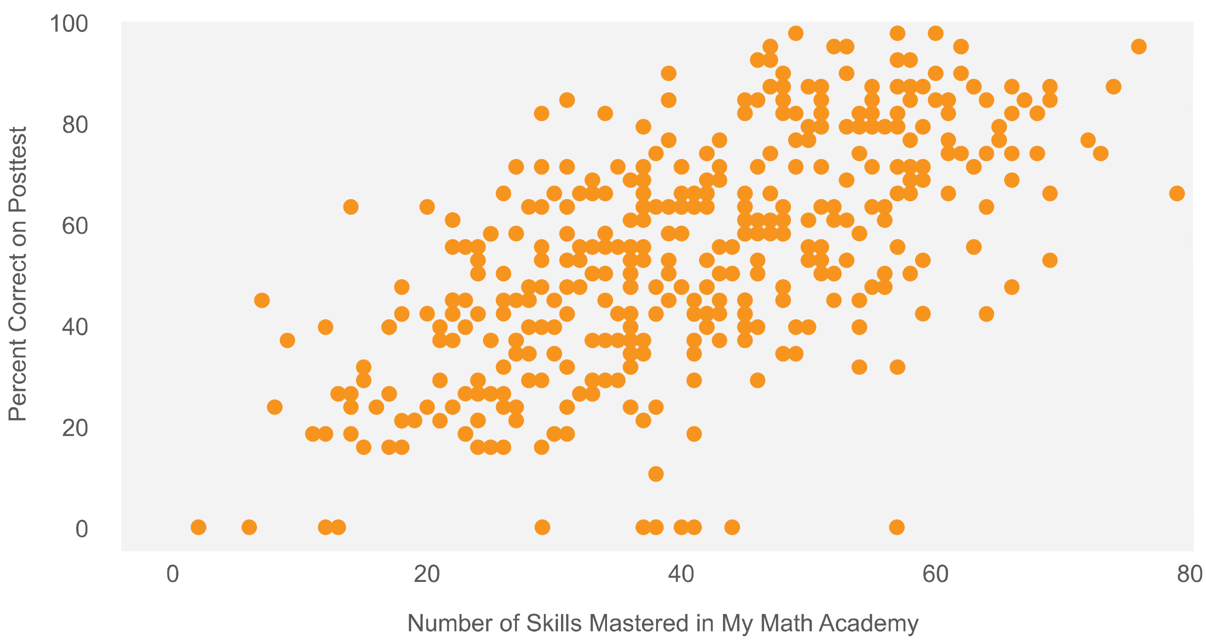

Figure 5. Examination of the correlational relationship between the number of skills students mastered in My Math Academy and their performance on the posttest ($n = 452$, $r = .73$, $p < .001$).

Finding 4. Greatest impacts were found where there was more room for growth: (a) among students with lower levels of math knowledge and (b) on the most difficult skills.

My Math Academy produced significantly greater learning gains in kindergarten students (treatment n = 249, control n = 252, 20.14 vs. 19.23 points, p = 0.01, effect size = 0.16). For first grade and second grade combined, the difference between the treatment and control groups is not statistically significant (treatment n = 203, control n = 182, 21.37 vs. 20.80, p = 0.36, effect size = 0.09). This finding indicates that the program benefited the students in kindergarten more than those in higher grades.[15]

Among the skills addressed in the assessment, My Math Academy had the greatest impact on the most difficult skills—the ones addressed in the additional items added to the posttest after observations that revealed many kindergartners accessing second grade-level games (see Figure 6). On the posttest, 34% of treatment versus 22% of control group students were able to use an algorithm to subtract without regrouping (X^2 [1, N = 886] = 17.49, p < .001); 50% of treatment versus 42% of control group students could create fact families using numbers between 1 and 18 (X^2 [1, N = 886] = 6.45, p < .05); 31% versus 23% of control group students could add three-digit numbers with regrouping in ones and tens places (X^2 [1, N = 886] = 6.73, p < .01); 27% of treatment versus 19% of control students could use an algorithm to add without regrouping (X^2 [1, N = 886] = 6.91, p < .01); and 29% of treatment versus 21% of control students could represent three-digit numbers using base-ten blocks (X^2 [1, N = 886] = 6.37, p < .05).

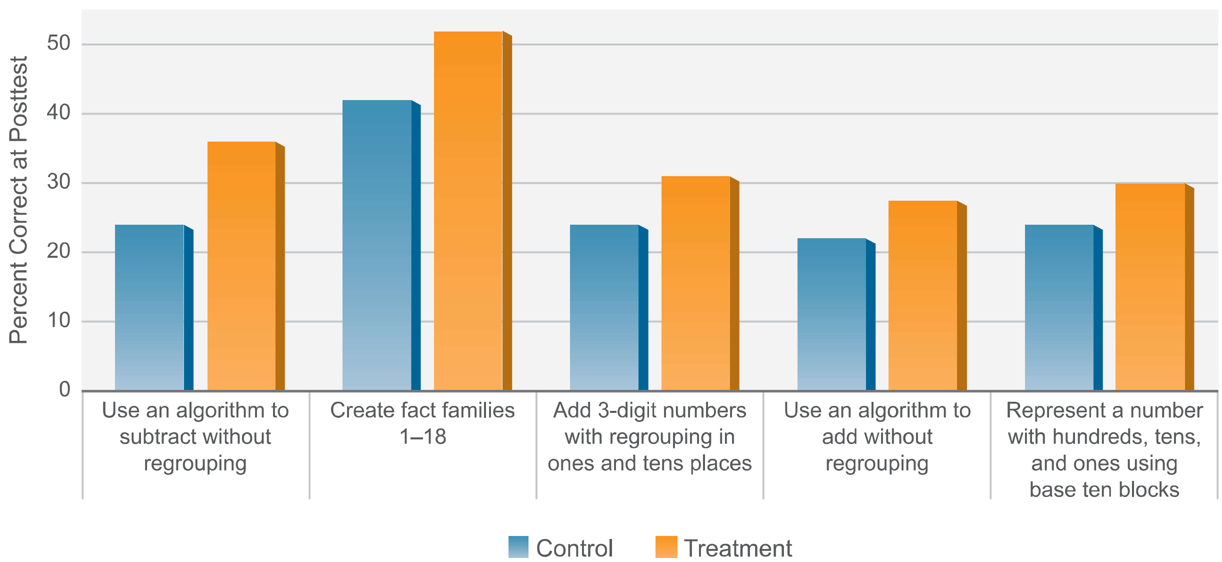

Figure 6. Percent correct on the most difficult assessment items at posttest for treatment (n = 452) and control (n = 434) students.

Conclusion

The results of this study replicate and extend upon those of an efficacy study conducted in 2017, which demonstrated the positive impacts of My Math Academy with pre-k and kindergarten classrooms over a period of 12 to 14 weeks.[16] Unlike the 2017 study, the My Math Academy version in this study included additional games that cover first and second grade content. This study's results showed that My Math Academy users had better mastery of second-grade-level content than the control group, suggesting that the benefit of My Math Academy can extend beyond kindergarten. Furthermore, teachers' positive perception of My Math Academy in this study was partly attributed to the user-friendliness of the program and students' increased engagement in learning math. The corroboration and elaboration of findings from the earlier study strengthens the evidence supporting the efficacy of My Math Academy in promoting math learning in young learners and the feasibility of using the program with ease in classroom settings.

15 This analysis was based on the sample with non-missing posttest (n = 922, treatment n = 465, control n = 457)

16 Thai, K. P., Li, L., & Schachner, A. (2018). My Math Academy™ significantly accelerates early mathematics learning. Age of Learning Research Brief. Retrieved from: https://www.ageoflearning.com/case_studies/MMA-Research-Brief_2018_UPDATE_06.pdf.