

LONG-TERM EFFECTS OF ENHANCED EARLY CHILDHOOD MATH INSTRUCTION

Executive Summary

The Impacts of Making Pre-K Count and High 5s on Third-Grade Outcomes



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BUILDING KNOWLEDGE
TO IMPROVE SOCIAL POLICY

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Overview

Studies have shown that math skills in early childhood are uniquely and strongly predictive of later outcomes across a range of domains and well into adulthood, including the likelihood of graduating from high school and college completion. The Making Pre-K Count and High 5s studies were designed to rigorously test the short- and long-term effects of improving children’s math experiences in prekindergarten (pre-K) and kindergarten.

Making Pre-K Count provided pre-K teachers in New York City with a high-quality, evidenced-based math curriculum (Building Blocks) and ongoing teacher training and coaching. The Making Pre-K Count study compared students who were exposed to this curriculum with their peers in pre-K as usual in public school and community-based sites. The High 5s math program was developed to offer children who had received Making Pre-K Count in pre-K in public schools hands-on, supplemental math enrichment in small groups, or clubs, outside of regular instructional time in kindergarten. The High 5s study compared students assigned to Making Pre-K Count in pre-K and High 5s in kindergarten with children assigned to Making Pre-K Count in pre-K and kindergarten as usual. The studies also compared two years of math enrichment with no math enrichment.

The studies used random assignment and tracked children through third grade to test the effects of these math enrichment programs. The confirmatory outcome examined was children’s third-grade math scores.

KEY FINDINGS

- **Making Pre-K Count:** Though not statistically significant, Making Pre-K Count had small, positive, longer-term impacts on children’s third-grade math test scores, compared with pre-K as usual in public school and community-based sites.
- **High 5s:** The impact of High 5s on children’s third-grade math test scores in public schools, over and above the effect of Making Pre-K Count alone, was close to zero and not statistically significant.
- **Making Pre-K Count plus High 5s:** Making Pre-K Count and High 5s together had moderate, statistically significant impacts on children’s math test scores, compared with pre-K and kindergarten as usual in public schools.

The study team also explored the impact of these two math interventions on children’s third-grade literacy test scores, chronic absenteeism, retention in a grade, and placement in special education. These exploratory analyses suggest that Making Pre-K Count alone and the two years of math enrichment together reduced chronic absenteeism and improved children’s literacy test scores, though findings were not always statistically significant for literacy test scores.

Taken together, the Making Pre-K Count and High 5s studies present new evidence about the long-term effects of early math interventions on children’s later outcomes. Early math enrichment experiences can lead to lasting gains for children across a variety of outcome domains, even years later. The findings suggest that high-quality early math instructional practices could make a difference, particularly for children with the greatest need.

Acknowledgments

The Making Pre-K Count and High 5s studies were a 10-year endeavor, supported by many contributors and collaborators over the years. First and foremost, we thank the children, families, teachers, and administrators who gave so generously of their time and cooperation, and without whom the study would not have been possible.

High 5s and Making Pre-K Count benefited greatly from the support of the coaches, facilitators, and supervisors at Bank Street College, and particularly our ongoing partnership with Katherine Baldwin. We also thank the current and former leadership at the New York City Department of Education's Division of Early Childhood Education and the Division of Child Care and Head Start at the Administration for Children's Services, who have continued to work with us throughout the study. We also appreciate the dedication of and thoughtful consultation with the developers of Building Blocks, Drs. Doug Clements and Julie Sarama, as well as Anna Erickson and Kristi Hanby at the University of Michigan, who helped conceptualize the High 5s intervention and training.

The execution of these studies was made possible by our research partners at RTI International, including Jean Lennon and Jennifer Keeney and the many dedicated data collectors, and by James Kemple at the Research Alliance for New York City Schools. We also extend our appreciation to the steering committees for Making Pre-K Count and High 5s and our academic partners Greg Duncan of the University of California-Irvine and Dale Farran of Vanderbilt University.

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The Authors

Executive Summary

Studies have found that math skills in early childhood are uniquely and strongly associated with outcomes later in life. Strong early math skills are correlated with not only later math achievement, but also with better reading skills and executive functioning.¹ Further, studies have shown that early math competencies predict outcomes well into adulthood, including the likelihood of graduating from high school and college completion.² The Making Pre-K Count and High 5s studies were designed to test the impact of early math enrichment interventions on children’s short- and longer-term outcomes.

The Making Pre-K Count study was designed to rigorously assess the short- and long-term effects of improving children’s math experiences in prekindergarten (pre-K). Making Pre-K Count operated in community-based and public school pre-K classrooms in New York City that served mostly children from families with low incomes. Making Pre-K Count provided teachers with a high-quality math curriculum (Building Blocks) and ongoing teacher training and coaching.³ In the Making Pre-K Count study, whole pre-K sites—community-based organizations and public schools—were randomly assigned to receive either the evidence-based math curriculum plus coaching and training (n = 35) or continue with pre-K-as-usual (n = 34). During the time when the program was implemented, there was a growing emphasis on early math instruction in all New York City schools.⁴ Children in the control group therefore received more math instruction than had previously been typical in prior studies of early math education programs.⁵

The High 5s program was developed to offer supplemental math enrichment outside of regular instructional time to kindergarten children who had received Making Pre-K Count in pre-K. High 5s grouped three to four children with one facilitator for math clubs that met three times a week for 30 minutes each session, outside of regular classroom instruction. Children who were in public schools that implemented Making Pre-K Count and stayed in the same public school were eligible for High 5s. In those Making Pre-K Count program public schools, individual children were randomly assigned within a school to either two years of math enrichment (Making Pre-K Count in pre-K plus

¹Greg J. Duncan, Chantelle J. Dowsett, Amy Claessens, Katherine Magnuson, Aletha C. Huston, Pamela Klebanov, Linda S. Pagani, Leon Feinstein, Mimi Engel, and Jeanne Brooks-Gunn, “School Readiness and Later Achievement,” *Developmental Psychology* 43, 6 (2007): 1,428–1,446; Douglas H. Clements, Julie Sarama, and Carrie Germeroth, “Learning Executive Function and Early Mathematics: Directions of Casual Relations,” *Early Childhood Research Quarterly* 36 (2016): 79–90.

²Greg J. Duncan and Katherine Magnuson, “Investing in Preschool Programs,” *The Journal of Economic Perspectives* 27, 2 (2013): 109–132; Greg J. Duncan and Katherine Magnuson, “The Nature and Impact of Early Achievement Skills, Attention Skills, and Behavior Problems,” pages 47–69 in Greg J. Duncan and Richard J. Murnane (eds.), *Whither Opportunity: Rising Inequality, Schools, and Children’s Life Chances* (New York: Russell Sage, 2011).

³Douglas H. Clements and Julie Sarama, *Building Blocks: Teacher’s Edition* (Columbus, OH: McGraw-Hill Companies, Inc., 2013)

⁴Pamela A. Morris, Shira K. Mattera, and Michelle F. Maier, *Making Pre-K Count: Improving Math Instruction in New York City* (New York: MDRC, 2016).

⁵Julie Sarama, Douglas H. Clements, Prentice Starkey, Alice Klein, and Ann Wakeley, “Scaling Up the Implementation of a Pre-Kindergarten Mathematics Curriculum: Teaching for Understanding with Trajectories and Technologies,” *Journal of Research on Educational Effectiveness* 1, 2 (2008): 89–119; Douglas H. Clements, Julie Sarama, Mary Elaine Spitler, Alissa A. Lange, and Christopher B. Wolfe, “Mathematics Learned by Young Children in an Intervention Based on Learning Trajectories: A Large-Scale Cluster Randomized Trial,” *Journal for Research in Mathematics Education* 42, 2 (2011): 127–166.

High 5s in kindergarten, n = 320) or one year of math enrichment (Making Pre-K Count in pre-K and kindergarten as usual, n = 335).

The studies were developed as part of the Robin Hood Early Childhood Research Initiative, which was established to identify and rigorously test promising early childhood interventions. The initiative is a partnership between Robin Hood, one of New York City's leading antipoverty organizations, and MDRC, a nonprofit, nonpartisan education and social policy research organization. Its flagship projects, Making Pre-K Count and High 5s, were conducted in collaboration with Bank Street College of Education and RTI International and supported with lead funding from the Heising-Simons Foundation, the Overdeck Family Foundation, and the Richard W. Goldman Family Foundation. This report is the fifth report based on these studies.

A key feature of the Making Pre-K Count and High 5s studies was a focus on developing the math competencies of children enrolled in pre-K as a pathway to improving a broader set of children's outcomes into elementary school. Third grade is considered a particularly important moment in a child's educational experience. Literacy skill levels in third grade predict rates of high school completion.⁶ While third grade may be a critical time for ensuring children's future success, few studies have tracked the effects of pre-K programs in the longer term, and the evidence on whether gains from pre-K interventions are sustained into early elementary school and beyond from those that have is mixed.⁷

The design of the Making Pre-K Count and High 5s studies makes it possible to rigorously assess the impact on children's outcomes from one year of math enrichment in pre-K (Making Pre-K Count compared with pre-K as usual), an additional year of math enrichment in kindergarten (Making Pre-K Count plus High 5s in kindergarten compared with Making Pre-K Count only), and two years of math enrichment (Making Pre-K Count plus High 5s in kindergarten compared with pre-K and kindergarten as usual). The samples of sites and children used in these analyses do not perfectly overlap, therefore the findings cannot be directly compared with one another. However, considered together, these analyses provide useful insights about the longer-term effects of early math enrichment interventions.

Earlier reports on these studies examined the effects of math enrichment at the end of pre-K and at the end of kindergarten.⁸ The pre-K math program had small but not statistically significant effects on children's math skills by the end of kindergarten, and statistically significant effects on children's

⁶Duncan and Magnuson (2011); Catherine E. Snow, Susan M. Burns, and Peg Griffin, *Preventing Reading Difficulties in Young Children* (Washington, DC: National Academy Press, 1998); Donald J. Hernandez, *Double Jeopardy: How Third-Grade Reading Skills and Poverty Influence High School Graduation* (Baltimore, MD: Annie E. Casey Foundation, 2011).

⁷Janet Currie and Duncan Thomas, "Does Head Start Make a Difference?" *The American Economic Review* 85, 3 (1995): 341–364; Eliana Garces, Duncan Thomas, and Janet Currie, "Longer-Term Effects of Head Start," *The American Economic Review* 92, 4 (2002): 999–1,012; James J. Heckman, Jora Stixrud, and Sergio Urzua, "The Effects of Cognitive and Non-cognitive Abilities on Labor Market Outcomes and Social Behavior," *Journal of Labor Economics* 24, 3 (2006): 411–482; Jens Ludwig and Douglas L. Miller, "Does Head Start Improve Children's Life Chances? Evidence from a Regression Discontinuity Design," *The Quarterly Journal of Economics* 122, 1 (2007): 159–208; David Deming, "Early Childhood Intervention and Life-Cycle Skill Development: Evidence from Head Start," *American Economic Journal: Applied Economics* 1, 3 (2009): 111–134; Lawrence J. Schweinhart, "Long-Term Follow-Up of a Preschool Experiment," *Journal of Experimental Criminology* 9, 4 (2013): 389–409.

⁸Morris, Mattera, and Maier (2016); Shira K. Mattera, Robin Jacob, and Pamela A. Morris, *Strengthening Children's Math Skills with Enhanced Instruction: The Impacts of Making Pre-K Count and High 5s on Kindergarten Outcomes* (New York: MDRC, 2018);

math attitudes and working memory. The kindergarten math clubs had positive effects equivalent to an additional 2.5 months of math learning on one of two math measures at the end of kindergarten. The two programs jointly had a positive effect on one of two measures of children's math skills by the end of kindergarten, equivalent to over four months of additional math learning.

The current report presents the longer-term impacts on third-grade outcomes. The confirmatory outcome for these studies is children's third-grade math scores, since math skills are the direct target of the Making Pre-K Count and High 5s programs. The key confirmatory findings at the end of third grade are the following:

- **One year of math enrichment in pre-K:** Though not statistically significant, Making Pre-K Count had a small, positive, longer-term impact on children's third-grade math test scores ($ES = 0.10$), compared with pre-K as usual in control sites.
- **An additional year of math enrichment in kindergarten:** The impact of High 5s on children's third-grade math test scores in public schools, over and above the effect of Making Pre-K Count alone, was close to zero and not statistically significant ($ES = 0.02$).
- **Two years of math enrichment (pre-K and kindergarten):** Making Pre-K Count and High 5s together had moderate, statistically significant impacts on children's math test scores, compared with pre-K and kindergarten as usual in public schools ($ES = 0.34$).

The finding that two years of math enrichment (Making Pre-K Count plus High 5s) had moderate effects seems counter-intuitive given the small effects of each of the two interventions separately. This pattern of results is likely due to differences among the samples of children used in each analysis. Exploratory subgroup analyses suggest that early math enrichment may have been particularly beneficial for children with the most room to grow. Making Pre-K Count's impacts on third-grade math scores were fairly large—ranging from one-quarter to over a third of a standard deviation—for those children entering pre-K with the weakest language and attention skills. It appears that children with the lowest scores on the third-grade tests were more prevalent in the sample used to estimate the impact of two years of early math enrichment, and this difference may have contributed to the larger impacts observed in the sample.

The Making Pre-K Count and High 5s studies were also designed to test whether early math enrichment could have effects on outcomes beyond math skills. These outcomes are not the explicit focus of the programs, and empirical evidence that early math programming can have an impact on these outcomes is more limited.

Exploration of these outcomes suggest that Making Pre-K Count alone and when supplemented with High 5s may reduce chronic absenteeism and improve children's literacy test scores in third grade, though the findings are not always statistically significant. Making Pre-K Count alone, and when combined with an additional year of early math enrichment, led to a statistically significant reduction in children's chronic absenteeism in third grade, equivalent to about 9 percentage points or 28 percent. The effects of the programs on children's third-grade literacy test scores were similar in magnitude to the effects on third-grade math scores. None of the early math enrichment programs had an effect, positive or negative, on children's retention in a grade or placement in special education.

IMPLICATIONS

The Making Pre-K Count and High 5s studies rigorously tested the potential of early math enrichment interventions to both improve children’s short-term outcomes and sustain these effects into elementary school.

- **These findings contribute to growing evidence about the longer-term importance of high-quality early math instruction for children, particularly those with the most room to grow.**

Correlational studies have suggested that early math skills could be a powerful lever for improving children’s later skills, in math and in other domains. These studies hypothesize that early math learning may help children develop other skills, such as language skills and executive functioning, which may set the stage for effects on a wider range of longer-term outcomes. However, few studies have examined the long-term effects of enriched early math instruction to see whether or not the gains are sustained into elementary school.

The Making Pre-K Count and High 5s studies were designed not only to test the effects of the programs on math skills, but also to test whether early math programs could affect outcomes in other domains as well. The Making Pre-K Count and High 5s studies add to the base of evidence by demonstrating that enriched early math instruction has the potential to improve children’s skills, both in math and other domains, and to sustain those improvements for at least four years.

Prior findings indicate that Making Pre-K Count had small, positive effects on outcomes in pre-K and kindergarten across multiple domains, including math skills, executive functioning, and children’s attitudes toward math. This report finds that the effects of Making Pre-K Count were sustained into third grade, with small effects on children’s math and literacy scores and favorable effects on chronic absenteeism. The effects of Making Pre-K Count on math test scores are comparable to those of other similar curricula implemented at scale and translate to approximately 12 percent of the achievement gap in fourth grade between low-income children and their high-income peers.⁹ When children received two years of early math enrichment, the effects on tests are equivalent to approximately 40 percent of the achievement gap in fourth grade between low-income children and their high-income peers.

⁹Long-term effects from other interventions implemented at scale range from effects of 0.28 on third-grade literacy test scores from a social-emotional learning intervention to effects of 0.26 on fifth-grade math skills in a study of Building Blocks. Meghan P. McCormick, Robin Neuhaus, Erin E. O’Connor, Hope I. White, E. Parham Horn, Samantha Harding, Elise Cappella, and Sandee McClowry, “Long-Term Effects of Social-Emotional Learning on Academic Skills: Evidence from a Randomized Trial of INSIGHTS,” *Journal of Research on Educational Effectiveness* 14, 1 (2021): 1–27; Tyler W. Watts, Greg J. Duncan, Douglas H. Clements, and Julie Sarama, “What Is the Long-Run Impact of Learning Mathematics During Preschool?” *Child Development* 89, 2 (2018): 539–555. Effect sizes in this study are standardized measures of the difference in outcomes at the end of third grade for the control and program groups. To contextualize these impacts, effect sizes are compared with other available standardized data on the difference in achievement between children who are eligible for free or reduced price lunch and those who are not eligible. Using National Assessment of Educational Progress data from 2,000 for children at the end of fourth grade, the achievement gap between those eligible for free or reduced price lunch and those not eligible was equivalent to 0.85 standardized units. Carolyn J. Hill, Howard S. Bloom, Alison Rebeck Black, and Mark W. Lipsey, “Empirical Benchmarks for Interpreting Effect Sizes in Research,” *Child Development Perspectives* 2, 3 (2008): 172–177. The effect of Making Pre-K Count on third-grade math scores (0.10) is equivalent to 12 percent of that difference.

The effects on chronic absenteeism are substantively meaningful. Rates of chronic absenteeism were approximately 33 percent among third-graders in the control group and 24 percent in the program group. Reducing absenteeism by 9 percentage points for third-graders citywide in New York City could lead to over 7,000 fewer chronically absent third-graders per year.¹⁰ Chronic absenteeism is associated with lower achievement in reading and math and poor socioemotional outcomes, even after controlling for a wide range of background characteristics.¹¹

The pattern of long-term effects, which suggests that impacts were largest for those with the most room to grow, supports the “academic risk hypothesis,” which posits that effects of early childhood education may be the largest for children who need the most support.¹²

- **Well-designed math enrichment programs can have an effect even when layered on top of existing math instruction.**

The Making Pre-K Count program compared students who were exposed to a well-implemented, evidence-based early math enrichment program with their peers in other New York City pre-K programs. All students in the sample attended pre-K. During the time in which the program was implemented, there was a growing emphasis on early math instruction in New York City schools, and even children in the control group received more math instruction than had been typical in previous studies of early math enrichment interventions.¹³ Thus, these long-term impacts reflect the added value of implementing high-quality math instruction in pre-K, above and beyond the impact of pre-K itself and of typical pre-K math instruction.

The Making Pre-K Count and High 5s studies contribute new evidence about the effects of early math enrichment experiences on children’s later outcomes. Such experiences can lead to lasting gains for children, particularly for children with the greatest need.

¹⁰New York City had 78,141 third-graders in 2019-2020. New York State Education Department, “NYC Public Schools at a Glance 2019-20” (2020), website: www.data.nysed.gov/profile.php?instid=7889678368. An analysis by New York University estimated that 22.8 percent of students were chronically absent in 2018. Research Alliance for New York City Schools, “How Has Attendance in NYC Schools Changed Over Time?” (2019), website: www.steinhardt.nyu.edu/research-alliance/research/spotlight-nyc-schools/how-has-attendance-nyc-schools-changed-over-time. According to those numbers, an estimated 17,816 third-graders would be chronically absent. After a reduction of chronic absenteeism by 9 percentage points, an estimated 10,784 third-graders would be chronically absent.

¹¹Maria José Romero and Young-Sun Lee, *A National Portrait of Chronic Absenteeism in the Early Grades* (New York: National Center for Children in Poverty, 2007); Michael A. Gottfried, “Chronic Absenteeism and Its Effects on Students’ Academic and Socioemotional Outcomes,” *Journal of Education for Students Placed at Risk* 19, 2 (2014): 53–75.

¹²Bridget K. Hamre and Robert C. Pianta, “Can Instructional and Emotional Support in the First-Grade Classroom Make a Difference for Children at Risk of School Failure?” *Child Development* 76, 5 (2005): 949–967; Bridget K. Hamre and Robert C. Pianta, “Early Teacher-Child Relationships and the Trajectory of Children’s School Outcomes through Eighth Grade” *Child Development* 72, 2 (2001): 625–638.

¹³Morris, Mattera, and Maier (2016); Sarama et al. (2008); Clements et al. (2011).

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