FEBRUARY 2017

SHIRA MATTERA
PAMELA MORRIS

COUNTING ON EARLY MATH SKILLS

Preliminary Kindergarten Impacts of the Making Pre-K Count and High 5s Programs

Early math ability is one of the best predictors of children's math and reading skills into late elementary school.[1] Children with stronger math proficiency in elementary school, in turn, are more likely to graduate from high school and attend college.[2] However, early math skills have not historically been a major focus of instruction in preschool and kindergarten classrooms.[3] This brief presents the findings from a study of two early math programs — Making Pre-K Count and High 5s.

The Making Pre-K Count and High 5s studies test two math programs to examine whether it is possible to improve children's early math abilities, and whether improvements in this "linchpin" outcome lead to impacts on children's other short- and longer-term outcomes. The current analysis examines the cumulative effects of both programs on children's math, language, and executive function skills in kindergarten.[4] The Making Pre-K Count program entailed a comprehensive redesign of both the content and teaching of math in the prekindergarten (pre-K) classroom, and the High 5s program provided a second year of math enrichment for a

1 Duncan et al. (2007).

2 Duncan and Magnuson (2009).

3 Ginsburg, Lee, and Boyd (2008); Lobman, Ryan, and McLaughlin (2005).

4 Executive function refers to a set of skills that underlie children's self-regulation, potentially making it easier to attend to the learning tasks of school.

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BOX 1

TWO EARLY MATH PROGRAMS: THE COMPONENTS OF MAKING PRE-K COUNT AND HIGH 5s

Making Pre-K Count focused on children's experiences in pre-K classrooms. It consisted of the following:

- *Building Blocks*, a 30-week, evidence-based math curriculum designed by Drs. Doug Clements and Julie Sarama to take into account children's natural developmental progression in math skills. Building Blocks includes four main components:
    1. Weekly whole-group math lessons
    2. Hands-on math materials for children to use in play centers
    3. Small-group math activities for teachers to conduct with three to four children at a time, allowing teachers more opportunity to work with children individually or in pairs
    4. Computer games that respond to the child's skill level
- Ongoing *teacher training* about the curriculum over two years
- *Coaching* of teachers in math instruction two to four times a month over two years

High 5s provided a supplemental math experience outside the classroom in kindergarten for some children who had Building Blocks in pre-K:

- Small groups of three to four children with a facilitator trained in the program by Bank Street College of Education
- 30-minute sessions, three times a week
- Short, fun math activities designed to build on children's pre-K math learning

subgroup of children who received Making Pre-K Count in preschool. High 5s was designed to build on children's pre-K experience using small-group math clubs — in which a trained facilitator works with three to four children on fun math activities three times a week outside the classroom — to supplement regular kindergarten instruction. Box 1 provides more information about these two early math programs.

These studies were designed 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. Making Pre-K Count and High 5s, conducted in collaboration with Bank Street College of Education and RTI International, are also supported with lead funding from the Heising-Simons Foundation, the Overdeck Family Foundation, and the Richard W. Goldman Family Foundation. MDRC consulted with the Division of Early Childhood Education at the New York City Department of Education (DOE) and the Administration for Children's Services' Division of Child Care and Head Start throughout the study. (See Box 2 for information about an earlier report, which describes the short-term impacts of Making Pre-K Count on teacher practices and children's outcomes in pre-K.)

This brief provides a preliminary glimpse at the impacts on child outcomes in the kindergarten year and represents the cumulative effects of Making Pre-K Count in pre-K, and High 5s in kindergarten. The general pattern of findings is positive, with statistically significant impacts (or program effects that were in all likelihood not a result of chance) on three out of six measures assessing four child outcome domains: math, math attitudes, language, and executive function. Future reports will examine the separate effects of the two programs on children's outcomes through third grade and will investigate how these results do or do not align with previous findings from this study and other studies of early math enrichment for children.

BOX 2

MAKING PRE-K COUNT: PRE-K FINDINGS FROM 2016

Previous findings to date from the Making Pre-K Count study, which are presented in more detail in the study's pre-K report,* include:

- **Implementation.** The Building Blocks math curriculum was supported by strong coaching and training for teachers. Teachers generally implemented Building Blocks in their classrooms well, with good implementation of three out of the four main curricular components: whole group activities were conducted on 92 percent of the days that children were in attendance; hands-on math materials were available for children to play with on 93 percent of days; and teachers were able to cycle most children through a small group during 85 percent of the weeks when the curriculum was implemented. Teachers were able to get most children to the computer to play math-related games for 65 percent of the weeks, slightly less often than the other components.

- **Impacts on teachers' instruction.** Teachers taught an additional 12 minutes of math a morning, across more math domains, in program classrooms. This extra time was on top of an unexpectedly large amount of math instruction (35 minutes) already in place in New York City pre-K classrooms, possibly attributable to the rollout of a number of early childhood initiatives at the time of the study, including the New York State Common Core pre-K standards for math and literacy and full-day pre-K for all four-year-olds in the city. The program also had small positive impacts (effect size = 0.45) on the quality of math instruction, although this finding did not generalize to the quality of all instruction in the classroom.†

- **Impacts on children's outcomes in pre-K.** Despite the effects on teacher practice, there were no impacts on children's math, language, or self-regulation outcomes at the end of pre-K. There was, however, an impact on children's math skills in the fall of the pre-K year (effect size = 0.31); this effect seemed to have faded out by the end of pre-K, however.

These findings do not align with previous published studies about the Building Blocks curriculum, which find moderate to large impacts on children's math skills at the end of pre-K. These early findings presented a number of questions about what might explain the divergence from other studies' findings and about likely effects in future years.

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* Morris, Mattera, and Maier (2016).

† An effect size is a statistical measure of the magnitude of an impact that is standardized. (That is, it has the same meaning no matter what unit is used to measure the impact.)

STUDY DESIGN

Making Pre-K Count took place in 69 pre-K sites that comprised 173 classrooms serving over 2,700 mostly low-income children of color in New York City.[5] Thirty-five sites were randomly assigned to receive Making Pre-K Count (the program group), which entailed two years of an evidence-based, developmentally appropriate math curriculum called Building Blocks, along with teacher training and in-classroom coaching. The remaining 34 sites were randomly assigned to continue their typical pre-K programming ("pre-K as usual," or the control group) and did not receive Making Pre-K Count or High 5s.

As children in the Making Pre-K Count program group sites entered kindergarten, a randomly selected subset was assigned to also receive a second year of math through High 5s, which provided small-group math club instruction in kindergarten. As a result, approximately one-fourth of the children included in the Making Pre-K Count program group in this analysis also participated in the High 5s clubs, while the remainder did not. Further, none of the children in the control sites participated in the High 5s clubs in kindergarten. As such, the High 5s study examines whether a supplemental dose of math in the kindergarten year, which was designed to reinforce and build on the new approach to math that preschoolers experienced with Making Pre-K Count, further helps improve children's math skills.

The children were followed into kindergarten to assess the longer-term impacts of Making Pre-K Count and the short-term effects of High 5s.

5 The analytic sample includes a randomly selected subset of 1,382 children who were chosen to participate in data collection.

FINDINGS

The current analysis is a preliminary look at the impacts on children's outcomes in kindergarten across the Making Pre-K Count and High 5s initiatives. The findings described in this brief do not attempt to disentangle these two samples or studies. Therefore, any impacts in these analyses may be driven by Making Pre-K Count in pre-K, High 5s in kindergarten, or the combination of the two. Future analytic work, which will be presented in later reports, will investigate the individual impacts of each program. The current analysis examines the cumulative effects of both programs on children's math, language, and executive function skills in kindergarten.

How Were Children's Skills Measured in Kindergarten?

A number of individually administered direct assessments were conducted with children at the end of the kindergarten year. Children's math skills were measured using two assessment instruments, both of which involve one-on-one engagement on a series of math activities between the child and an assessor. A detailed measure, Research-Based Early Math Assessment–Kindergarten (REMA-K), was used to assess children's knowledge of numbers, operations, geometry, patterning, and measurement.[6] A more global measure (Woodcock-Johnson Applied Problems) was used to examine children's quantitative reasoning.[7] Children's attitudes toward math were assessed by asking them to point to a set of five faces, ranging from smiling to sad.

6 REMA-K is an adaptation of the REMA (Clements, Sarama, and Liu, 2008). It consists of a subset of items that are most appropriate for this age range and reflect the following key math topics: number/operations, measurement, patterning, and geometry.

7 Woodcock, McGrew, and Mather (2001).

Because of the language-rich nature of the interventions, which asked children to explain their mathematical thinking as they solved problems, children's language skills were assessed using a measure of their receptive vocabulary (ROWPVT-4) — that is, their understanding of spoken words.[8] Further, because math requires children to problem solve and shift between different math concepts, two measures of executive function were also assessed. Working memory, or a child's ability to retain pieces of information and move them around mentally, was assessed by asking children to point to a set of ordered blocks in the reverse order to which they were presented (Corsi Blocks backwards); and inhibitory control, or how children stop themselves from providing an expected response, was assessed using a computer game that asked children to alternate between touching the same or the opposite side of a tablet when presented with different pictures and rules (Hearts and Flowers).[9]

What Did the Study Find?

Table 1 shows comparisons between children in the control group and children in the program group.[10] All of the children in the program group received enhanced math instruction in pre-K through Making Pre-K Count, and one-fourth received additional math instruction in kindergarten through High 5s clubs. Positive impacts were observed in three out of the six measures examined across four domains of children's outcomes assessed in kindergarten. The findings show positive impacts on one measure of children's math skills, a measure of children's attitudes toward math, and one measure of executive function.

The first row of the table shows that the interventions appear to have a statistically significant, modest impact on a detailed and comprehensive assessment of children's math skills (REMA-K). This effect is similar to the size of effects seen in other large-scale evaluations of preschool curricula one year after the children leave preschool.[11] (For instance, a previous large study of Building Blocks in three cities found impacts with effect sizes ranging from 0.13 to 0.19 in the kindergarten year, although those impacts were not statistically significant.)[12] On the more global measure of children's math skills (Woodcock-Johnson Applied Problems), shown in the second row of the table, children in both groups scored similarly. This global math measure focuses more on basic counting and less on geometry — a unique focus of the math interventions evaluated here — and may be less sensitive to the interventions' effects as a result. Children who received enriched math instruction also reported a slightly more positive attitude toward math than did children who did not receive these programs, although both groups reported generally positive feelings on this question (with an average of around 3.5 on a scale of 1 to 5).

At the outset of this study, it was hoped that greater instruction in math might improve aspects

8 Martin and Brownell (2011).

9 Corsi (1972); Wright and Diamond (2014).

10 Multilevel modeling accounted for the clustering of children within their original pre-K sites. Program impacts were estimated by comparing mean outcomes in kindergarten for the group assigned to the program during pre-K with corresponding means for children assigned to the control group during pre-K, with an adjustment for a small set of background characteristics and dummy variables for random assignment blocks. As mentioned earlier, one-fourth of the group assigned to the Making Pre-K Count program also received the High 5s intervention.

11 See, for example, Bierman et al. (2014); Morris et al. (2014); Sarama, Clements, Wolfe, and Spitler (2012).

12 Hofer, Lipsey, Dong, and Farran (2013). Effect size is a measure of the magnitude of an impact that is standardized; that is, it has the same meaning no matter what unit is used to measure the impact.

TABLE 1

CHILD-LEVEL IMPACTS OF ENRICHED MATH INSTRUCTION, SPRING OF THE KINDERGARTEN YEAR

OUTCOME	PROGRAM GROUP MEAN	CONTROL GROUP MEAN	DIFFERENCE (IMPACT)	STANDARD ERROR	EFFECT SIZE[a]
Math					
Detailed math score (REMA-K)[b]	38.81	37.68	1.13**	0.48	0.13
Global math score (Woodcock-Johnson Applied Problems)[c]	104.37	104.37	0.00	0.72	0.00
Math attitudes					
Children's attitudes toward math[d] (1-5)	3.59	3.44	0.14*	0.08	0.09
Language					
Receptive vocabulary[e]	98.32	97.61	0.71	1.02	0.05
Executive function					
Inhibitory control[f] (0-1)	0.69	0.68	0.01	0.01	0.04
Working memory[g]	2.41	2.22	0.19**	0.08	0.13
Sample size					
Blocks	16	16			
Sites	35	34			
Children	698	684			

SOURCE: MDRC calculations based on the direct child assessments administered in spring 2016.

NOTES: Statistical significance levels are indicated as follows: *** = 1 percent; ** = 5 percent; * = 10 percent.

Rounding may cause slight discrepancies in sums and differences.

[a]Effect size is calculated by dividing the impact of the program (the difference between the means for the program group and the control group) by the standard deviation for the control group.

[b]This study used an adaptation of the Research-Based Early Math Assessment-Kindergarten (REMA-K; Clements, Sarama, and Liu, 2008). Item selection represents the full range of early mathematics competencies applicable within the prekindergarten, kindergarten, and early first grade years. The score in this table is the Item Response Theory (IRT)-based score.

[c]Woodcock-Johnson Applied Problems is a subscale of the Woodcock-Johnson III Tests of Achievement (Woodcock, McGrew, and Mather, 2001). The score is age normalized to 100, with a standard deviation of 15.

[d]The research team at MDRC created an assessment to measure children's attitudes toward math and school. Children were asked to use a showcard that displayed a range of five sad to smiling faces to describe how happy or unhappy school and math made them feel. A 1 rating indicates that they felt very unhappy and a 5 rating indicates that they felt very happy.

[e]Receptive One-Word Picture Vocabulary Test (ROWPVT-4; Martin and Brownell, 2011). The score is age normalized to 100, with a standard deviation of 15.

[f]Hearts and Flowers (Wright and Diamond, 2014) is a computerized task that measures inhibitory control. The proportion correct score assesses how many trials a child gets correct out of 33 "mixed" trials where children must select the button on the same side if a heart appears and on the opposite side if a flower appears, excluding trials with response times faster than 200 milliseconds.

[g]Corsi Blocks (Corsi, 1972; Lezak, 1983). A child is asked to repeat a sequence of blocks tapped by an assessor, tapping the blocks in reverse order. The child begins with a sequence of two blocks and more blocks are added to the sequence. Children receive a score of zero if they fail the first two trials; otherwise, the score reports the highest number of blocks the child is able to tap in correct order in two attempts.

of young children's executive function skills. In fact, children in the program group performed better on a task of working memory but not on a task of inhibitory skills in kindergarten than children who received a typical math experience.

WHAT'S NEXT?

These preliminary findings demonstrate that an enhanced early math experience can have positive, albeit modest, impacts on children's math and executive function skills in kindergarten. This conclusion seems to align with the pattern of findings from a Building Blocks study that took place in San Diego, a context similar to New York City in that it has a relatively high level of math instruction in pre-K and a large Hispanic population.[13] In that study, there were no statistically significant impacts at the end of pre-K, but program effects similar in magnitude to those in this report emerged by the end of kindergarten. The magnitude of the impacts described here is similar to the size of impacts one year after implementation in other studies of preschool curricula, which typically have ranged from around 0.10 to 0.30.[14] However, few studies have followed up with children past elementary school, making it difficult to assess the long-term implications of these findings for children's outcomes into adolescence and adulthood.

Future analysis of the Making Pre-K Count and High 5s programs will be critical for interpreting the preliminary findings and for more completely assessing preschool and kindergarten program impacts:

- First, as discussed earlier, it is not clear whether the effects described in this brief occur directly though the Making Pre-K Count math program, the High 5s kindergarten math clubs, or the combination of the two programs. Future analyses will examine the impacts of High 5s alone on children's kindergarten outcomes and will attempt to disentangle the two programs' effects to identify the unique impact of Making Pre-K Count alone.

- Second, further analysis will examine the role of measurement in the pattern of results and why math gains are evident in a detailed measure of children's math competencies but not another more global, nationally normed measure of children's math skills. Additional analysis will aim to determine whether different measures were more or less sensitive to impacts in particular areas of math learning, (numeracy, patterning, or geometry), the latter of which was a particular focus of these math programs.

- Third, future analytic work will delve into subgroup analyses to try to explain the pattern of impacts more deeply and to examine whether particular groups of children benefit more or less from the math interventions.

- Finally, further follow-up of children who were in the Making Pre-K Count and High 5s programs is critical for understanding whether these gains persist as children advance through successive elementary school years.

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13 Clements et al. (2016).

14 See, for example, Bierman et al. (2014); Morris et al. (2014); and Sarama, Clements, Wolfe, and Spitler (2012).

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ACKNOWLEDGMENTS

Thanks to Desiree Alderson, Gordon Berlin, Alvin Christian, Adam Greeney, JoAnn Hsueh, Sharon Huang, John Hutchins, Rob Ivry, Robin Jacob, Ann Kottner, Anne Kou, Michelle Maier, Lyndsay McDonough, Aimee Mun, Roxana Obregon, and Alice Tufel for their assistance in preparing this brief.

This publication is made possible through funding from the Robin Hood Foundation, the Heising-Simons Foundation, the Overdeck Family Foundation, and the Richard W. Goldman Family Foundation.

Dissemination of MDRC publications is supported by the following funders that help finance MDRC's public policy outreach and expanding efforts to communicate the results and implications of our work to policymakers, practitioners, and others: The Annie E. Casey Foundation, Charles and Lynn Schusterman Family Foundation, The Edna McConnell Clark Foundation, Ford Foundation, The George Gund Foundation, Daniel and Corinne Goldman, The Harry and Jeanette Weinberg Foundation, Inc., The JBP Foundation, The Joyce Foundation, The Kresge Foundation, Laura and John Arnold Foundation, Sandler Foundation, and The Starr Foundation.

In addition, earnings from the MDRC Endowment help sustain our dissemination efforts. Contributors to the MDRC Endowment include Alcoa Foundation, The Ambrose Monell Foundation, Anheuser-Busch Foundation, Bristol-Myers Squibb Foundation, Charles Stewart Mott Foundation, Ford Foundation, The George Gund Foundation, The Grable Foundation, The Lizabeth and Frank Newman Charitable Foundation, The New York Times Company Foundation, Jan Nicholson, Paul H. O'Neill Charitable Foundation, John S. Reed, Sandler Foundation, and The Stupski Family Fund, as well as other individual contributors.

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NEW YORK
16 East 34th Street, New York, NY 10016-4326
Tel: 212 532 3200; Fax: 212 684 0832

CALIFORNIA
475 14th Street, Suite 750, Oakland, CA 94612-1900
Tel: 510 663 6372; Fax: 510 844 0288