

Math for Love 2016 Seattle Summer Staircase Curriculum Evaluation: Key Findings for Mathematical Learning

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Summary

Seattle-based math education consultancy Math for Love (mathforlove.com) conducted a multi-faceted evaluation of the play-based math curriculum they developed for the Seattle Public School District's 2016 Summer Staircase program. The goal of the evaluation was to better understand the effectiveness of the curriculum for supporting children's mathematical learning.

This report presents key findings for students' mathematical learning over the course of the program. Learning was described broadly to account for cognitive and dispositional growth. Three learning constructs were investigated:

- Mathematical conceptual understanding
- Mathematical fluency
- Mathematical habits of mind, including engagement and enthusiasm

Learning constructs mapped onto Common Core Mathematical Standards and Common Core Standards of Mathematical Practice.

Classroom observations were conducted from various vantage points in order to understand how and to what extent the Math for Love curriculum and teachers' instructional practices engaged students in mathematical thinking and doing. Finally, teacher feedback was examined to understand teacher perspectives on student growth, the strengths of the curriculum, and areas of improvement.

About Math for Love's Summer Staircase Math Curriculum

Summer Staircase is a summer literacy and math intervention program for Seattle Public School students following their Kindergarten through fourth grade year. Although open to all students, the program is targeted at learners below grade level in an effort to bolster foundational skills while staving off the erosion of progress in math and literacy known as the "summer slide".

Nearly 2,000 elementary school students at 19 school sites participated in 2016 Seattle Summer Staircase. 2016 marked Math for Love's third year collaborating with Seattle Public Schools on Summer Staircase. Math for Love provided math curriculum in three grade bands: Kindergarten; Grades 1-2; and Grades 3-4. Additionally, Math for Love conducted trainings for teacher and

instructional aids in the curriculum and corresponding instructional practices before Summer Staircase began, and offered ongoing teacher support throughout the program.

The curriculum crafted by Math for Love for Summer Staircase was at once rigorous and play-based. It was designed to provide abundant opportunities for all students (from struggling students to those making excellent progress) to develop critical thinking skills, build their mathematical content knowledge and skills, and to hone their mathematical habits of mind, including perseverance. Importantly, Math for Love sought to provide in Summer Staircase an unequivocally positive mathematical experience, and games and manipulative were an essential part of the curriculum.

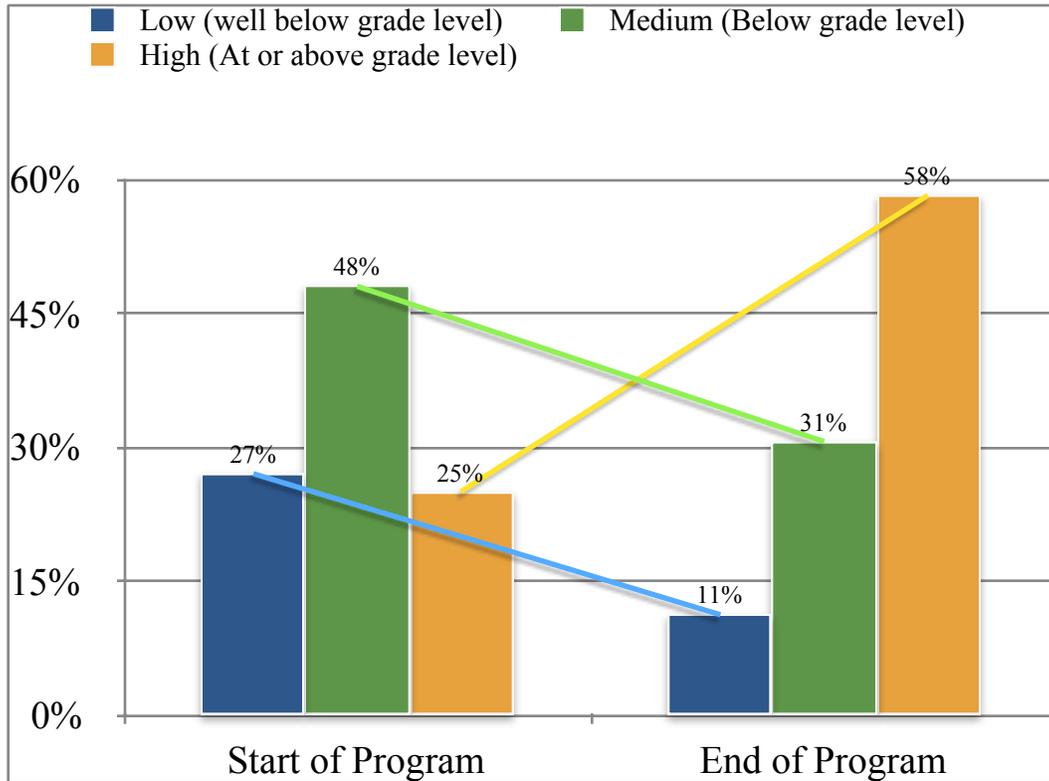
Findings for Mathematical Learning

The data show many successes for Summer Staircase students across program sites and demographics. Main findings include growth for the majority of students in their mathematical conceptual understanding, fluency, and habits of mind. Growth occurred for struggling students and students at or above grade level alike. Data from the program suggests that third and fourth grade students experienced the largest mean growth in habits of mind and conceptual understanding (See Table A).

Table A. Student Growth in Conceptual Knowledge and Habits of Mind

Grade Band	Mean Conceptual Understanding Score Gain	Mean Habits of Mind Score Gain
Kindergarten	16.5 percentile points	18.25 percentile points
1st/2nd Grade	13.7 percentile points	15.5 percentile points
3rd/4th Grade	22.0 percentile points	27.25 percentile points

Student “Math Profile” Change from Start to End of Program, by percentage



Classroom observations demonstrated that the majority of program teachers successfully fostered classroom environments that rigorously engaged students’ in mathematical doing and thinking. Students’ critical thinking was supported by, among other instructional practices, teachers asking open-ended questions that prompted children to explain their thinking and make connections between ideas. Engagement in math activity was facilitated by the curriculum’s games and playful activities as well as teachers’ organizational choices in the stations, and comfort with and enthusiasm for the curriculum.

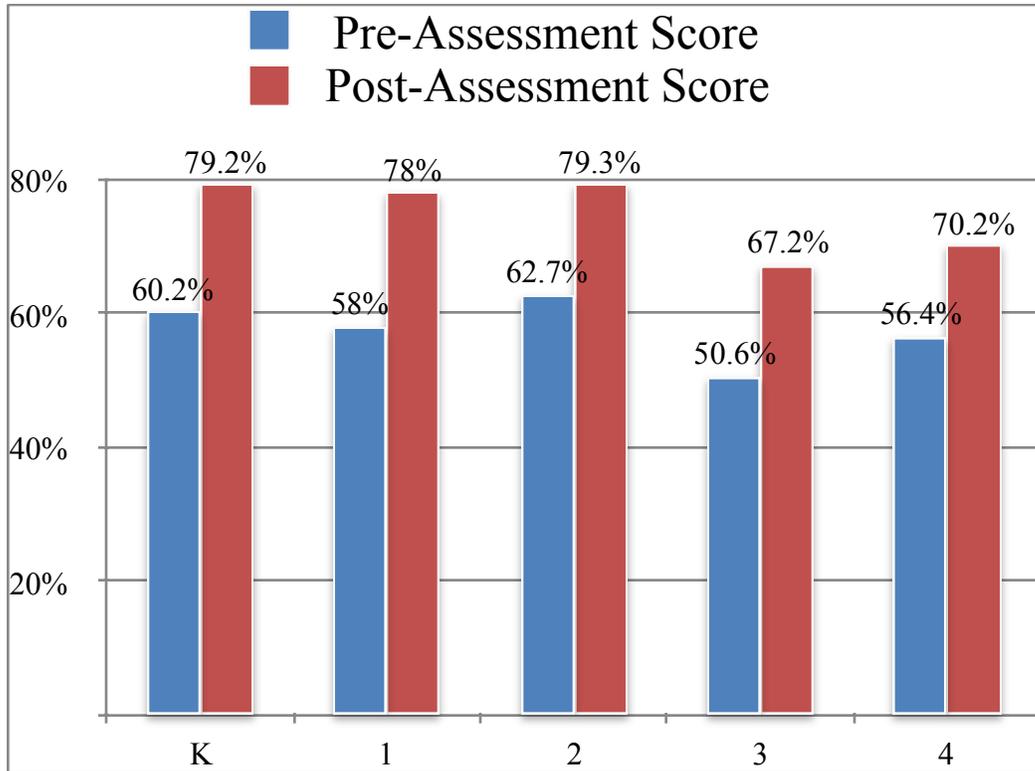
Teacher survey results show that over the course of the six-week program, teachers saw many of their students gain not only in fluency and conceptual understanding, but also in confidence, persistence in the face of challenge, and critically, in their enjoyment of math. Of those surveyed, 94% of teachers said the curriculum supported student engagement, and 85% said it supported student critical thinking. It is Math for Love’s hope that these positive approaches to math work will support students in their school year math classrooms.

In mathematical fluency, as measured by a pre/post assessment, 76% of students who scored below 90% on the pre-assessment, showed improved results on their post-assessment. The results in this cohort were consistent across grade levels (See Table B).

Table B. Fluency Improvements for Students Scoring Below 90% on the Pre-assessment

Mean Pre Assessment Score (out of 10)	Mean Post Assessment Score (out of 10)	Improvement	Percentage Point Increase	Percentage Increase
5.76	7.50	1.74	17%	30%

Mean Pre- and Post-Assessment Fluency Scores by Grade for Students Scoring Below 90% on the Pre-assessment



Overall, the Summer Staircase curriculum has the potential to be a model for summer intervention program in math, and a powerful tool to help build mathematical success for elementary students at all levels.

Introduction

A Story from a Summer Staircase Math Classroom in Action

Energetic and charismatic with black basketball socks pulled up to his knees, fourth grader Tyrell flicks the die across the desks pushed together to make a long table in the center of the classroom. Tyrell and his partner Ernest both lean over the table to see the result. Tyrell grins and laughs; Ernest shakes his head. Tyrell scribbles on his score sheet, adding the number he rolled to his banked points. He is fast approaching fifty points and another win. Tyrell scoops up the die to roll again. “Have you gotten to go?” the boys’ teacher, Ms. I calls to Ernest from her own game further down the table. “No, Tyrell keeps going,” Ernest replies good-naturedly, more bemused than annoyed. “Yep,” says Tyrell. “You haven’t rolled a 1?” she asks. Rolling a 1 means that a player loses all of his unbanked points, and his turn is over. “No,” says Tyrell, “I’m on fire!” Ms. I is surprised. “You somehow keep going without a 1?” she confirms. “Yes, I’m on fire. Tell them I’m on fire.” Ms. I smiles at Tyrell and Ernest. “You’re on fire!” she says.

The classroom hums with activity. At Tyrell and Ernest’s table, dice crack against the table as students play the game Pig in pairs. At another table, students arrange pattern blocks into representations of multiplication equations. A third table is piled high with bins of manipulatives and photocopied game boards. There, students choose from familiar math games introduced earlier in the week.

Pig is the day’s new game in Ms. I’s class. It is simple but mathematically rich. As they play Pig, students are practicing addition writing equations, and thinking through probability as they devise strategies to determine when to stop their turn to bank their points. Every roll risks turning up the dreaded “1”. Soon the students in Ms. I’s class will learn an extension of Pig called Odd Pig Out. Odd Pig Out uses two dice and involves multiplication as well as addition, strategy and chance. Students roll, and then find the product of the dice. If the product is even, they add it to their point tally for that turn, then choose between banking their points, or rolling again. But if the product is odd, they lose all of their unbanked points.

Tyrell and Ernest are well into their next game of Pig with Ms. I’s timer goes off. “Alright, Seahawks, Mariners and Sounders,” Ms. I calls to the three table group, “It’s time to rotate!” Students quickly clean up and move to their next table, eager to jump into the next activity.

Tyrell, Ernest and their classmates are enjoying themselves so much it is hard to believe they are in summer school. Yet the scene in Ms. I’s classroom is a familiar one in Seattle Summer Staircase where students are engaged, having fun, and, critically, doing math – lots of math. And this is entirely the point of the Summer Staircase math program designed by Seattle-based math education consultancy Math for Love (mathforlove.com).

Math for Love Curriculum Evaluation

In this report, we share key findings regarding students' mathematical learning in Summer Staircase. Math for Love conducted a multifaceted evaluation of its 2016 Summer Staircase curriculum, in an effort to understand the effectiveness of the program and areas to improve for future iterations of Summer Staircase. These efforts included collecting and analyzing:

- Student learning data
- Classroom observations
- Feedback from teachers and site leaders

Part one of this report documents growth in students' conceptual understanding, habits of mind, and mathematical fluency as measured by curricular assessments. Part two draws on more qualitative data sources to share how and to what extent the Math for Love curriculum and teachers' instructional practices engaged students in mathematical thinking and doing. Teacher perspectives on the curriculum and student growth are also analyzed in part two.

About Seattle Summer Staircase

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Nearly 2,000 elementary school students at 19 school sites participated in 2016 Seattle Summer Staircase. 2016 marked Math for Love's third year collaborating with Seattle Public Schools on Summer Staircase. Math for Love provided math curriculum in three grade bands: Kindergarten; Grades 1-2; and Grades 3-4. Additionally, Math for Love conducted trainings for teacher and instructional aids in the curriculum and corresponding instructional practices before Summer Staircase began, and offered ongoing teacher support throughout the program.

Summer Staircase 2016 was a half-day summer intervention program that ran for 24 days across five weeks or 27 days across six weeks depending on the school site. Students in all three grade bands attended a literacy block and a math block daily; each block lasted 75 – 90 minutes. Breakfast and lunch were provided to students, as was transportation to and from school sites.

In 2016, Summer Staircase employed 56 math teachers, over half of whom had taught in the program in past years. Teachers taught two sections of the same grade band; teachers saw both classes everyday of the program. Classes ranged from 16-20 students. Math teachers were assigned two instructional aides to assist in their classrooms. A team comprised of three district math coaches and the two Math for Love co-founders supported math teachers throughout the program.

About the Math for Love Summer Staircase Curriculum

Math for Love created a rigorous, play-based math curriculum for Summer Staircase. While targeted to struggling students, the curriculum was differentiated in order to meet the needs of all learners. The curriculum was designed provide abundant opportunities for students to develop critical thinking skills, build their mathematical content knowledge and skills, and to hone their mathematical habits of mind, including perseverance.

Importantly, Math for Love sought to provide in Summer Staircase an unequivocally positive mathematical experience. Games and manipulative were an essential part of the curriculum. Teacher trainings in the math curriculum and related instructional practices stressed the importance of engaging students in rigorous, playful mathematical work and of building positive student-teacher relationships. The trainings also focused on creating a classroom culture that embodied a growth mindset, privileging the idea that working hard, and not some sort of innate ability, is most critical for learning math.

Detailed lesson plans were provided for each day of the Summer Staircase program. A station-based model was employed in order to engage students and keep them engaged, provide opportunities to revisit older materials and practice skills, and introduce and work with new materials in a smaller group.

Main Elements of a Typical Math for Love Daily Lesson Plan

1. Teacher-led warm-up (10 minutes)
2. Instruction on new games, or a mini-lesson on new content (10 minutes)
3. Three stations (45 - 60 minutes)
 - a. Teacher Led: New material
 - b. Instructional Aid Led: Familiar games or skill practice
 - c. Instructional Aid Led: Choice Time
4. Teacher-led wrap-up (5-10 minutes)

Three forms of assessment were built into the math curriculum:

- A written pre/ post assessment
- Teacher observations of students' conceptual understanding and skills taken at the beginning and end of the program
- Teacher observations of students' mathematical habits of mind taken at the beginning and end of the program.

Findings 1: Impacts on Student Learning

We investigated growth in three related areas of student mathematical learning over the course of Summer Staircase.

- Mathematical conceptual understanding, corresponding to the Common Core Math Standards, especially:
 - Operations and Algebraic Thinking (OA)
 - Numbers and Operations in Base 10 (NBT)
 - Counting and Cardinality (CC - Kindergarten only).
- Mathematical habits of mind, corresponding to the Common Core Standards of Mathematical Practice, especially
 - Math Practice 1: Make sense of problems and persevere in solving them.
 - Math Practice 3: Construct viable arguments and critique the reasoning of others.
- Mathematical fluency, corresponding to Common Core Math Standards in the OA & NBT clusters.

Growth in Conceptual Understanding and Habits of Mind

Sample.

Complete data was available for 400 of the 1,866 students enrolled in Summer Staircase, or 21% of students. Sample data came from 14 classrooms (25% of classrooms) at eleven school sites (58% of all school sites). The sample comprises a representative range of grade levels, school geography and demographics, new and returning school sites, and new and returning teachers. Thus, findings may be generalized to the Summer Staircase program as a whole.

Table 1: Number of Students in Each Grade Band in Sample

Grade	Number of Students
Kindergarten	134
Grades 1-2	135
Grades 3-4	131
Total	400

Measures and analytical techniques.

Teachers assessed students' conceptual understanding and habits of mind in multiple domains at the beginning and end of Summer Staircase using a five-point rating scale developed by Math for Love. The rating scale is shown below.

Rating Scale for Teacher Assessments

- 1 - Not ready to begin learning this topic, needs more attention on prerequisites
- 2 - Ready to begin learning about topic
- 3 - Making basic progress
- 4 - Strong knowledge, with some gaps
- 5 - Student shows mastery, or excellent progress

For each student, domain scores were combined to yield a Beginning Total Score and an Ending Total Score. The difference between Ending Total Score and Beginning Total Score yielded an Improvement Score. Improvement Scores were analyzed to understand student growth in each grade band (Kindergarten; Grades 1-2; Grades 3-4) over the course of the Summer Staircase program.

Habits of mind was assessed in three domains. Domains 1 and 3 correspond to Common Core Practice Standards 1 (Make sense of problems and persevere in solving them) and 3 (Construct viable arguments and critique the reasoning of others), respectively. Domain 2 involved student enjoyment and enthusiasm for math. The habits of mind domains were the same for all grade bands.

Habits of Mind Domains

- 1. Perseverance and sense making
- 2. Plays and enjoys math games and activities
- 3. Asks questions and provides arguments

Conceptual understanding was assessed in five domains for Grades 1-2 and six domains for Kindergarten and Grades 3-4. Domains correspond to Common Core Content Standards, especially in Number and Operation (and Counting and Cardinality for Kindergarteners)

Conceptual Understanding Domains

Kindergarten

1. One-to-One correspondence and cardinality
2. Counting to 20
3. Writing numbers
4. Comparing numbers
5. Addition within 10
6. Subtraction within 10

Grades 1-2

1. Accurately counts and compares collections of objects
2. Knows pairs of numbers that add to 10
3. Addition within 20
4. Subtraction within 20
5. Can understand, compare and work with two-digit numbers

Grades 3-4

1. Understands multiplication conceptually
2. Can build an array or draw a picture to solve multiplication
3. Can fluently solve 1-digit multiplication
4. Understands division conceptually

Summer Staircase serves a diverse group of learners. Although the program is designed as an intervention for struggling students, it is open to all students. This means that while many students began Summer Staircase below grade level in one or more conceptual understanding domains, some students entered the program already making basic progress, while still others were making excellent progress (See Table 2a).

To understand growth relative to students' starting places and in the context of students' progression as learners, we developed a Conceptual Understanding Profile heuristic. Our exploration of Beginning Total Scores and domain scores suggested six distinct profiles, with each profile corresponding to a range of Beginning Total Scores and to a particular constellation of domain scores.

We assigned each student a Beginning Profile and an Ending Profile. Variation in Beginning Profiles existed among the grade bands. A significant majority of students in grades 3-4 (70%) entered Summer Staircase below grade level in one or more conceptual understanding domains. Roughly half of Kindergarteners and one third of first and second graders were in the Medium

Profile group at the beginning of Summer Staircase, meaning that they were making basic progress in all domains. Table 2b shows the number of students in each profile group at the program’s end.

Table 2a. Number of Students in Profile Groups at Beginning of Program

Grade Band	Total Students	Very-Low, Low, or Medium-Low Profile Groups	Medium Profile Group	Medium-High or High Profile Groups
Kindergarten	134	36 (27%)	64 (48%)	34 (25%)
Grades 1-2	135	44 (33%)	52 (39%)	39 (29%)
Grades 3-4	131	92 (70%)	27 (21%)	12 (9%)

Percentage of Students in Profile Groups at Start of Program

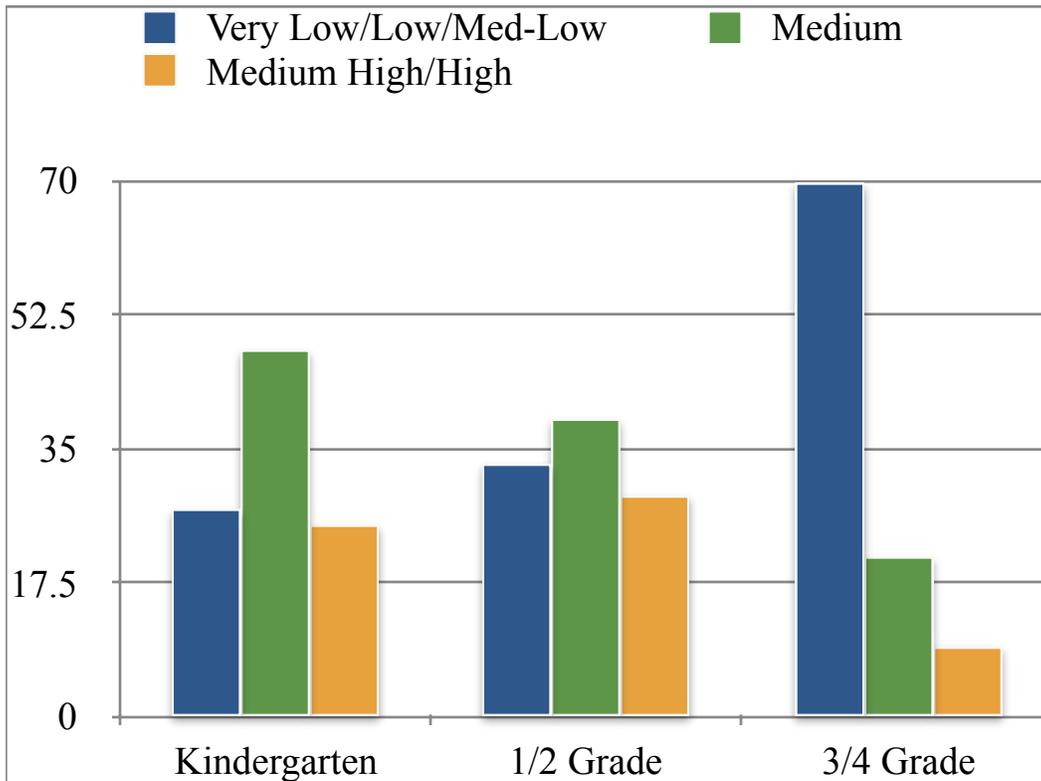
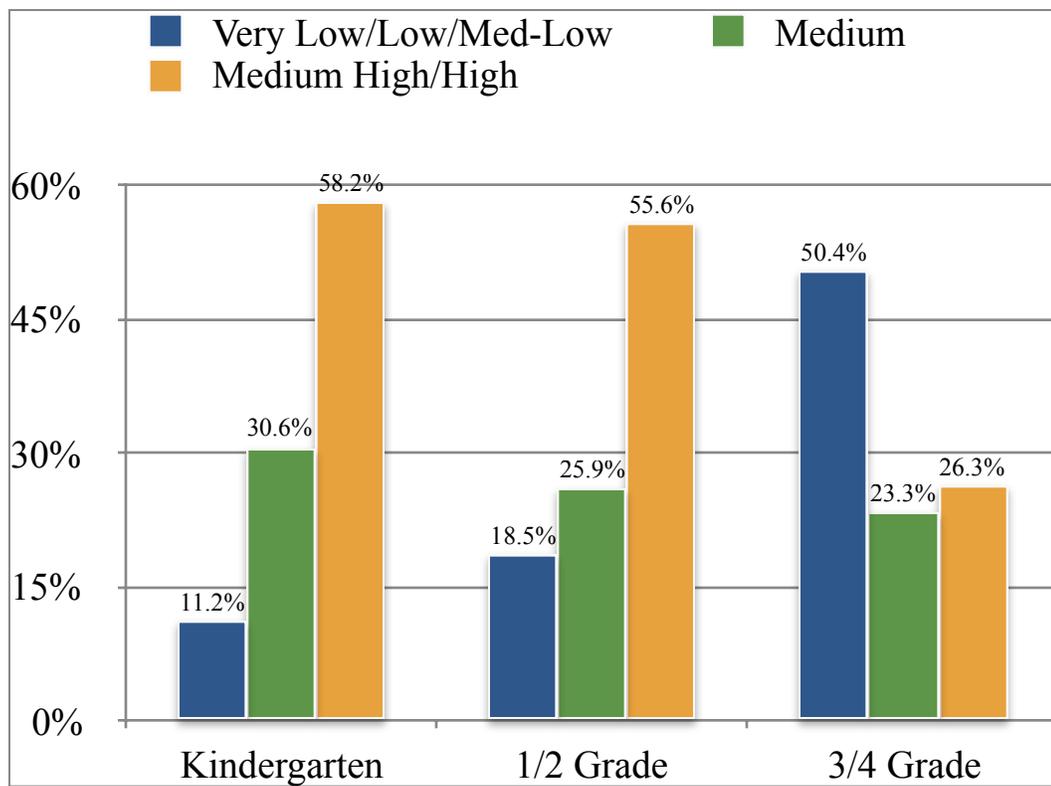


Table 2b. Number of Students in Profile Groups at End of Program

Grade Band	Total Students	Very-Low, Low, or Medium-Low Profile Groups	Medium Profile Group	Medium-High or High Profile Groups
Kindergarten	134	15 (11%)	41 (31%)	78 (58%)
Grades 1-2	135	25 (18%)	35 (26%)	75 (56%)
Grades 3-4	131	67 (50%)	31 (23%)	35 (26%)

Percentage of Students in Profile Groups at End of Program



Percentage of Grade in Low/Medium/High Profiles at beginning of Summer, 2016

We analyzed changes from Beginning to Ending Profiles to understand the degree of growth and what growth meant for students in the context of making basic progress on state standards for mathematical learning. It is important to note that improvement in Total Score did not always translate into students vaulting into the next profile group.

Results.

Results for each grade band are presented in Tables 3-5.

Table 3. Kindergarten Results

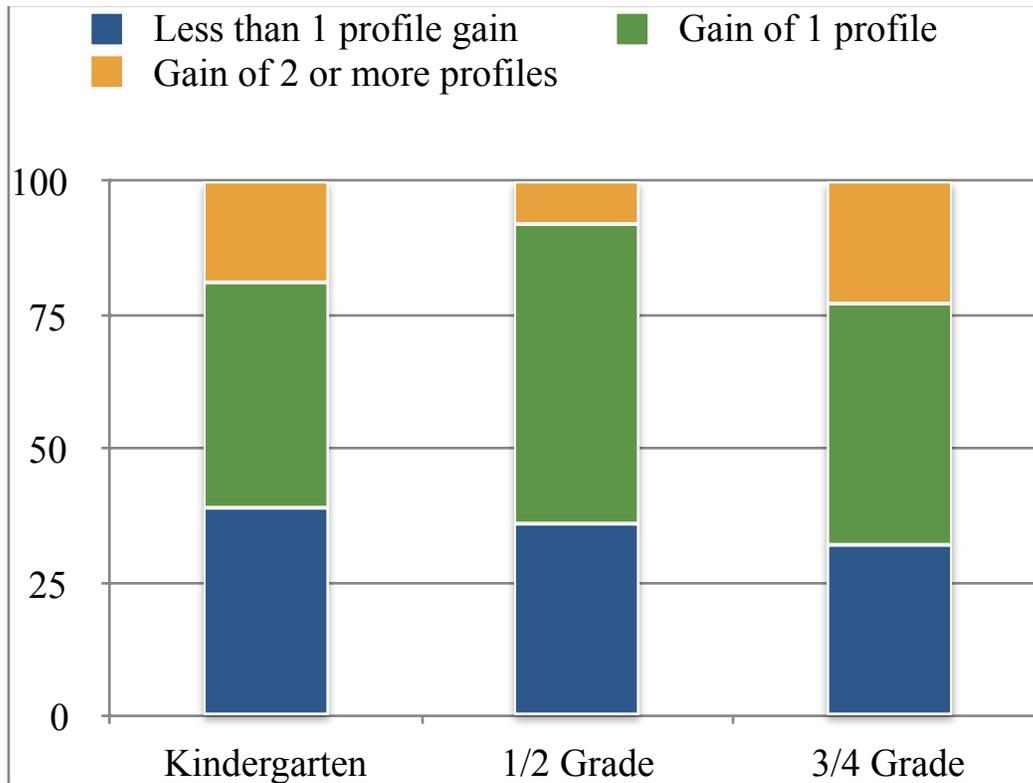
Number of Students / Number of Class Sessions	Mean Conceptual Understanding Gain (Out of 24)	Gained at least one Conceptual Understanding Profile	Gained two Conceptual Understanding Profile	Mean Habits of Mind Gain (Out of 12)
134 / 10	3.97	82 students (61%)	26 students (19%)	2.19

Table 4. Grades 1-2 Results

Number of Students / Number of Class Sessions	Mean Conceptual Understanding Gain (Out of 20)	Gained at least one Conceptual Understanding Profile	Gained two Conceptual Understanding Profile	Mean Habits of Mind Gain (Out of 12)
135 / 8	2.74	87 students (64%)	11 students (8%)	1.86

Table 5. Grades 3-4 Results

Number of Students / Number of Class Sessions	Mean Conceptual Understanding Gain (Out of 24)	Gained at least one Conceptual Understanding Profile	Gained two Conceptual Understanding Profile	Mean Habits of Mind Gain (Out of 12)
131 / 9	5.27	89 students (68%)	30 students (23%)	3.27



Mean growth in habits of mind.

Grade band means for Habits of Mind Improvement Scores show student growth in mathematical practice in each grade band, with the most growth seen in the Grade 3-4 grade band. The Kindergarten mean Habits of Mind Improvement Score was 2.19 out of 12, an improvement of 18 percentile points. The Grades 1-2 Class Mean Habits of Mind Improvement Score was 1.86 out of 12, an improvement of 16 percentage points. The Grades 3-4 Class Mean Habit of Mind Improvement Score was 3.27 out of 12, an improvement of 27 percentage points.

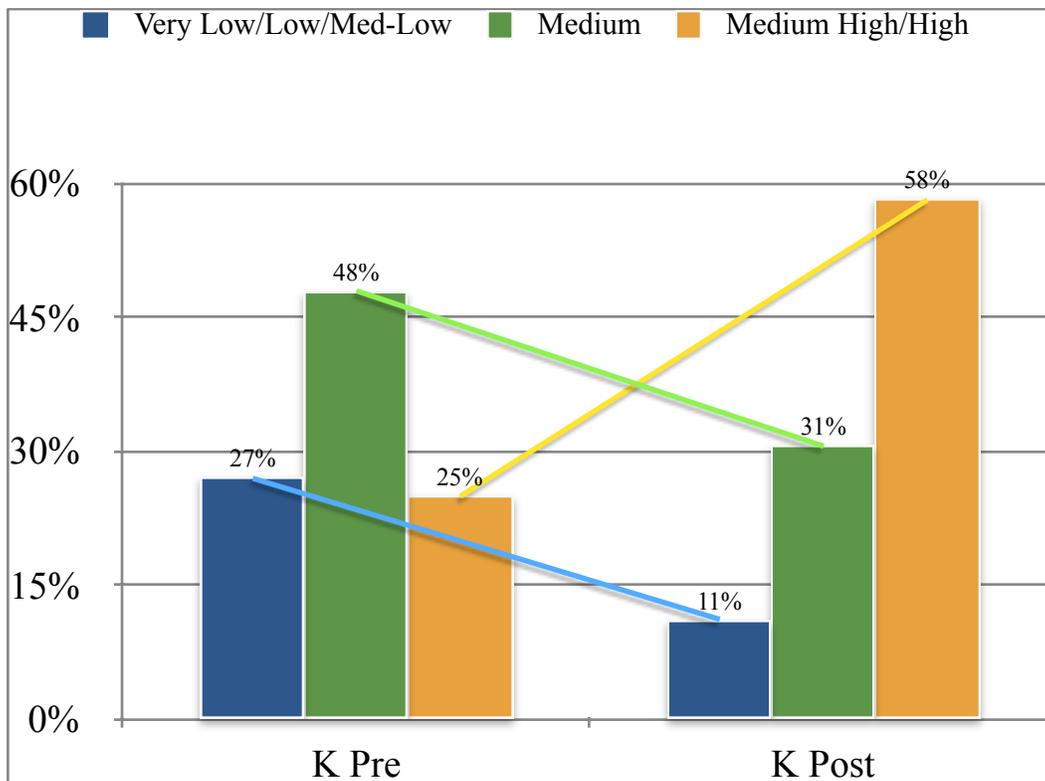
Mean growth in conceptual understanding.

Grade band means for Conceptual Understanding Improvement Scores show student growth in mathematical content knowledge in each grade band, again with the most growth seen in the Grades 3-4 grade band. The Kindergarten Class Mean Conceptual Understanding Improvement Score was 3.97 out of 24, an increase of 17 percentile points. The Grades 1-2 Class Mean Conceptual Understanding Improvement Score was 2.74 out of 20, an increase of 14 percentile points. The Grades 3-4 Class Mean Conceptual Understanding Improvement Score was 5.27 out of 24, an increase of 22 percentile points.

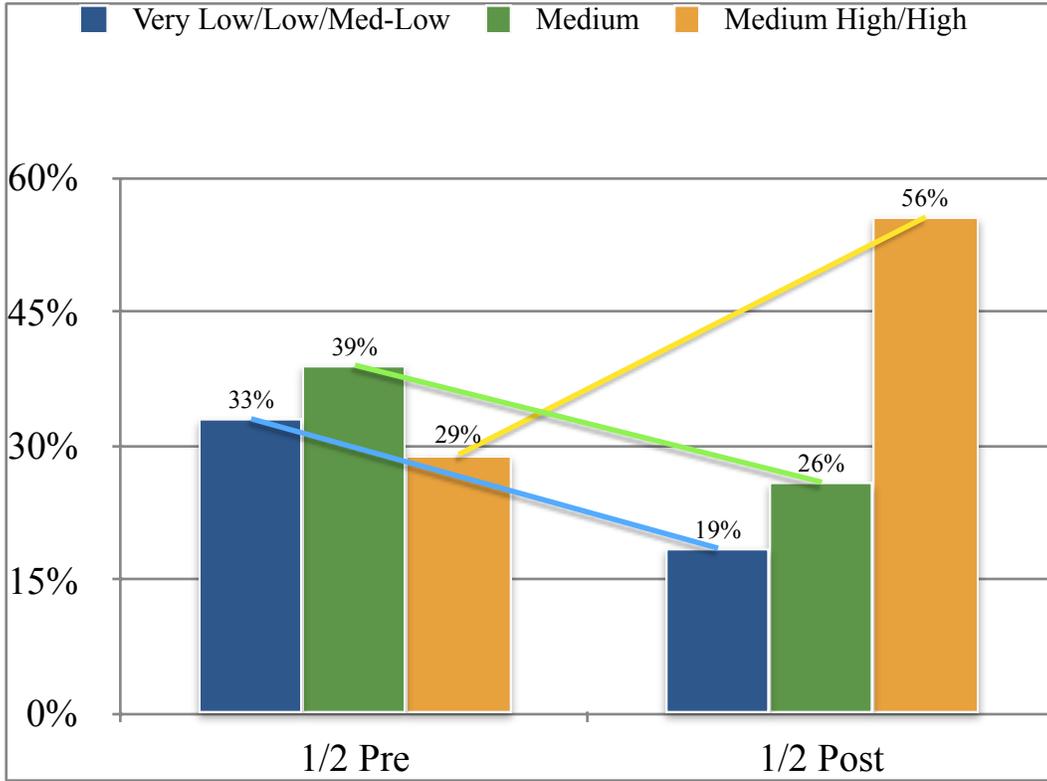
Unsurprisingly, grade band mean gains in habits of mind and conceptual understanding seem to run parallel, suggesting that these constructs are correlated. It makes sense that as students improve in conceptual understanding they also hone habits of mind given that teachers instruct for both and curriculum is designed to enhance both aspects of mathematical learning.

Growth in conceptual understanding profile groups.

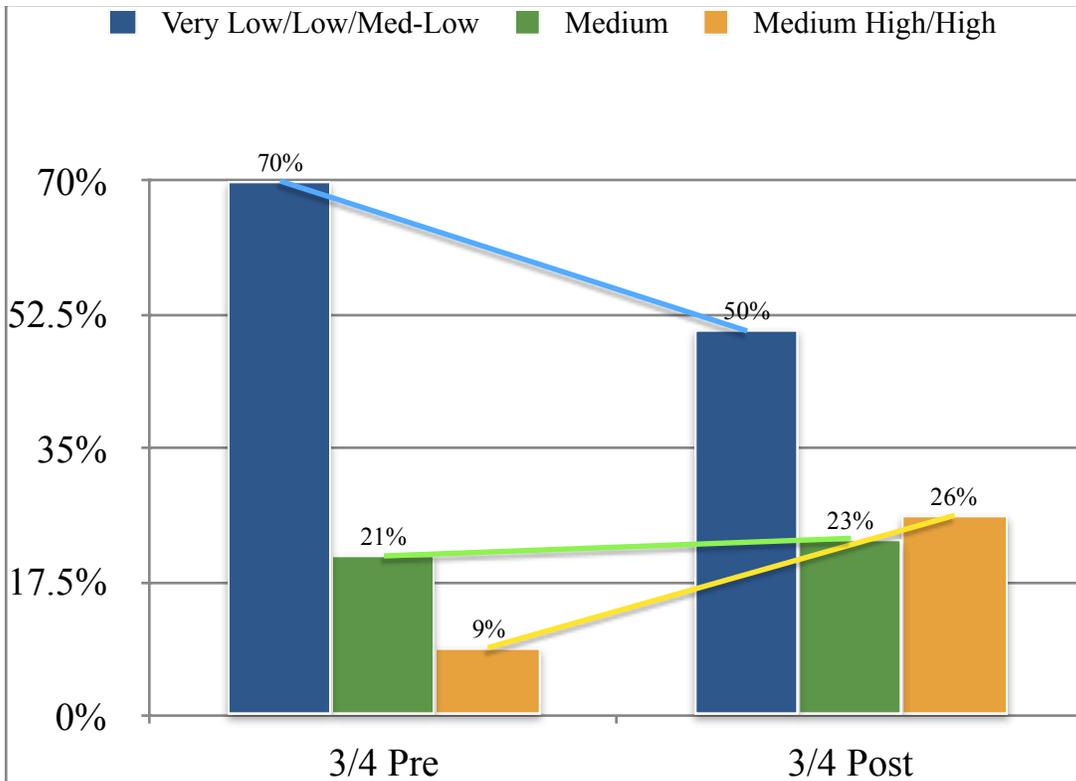
**Profile Group Change in Kindergarten from Start to End of Program,
by Percentage of Students in each Profile Range**



**Profile Group Change in 1st/2nd Grade from Start to End of Program,
by Percentage of Students in each Profile Range**



**Profile Group Change in 3rd/4th Grade from Start to End of Program,
by Percentage of Students in each Profile Range**



Roughly two-thirds of students in each grade band improved at least one profile over the course of the program. For Kindergarten, 61% improved at least one profile and 19% improved two profiles. For Grades 1-2, 64% improved at least one profile 8% improved two profiles. For Grades 3-4, 68% improved at least one profile and 23% gained two profile levels. This substantial program wide growth demonstrates the effectiveness of Summer Staircase as an intervention for boosting students' conceptual understanding. Indeed, we imagine that the effect will be cumulative for returning students. In other words, for Kindergarteners entering Summer Staircase needing remediation could be making excellent progress on Common Core math standards by 5th grade provided they made standard progress during the school year.

We explored trends in growth for Conceptual Understanding Profile Groups in order to determine whether the Summer Staircase worked equally well for all students, regardless of whether they entered the program below grade level, making basic progress or already approaching mastery. To answer this question we looked at the students who did not gain at least one profile (roughly 1/3 of students in each grade band) and sought to determine if any of the profiles from Very Low through Medium-High were overrepresented. None of these profiles are overrepresented, which is excellent news for an intervention program tasked with serving a highly diverse group of learners. That a student's beginning profile group does not predict whether he or she will improve one or more profiles over the course of the program additionally suggests that there is something in the program to spark all learners and that the curriculum is adequately differentiated, both in design and in execution.

Future program evaluations may build a more nuanced profile heuristic that accounts for growth in habits of mind in addition to conceptual understanding. Additionally, gathering data for all students in the program would strengthen the preliminary results suggested by this analysis of the subsample of student data available.

Mathematical fluency. [H3]

Mathematical fluency was measured by embedded written pre-post-tests administered by teachers at the beginning and end of the program. These assessments were designed by Math for Love and each comprise ten questions, each worth 1 point. Assessments were scored from 0 – 10 points.

Sample. [H4]

Complete data was available for 1,555 students (83% of Summer Staircase student population). All program sites and classrooms are represented in the sample.

Measures and analytical techniques.

We looked at improvement from pre to post-test to understand growth in students' mathematical fluency over the course of Summer Staircase.

Results.

Fifty-seven percent of students (890 students) in the sample improved their scores from the pre to the post-test. Many students scored well on both the pre and post-test. Seventy-one percent of students (1,101 students) improved their scores from pre to post-test, or scored a 90% or 100% on both the pre and post-tests.

For the most part, students experienced gains in their mathematical fluency as measured by the pre/post-test. Program-wide, the mean pre-assessment score was 6.94, and the mean post-assessment score was 8.00. The mean improvement pre to post assessment was 1.06 points out of ten, an increase of just over ten percentage points, or a 15% increase from the starting score. We found variation in mean gains among the grade levels. For students in Kindergarten, First Grade, Second Grade, and Third Grade, the mean gain was just over one point, while for students in fourth grade, the mean gain was half a point).

Variation in student gains in mathematical fluency was found among program sites as well. Mean gains from pre to post-test ranged from 2.12 – 0.14. The percentages of students who improved from the pre to post-test ranged from 84% – 35%.

The impact on fluency for students was more obvious when we remove students who scored 9 or 10 out of 10 on the pre-test, and focus on those with pre-test scores of between 0 and 8. There were 497 students (32% of total) who received a score of 9 or 10 on the pre-assessment, which suggests increasing the range of difficulty on future assessments. For these high performers, the conceptual understanding scores are a better way to track gains. There were 1058 students (68%

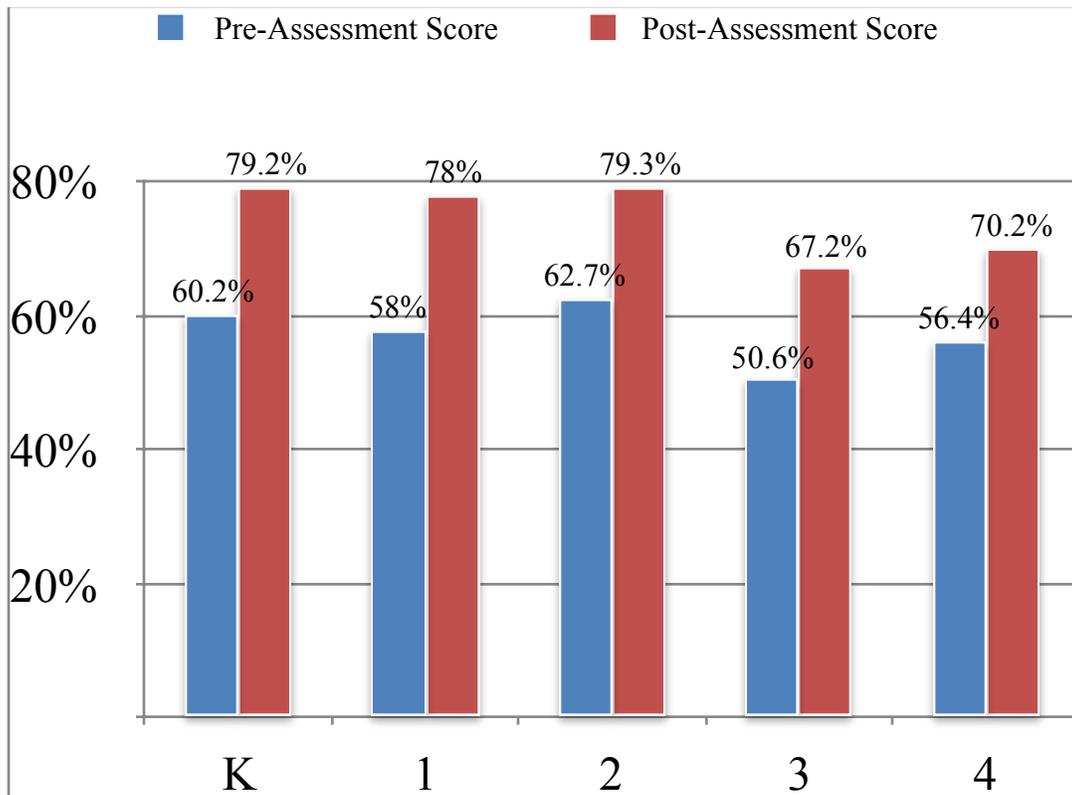
of total) who scored 0 to 8 on the fluency pre-test. Honing in on the latter group, we see a more dramatic improvement in mathematical fluency (See Table 6).

Table 6. Fluency Score Improvement for Students Scoring Below 90% on Fluency Pre-Assessment

Mean Pre Assessment Score (out of 10)	Mean Post Assessment Score (out of 10)	Improvement (out of 10)	Percentage Point Increase	Percentage Increase
5.76	7.50	1.74	17%	30%

Among this cohort, 76% improved their score on the post-assessment. Improvement in fluency scores in this cohort was visible at all grade levels.

Mean Pre- and Post-Assessment Scores by Grade for Students Scoring Below 90% on Fluency Pre-Assessment



Findings 2: Mathematical Doing and Thinking in Summer Staircase Classrooms

The second half of this evaluation reports on our investigation of student engagement in mathematical doing and thinking in their Summer Staircase math classrooms. We explored mathematical doing and thinking at the classroom level, looking at student engagement in the lessons and materials, student-teacher interaction, student-student interaction, and teachers' instructional practice. Additionally, teacher feedback was explored to understand teacher perspectives on student growth, strengths of the curriculum, and areas of improvement.

Data sources for this analysis include

- Math coach classroom observations
- Ethnographic field notes collected by an educational researcher who observed a selection of classrooms during Summer Staircase.
- Teacher feedback from the end of program survey of teachers

Math Coach Classroom Observations

Sample and measures.

Classroom observations were conducted by five math coaches, including three Seattle Public Schools math specialists hired for the summer and trained by Math for Love in addition to the two Math for Love co-founders. The purpose of math coach classroom observations was to provide teacher support and to ensure program quality. Coaches observed classrooms for partial or complete class periods. Coaches also made themselves available to teach the day's warm-up Number Talk as a way of demonstrating best instructional practices, or to assist in other ways during their observation, depending on the specifics of each classroom and the needs of the teacher.

All classrooms were observed within the first two weeks the program. For classrooms running smoothly, formal follow-up observations were not always conducted. [Note: all classrooms received some feedback.] For struggling classrooms, math coaches gave targeted feedback to the teacher, with follow-up observations conducted as needed.

For each classroom visit, math coaches completed an observation form where they ranked classrooms from 1-5 (weak to strong) in five areas: *spirit*, *fidelity*, *differentiation*, *engagement*, and *thinking*. Additionally, on the observation forms math coaches provided short written notes to explain their ratings, and document areas of concern or excellence.

Math coaches completed a total of 121 classroom observations over the course of Summer Staircase. Each classroom was observed formally between one - four times, with an average of two observations per classroom.

This analysis is concerned with the “engagement” and “thinking” scores from classroom observations and math coaches’ corresponding written notes on these areas. These constructs of “engagement” and “thinking” are clearly related. Math for Love holds that engagement in mathematically rich games and activities provides opportunities for deep mathematical thinking. Thus, engagement might be seen as a necessary precursor and vital context for critical mathematical thinking.

Results.

Looking at all classroom observations, we found a mean engagement score of 4.05 out of 5 and a mean thinking score of 3.77 out of 5.

Doing classrooms.

The strong mean engagement score is heartening and suggests that the program is fulfilling its mission to provide an engaging and fun summer school experience for students of all math backgrounds. High engagement scores are to be expected given that the play-based Math for Love Summer Staircase curriculum relies heavily on math games and problems that are purposefully designed to draw students in. If introduced by teachers with appropriate options for up and down leveling, these activities are accessible, fun and, importantly, powerful vehicles for math learning for students of all math backgrounds.

Math coach comments indicate that in classrooms with high engagement scores (or “doing classrooms”), students actively participating in the station games and activities, and in teacher-led warm-ups, including Number Talks. Comments also indicate that students were having fun, as evidenced by laughing, smiling and joking while doing math with each other and with the adults in their classrooms. Classrooms with high engagement scores were described as running well or smoothly, suggesting that students and teachers had routines and norms down, and had solid peer and student-teacher relationships that supported game playing, such as conflict-resolution and trust with materials.

Math coach comments point to several culprits for lower student engagement. Overly long warm-ups and launches, or warm-ups that only asked for participation from a handful of students challenged engagement as many students lost focus. Additionally, students were not engaged if there were too few options or not challenging enough options at the choice station.

Thinking classrooms.

The mean thinking score for the sample of math coach classroom observations was 3.77. This score is slightly lower than the mean engagement score (4.05), suggesting that it was more challenging for Summer Staircase math teachers to build thinking classrooms than doing classrooms. This agrees with the perspective that doing classrooms are a prerequisite of thinking

classrooms. Of course, the teacher is one actor of many in the classroom, and classroom cultures are co-constructed by all the adults and children in the room and also nestled within the larger community of the school and the Summer Staircase Program. And yet teachers have immense generative power for classroom culture, and the Math for Love curriculum and corresponding teacher trainings highlighted the importance of teacher instructional practices for creating thinking and doing classrooms.

Building a thinking classroom requires teachers to create opportunities, as well as seize opportunities on the fly, for students to think deeply about the mathematics work they are doing in class. While participating in the curriculum's rich games and activities inherently involves thinking, teachers are expected to purposefully draw connections between ideas and practices, to ask students to reflect on their learning and make their own connections, and to crystalize central mathematical ideas.

In order to build a thinking classroom, teachers must recognize the possibilities for deep, critical thinking that already exist in the curriculum's games and activities. Additionally, teachers must know their students' math skill set well enough to differentiate activities appropriately.

Math coach comments indicate that in classrooms with high thinking scores, teachers incorporated wrap-ups and reflections at the station level, in whole class discussion at the end of class, or both. Additionally, teachers asked open-ended questions and prompted students to explain their thinking and strategies.

Math coach comments highlight common deficiencies in classrooms with lower thinking scores. These classrooms were characterized by missed opportunity. The daily lesson plans' wrap-up and reflection times were skipped all together or given only cursory attention. Recall, rather than conceptual growth, was the focus, and opportunities throughout the daily lesson plan to support student thinking were not seized, and perhaps not recognized as opportunities.

Given the importance of thinking classrooms for student learning, encouraging classroom thinking is an area for Math for Love to address in future years in both the teacher training before Summer Staircase beings, and in teacher support offered by math coach's during the program.

Feedback and improvement.

Follow-up observations show improvement in some classrooms as teachers implemented feedback from math coaches. This suggests that math coaches are valuable teacher support resources and critical to program success.

Ethnographic Classroom and Teacher Observations

In order to better understand the factors that supported students' mathematical learning and contributed to fun, positive math experiences in Summer Staircase, we observed a selection of

exemplary classrooms using data collection techniques drawn from educational ethnography methodologies. Exemplary classrooms were distinguished by being solid “doing” and “thinking” classrooms.

Sample and measures.

The sample for this analysis comprises field notes from ethnographic observations of four teachers and their classrooms over the course of Summer Staircase. Relevant sample characteristics of the teachers in the sample are documented in Table 7. Three of the four teachers taught Summer Staircase at the elementary schools where they also teach during the school year. Two were very experienced teachers, and two were less experienced. Two of the teachers were general classroom teachers during the school year, whereas the other two teachers were math and science specialists.

Table 7. Teacher Characteristics

Teacher	Grade Band	Experience	School Year Role	At Home School?	Number of Observations
Ms. A	3-4	2 years	Math / Science Specialist	No	Two
Ms. S	1-2	19 years	General	Yes	Two
Ms. I	3-4	1 year	Math / Science Specialist	Yes	Two
Ms. G	1-2	10 years	General	Yes	One

Classrooms were observed for the entire class period. Field notes concentrated on documenting teacher instructional practice, teacher-student interaction, student-student interactions, and features of classroom culture. Talk and gestures both were recorded.

Analytical techniques.

Field notes were analyzed using grounded theory techniques, meaning that we did not predetermine data coding structures but instead let key themes emerge. Analysis focused on identifying common supports and challenges across exemplary teachers and classrooms in order to inform program development.

Results.

The four teachers in this sample were distinguished by excellent, positive relationships with students. They drew on students' interests in small but important ways. For example, Ms. I named the station groups after Seattle sports teams because her class contained many sports fans. Ms. A included "getting to know you" questions in her circle time warm-ups, for example, "what is your favorite movie?" and Ms. S asked students to share their fourth of July plans with the class.

All teachers in the sample were observed successfully attending to students who were having a hard time staying focused. Larger socio-emotional challenges were also handled with grace. Ms. G masterfully worked with a little boy who came to class so upset that he chose to sit on the ground in the corner instead of on the front carpet with the rest of the class for Ms. G's warm-up Number Talk. Ms. G encouraged him to take a break as long as he needed. Later on, when he had still not joined the class, Ms. found him, talked with him, convinced him to participate in the short transition game that the rest of the class was playing between station rotations, and then expertly incorporated him into the classroom activity.

The classroom cultures in the sample were characterized by mutual respect, knowing and valuing each student, and a view of math as fun, important and accessible to everyone. All classrooms had strong routines that aided a smooth flow between activities, as well as clear expectations for student participation. These classroom cultures and norms enabled high levels of student engagement in the mathematical activities as well as copious mathematical activity, especially in Ms. S's, Ms. G's, and Ms. I's classrooms. Indeed, in these three classrooms, the adults and children were busy doing math from the first math warm-up through the last station rotation timer beep. Ms. A's class was as well busy and engaged, but her class size was relatively small, allowing her pace to be more leisurely comparatively.

A common instructional and relational practice shared by the teachers in this sample is that not only did they work hard to engage students in mathematical thinking but they very purposefully engaged with students' mathematical thinking. All of the teachers did so in one on one interaction during warm-ups and station rotations. This most often took the form of asking students to explain their thinking when students offered answers or ideas. Ms. A especially engaged students one-on-one during station rotations, for example asking students about their strategies when playing the game Territory and their answers to her "trick questions" in a Broken Calculator activity.

Ms. G and Ms. I were observed engaging students' thinking at their stations by asking open-ended wrap-up questions, often drawn from the Math for Love curriculum. For example, on the day she was observed, Ms. G's station involved students working together to organize a pile of dominos in order from smallest to largest. Eventually, the students created a number line array spread across the table. In the final moments of the station rotation, Ms. G posed this question to her first station group, "If you're looking at this, can you see which number we see the most?"

She asked another group, “How can you tell the middle just by looking?” These questions focused students’ attention on the information this array conveyed – the meaning within the shape.

Station-based wrap-ups have the potential to serve as valuable contexts for students to crystalize central mathematical ideas and draw connections among them. Time was a challenge to station-based wrap-ups, as often teachers would only have a minute or two to wrap-up if any time at all, and would be cut short by the timer’s beep.

In fact, the press for time was a common challenging factor identified across sites. A three-station rotation plus a warm-up, a launch or mini-lesson for the day’s material, and a reflective warm-up was a significant amount to accomplish in 75 minutes. At the same time, the three-station model allowed for teacher-led small group time at the teacher’s station and very effectively and efficiently deployed the classroom’s three adults. The fast pace of the daily lesson plan also contributed to student engagement, as there was not much down time in a well-run class to challenge students’ focus. At the same time, it is possible that being perennially pressed for time limits opportunities for teachers to work with students to draw conclusions from individual lessons and across lessons, and to engage with students’ thinking, which is critical for learning and also teacher on-going assessment of student learning.

Math Teacher Perspectives on Student Growth

Sample and measures.

Teacher feedback is critical to understanding how the math curriculum played out in Summer Staircase classrooms. To gather teacher feedback, Math for Love surveyed math teachers at the conclusion of Summer Staircase using an online questionnaire. The questionnaire included scaled and open-ended questions. Teachers were asked to provide feedback about teacher trainings, professional development support during the program, how well the curriculum accomplished its goals, and student growth, among other facets of Summer Staircase. Teachers were invited but not required to provide identifying information.

Thirty-four teachers (61% of teachers) completed the end of program survey. Respondents comprised 10 Kindergarten teachers, 10 Grades 1-2 teachers, 10 Grades 3-4 teachers and four teachers who identified as teaching other grade configurations. Respondents had taught at a range of school sites.

Results.

Here we present findings from the survey that speaks to student growth as mathematicians over the course of Summer Staircase.

Teachers were asked to rate the Math for Love Summer Staircase math curriculum from 1 (weak) – 5 (strong) on the extent to which the curriculum supported students' engagement in mathematics, critical thinking, and productive disposition. The vast majority of teachers gave the curriculum very high marks. Results are presented in Table 8.

Table 8. Teacher Ratings of Curriculum

Percentage of teacher respondents rating the curriculum 4 or 5 (out of 5)	Factors
94%	Supporting Student Engagement
85%	Supporting Student Critical Thinking
76%	Supporting Student Productive Disposition

The survey asked teachers to rate on a scale of 1 (a little) – 5 (substantial) how much student growth they saw over the course of the summer as well as to share in responses to open-ended questions the ways their students grew as mathematicians. The majority of teacher respondents (61%) reported strong growth in their classroom, rating overall student growth at a four or five. One third of respondents experienced middle-range growth, rating their classroom at a three.

In their responses to open-ended questions, teachers identified areas where students grew as mathematicians over the course of Summer Staircase. Analysis of teacher responses yielded common areas of growth across teachers and classrooms.

Teacher-Identified Areas of Student Growth in Summer Staircase

- ❖ Conceptual understanding and skills (including counting, number sense, understanding of multiplication)
- ❖ Confidence and perseverance
- ❖ Enthusiasm and engagement
- ❖ Enjoyment of math
- ❖ Explaining their thinking
- ❖ Seeing and expressing different strategies for how to approach problems
- ❖ Being good sports while playing games

Summer Staircase students did not grow as mathematicians in the same ways. A handful of teachers pointed to uneven growth in conceptual understanding and skill development in their classrooms, noting that while many students made gains in these areas, other students continued to struggle with certain foundational ideas and skills. One teacher offered a hope that if the students experiencing “roadblocks” to their engagement in critical thinking are offered more math work like they experienced in their Summer Staircase math classrooms, “they will become more comfortable and fluent with analytical thinking.” Advanced students were also identified by some teachers as a group in need of further opportunities for challenge.

Finally, we asked teachers to tell us about a student for whom the Summer Staircase math program worked beautifully. Teachers shared about students gaining confidence as mathematicians, growth in conceptual understanding and skills, as well as dramatic positive shifts in how students participated in the classroom. A selection of responses are shared below.

Teacher Stories of Student Success

One of my students was very reserved in the beginning and had a very negative attitude towards math. A couple of weeks into the program he really opened up and started participating in the discussions and enjoyed the math games.

There were several students who simply didn't feel that they were 'smart' or 'good at math' and they always reflected that it was actually fun, or they were learning new ways to do math, enjoying the games and time to share out their thinking- they were each day feeling stronger and prouder of how they too were joining this 'elite group' (in their mind) of 'people who understand math'!

I had one little boy that loved to guess. As time went along with prompting him he learned that you can count things, use you fingers to find the answers. While he was doing building equations yesterday I over heard him saying, “I can do this!” I told him, “Yes, you can!”

Conclusion

By implementing the lessons learned in previous years and continuing to focus on providing rigorous, play-based curricula with aligned training and support, 2016 was the most mathematically successful year for Summer Staircase yet. Students across all program sites and demographics gained ground in mathematical content knowledge, confidence, and enthusiasm.

The Math for Love curriculum and program stood out especially for its:

- **Positive impact on student conceptual understanding and mathematical fluency**
- **Positive impact on students' mathematical habits of mind, including perseverance, confidence, and enjoyment of math**
- **Fostering of classroom environments that rigorously engaged students' in mathematical thinking and doing**

Overall, this program has the potential to be a model summer intervention program for math, and a powerful tool for Seattle Public Schools—and other school districts—to help build mathematical success for all its students.