Math Strong – Year 1 Evaluation

Kevin Miller
Professor of Psychology & Educational Studies, University of Michigan

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Executive Summary

MathStrong is a professional development program aimed at ensuring that all students develop a strong foundation of conceptual understanding, procedural skills and fluency and math problem solving skills. It aims to do so by providing classroom teachers with professional development consisting of comprehensive teacher professional development, lesson study, pedagogy, coaching), content and feedback.

The evaluation focused on three questions:

1. Did the PD increase teacher mathematical knowledge?
2. Did the PD improve teacher’s classroom mathematical teaching?
3. Did the PD lead to increases in student mathematical competence?

Q1: The available evidence suggests that the PD *did* improve teacher mathematical knowledge, as well as attitudes and beliefs relevant to improving mathematics instruction. There are some important caveats due to the small sample size, limited measures of how much teachers took up what they were learning and applied it, and large differences between the control and treatment schools, teachers, and students, but overall the results indicate that the PD led to measurable improvements in treatment teacher’s knowledge of mathematics relevant to teaching.

Q2: There was not evidence that these changes in teacher knowledge and beliefs led to significant changes in classroom practices. There are several reasons for this – it is, in general, harder to change classroom practices than it is to change knowledge and beliefs. The original plan to collect data on classroom discourse had to be changed, meaning that data on classroom practices relied primarily on a self-report measure (the Survey of Enacted Curriculum). Changes in Year 2’s PD are recommended that may help teachers better connect what they are learning to classroom practices.

Q3: The changes observed in teacher mathematical knowledge did not in general lead to measurable increases in student achievement. This was difficult to assess because the students in the control group performed much better than did students in the treatment group, both at the beginning and at the end of the treatment. In Year 2 we hope to get more granular data from the main achievement test (STAR Math) that will enable us to look more closely at student achievement. Having additional data on classroom practices will enable us to see whether changes in such practices are associated with increases in student learning.

Overall this appears to be a promising intervention. Modifications to help teachers connect the PD to classroom practice, and more data on changes in classroom practice should lead to clearer answers to whether it is effective in changing how teachers teach mathematics, and whether such changes in knowledge and teaching practices lead to changes in student achievement.
Structure of the report

The remainder of the report is organized around the three major assessment questions.

1. Did the PD increase teacher mathematical knowledge?
2. Did the PD improve teacher’s classroom mathematical teaching?
3. Did the PD lead to increases in student mathematical competence?

Each section describes the data used to evaluate the question and presents the analysis and results.

A final section presents recommendations for modifications in Year 2 of this project.
Q1: Did the PD increase teacher mathematical knowledge?

Primary Data source: Learning Mathematics for Teaching – Teacher Knowledge Assessment System (LMT-TKAS)

A key goal of the project was changing teacher knowledge, particularly knowledge about mathematics useful for teaching early number concepts and skills. To assess this the project team asked both treatment and control teachers to take the TKAS (Teacher Knowledge Assessment System (TKAS), which is an online system for administering the Learning Mathematics for Teaching (LMT) assessment questions. LMT assessments focus on the specialized forms of knowledge teachers’ use in providing their students opportunities to develop deep mathematical knowledge. LMT/TKAS was designed to assess both basic mathematical knowledge and teachers’ pedagogical content knowledge in mathematics – their understanding of mathematical knowledge in the context of how to explain it to children and to understand and respond to student misconceptions (Hill, Schilling, & Ball, 2004; Phelps, 2011).

The LMT-TKAS items are scaled using item response theory to produce a calibrated set of items arranged so that someone who passes item N should also pass all easier items, and someone who fails item P should fail all harder items. This permits the use of computerized adaptive testing to efficiently estimate ability by administering only a subset of a much larger pool of test questions. Computerized adaptive testing produces IRT scores, which are scaled in terms of variation in the original norm group, with items that range (in this case between approximately -3.0 and 3.0, with a 0 score representing roughly a mean value in the original norm group).

Two subscales from the TKAS were selected for the assessment. **Number Concepts and Operations** (TKAS-NCOP) was expected to improve based on the content of the Professional Development. **Patterns, Functions, and Algebra** (TKAS-PFAS) assessed areas of mathematics that were not a focus of the Professional Development. To the extent that the Professional Development leads to improvement in this area, it would likely be through a general increase in engagement to mathematics rather than to specific instruction.

Participating teachers took the TKAS at the beginning of the school year before the PD started and again in May. A total of 22 teachers in the Control group took the TKAS both times and 22 in the Treatment condition. One teacher in the Treatment condition did not complete the TKAS-PFAS subtest, so the degrees of freedom differs by one in that analysis.
Results.

1. **Number concepts and operations.** A 2 (Condition: Treatment, Control) x 2 (Time: Pretest, Post-test) ANOVA of the TKAS-NCOP scores, with time as a repeated measure did not find significant main effects of either Time ($F(1,42)=.658$, ns., $\eta^2=.005$), or Condition ($F(1,42)=1.31$, ns., $\eta^2=.030$), but there was a significant Condition x TIME interaction ($F(1,42)=8.81$, $p<.01$, $\eta^2=.173$).

The chart below shows the change in TKAS-NCOP scores in the two groups. The Treatment group began by performing worse than did the Control group, but this difference went away after the PD, as predicted. The drop in scores for the Control group was not predicted, however, and this may serve to inflate the effect of the PD.
2. **Patterns, Functions, and Algebra.** A 2 (Condition: Treatment, Control) x 2 (Time: Pretest, Post-test) ANOVA of the TKAS-PFA scores, with time as a repeated measure did not find significant main effects of either Time ($F(1,41)=.422$, ns., $\eta^2=.010$), or Condition ($F(1,42)=.278$, ns., $\eta^2=.0070$), but there was a significant Condition x TIME interaction ($F(1,42)=5.445$, $p<.05$, $\eta^2=.117$).

The chart below shows the change in TKAS-PFA scores in the two groups. As with the Number Concepts and Operation results, the Treatment group began by performing worse than did the Control group, but this difference went away after the PD, as predicted. The drop in scores for the Control group was not predicted, however, and this may serve to inflate the effect of the PD.
3. **Participation and change.** Because participants varied in how much they engaged in the PD, we looked at the correlation between number of hours logged (which varied between 54 and 121 across the year) in Fall, Winter, and Total and improvement in the TKAS-NCOP and TKAS-PFA. None of these relations were significant; the highest correlation was between NCOP change and participation in the Fall (including the initial intensive workshop). The correlation was $r(23)=.226$, ns.

This need not imply that engagement in the project did not affect teacher growth, but just that hours logged in PD and observation may not be the best measure of that engagement. There was a strong correlation between improvement on the two TKAS subtests (NCOP & PFAS), $r(.42)=.654$, $p<.001$. The team should explore other possible measures of engagement with the project.

Qualitative data:

Teachers who participated in the PD were asked to describe how it increased their content knowledge about mathematics. They reported changes in the following areas

- Strategies for struggling students.
- Developmentally appropriate math instruction

Good review of a range of math content

As a new teacher, the PD increased content knowledge greatly. It has helped me to understand some better strategies to teach mathematics.

Having a greater understanding of math and how it applies to student learning. It gave me more ways to think about how I teach math and how students learn.

Having the guests (Dr. Matnye) a part of the grant help tremendously. He gave us background info and great things to ponder.

Better understanding of progression of standards
- better understanding of the definition of fluency.

Knowledge of other grade levels besides just mine.

Basic math facts
- understanding what and how often grades work.
Have tried to make sure instruction is more open and student led.
Try to make sure students have for understand all concepts of what is being taught/asked.
Summary:

Results suggest that participating teachers believed that the PD led to increases in their mathematical content knowledge and improvements in their attitudes and beliefs toward mathematics. Results from the measure of teacher content/pedagogical content knowledge in mathematics also supported this conclusion, although results were magnified by a decrease in these measures for the control group, which was unexpected.
Q2: Did the PD improve teacher’s classroom mathematical teaching?

The connection between changes in teachers’ knowledge and increases in student learning runs through improvements in classroom teaching. The project originally planned to use the LENA system (https://www.lenafoundation.org/lena-pro/) to collect and analyze data on classroom discourse. Unfortunately, the LENA Foundation was not able to provide the system the project intended to use, which led to a gap in data on classroom practice. The project team reports that they plan to gather this data using a different approach in Year 2, and to incorporate classroom video into the PD. This may help participating teachers to connect what they are learning to classroom practice, as well as providing behavioral data on whether or not the PD leads to changes in teaching practices.

Data on changes in classroom mathematical teaching came from the Survey of Enacted Curriculum as well as teacher responses to a query about changes in their teaching.

Survey of Enacted Curriculum Results

The Surveys of Enacted Curriculum (Blank, 2002) is an online survey developed by the Council of Chief State School Officers and the Wisconsin Center for Education Research. It asks teachers about the amount of time they devote to specific instructional goals. The survey reflects Porter’s (2006) distinction among intended, enacted, assessed, and learned curricula, following earlier work showing often major discrepancies between the content that state and district policy makers intended to be taught and what students actually had the opportunity to learn (summarized in Porter & Smithson, 2001).

The Wisconsin Center for Education Research provides an online tool to collect and report data on Surveys of Enacted Curriculum (https://secure.wceruw.org/seconline/secWebHome.htm) which was used in this project.

The SEConline software produces a series of graphs of teacher reports of percentage of overall mathematics instructional time on various topics or strategies as they relate to various standards and to the reports from other groups.

Looking at mathematics content, results are broken down into a series of broad topics cross with student expectations divided into 5 categories:

1. Memorize facts, definitions, formulas
2. Perform procedures
3. Demonstrate understanding
4. Conjecture, analyze, generalize, prove
5. Solve non-routine problems / make connections

SEConline also provides a measure of alignment, which compares the percentage of time devoted to a particular topic in two groups (either participants or benchmarks), and selects the minimum (e.g., if one group spent 5% on functions and the other 10%, it would select 5%, as both groups spent at least 5% on functions). The alignment measure is the sum of these
proportions and thus represents the proportion of time that each group spent on the same on content or teaching methods. So, for example, if a set of teachers have an alignment with Ohio Benchmarks of .69, that means that they reported that 69% of classroom time was spent as prescribed by the Benchmarks. The remainder involved some combination of additional time on some topic or less time on the topic than recommended.

A variety of chart types are available, but the most interpretable are “tile” charts, which provide a heat map for the percent of instructional time use for a topic divided among the 5 types of student expectations. Roughly, the darker the color toward the right of each row of tiles, the more time was spent on more advanced kinds of activities. White tiles correspond to topics or expectations that were omitted.

Data are available for both the beginning of the school year (2015) and the end (2016). The Ohio Benchmark data did not change during this period, but results are compared to both the K-2 and grades 3-5 Benchmarks as teachers from both levels participated.

Changes in instructional activities.
The Treatment group reported more change in instructional activities across the year, with more endorsement of the importance of more active and student-centered activities, such as presenting or demonstrating material to others.

Content of enacted curriculum. The analysis will look at instructional content, comparing teachers in the Treatment and Control groups with each other at the start and end of the project, with the K-2 and 3-5 Ohio Benchmarks, and looking at how they changed over time.

Details follow, but a summary of the key results are as follows:

Teachers from both groups were quite similar in reported time use at both the start (87%) and end (86%) of the year. Each group was quite stable, particularly the Control group (92%) but also the Treatment group (86%).

Alignment with Ohio Benchmarks was lower as this table shows:

The Treatment group showed more movement toward the Ohio benchmarks than did the Control group, but overall the teachers reported dispersing their time over more topics than recommended by the Ohio Benchmarks.

<table>
<thead>
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<th>Group</th>
<th>Alignment</th>
<th>Start of year</th>
<th>End of year</th>
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<td>Ohio 3-4</td>
<td>52.37</td>
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</table>
Teacher beliefs were also surveyed on the SEConline system. Teacher beliefs did not differ dramatically between the two groups, however there were some interesting differences. More teachers in the Treatment group agreed that “Students learn mathematics best when they ask a lot of questions”, “Mathematics teachers in this school regularly share ideas and materials”, “I have adequate curriculum materials available for instruction”, “I have many opportunities to learn new things about teaching mathematics in my present job,” and “My school supports co-teaching and collaboration between general and special educators in the teaching of mathematics.”

Sources of influence. Teachers were asked for sources of influence on their instruction. Teachers in the two groups were generally in agreement on sources of influence, but the Treatment group described more influence from Professional Development experiences, as well as textbook and instructional materials and district curriculum frameworks.

Qualitative data:

Teachers who participated in the PD were asked to describe how it increased their mathematics teaching changed as a function of the PD. They reported changes in the following areas:

- Enriched my small group instruction
- Began implementing number talks
- Getting students talking about math/explaining their thinking more frequently.

- More chances for student response and involvement in problem solving:
  - Number talk
  - Think, (Ink), Pair, Share
  - Intervention strategies
  - Use of number line

- It has helped me be more mindful in having more meaningful math conversations. This includes having students and teacher-led examples and discussions using students as leaders in small group learning helped students learn from one another.

- It has changed my instructional practices by having me go into depth more in my questions. I question and have the students explain their reasoning.

- It has given me a lot of background knowledge on how students think. I now think more about student learning and how they learn.
  - Subitizing
  - All the resources you provided from Howard Count website- love them and will use them.

- More group time for the kids to work together and solve problems
  - Increased content knowledge
  - I learned about subitizing.
More use of open number line
- increased discussion on problem solving
- more use of subitizing dots

Understanding all different grade levels and where to go to my instructions for the students to continue to grow in math. Example getting a understanding of addition to numbers of 10

I’ve used games, manipulatives and activities we learned in our meetings. I’ve changed more small groups and whole group teaching.

- # talks
- target #’s
- working on more student led activities.

Conclusions: Overall, results are consistent in indicating that the PD had an effect on Treatment teachers’ attitudes and beliefs. Teaching practice is often harder and slower to change, and results showed less evidence of change in these aspects of teaching from the first year’s implementation of a professional development program.

References


1. Comparing the Treatment and Control groups at the start of the school year.

Overall similarity was quite high, with 87.02% of time spent in the same way. To the extent that the groups differed, the Treatment teachers reported spending more time in more advanced treatment of a number of topics.
2. Comparing the Treatment and Control groups at the end of the school year.

Overall similarity remained quite high, with 86.64% of time spent in the same way. To the extent that the groups differed, the Treatment teachers reported spending more time in several topics (Trigonometry and Special Topics) but less in Advanced Algebra and Analysis.

### Mathematics Content

**Percentage of Overall Mathematics Instructional Time**

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<tr>
<th>Administration Year: 2016</th>
<th>Coarse Grain Alignment: 0.8664</th>
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**Ohio**

- = Not Covered
- = <= 2.5%
- = <= 5.0%
- = <= 7.5%
- = >= 7.5%

**Student Expectations**

I. Memorize Facts, Definitions, Formulas
II. Perform Procedures
III. Demonstrate Understanding
IV. Conjecture, Analyze, Generalize, Prove
V. Solve Non-Routine Problems/Make Connections

Show Data Tables

- Number Sense / Properties / Relationships
- Operations
- Measurement
- Consumer Applications
- Basic Algebra
- Advanced Algebra
- Geometric Concepts
- Advanced Geometry
- Data Displays
- Statistics
- Probability
- Analysis
- Trigonometry
- Special Topics
- Functions
- Instructional Technology

Update

Coarse Grain Alignment: 0.8664
3. Comparison to Ohio Benchmarks – K-2 – Treatment group – start of school year

Overall, the group reported spending 65.6% of time spent as prescribed by this Benchmark. Time was more dispersed than the Benchmarks recommended, with less time on Measurement and basic number sense and more on most other topics.

## Mathematics Content

### Percentage of Overall Mathematics Instructional Time

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**Count:** 25

### Student Expectations

- I. Memorize Facts, Definitions, Formulas
- II. Perform Procedures
- III. Demonstrate Understanding
- IV. Conjecture, Analyze, Generalize, Prove
- V. Solve Non-Routine Problems/Make Connections

[Show Data Tables]

- [Number Sense / Properties / Relationships]
- [Operations]
- [Measurement]
- [Consumer Applications]
- [Basic Algebra]
- [Advanced Algebra]
- [Geometric Concepts]
- [Advanced Geometry]
- [Data Displays]
- [Statistics]
- [Probability]
- [Analysis]
- [Trigonometry]
- [Special Topics]
- [Functions]
- [Instructional Technology]
4. Comparison to Ohio Benchmarks – 3-4 – Treatment group – start of school year

Overall, the group reported spending 56.8% of time spent as prescribed by this Benchmark. As at the start of the year, time was more dispersed than the Benchmarks recommended, with less time on algebra and measurement and more on most other topics.

Mathematics Content

Percentage of Overall Mathematics Instructional Time

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☐ Show Data Tables

- Number Sense / Properties / Relationships
- Operations
- Measurement
- Consumer Applications
- Basic Algebra
- Advanced Algebra
- Geometric Concepts
- Advanced Geometry
- Data Displays
- Statistics
- Probability
- Analysis
- Trigonometry
- Special Topics
- Functions
- Instructional Technology

Student Expectations

I. Memorize Facts, Definitions, Formulas
II. Perform Procedures
III. Demonstrate Understanding
IV. Conjecture, Analyze, Generalize, Prove
V. Solve Non-Routine Problems/Make Connections

Display Selected Fine Grain Charts  Return to Report Generator
5. Comparison to Ohio Benchmarks – K-2 – Control group – start of school year

Overall, the group reported spending 69.7% of time spent as prescribed by this Benchmark. Time was more dispersed than the Benchmarks recommended, with less time on Measurement and more on most other topics.

**Mathematics Content**

**Ohio**

**Percentage of Overall Mathematics Instructional Time**

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**Coarse Grain Alignment:** 0.6969

**Sample Selection:** Math Strong Control Data

**Report By:** All Data

**Count:** 24

**Show Data Tables**

- Number Sense / Properties / Relationships
- Operations
- Measurement
- Consumer Applications
- Basic Algebra
- Advanced Algebra
- Geometric Concepts
- Advanced Geometry
- Data Displays
- Statistics
- Probability
- Analysis
- Trigonometry
- Special Topics
- Functions
- Instructional Technology

**Student Expectations**

I. Memorize Facts, Definitions, Formulas
II. Perform Procedures
III. Demonstrate Understanding
IV. Conjecture, Analyze, Generalize, Prove
V. Solve Non-Routine Problems/Make Connections
Overall, the group reported spending 52.37% of time spent as prescribed by this Benchmark. Time was more dispersed than the Benchmarks recommended, with less time on Measurement and Operations and more on most other topics.

### Mathematics Content

#### Percentage of Overall Mathematics Instructional Time

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**Student Expectations**

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<td>V. Solve Non-Routine Problems/Make Connections</td>
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Display Selected Fine Grain Charts

Return to Report Generator
7. Comparison to Ohio Benchmarks – K-2 – Treatment group – end of school year

Overall, the group reported spending 69% of time spent as prescribed by this Benchmark. Time was more dispersed than the Benchmarks recommended, with less time on Measurement and more on most other topics.

**Mathematics Content**

<table>
<thead>
<tr>
<th>Percentage of Overall Mathematics Instructional Time</th>
<th>Ohio</th>
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<td>Coarse Grain Alignment: 0.69</td>
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<td>= &gt;= 7.5%</td>
<td>OH Bnchmrks Gr. k.2</td>
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- **Number Sense / Properties / Relationships**
- **Operations**
- **Measurement**
- **Consumer Applications**
- **Basic Algebra**
- **Advanced Algebra**
- **Geometric Concepts**
- **Advanced Geometry**
- **Data Displays**
- **Statistics**
- **Probability**
- **Analysis**
- **Trigonometry**
- **Special Topics**
- **Functions**
- **Instructional Technology**

**Student Expectations**

1. Memorize Facts, Definitions, Formulas
2. Perform Procedures
3. Demonstrate Understanding
4. Conjecture, Analyze, Generalize, Prove Solve Non-Routine Problems
5. Connections

- **Display Selected Fine Grain Charts**
- **Return to Report Generator**
8. Comparison to Ohio Benchmarks – 3-4 – Treatment group – end of school year

Overall, the group reported spending 54.66% of time spent as prescribed by this Benchmark. Time was more dispersed than the Benchmarks recommended, with less time on Geometric Concepts and Basic Algebra and more on most other topics.

### Mathematics Content

#### Percentage of Overall Mathematics Instructional Time

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<th>Percentage of Overall Mathematics Instructional Time</th>
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#### Student Expectations

<table>
<thead>
<tr>
<th>I. Memorize Facts, Definitions, Formulas</th>
<th>II. Perform Procedures</th>
<th>III. Demonstrate Understanding</th>
<th>IV. Conjecture, Analyze, Generalize, Prove</th>
<th>V. Solve Non-Routine Problems/Make Connections</th>
</tr>
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<td>L.</td>
<td>I.</td>
<td>IV.</td>
<td>V.</td>
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</tbody>
</table>

Return to Report Generator
9. Comparison to Ohio Benchmarks – K-2 – Control group – end of school year

Overall, the group reported spending 70.57% of time spent as prescribed by this Benchmark. Time was more dispersed than the Benchmarks recommended, with less time on Measurement and Operations and more on most other topics.

### Mathematics Content

#### Percentage of Overall Mathematics Instructional Time

<table>
<thead>
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<th>Mathematics Content</th>
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- **Number Sense / Properties / Relationships**
- **Operations**
- **Measurement**
- **Consumer Applications**
- **Basic Algebra**
- **Advanced Algebra**
- **Geometric Concepts**
- **Advanced Geometry**
- **Data Displays**
- **Statistics**
- **Probability**
- **Analysis**
- **Trigonometry**
- **Special Topics**
- **Functions**
- **Instructional Technology**

- **Student Expectations**
  - I. Memorize Facts, Definitions, Formulas
  - II. Perform Procedures
  - III. Demonstrate Understanding
  - IV. Conjecture, Analyze, Generalize, Prove
  - V. Solve Non-Routine Problems/Make Connections

- **Show Data Tables**
- **Display Selected Fine Grain Charts**
- **Return to Report Generator**
Overall, the group reported spending 70.57% of time spent as prescribed by this Benchmark. Time was more dispersed than the Benchmarks recommended, with less time on Measurement and Geometric Concepts and more on most other topics.

### Mathematics Content

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**Sample Selection:** Math Strong Control Data

**Report By:** All Data

**Count:** 39

**Coarse Grain Alignment:** 0.513

**Update**

- **Number Sense / Properties / Relationships**
- **Operations**
- **Measurement**
- **Consumer Applications**
- **Basic Algebra**
- **Advanced Algebra**
- **Geometric Concepts**
- **Advanced Geometry**
- **Data Displays**
- **Statistics**
- **Probability**
- **Analysis**
- **Trigonometry**
- **Special Topics**
- **Functions**
- **Instructional Technology**

**Student Expectations**

1. Memorize Facts, Definitions, Formulas
2. Perform Procedures
3. Demonstrate Understanding
4. Conjecture, Analyze, Generalize, Prove
5. Solve Non-Routine Problems/Make Connections

**Display Selected Fine Grain Charts**

**Return to Report Generator**
11. Change over year – Treatment group

Overall, there was substantial stability how these teachers reported spending time, with 86.24% of the time the same across the year. Time was somewhat more dispersed at the start of the year; by the end teachers reported spending no time on Functions or Advanced Algebra, in contrast to the start of the school year.

### Mathematics Content

#### Percentage of Overall Mathematics Instructional Time

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#### Ohio

Coarse Grain Alignment: 0.8624

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- [ ] Show Data Tables
  - Number Sense / Properties / Relationships
  - Operations
  - Measurement
  - Consumer Applications
  - Basic Algebra
  - Advanced Algebra
  - Geometric Concepts
  - Advanced Geometry
  - Data Displays
  - Statistics
  - Probability
  - Analysis
  - Trigonometry
  - Special Topics
  - Functions
  - Instructional Technology

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Update Ohio 2016

23
12. Change over year – Control group

Overall, there was enormous stability how these teachers reported spending time, with 92.51% of the time the same across the year. Time was somewhat more dispersed at the start of the year; by the end teachers reported spending no time on Functions, Trigonometry, and Special Topics, but more time on Measurement.

Mathematics Content

<table>
<thead>
<tr>
<th>Percentage of Overall Mathematics Instructional Time</th>
<th>Ohio</th>
</tr>
</thead>
<tbody>
<tr>
<td>= Not Covered</td>
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<tr>
<td>= &lt; 2.5%</td>
<td></td>
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<td>= &lt; 7.5%</td>
<td></td>
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<td>= &gt;= 7.5%</td>
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Coarse Grain Alignment: 0.9251

Administration Year: 2015 2016
Sample Selection: Math Strong Control Data Math Strong Control Data
Report By: All Data All Data
Count: 24 39
13. Teacher opinions and beliefs – End of School year

Teacher beliefs did not differ dramatically between the two groups, however there were some interesting differences. More teachers in the Treatment group agreed that “Students learn mathematics best when they ask a lot of questions”, “Mathematics teachers in this school regularly share ideas and materials”, “I have adequate curriculum materials available for instruction”, “I have many opportunities to learn new things about teaching mathematics in my present job,” and “My school supports co-teaching and collaboration between general and special educators in the teaching of mathematics.”

(data follow on the next several pages).
14. Teacher opinions and beliefs – End of School year (continued)
15. Teacher opinions and beliefs – End of School year (continued)
16. Teacher opinions and beliefs – End of School year (continued)

<table>
<thead>
<tr>
<th>Mathematics teachers in this school regularly observe each other teaching classes.</th>
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<tbody>
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<td>All [21]</td>
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<tr>
<td>9-12 [0]</td>
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<td>5-8 [2]</td>
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<tr>
<td>K-4 [19]</td>
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<tr>
<td>0: Strongly Disagree 1: Disagree</td>
</tr>
<tr>
<td>2: Neutral/Undecided 3: Agree</td>
</tr>
<tr>
<td>4: Strongly Agree</td>
</tr>
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</table>

I have adequate curriculum materials available for instruction.

| All [21] |
| 9-12 [0] |
| 5-8 [2] |
| K-4 [19] |
| 0: Strongly Disagree 1: Disagree |
| 2: Neutral/Undecided 3: Agree |
| 4: Strongly Agree |

I have many opportunities to learn new things about teaching mathematics in my present job.

| All [21] |
| 9-12 [0] |
| 5-8 [2] |
| K-4 [19] |
| 0: Strongly Disagree 1: Disagree |
| 2: Neutral/Undecided 3: Agree |
| 4: Strongly Agree |

I have adequate time during the regular school week to work with my peers on mathematics curriculum or instruction.

| All [21] |
| 9-12 [0] |
| 5-8 [2] |
| K-4 [19] |
| 0: Strongly Disagree 1: Disagree |
| 2: Neutral/Undecided 3: Agree |
| 4: Strongly Agree |
17. Teacher opinions and beliefs – End of School year (continued)

**Most teachers in this school contribute actively to making decisions about the curriculum.**

**My school supports co-teaching and collaboration between general and special educators in the teaching of mathematics.**
18. Instructional Activities in Mathematics – Treatment Group – change across school year

Across the year, the Treatment group teachers increased their endorsement of the importance of the following activities:

- *Listen to the teacher explain, or observe the teacher demonstrate or model a math procedure or solve a problem*
- *Present or demonstrate to others*
- *Work individually on mathematics assignments*
- *Use computers, calculators, or other technology to learn, practice or explore mathematics*

And less time on:

- *Engage in learning activities outside the classroom*

Data follow on the next several pages…
How much of the mathematics instructional time in the target class do students use to engage in the following tasks?

Listen to the teacher explain, or observe the teacher demonstrate or model a math procedure or solve a problem

Read and comprehend mathematics information from multiple sources

Collect, summarize, and/or analyze information or data from multiple sources
Present or demonstrate to others

Work individually on mathematics assignments

Participate in whole-class discussions about mathematics

Engage in a writing process to support arguments with evidence

Use hands-on materials
Work in pairs or small groups on mathematics exercises, problems, investigations, or tasks

Engage in learning activities outside the classroom

Use computers, calculators, or other technology to learn, practice or explore mathematics

Maintain and reflect on a portfolio of their own work

Practice test-taking strategies
Take a quiz or test
19. Instructional Activities in Mathematics – Control Group – change across school year

Across the year, the Control group teachers showed relatively small changes, but they increased their endorsement of the importance of the following activity:

*Use of hands-on materials.*

And less time on most other aspects of learning mathematics, including:

*Listen to the teacher explain, or observe the teacher demonstrate or model a math procedure or solve a problem*

*Participate in whole-class discussions about mathematics*

*Engage in learning activities outside the classroom*

Data follow on the next several pages…
How much of the mathematics instructional time in the target class do students use to engage in the following tasks?

Listen to the teacher explain, or observe the teacher demonstrate or model a math procedure or solve a problem

Read and comprehend mathematics information from multiple sources

Collect, summarize, and/or analyze information or data from multiple sources
Present or demonstrate to others

Work *individually* on mathematics assignments

Participate in whole-class discussions about mathematics

Engage in a writing process to support arguments with evidence

Use hands-on materials
Work in pairs or small groups on mathematics exercises, problems, investigations, or tasks

Engage in learning activities outside the classroom

Use computers, calculators, or other technology to learn, practice or explore mathematics

Maintain and reflect on a portfolio of their own work

Practice test-taking strategies
Take a quiz or test

- All [27]
- 9-12 [0]
- 5-8 [1]
- K-4 [26]

0: None 0.5: < 10%
1: 10-25% 2.5: 26-50%
4: More than 50%

- All [42]
- 9-12 [0]
- 5-8 [1]
- K-4 [41]

0: None 0.5: < 10%
1: 10-25% 2.5: 26-50%
4: More than 50%

Return
20. Instructional Activities in Mathematics – Differences between Treatment & Control Group – end of school year

Compared to the Control group, the Treatment group teachers showed stronger endorsement of the importance of:

*Listen to the teacher explain, or observe the teacher demonstrate or model a math procedure or solve a problem*

*Work individually* on mathematics assignments

*Participate in whole-class discussions about mathematics*

*Use hands-on materials*

*Work in pairs or small groups on mathematics exercises, problems, investigations, or tasks.*

And on these aspects of learning mathematics:

*Practice test-taking strategies*

Data follow on the next several pages…
How much of the mathematics instructional time in the target class do students use to engage in the following tasks?

Listen to the teacher explain, or observe the teacher demonstrate or model a math procedure or solve a problem

Read and comprehend mathematics information from multiple sources

Collect, summarize, and/or analyze information or data from multiple sources
Present or demonstrate to others

Work *individually* on mathematics assignments

Participate in whole-class discussions about mathematics

Engage in a writing process to support arguments with evidence

Use hands-on materials
Work in pairs or small groups on mathematics exercises, problems, investigations, or tasks.

Engage in learning activities outside the classroom.

Use computers, calculators, or other technology to learn, practice or explore mathematics.

Maintain and reflect on a portfolio of their own work.

Practice test-taking strategies.
21. Instructional influences in Mathematics – Differences between Treatment & Control Group – end of school year

The two groups of teachers were generally in agreement on the influences on their instruction, but the Treatment group reported more and more positive influence from:

- Textbook or instructional materials
- District curriculum framework, standards, or guidelines

And, notably:

- Professional development experiences.

And less from

- State test or results from test.

Data follow on the next several pages…
Instructional Influences

Your state's curriculum framework or content standards

Your district's curriculum framework, standards, or guidelines

Textbook or instructional materials

State test or results from test
District test or results from test

National Council of Teachers of Mathematics Education Standards

Your pre-service preparation

Students' special needs

Preparation of students for next grade or level
<table>
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<tr>
<th>Local priorities, directives, or policies</th>
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<tbody>
<tr>
<td>Your professional development experiences</td>
</tr>
<tr>
<td>Screening, diagnostic, or classroom assessment results</td>
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</table>
Q3: Did the PD lead to increases in student mathematical competence?

Evaluating changes in student achievement was complicated because of the broad range of age groups studied. Results for pre-K and Kindergarten students will be discussed first, followed by results for elementary school students.

A. Preschool/K Student achievement gains

Research-Based Early Mathematics Assessment (REMA)

The Research-Based Early Mathematics Assessment (REMA) (Clements, Sarama, & Liu, 2008) was developed to provide a validated measure of preschool and kindergarten mathematics achievement. Weiland et al. (2011) developed and validated a 19-item (compared to 125 items) short form of the REMA, which was used here.

REMA provides scores in two areas, number and geometric/spatial competencies. Only the number domain was assessed here, as that was the focus of the project.

A total of 2 teachers (with 38 students) in the Control condition and 4 (with 71 students) in the Treatment condition participated, although 2 of the preschool teachers (with 30 students) in the Treatment condition dropped out before completing the PD.

Because of the small sample size, we did not run a nested analysis taking teacher effects into account, but rather a simple comparison of the treatment and control groups ignoring teacher variation within the two groups. We did two pre-post comparisons of REMA results for the Treatment and Control conditions. The first included students of all teachers while the second included only students of teachers who completed the PD.
Results.

1. **REMA results (all teachers).** A 2 (Condition: Treatment, Control) x 2 (Time: Pretest, Post-test) ANOVA of the REMA raw scores, with time as a repeated measure found significant improvement in both groups between pre- and post-test ($F(1,78)=25.8, P < .001, \eta^2=.249$), but no significant main effect of Condition ($F(1,78)=.001, \text{ns.}$), and no significant Condition x Treatment interaction ($F(1,78)=.194, \text{ns.}$).

The chart below shows the change in REMA scores in the two groups. Because 2 of the 4 preschool/Kindergarten teachers in the Treatment group did not complete the PD, we reanalyzed the data looking at only the completing teachers.
2. **REMA results (only teachers who completed PD).** A 2 (Condition: Treatment, Control) x 2 (Time: Pretest, Post-test) ANOVA of the REMA raw scores, with time as a repeated measure found significant improvement over Time ($F(1,29)=19.86, p<.01$, $\eta^2=.293$), and a marginal main effect for Condition ($F(1,48)=31.36, .05 < p < .10$, $\eta^2=.058$), and no significant Condition x Treatment interaction ($F(1,48)=.220$, ns., $\eta^2=.005$).

The chart below shows the REMA results omitting the Treatment teachers who did not complete the PD.

![REMA Number results - Finishers only](image)

The small number of preschool teachers who completed the PD makes it difficult to draw conclusions about changes in student learning. Data on additional measures developed by the project team are being analyzed and they may clarify the likelihood of obtaining achievement results with an improved PD.

The inherently small sample size of preschool and Kindergarten teachers in any school district may mean that it will be difficult to find achievement effects. That may be acceptable to the project team, given that these students will enter elementary school and so any advantage that they received due to increases in their teachers’ mathematical knowledge may carry over and be reflected in achievement gains in later grades.

**References**

B. Achievement results for elementary school students

Elementary Student achievement gains

STAR Math (Enterprise)

STAR (original Standardized Test for the Assessment of Reading) is a computerized adaptive assessment developed by Renaissance Learning for K-12 assessment. A range of scaled scores are reported, but for this evaluation we looked at Percentile Rank data as they are scaled for grade level.

One limitation of the analysis is that we were not able to get the data from Renaissance Learning in a form that could be analyzed. Instead, we had to take the data from PDF files, which limited what we were able to do. Hopefully that problem will be resolved with the Year 2 data.

We had STAR math data from a total of 25 teachers, 9 in the Control condition and 16 in the Treatment condition. We analyzed the average score for each teacher pre- and post-treatment.
Results.

1. **STAR Math results.** A 2 (Condition: Treatment, Control) x 2 (Time: Pretest, Post-test) ANOVA of the STAR Math percentile rank data, with time as a repeated measure found significant improvement in both groups between pre- and post-test ($F(1,78)=25.8, P < .001, \eta^2=.661$), a significant main effect of Condition ($F(1,21)= 6.469, p < .05, \eta^2=.236$), and a significant Time x Condition interaction ($F(1,21)= 10.550, p < .01, \eta^2=.334$).

The chart below shows the change in average STAR Math percentile ranks for the two groups. The Control began significantly lower than did the Treatment group, and this difference increased during the period of the intervention.

These results are not encouraging, although the differences in initial performance were quite large. But they may suggest that the PD used in Year 1 is not sufficient, in itself, to lead to increases in student learning. Revisions to the PD that may help teachers in using the concepts and strategies may be effective in connecting the gains observed in teacher knowledge to changes in student learning.
Conclusions: Year 1 of the PD did not produce measurable changes in student learning. It was difficult to evaluate because there were large pre-existing differences between the control and treatment students. Change in student learning is often a trailing indicator that lags after changes in classroom practices that in turn follows from changes in teacher knowledge and beliefs. It would also be useful to add a team-administered measure such as the DIBELS Math test that could provide more differentiated information in a form that allowed deeper analysis.
Summary and Recommendations.

The Math Strong PD was able to produce measurable changes in teacher mathematical understanding and positive changes in attitudes toward teaching mathematics. It did not lead to measurable changes in teaching practices. This reflects limitations in the measures of teaching practices (primarily self-report of the percentage of time spent on different activities), but it may indicate that the PD should be changed to draw more concrete connections with classroom practice. The team plans to use video cases to promote these connections, which is a promising idea. The PD did not lead to measurable improvements in student learning. Incorporating additional achievement measures and getting treatment and control schools that are initially more similar should help clarify this question.

Recommendations (these recommendations have been discussed with the team and I believe they intend to incorporate all of them in Year 2):

1. Because not all teachers engage to the same degree with the PD, a better measure of that engagement should be sought. Hours of participation did not prove a good measure of this engagement, so it would be helpful to ask teachers how engaged they were in the PD.

2. The team should include measures of classroom practice into the data collection and incorporate them into the PD itself. Providing teachers with concrete examples of how to use the ideas that they are taught should help them to turn knowledge into practice.

3. The team should incorporate a more differentiated measure of mathematics achievement, such as the DIBELS Math that would give us access to student responses.

4. Treatment and Control schools should be sought that are more similar to each other than turned out to be the case this year.

5. To the extent that budget permits, an increased sample size of teachers, particularly in the treatment condition, would provide more power in analyzing effects of the PD.