Better Math Teaching Through a Networked Improvement Community
Better Math Teaching Network

Better Math Teaching Through a Networked Improvement Community
Oct. 26, 2017
Moderator: Eve Goldberg, Nellie Mae Education Foundation
Presenter: Toni Smith, AIR
Presenter: Kirk Walters, AIR
Overview

• Problem
• Our network
• What we’re learning
• Where we’re headed
• Q&A
Problem

"Big deal, an A in math. That would be a D in any other country."
Programme for International Student Assessments
National Assessment of Education Progress
What is the source of the problem?

- Societal values?
- Teacher workforce?
- Pedagogy?
- Resources?
- Some combination?
- Other?
We decided to focus on instruction

• Good teachers make a difference
• Teaching is complex and cannot be done well in isolation
• Some emerging evidence in support of deeper, “student-centered” instructional techniques

Including some of our own work
Ambitious instruction requires support

- Professional development doesn’t always work as intended
- One hypothesis is that it isn’t integrated into teachers’ daily work
- And we’ve been thinking about this a lot:
Creating a Networked Improvement Community (NIC)

- Highly collaborative
- Uses principles of improvement science
- Strongly rooted in teachers’ daily, messy work
- Focus is on making incremental improvements
Our network
Better Math Teaching Network

• 41 high school algebra (or equivalent) teachers
• 11 instructional leaders (state-, district- and school-level)
• 2 math education researchers/improvement scientists
• 1 front-line, practitioner expert
• 1 research associate
• 1 project manager
• 2 communications associates
Our core principles

Teachers are central to change.

Teachers shape students’ learning experiences and beliefs about math. It is possible to create classrooms that are more strongly student-centered—classrooms in which all students are actively and meaningfully engaged in learning math.
Our core principles

#2

Student-centered teaching is complex and almost impossible to do in isolation.

Teaching to maximize student engagement and understanding is complex. One way to deal with this complexity is for teachers to participate in structured, collaborative learning with other teachers and researchers.
Our core principles

Teaching can be continuously improved.

Teaching is a craft to continuously hone. Teachers use practices daily that lend themselves to ongoing, incremental improvement. Continuous improvement methods from industry and healthcare hold promise for education.
Quick-cycle improvement methods provide opportunities to study and improve teaching.

Many of the practices teachers want to improve can be studied with quick-cycle research and development methods. Teachers can test and refine strategies within and across lessons, realizing improvements every few weeks, rather than waiting until summer break.
Our core principles

Research and practice should be seamlessly integrated.

Too often, research and practice fail to inform each other. Our network includes researchers and practitioners working arm-in-arm to test and refine improvement strategies in real classroom settings. Mutual respect fuels our work.
Aim statement

2,019 in 2019

By 2019, the number of students who connect, justify, and solve with depth in Algebra on a daily basis will increase by 2,019.
Deep engagement in learning algebra

- **Connect:** Make connections among mathematical procedures, concepts and application to real-world contexts, where appropriate
- **Justify:** Communicate and justify mathematical thinking as well as critique the reasoning of others
- **Solve:** Make sense of and solve challenging problems that extend beyond rote application of procedures
Driver diagram

Deep Student Engagement in Algebra

2019 in 2019: By 2019, the number of students who connect, justify, and solve with depth in algebra will increase by 2,019.

Connect: Make connections among mathematical algorithms, concepts, and application to real-world contexts, where appropriate.

Justify: Communicate and justify mathematical thinking as well as critique the reasoning of others.

Solve: Make sense of and solve challenging math problems that extend beyond rote application of algorithms.

AIM Statement

Mathematics Instruction

Mathematical instruction provides ongoing opportunities for all students to connect, justify, and solve in algebra through the choice of task/activity and by shifting the academic responsibility to the students.

(Instruction is student-centered)

Primary Drivers (WHAT?)

Secondary Drivers (WHERE?)

Change Ideas (HOW?)

Instructional Routines to Introduce New Material

Instructional Routines to Practice/Reinforce Previously Introduced Material

Classroom Environment

Positive, caring learning environment for all students

Student Attitudes

Students see school and learning as important and valuable

Student Readiness

Students enter algebra with the requisite knowledge, skills, and dispositions to succeed
Our activities

- Small groups of teachers (2-3) conduct PDSA testing in their classrooms throughout the school year.
- Groups are organized by their student-centered instruction approach, or “change idea”.
- The groups meet via video conference every 4-6 weeks, sharing what they are learning from their testing.
- The whole network meets in-person 5 times a year, including a multi-day summer institute.
- Teacher commitment is approx. 100 hours per school year.
Our activities

• Group of instructional leaders at school-, district-, or state-level provide support to network teachers, through:
  • Replicating teachers’ change ideas in their own jurisdictions and reporting back results
  • Sharing promising instruction resources or routines for potential testing
  • Providing updates on relevant policy issues related to student-centered instruction
  • Recruiting teachers and other instructional leaders to join the network

• Instructional leaders meet 5 times per year via video conference and 2 times in person
What kinds of routines are we testing?

- Introducing new material using open-ended problem to encourage students to make connections
- Adapting exit tickets to provide students opportunities to make conceptual and real world connections
What kinds of routines are we testing?

Using “stuck points” to encourage justification, critique, and shared learning

Providing and, ultimately removing, scaffolds for students to use claim-evidence-reasoning in justifications

Using non-routine problems to encourage justification and critique

Justify
What kinds of routines are we testing?

- Integrating more non-rote problems into my teaching when I introduce new material
- Using a protocol for students to provide and critique problem solving approaches when practicing previously introduced material
Did the routine lead to an improvement?

• We ask ourselves 3 questions with each PDSA test:
  • Will I implement the change idea as planned?
  • Will my students engage—i.e., give it a fair shot?
  • Did my students engage with depth?

• We measure improvement with different types of data:
  • Teacher journal
  • Student surveys
  • Student work (e.g., exit tickets, formative assessments)
  • Observation
  • Video/audio recordings
Keeping track of our work: PDSA form

<table>
<thead>
<tr>
<th>PLAN</th>
<th>ACT</th>
<th>DO</th>
<th>STUDY</th>
</tr>
</thead>
</table>

1. PLAN
   - Describe the what/when/where of the test. Include your data collection plan.
   - Questions: What do you want to learn? What will happen?
   - Predictions: Make a prediction for each question. Not optional.
   - Data: Data collected against test predictions.

2. DO
   - Briefly describe what happened during the test, surprises, difficulty getting data, obstacles, successes, etc.

3. STUDY
   - Questions: What do you want to learn? What will happen?
   - Predictions: Make a prediction for each question. Not optional.
   - What were the results? Comment on your predictions in the row below. Were the correct? Record any data summaries as well.

4. ACT
   - Describe modifications and/or decisions for the next cycle, what will you do next?

<table>
<thead>
<tr>
<th>Trial 1 Prediction</th>
<th>Trial 2 Prediction</th>
<th>Trial 3 Prediction</th>
<th>Trial 1 Data</th>
<th>Trial 2 Data</th>
<th>Trial 3 Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>b</td>
<td>b</td>
<td>b</td>
<td>b</td>
<td>b</td>
<td>b</td>
</tr>
</tbody>
</table>

Footnotes:

- b: nothing to do
Will I implement the change idea as planned?

<table>
<thead>
<tr>
<th>Questions: Questions you have about what will happen. What do you want to learn? (From Plan – Step 1)</th>
<th>Predictions: Make a prediction for each question. Not optional. (From Plan – Step 1)</th>
<th>What were the results? Comment on your predictions in the rows below. Were the correct? Record any data summaries as well.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Will I do this consistently?</td>
<td>I predict that I can do this an average of twice in a two week period.</td>
<td>I did this twice this week. I thought I would be able to do this on the one day I had before Thanksgiving but I didn’t. I can do this consistently.</td>
</tr>
</tbody>
</table>

Most of our teachers are implementing close to the expected consistency.
Will students engage?

PDSA Form

<table>
<thead>
<tr>
<th>Questions: Questions you have about what will happen. What do you want to learn? (From Plan – Step 1)</th>
<th>Predictions: Make a prediction for each question. Not optional. (From Plan – Step 1)</th>
<th>What were the results? Comment on your predictions in the rows below. Were the correct? Record any data summaries as well</th>
</tr>
</thead>
<tbody>
<tr>
<td>Will students write a critique?</td>
<td>Based on the increase in students writing critiques from the first cycle, I predict that 70% of the students will write a critique. Students who do this will: 1. Write at least a couple of sentences describing what the student did, where the student went wrong, what they did well, how they did their work, what they could have done, etc.</td>
<td>I did my PDSA twice with an average of 97% of students writing a critique. Monday Nov 28th, 94% of students wrote a critique. Wednesday Nov 30th, 100% of students wrote a critique.</td>
</tr>
</tbody>
</table>

Most of the students are engaging with the strategies.
Will students engage with depth?

<table>
<thead>
<tr>
<th>Questions</th>
<th>Predictions</th>
<th>What were the results?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Will students write a quality critique?</td>
<td>I predict that 40% of students will write a critique with quality. Students who write a quality critique will: 1. Determine and reference if the work is correct. 2. Use justifications in their reasoning.</td>
<td>On average, 47.5% of students wrote a quality critique. Nov 28th: 38% had a quality critique; Nov 30th: 57% had a quality critique.</td>
</tr>
</tbody>
</table>

Students are achieving mixed levels of quality. This is a big challenge for us (and for teaching more broadly).
Measuring depth

Some teachers use 3 or 4 point rubrics they have created or adapted (Connect)

Others use binary indicators of particular behaviors (Connect)

<table>
<thead>
<tr>
<th>Score</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No reflection attempted</td>
</tr>
<tr>
<td>1 / Beginning</td>
<td>Student reflection:</td>
</tr>
<tr>
<td></td>
<td>- Has no connection to the concepts or the meaning that underlie the procedure being used</td>
</tr>
<tr>
<td></td>
<td>- Explanations focus solely on describing the procedure that was used</td>
</tr>
<tr>
<td>2 / Emerging</td>
<td>Student reflection:</td>
</tr>
<tr>
<td></td>
<td>- Explains the use of procedures for the purpose of developing deeper levels of understanding of mathematical concepts and ideas</td>
</tr>
<tr>
<td></td>
<td>- Student makes connections among multiple representations to help develop meaning</td>
</tr>
<tr>
<td></td>
<td>- Student engages with conceptual ideas that underlie the procedures to develop understanding</td>
</tr>
<tr>
<td>3 / Connecting</td>
<td>Student reflection:</td>
</tr>
<tr>
<td></td>
<td>- Student is able to independently explore and understand the nature of mathematical concepts, processes, or relationships</td>
</tr>
<tr>
<td></td>
<td>- Explains that broad general procedures have close connections to underlying conceptual ideas</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<td>Bridget</td>
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<tr>
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<td>TOTALS</td>
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<table>
<thead>
<tr>
<th>Mode</th>
<th>Median</th>
<th>Mean</th>
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</thead>
<tbody>
<tr>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
</tr>
</tbody>
</table>
What are we learning?
Teachers like giving and receiving feedback

They provide regular feedback to each other in their smaller PDSA groups.
Teachers like sharing what they are learning

- Teachers have access to each other’s routines and measures – shared workspace
- Teachers share within their smaller PDSA testing groups every few weeks
- Teachers share across PDSA testing groups during in-person meetings every few months
What teachers said on a survey

Responses from a survey by our external evaluator

- The work I am doing in the BMTN is consistent with my school's priorities
- School leaders prioritize our work enough to allocate resources to it
- Work I am doing in the BMTN is consistent with my state's other programs and policies
- Network leaders inspire me to participate and contribute to network aims
- Network members share common understanding about what makes the BMTN special
- I value the opportunity to be part of the BMTN
- The BMTN is worth the time it takes
- Network leaders convey message of hopefulness in what we can accomplish together
Student perceptions

In math class how often do you...

- Make sense of mathematical rules, concepts, and relationships?
- Make connections to math concepts from other classes—either classes you’ve taken before or ones you might take in the future?
- Make connections between math and real-world situations?
- Examine why the steps to solving a math problem or following a procedure work?
- Make connections to math concepts you learned previously in this class?

51% of students in spring 2017 reported making connections between math and real-world often or daily, vs. 30% in fall 2016.
Student perceptions

In math class how often do you...

<table>
<thead>
<tr>
<th>Activity</th>
<th>Spring (n=419)</th>
<th>Fall (n=440)</th>
<th>Spring (n=420)</th>
<th>Fall (n=441)</th>
<th>Spring (n=415)</th>
<th>Fall (n=433)</th>
<th>Spring (n=421)</th>
<th>Fall (n=442)</th>
<th>Spring (n=423)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discuss possible solutions to math problems with other students?</td>
<td>Sometimes: 54</td>
<td>Sometimes: 51</td>
<td>Sometimes: 64</td>
<td>Sometimes: 44</td>
<td>Sometimes: 48</td>
<td>Sometimes: 35</td>
<td>Sometimes: 59</td>
<td>Sometimes: 36</td>
<td>Sometimes: 54</td>
</tr>
<tr>
<td>Critique the mathematical reasoning of others—either written or spoken?</td>
<td>Almost Every Day/Often: 40</td>
<td>Almost Every Day/Often: 31</td>
<td>Almost Every Day/Often: 26</td>
<td>Almost Every Day/Often: 32</td>
<td>Almost Every Day/Often: 14</td>
<td>Almost Every Day/Often: 24</td>
<td>Almost Every Day/Often: 14</td>
<td>Almost Every Day/Often: 27</td>
<td>Almost Every Day/Often: 31</td>
</tr>
</tbody>
</table>

% of students critiquing the reasoning of others often or daily almost doubled from fall 2016 to spring 2017.
Student perceptions

In math class how often do you...

- **Solve math problems with multiple steps that take more than 20 minutes to solve?**
  - Fall (n=437): 16% Rarely/Never, 35% Sometimes, 48% Almost Every Day/Often
  - Spring (n=419): 23% Rarely/Never, 29% Sometimes, 53% Almost Every Day/Often

- **Keep trying different ways to solve math problems even when they are hard?**
  - Fall (n=440): 14% Rarely/Never, 33% Sometimes, 53% Almost Every Day/Often
  - Spring (n=423): 13% Rarely/Never, 33% Sometimes, 54% Almost Every Day/Often

- **Re-read or go over a math problem again if you have trouble understanding it?**
  - Fall (n=443): 6% Rarely/Never, 16% Sometimes, 87% Almost Every Day/Often
  - Spring (n=411): 8% Rarely/Never, 23% Sometimes, 65% Almost Every Day/Often

- **Keep working on math problems even when you are stuck?**
  - Fall (n=438): 16% Rarely/Never, 26% Sometimes, 65% Almost Every Day/Often
  - Spring (n=417): 6% Rarely/Never, 23% Sometimes, 65% Almost Every Day/Often

- **Determine if your answers to complex math problems make sense?**
  - Fall (n=443): 13% Rarely/Never, 32% Sometimes, 54% Almost Every Day/Often
  - Spring (n=418): 9% Rarely/Never, 29% Sometimes, 62% Almost Every Day/Often

% of students who reported regularly solving multi-step math problems that take 20+ minutes nearly tripled from fall 2016 to spring 2017.
Where are we headed?
Sharing refined routines with others

- In July, new and returning teachers had time during the summer institute to review the refined routines.
- Several have selected one of these routines as the focus of their first round of PDSA testing in the 2017-18 school year.
- Later this fall, the refined routines will be made available on the BMTN website to increase sharing beyond the network.
Change idea testing summary

Using Written Examples to Help Students Explain Thinking
Amber Emmett
6/4/17

Problem:
As part of my practice and reinforcement routine, I try to incorporate problems where students have to explain their solution in the context of the problem. I found that often students could use skills and procedures and get the "right answer" but do not understand how that answer was significant to the problem itself. I also found when reviewing student work I would commonly receive answers to a complex task like "x=3" without any context or explanation. The goal of this change idea was to get students writing about mathematics as a means of working with non-routine problems to understand what the question is asking, mathematics the situation (in real-world cases), and make sense of the solution.

Change idea:
I decided to use a new routine to provide structure for students to write about and explain mathematics, utilizing models of both successful and weak explanations as well as checklists when problem solving (during the practice/reinforcement chunk of my lesson). The goal of the new routine was to encourage students to write a quality explanation of their process and their solution(s) in the context of the problem.

Refined routine:
I tested this routine several times, with adjustments made over time to increase performance as defined in the rubric (Measures, Example 1). The following routine maximized the number of students actively engaged in writing about mathematics explaining their solution.

1. Provide students with 2 examples of possible responses to the first-part of the assignment (one quality example and the other a non-example of a quality response). (Resources, Example 1)
2. Provide students with 3-4 minutes to study the responses and discuss with their partners.
3. Ask students which explanation is better and why.
4. Discuss positive qualities included in each explanation, and the reasons the student could have classified to improve their explanation.
5. Provide students with checklist of key components of a quality problem-solving response. (Resources, Example 2)
6. Encourage students to provide each other with quality feedback when working on writing explanations. I encourage peer feedback by prompting student conversations as I circulate around the classroom.

Evidence of promise:
Initially, I was collecting data on the five problem solving components below (see rubric under Measures). Due to time restrictions this was not manageable to do consistently so I focused on students’ ability to make sense of the solution. When I focused on students making sense of the solution I collected data on the last 2 columns of the initial rubric. By the end of my PD testing, just over 75% of students were consistently making sense of and explaining their solution in the context of the problem. While not yet 100%, this rate was much higher than the 47% of students engaged after my first test. Student accuracy and explanations also varied depending on the student interest level on each task.

Advice:
Students struggled with writing at first. Eventually students were able to explain themselves in more detail. I found having the examples to be helpful when circulating around the classroom because I could remind students what I meant by a "quality response" based on our discussion and analysis of the examples on the board. Projecting the examples on the document camera was helpful, creating a constant, easy reference.

Evidence of promise from the ongoing testing

Advice for other implementers and context

Recommended implementation approach, informed by what was learned in testing

Brief description of the change idea

Problem that prompted the change idea
## Associated measures and tools

### Small Group Critiquing Template

**Name:**

The following solution was produced by a student from our last learning check. It may or may not contain errors. What did you notice about this problem and the work?

| Discuss how this problem was worked out with a partner. **Defend your answers.** |
| Possible discussion points: |
| • Do you agree or disagree with the work above? Why? |
| • Can you tell how they arrived at their answer? Was the work easy to follow? |
| • Was an efficient strategy used or can you find one that is better? |
| • If no mistakes were made, was a complete solution given? |
| • Do you have any questions or is there anything you wonder about the work you reviewed? |

Complete the following:

1. Were mistake(s) found? ________ If so, how many? ________
2. Summarize your discussion below. You may use the back of the page if needed.

### Whole-Class Discussion Template

**Name:**

During the critiquing activity...

- [ ] I used my student role during the critiquing activity to participate in my group discussion.
- [ ] I did not use my student role during the critiquing activity to participate in my group discussion.

Use the space below to answer the following questions from the whiteboard.

---

*Note: The text is not fully visible in the image.*
What are the biggest challenges?

- Quality
  - Increasing the proportion of students who engage with quality is hard

- Content
  - The strategy can play out differently depending on the topic (e.g., linear equations, polynomials) and lesson type (e.g., introduction, reinforcement)

- Spread
  - How can we best share promising routines and track whether and how they lead to improvements in other contexts?
Questions?
Thank You!

For more information, please visit our website at:
BetterMathTeachingNetwork.org

Or contact us:
Toni Smith, tsmith@air.org
Kirk Walters, kwalters@air.org

Special thanks to: nmefoundation.org