Principles to Actions

Day 6: Monday June 27, 2016

Strong Start Math Project
New major NCTM Publication!!

Released April 2014

National Council of Teachers of Mathematics
The influence of a good teacher can never be erased.
- Background
- Beliefs about Teaching and Learning
- NCTM Core Set of Effective Mathematics Teaching Practices
- Narrative Case of a Classroom Lesson
Professional Learning Goals

We are learning to recognize and strengthen those aspects of our teaching practice that provide high leverage in furthering student success in mathematics.
Background
25-years of Mathematics Education Reform

1989
Curriculum Standards for School Mathematics

Grade Bands
K-4, 6-8, 9-12

2000
Principles & Standards for School Mathematics

Grade Bands
PK-2, 3-5, 6-8, 9-12

2010
Common Core State Standards

K-8 Grade Levels
HS Conceptual Categories
Rigorous Content Standards define student learning expectations, but it takes effective teaching to ensure that students actually learn that mathematics.
Guiding Principles for School Mathematics

- Teaching and Learning
- Access and Equity
- Curriculum
- Tools and Technology
- Assessment
- Professionalism
Guiding Principles for School Mathematics
Guiding Principle:
Teaching and Learning

An excellent mathematics program requires **effective teaching** that engages students in **meaningful learning** through individual and collaborative experiences that promote their ability to make sense of mathematical ideas and reason mathematically.
Effective teaching is the non-negotiable core that ensures that *all* students learn mathematics at high levels.

*Principles to Actions* (NCTM, 2014, p. 4)
Obstacles
Beliefs should not be viewed as good or bad.

Beliefs are unproductive when they hinder the implementation of effective instruction or limit student access to important mathematics content and practices.

*Principles to Actions* (NCTM, 2014, p. 11)
• Work as a table group.

• **Only** set out the **two blue Belief cards**.

• Then **wait** for the next set of directions.
Take turns:

• Draw a card. Read it to your group.

• Place it on the continuum and discuss “why.”

• Consider also: Where might parents, students, community members, or other teachers place it?

• Then next person draws a card and repeat.
## Beliefs about teaching and learning mathematics

<table>
<thead>
<tr>
<th>Unproductive beliefs</th>
<th>Productive beliefs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics learning should focus on practicing procedures and memorizing basic number combinations.</td>
<td>Mathematics learning should focus on developing understanding of concepts and procedures through problem solving, reasoning, and discourse.</td>
</tr>
<tr>
<td>Students need only to learn and use the same standard computational algorithms and the same prescribed methods to solve algebraic problems.</td>
<td>All students need to have a range of strategies and approaches from which to choose in solving problems, including, but not limited to, general methods, standard algorithms, and procedures.</td>
</tr>
<tr>
<td>Students can learn to apply mathematics only after they have mastered the basic skills.</td>
<td>Students can learn mathematics through exploring and solving contextual and mathematical problems.</td>
</tr>
<tr>
<td>The role of the teacher is to tell students exactly what definitions, formulas, and rules they should know and demonstrate how to use this information to solve mathematics problems.</td>
<td>The role of the teacher is to engage students in tasks that promote reasoning and problem solving and facilitate discourse that moves students toward shared understanding of mathematics.</td>
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<td>The role of the student is to memorize information that is presented and then use it to solve routine problems on homework, quizzes, and tests.</td>
<td>The role of the student is to be actively involved in making sense of mathematics tasks by using varied strategies and representations, justifying solutions, making connections to prior knowledge or familiar contexts and experiences, and considering the reasoning of others.</td>
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<td>An effective teacher makes the mathematics easy for students by guiding them step by step through problem solving to ensure that they are not frustrated or confused.</td>
<td>An effective teacher provides students with appropriate challenge, encourages perseverance in solving problems, and supports productive struggle in learning mathematics.</td>
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</table>
PtA Book, p. 9-11

Read: “Obstacles” section

Jot down in your notebook one key message that you want to hold on to for your professional work and identify the audience for that message (e.g., self, other teachers, administrators, students, or parents).
NCTM’s Core Set of Effective Mathematics Teaching Practices
High-leverage, Effective Mathematics Teaching Practices

“Those practices at the heart of the work of teaching that are most likely to affect student learning.”

(Ball & Forzani, 2010, p 45)
Establish math goals to focus learning
Implement tasks that promote reasoning & problem solving
Use and connect mathematical representations
Facilitate meaningful mathematical discourse
Pose purposeful questions
Build procedural fluency from conceptual understanding
Support productive struggle in learning mathematics
Elicit & use evidence of student thinking
Effective Mathematics Teaching Practices
Effective Mathematics Teaching Practices

- Establish math goals to focus learning
- Implement tasks that promote reasoning & problem solving
- Use and connect mathematical representations
- Facilitate meaningful mathematical discourse
- Elicit & use evidence of student thinking
- Support productive struggle in learning mathematics
- Build procedural fluency from conceptual understanding
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A consensus on what constitutes effective teaching accumulated over the past 25 years.

- Establish math goals to focus learning
- Implement tasks that promote reasoning & problem solving
- Use and connect mathematical representations
- Facilitate meaningful mathematical discourse
- Elicit & use evidence of student thinking
- Build procedural fluency from conceptual understanding
- Pose purposeful questions
- Support productive struggle in learning mathematics

Effective Mathematics Teaching Practices
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Handout
Read and highlight key phrases.

Turn & Talk (shoulder partners)

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2. Wondering?
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Very Hungry Caterpillar Task
The Very Hungry Caterpillar

How much fruit did he eat?

On Monday he ate through 1 apple.

On Tuesday he ate through two pears!

On Wednesday he ate through three plums!

On Thursday he ate through 4 strawberries.

On Friday he ate through 5 oranges.
Hungry Caterpillar Task

On Monday, the hungry caterpillar ate through one apple, but he was still hungry. On Tuesday he ate through two pears, but he was still hungry. On Wednesday he ate through three plums. On Thursday he ate through four strawberries. On Friday he ate through five oranges.

How many pieces of fruit did the hungry caterpillar eat during the week?
Case of Ms. Bouchard and the Hungry Caterpillar Task
The Case of Ms. Bouchard and the Hungry Caterpillar Task

• **Read** the Case of Ms. Bouchard and study the strategies used by her students.

• **Note** use of the effective teaching practices used in the lesson to support student learning.  
  
  [Write on the recording sheet or jot down notes in the margins.]
Establish math goals to focus learning

Elicit & use evidence of student thinking

Support productive struggle in learning mathematics

Build procedural fluency from conceptual understanding

Pose purposeful questions

Implement tasks that promote reasoning & problem solving

Use and connect mathematical representations

Facilitate meaningful mathematical discourse

Effective Mathematics Teaching Practices
The Case of Ms. Bouchard and the Hungry Caterpillar Task

Table Groups will be assigned a teaching practice.

As a table group, discuss how your teaching practice was evident in the case.

• Select 1-2 examples, identify the line numbers, and prepare to report to the whole group, linking the teacher actions to specific aspects of the teaching practice.
#1. Establish mathematics goals to focus learning.

Effective teaching of mathematics establishes clear goals for the mathematics that students are learning, situates goals within learning progressions, and uses the goals to guide instructional decisions.
Mathematics Learning Goals

Tasks

Evidence

Productive Struggle

Understanding & Fluency

Representations

Discourse

Questions
#2. Implement tasks that promote reasoning and problem solving.

Effective teaching of mathematics engages students in solving and discussing tasks that promote mathematical reasoning and problem solving and allow multiple entry points and varied solution strategies.
Student learning is greatest in classrooms where the tasks consistently encourage high-level student thinking and reasoning and least in classrooms where the tasks are routinely procedural in nature.

Boaler & Staples (2008)
Stein & Lane (1996)
#3. Use and connect mathematical representations.

Effective teaching of mathematics engages students in making connections among mathematical representations to deepen understanding of mathematics concepts and procedures and as tools for problem solving.
“The teaching of representational competence should lie at the center of classroom practice in math and science.”

Developed by Beth Schefelker (South Milwaukee School District) and DeAnn Huinker (University of Wisconsin-Milwaukee)
#4. Facilitate meaningful mathematical discourse.

Effective teaching of mathematics facilitates discourse among students to build shared understanding of mathematical ideas by analyzing and comparing student approaches and arguments.
Sharing of student work should not just be “Show and Tell” by those students who volunteer.

It should be purposeful, intentional, and move students further toward the intended learning goals.
#5. Pose purposeful questions.

Effective teaching of mathematics uses purposeful questions to assess and advance students’ reasoning and sense making about important mathematical ideas and relationships.
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#6. Build procedural fluency from conceptual understanding.

Effective teaching of mathematics builds fluency with procedures on a foundation of conceptual understanding so that students, over time, become skillful in using procedures flexibly as they solve contextual and mathematical problems.
A rush to fluency undermines students’ confidence and interest in mathematics and is considered a cause of mathematics anxiety.

(Ashcraft 2002; Ramirez et al., 2013)

Fluency develops over time... and it builds from conceptual understanding.

*Initial exploration and discussion*

*Informal reasoning strategies*

*Eventual use of general methods*

*Principles to Actions* (NCTM, 2014, p. 42)
Effective Mathematics Teaching Practices

#7. Support productive struggle in learning mathematics.

Effective teaching of mathematics consistently provides students, individually and collectively, with opportunities and supports to engage in productive struggle as they grapple with mathematical ideas and relationships.
In comparison to high-achieving countries, teachers in the United States rarely allowed students to reason or struggle with mathematical ideas. Teachers almost always stepped in and did the work for the students.

TIMSS Study
(Hiebert & Stigler, 2004)

(Percent of Tasks, 1999 TIMMS Video Study)

Effective Mathematics Teaching Practices

#8. Elicit and use evidence of student thinking.

Effective teaching of mathematics uses evidence of student thinking to assess progress toward mathematical understanding and to adjust instruction continually in ways that support and extend learning.
Identify indicators of student learning related to math goals

Plan for ways to elicit that information (questions, prompts, tasks)

Interpret what the evidence means with respect to student learning

Decide how to respond to students
NCTM’s Core Set of High-leverage, Effective Mathematics Teaching Practices

“Although the important work of teaching is not limited to the eight Mathematics Teaching Practices, this core set of research-informed practices is offered as a framework for strengthening the teaching and learning of mathematics.”

Principles to Actions (NCTM, 2014, p. 57)
Effective Mathematics Teaching Practices
“Building a Teaching Framework”

Establish math goals to focus learning

Implement tasks that promote reasoning and problem solving

Facilitate meaningful mathematical discourse

Pose purposeful questions
Elicit and use evidence of student thinking

Use and connect mathematical representations
Support productive struggle in learning mathematics

Build procedural fluency from conceptual understanding
Scaffolding Thinking: Putting Students' Visual Representations to Work in the Primary Mathematics Classroom

Strong Start Math Project
Monday, June 27, 2016
Today we will...

• representational competence for teachers and students.
• the role representations play in supporting classroom discussions.
• strategies for engaging young learners in mathematical discussions that scaffold their representational competence.
Learning Intentions and Success Criteria

We are learning to...

• Explore ways to help young learners translate between mathematical representations so they can share their thinking.

We will be successful when we can...

• Use young learners’ visual representations as sites for discussions of mathematical ideas.
• Engage in Math Teaching Practice 3: Use and connect mathematical representations.
Principles to Action
Use and Connect Representations
High-leverage Teaching Practice #3

**Use and Connect Mathematical Representations**

**Physical**: Use concrete objects to show, study, act upon, or manipulate mathematical ideas (e.g., cubes, counters, paper strips).

**Contextual**: Situate mathematical ideas in everyday, real-world, imaginary, or mathematical situations and contexts.

**Visual**: Illustrate, show, or work with mathematical ideas using diagrams, pictures, number lines, graphs, and other math drawings.

**Symbolic**: Record or work with mathematical ideas using numerals, variables, tables, and other symbols.

**Verbal**: Use language (words) to interpret, state, define, or describe mathematical ideas.

High-leverage Teaching Practice #3

Use and Connect Mathematical Representations

Represent It!

- Draw It
- Write it with numbers
- Build It
- Talk It
- Write a story
Developing representational competence in young learners

...knowing how and when to use particular mathematical representations.

Students’ Representational Competence

Young learners will:

• Know how and when to use particular mathematical representations
• Self-select representations to use during problem solving.
• Make and explain connections between the representations.

“This implies students view representations as tools they can use to help them solve problems, rather than an end in themselves” (NCTM, 2014, p. 26).
The Very Hungry Caterpillar
A Day In First Grade

On Monday he ate through 1 apple.

On Tuesday he ate through two pears!

On Wednesday he ate Through three plums!

On Thursday he ate Through 4 strawberries.

On Friday he ate Through 5 oranges.
Hungry Caterpillar
Getting to Work

“Represent your thinking!”
“I need to see what’s in your head.”

Review the packet of student:

• Identify the representations you see on each piece of student work.
Student A

Student B
Student E

Student F

5 + 5 + 5 = 15

Mika
Student G
What do representations do?

“In essence, when we ask our students to create mathematical [representations], we challenge them to represent their math understanding—to get it out of their heads” (O’Connell & SanGiovanni, 2013, p. 62).

Representations help students:
• see the problem more clearly.
• visualize the problem.
• simplify the problem.
• make sense of the problem.
• engage in mathematical discourse.
What do representations do?

“In essence, when we ask our students to create mathematical [representations], we challenge them to represent their math understanding—to get it out of their heads” (O’Connell & SanGiovanni, 2013, p. 62).

Representations help students:
• see the problem more clearly.
• visualize the problem.
• simplify the problem.
• make sense of the problem.
• engage in mathematical discourse.
“But I don’t know what’s in my head.”

How might we put these visual representations “to work” to help a child who does not know what is in his/her head?

I know the answer is 15. but I don’t know how to show my thinking.
Tapping into Teachers’ Representational Competence

Representations are tools to model and interpret mathematical phenomena, represent aspects of situations in mathematical terms, and emphasize the importance of representing mathematics ideas in a variety of ways. (NCTM, 2000)
Teachers’ Representational Competence

Teachers will:

• Encourage purposeful selection of representations.
• Engage in dialogue about explicit connections among representations.
• Alternate the direction of the connections made among representations.

(NCTM, 2014, p. 26)
Teachers’ Representational Competence

Teachers will:

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(NCTM, 2014, p. 26)
**Strategy #1**

Encourage purposeful selection of representations.

Read “Encourage Purposeful Selection” (p. 44)

Turn and share the authors’ message.

Revisit each piece of student work.

- Select 2-3 pieces of student work that honor the context of the story.
- Explain how you would use this work to discuss features of a visual representation that connects with the context of the story.
Teachers’ Representational Competence

Teachers will:

• Encourage purposeful selection of representations.

• Engage in dialogue about explicit connections among representations.

• Alternate the direction of the connections made among representations.

(NCTM, 2014, p. 26)
Strategy #2
Engage in dialogue about explicit connections among representations.

Read “Engage in dialogue” (p. 43)
Turn and share the authors’ message.

Read the section on
• Select 2-3 pieces of student work that show a range of representations.
• Craft a dialogue discussing the similarities and differences between the representations in the student work.
Teachers’ Representational Competence

Teachers will:

• Encourage purposeful selection of representations.

• Engage in dialogue about explicit connections among representations.

• Alternate the direction of the connections made among representations.

(NCTM, 2014, p. 26)
Strategy #3
Alternate the direction of connections made among representations

Read “Alternate directionality” (p. 44). Turn and share the authors’ message.

Place this student work on your table.
• Student Work E
• Student Work C (Daman)
• Student Work A (Evan)
• Student Work F (Mikaela)
Alternating Directionality

Step #1
Pick one student. Identify the representations that the student has used. (strength)

Step #2
Use the star model. Select a different representation that is not evidenced on the student work. Discuss reasons for this selection.

Step #3
Craft a question that would allow students to make connections between the two representations.
Use and Connect Mathematical Representations

Different representations should:

• Be introduced, discussed, and connected;
• Focus students’ attention on the structure or essential features of mathematical ideas; and
• Support students’ ability to justify and explain their reasoning.

*Strengthening the ability to move between and among these representations improves the growth of children’s understanding of mathematical concepts.*

Lesh, Post, & Behr, 1987
Learning Intentions and Success Criteria

We are learning to...

• Explore ways to help young learners translate between mathematical representations so they can share their thinking.

We will be successful when we can...

• Use young learners’ visual representations as sites for discussions of mathematical ideas.
• Engage in Math Teaching Practice 3: *Use and connect mathematical representations.*
PRR: Principles to Action

Use and connect mathematical representations
Read and highlight p. 24-26

Select two ideas that resonate with you as consider your “transition goal” that is part of your team project.

State and briefly describe those two ideas. Share why they resonate with you and how they may contribute to your transition goal.
Morning Reflection/Summary

• Summarize some key points and classroom ideas related to the topics or focus standards in this session.

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<th>Summary of Key Points</th>
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Mathematical Curiosities
How is Hungry Caterpillar Task related to our previous discussion of triangular numbers?

Finding the sum of $1 + 2 + 3 + 4 + 5$ is a triangular number.

Who recalls the story of Guass from the previous discussion and what he was able to do at the age of 7 that amazed his teachers?
Relating the Hungry Caterpillar Task to Gauss’ Discovery

Carl Friedrich Gauss is sometimes referred to as the "Prince of Mathematicians" and the "greatest mathematician since antiquity". He has had a remarkable influence in many fields of mathematics and science and is ranked as one of history's most influential mathematicians.

At the age of 7, Gauss is reported to have amazed his teachers by summing the integers from 1 to 100 almost instantly (having quickly spotted that the sum was actually 50 pairs of numbers, with each pair summing to 101, totaling 5,050).

http://www.storyofmathematics.com/19th_gauss.html
How did Gauss find the sum of the integers from 1 to 100 almost instantly?

Consider a simpler problem. What if he was finding the sum of the integers from 1 to 3? from 1 to 5?
Sum of Consecutive Integers

1 + 2 + 3 + ... + 20

1. Use formula $n(n+1)/2$
2. Divide even number by 2
3. Multiply by the other number

$$\frac{(20)(21)}{2}$$

10(21) = 210
Halli-Galli
Game Protocol

- Mathematical Curiosities
- Foundational Math Concepts
- Math Skill
- Purposeful Questions for Skills
- Equitable Engagement and Access
- Best Use
Individual Projects
Facilitated Group
Work Time by Standard
Individual Project

• Focus on a standard. Ground that standard by describing it fully, giving examples, and connecting it to the learning trajectories.

• Create a CORE Assessment (with 3 items) and anticipate responses. Connect it to skills, knowledge and instructional tasks.

• Create a FOLLOW-UP Assessment for successful students and a FOLLOW-UP Assessment for struggling students. Make the same connections.
Afternoon Reflection/Summary

- Summarize some key points and classroom ideas related to the topics or focus standards in this session.

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Disclaimer

Strong Start Math Project
University of Wisconsin-Milwaukee, 2015-2018

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