Research-Informed Instructional Practices: The Non-negotiable Core

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Goals

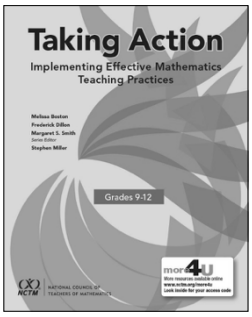
- Provide an overview of the eight research informed instructional strategies from NCTM's *Principles to Actions*.
- Connect some of these strategies to AMATYC's *Beyond Crossroads*
- Engage you in observing some of the strategies in the classroom.

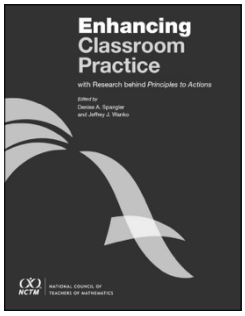
Principles to Actions: Ensuring Mathematical Success for All

"The primary purpose of PtA is to fill the gap between the adoption of standards and the enactment of practices, policies, programs and actions required for successful implementation of those standards."

—NCTM, *Principles to Actions: Ensuring Mathematical Success for All* (2014), p. 4

Additional Principles to Actions Resources





Guiding Principles for School Mathematics

Teaching and Learning

1. Access and Equity
2. Curriculum
3. Tools and Technology
4. Assessment
5. Professionalism

(NCTM, 2014)

Principles to Actions: Ensuring Mathematical Success for All

"The overarching message is that effective teaching is the non-negotiable core necessary to ensure that all students learn mathematics. The six guiding principles constitute the foundation of PtA that describe high-quality mathematics education."

—NCTM, 2014, p. 4

Teaching and Learning 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."

—NCTM, 2014, p. 9

AMATYC: *Beyond Crossroads*

Instruction Standard: Mathematics faculty will use a variety of teaching strategies that reflect the results of research to enhance student learning.

— AMATYC. *Beyond Crossroads: Implementing Mathematics Standards in the First Two Years of College.* (2006). p. 51

Eight Research-Informed Instructional Practices

- Establish mathematics **goals** to focus learning.
- Implement **tasks** that promote reasoning and problem solving.
- Use and connect mathematical **representations**.
- Facilitate meaningful mathematical **discourse**.

—NCTM, 2014, p. 10

Eight Research-Informed Instructional Practices

- Pose purposeful **questions**.
- Build **procedural fluency** from conceptual understanding.
- Support **productive struggle** in learning mathematics.
- **Elicit and use evidence** of student thinking.

—NCTM, 2014, p. 10

Eight Research-Informed Instructional Practices

"Establish mathematics goals to focus learning.

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

—NCTM, 2014, p. 12

What Are Teachers Doing?

"Establishing clear goals that articulate the mathematics that students are learning as a result of instruction in a lesson, over a series of lessons, or throughout a unit."

—NCTM, 2014, p. 16

Eight Research-Informed Instructional Practices

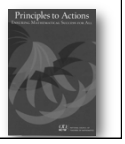
"<u>Implement tasks that promote reasoning and problem solving</u>.

"Effective teaching of mathematics engages students in solving and discussing tasks that promote mathematical reasoning and problem solving and that allow for multiple entry points and varied solution strategies."

—NCTM, 2014, p. 17

Task A: Smartphone Plans	Task B: Solving systems of equations
You are trying to decide which of two smartphone plans would be better. Plan A charges a basic fee of $30 per month and 10 cents per text message. Plan B charges a basic fee of $50 per month and 5 cents per text message. How many text messages would you need to send per month for plan B to be the better option? Explain your decision. (Adapted from Illustrative Mathematics Illustrations: www.illustrativemathematics.org/illustrations/469.)	Solve each of the following systems: $-4x - 2y = -12$ $4x + 8y = -24$ $x - y = 11$ $2x + y = 19$ $8x + y = -1$ $-3x + y = -5$ $5x + y = 9$ $10x - 7y = -18$

—NCTM, 2014, p. 20



Cognitively-Demanding Tasks Are Atypical

"[T]ypical classroom mathematics teaching in the United States tends not to use challenging tasks, nor to promote students' thinking about and engagement with mathematical ideas, and thus fails to help students develop understanding of the mathematics they are learning."

—Silver, "Examining What Teachers Do When They Display Their Best Practice: Teaching Mathematics for Understanding," *Journal of Mathematics Education at Teachers College*, 2010, *1*(1), p. 1

Type and Quality of Instruction Matters

"Greater exposure to pure mathematics tasks and <u>concepts</u> has a strong relationship with higher performance.

"The data suggest that exposing all students to <u>challenging problems</u> and <u>conceptual knowledge</u> in mathematics classes can have a large impact on performance."

—OECD, 2016, p. 3

Selecting a Quality Task Is Not Enough

"Selecting a task with high cognitive demand does not ensure that students will be provided opportunities to engage in rigorous mathematical activity."

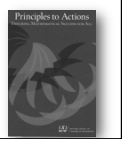
—Jackson, et al., "Exploring Relationships Between Setting Up Complex Tasks and Opportunities to Learn in Concluding Whole-Class Discussions in Middle Grades Mathematics Instruction," *Journal for Research in Mathematics Education*, 2013, *44*(4), 651.

Eight Research-Informed Instructional Practices

"<u>Support productive struggle in learning mathematics</u>.

"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."

—NCTM, 2014, p. 48



AMATYC: *Beyond Crossroads*

Student Learning and the Learning Environment Implementation Standard:

"Students will be expected to conscientiously persist in each mathematics course."

— AMATYC. *Beyond Crossroads: Implementing Mathematics Standards in the First Two Years of College.* (2006). p. 18

Selecting a Quality Task Is Not Enough

"The cognitive demand of a high-level task can be lowered if a teacher or student suggests a solution path before students begin to solve a problem or if a teacher alters the directions of the task such that students are no longer required to justify their thinking or solve the more challenging aspects of the task."

—Jackson et al., 2013, p. 651

The "Didactic Contract"

"A common situation in mathematics classes occurs whereby teachers are called over to students who ask for help; the students expect to be helped, and teachers know it is their role to help them, so the teachers break down the problem and make it easier. In doing so they empty the problem of its cognitive demand."

—Boaler, *Mathematical Mindsets: Unleashing Students' Potential Through Creative Math, Inspiring Messages, and Innovated Teaching* (2016)

Support Productive Struggle in Learning Mathematics

"Teachers sometimes perceive student frustration or lack of immediate success as indicators that they have somehow failed their students."

—NCTM, 2014, p. 48

Struggle vs. Frustration

"Struggle does not mean needless frustration or extreme levels of challenge. It means students expend some effort to make sense of mathematics."

—Hiebert & Grouws, "The Effects of Classroom Mathematics Teaching on Students' Learning," in Lester (Ed.), *Second Handbook of Research on Mathematics Teaching and Learning* (2007), p. 387

Productive Struggle

Research indicates that teachers who closely attend to how students are making sense of the task (e.g., pressing students to justify, explain and/or make meaning) and/or actively assisting student thinking without taking over and doing the thinking for students are those who maintain a high level of cognitive demand.

(Kisa & Stein, "Learning to See Teaching in New Ways: A Foundation for Maintaining Cognitive Demand," *American Educational Research Journal*, 2015, *52*[1], 105–136

Successful Productive Struggle

- Engages students with a worthwhile task—one that captures the central idea of a lesson.
- Stretches students' thinking and performance just beyond the level they can do on their own.
- Teachers provide timely assistance.

(Emerling, Hiebert & Gallimore, "Beyond Growth Mindset: Creating Classroom Opportunities for Meaningful Struggle," *Education Week Teacher*, December 7, 2015)

What Are Teachers Doing?

- "Anticipating what students might struggle with during a lesson and being prepared to support them productively through the struggle."
- "Praising students for their efforts in making sense of mathematical ideas and perseverance in reasoning through problems."

—NCTM, 2014, p. 52

The Importance of Productive Struggle (Perseverance)

The greatest student learning gains occur in classrooms in which the high-level cognitive demands of mathematical tasks are consistently maintained throughout the instructional episode.

(Boaler & Staples, "Creating Mathematical Futures Through an Equitable Teaching Approach: The Case of Railsdale School," *Teachers College Record*, 2008, *110*, 608–645)

"If your students are going home at the end of the day less tired than you are, the division of labor in your classroom requires some attention."

—Wiliam, 2011, p. 49

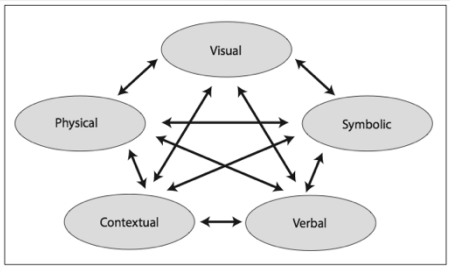
Eight Research-Informed Instructional Practices

"**<u>Use and connect mathematical representations</u>.**

"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."

—NCTM, 2014, p. 24

Use and Connect Mathematical Representations



—NCTM, 2014, p. 25

AMATYC: *Beyond Crossroads*

Instruction Standard: Mathematics faculty will use a variety of teaching strategies that reflect the results of research to enhance student learning.

- Present multiple representations of mathematical concepts.

— AMATYC. *Beyond Crossroads: Implementing Mathematics Standards in the First Two Years of College.* (2006). p. 53

What Are Teachers Doing?

- "Focusing students' attention on the structure or essential features of mathematical ideas that appear, regardless of the representation."
- "Allocating substantial instructional time for students to use, discuss, and make connections among representations."

—NCTM, 2014, p. 29

Eight Research-Informed Instructional Practices

"**Facilitate meaningful mathematical discourse**.

"Effective teaching of mathematics facilitates discourse among students in order to build shared understanding of mathematical ideas by analyzing and comparing student approaches and arguments."

—NCTM, 2014, p. 29

Facilitate Meaningful Mathematical Discourse

"Students who learn to articulate and justify their own mathematical ideas, reason through their own and others' mathematical explanations, and provide a rationale for their answers develop a deep understanding that is critical to their future success in mathematics."

—Carpenter, Franke, & Levi, *Thinking Mathematically: Integrating Arithmetic and Algebra in Elementary Schools* (2003)

Five Practices to Promote Productive Math Discussions

Anticipating • Monitoring • Selecting • Sequencing • Connecting

(Smith & Stein, *5 practices for Orchestrating Productive Mathematics Discussions*, 2011)

AMATYC: *Beyond Crossroads*

Student Learning Strategies:

- Discuss concepts with the instructor and other students.
- Listen to classmates' explanations.
- Explain how to solve a problem to a classmate.

— AMATYC. *Beyond Crossroads: Implementing Mathematics Standards in the First Two Years of College.* (2006). p. 21

Eight Research-Informed Instructional Practices

"Pose purposeful questions.

"Effective teaching of mathematics uses purposeful questions to assess and advance student reasoning and sense making about important mathematical ideas and relationships."

—NCTM, 2014, p. 35

Effective Teachers Are Effective Questioners

"Effective mathematics teachers . . . pose more questions with higher cognitive demand and ask more follow-up questions."

—McREL, *What We Know About Mathematics Teaching and Learning* (2010), p. 22

We Need More Challenging Questions

"If the questions are not causing students to struggle and think, they are probably not worth asking.

"Mistakes are evidence that the questions asked are tough enough to make students smarter."

—Wiliam, "The Right Questions, the Right Way," *Educational Leadership*, 2014, *71*, 16–19

Questioning

Teachers, through quality questioning techniques, can transform typical mathematics classrooms into more student-centered, inquiry-based classrooms in which students are thinking and reasoning at high levels.

(Walsh & Sattes, *Quality Questioning: Research-Based Practice to Engage Every Learner*, 2005)

Make classroom mantras from:

- "Why?"
- "How do you know?"
- "Can you explain?"
- "Do you agree or disagree?"

(Leinwand, *Accessible Mathematics: 10 Instructional Shifts That Raise Student Achievement*, 2009)

AMATYC: *Beyond Crossroads*

Instruction Standard: Mathematics faculty will use a variety of teaching strategies that reflect the results of research to enhance student learning.

- Ask questions to guide students to solutions to problems.

— AMATYC. *Beyond Crossroads: Implementing Mathematics Standards in the First Two Years of College.* (2006). p. 53

Eight Research-Informed Instructional Practices

"<u>Build procedural fluency from conceptual understanding</u>.

"Effective teaching of mathematics builds fluency with procedures on a foundation of conceptual understanding. . . ."

—NCTM, 2014, p. 42

AMATYC: *Beyond Crossroads*

Instruction Standard: Mathematics faculty will use a variety of teaching strategies that reflect the results of research to enhance student learning.

- Engage students in activities that lead them to develop conceptual understandings.

— AMATYC. *Beyond Crossroads: Implementing Mathematics Standards in the First Two Years of College.* (2006). p. 53

Eight Research-Informed Instructional Practices

"<u>Elicit and use evidence of student thinking</u>.

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."

—NCTM, 2014, p. 53

Guiding Principles for School Mathematics: Assessment

<u>"Assessment</u>. An excellent mathematics program ensures that assessment is an integral part of instruction … and informs feedback to students, instructional decisions, and program improvement."

—NCTM, 2014, p. 89

AMATYC: *Beyond Crossroads*

Assessment of Student Learning Standard:

Assessment of student learning is a process of helping mathematics faculty adapt instruction to the needs of students … assessment is an ongoing activity that leads to improvement in student learning by providing data necessary for making informed decisions at the class, course, and program levels.

— AMATYC. *Beyond Crossroads: Implementing Mathematics Standards in the First Two Years of College.* (2006). p. 29

What Instructional Strategies Do You Observe?

What Instructional Strategies Do You Observe?

What Instructional Strategies Did You See?

- Establish mathematics **goals** to focus learning.
- Implement **tasks** that promote reasoning and 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 and use evidence** of student thinking.

Goals

- Provide an overview of the eight research informed instructional strategies from NCTM's *Principles to Actions*.
- Connect some of these strategies to AMATYC's *Beyond Crossroads*
- Engage you in observing some of the strategies in the classroom.

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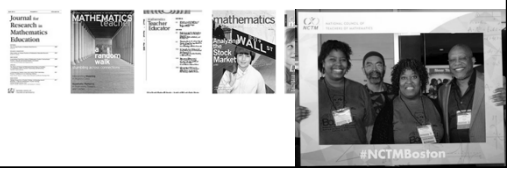

- Explicitly broaden the purposes for teaching high school mathematics.
- Catalyze a serious discussion of the challenges facing high school mathematics.
- Define imperatives for high school mathematics in the areas of structures, instructional practices, curriculum, and pathways.
- Identify essential concepts for focus that all high school students should learn at a deep level of understanding.
- Provide examples of 4-year pathways that include 2.5 years of mathematical study expected of high school students followed by 1.5 of alternate paths of study.