Preparing Teachers and Teacher Leaders in the Era of the Common Core State Standards: Mathematics Teacher Educators' Perspectives

October 3, 2011

A panel of mathematics teacher educators will address the unique opportunity for higher education and school systems to support teacher preparation and professional development in relation to the Common Core State Standards for Mathematics and the related assessments across grades levels.

What Is the Role of Mathematics Teacher Educators?

Marilyn Strutchens

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Mathematics Educator Position Announcement

- **Qualifications required:**
  - Doctorate in mathematics education or related field;
  - Strong background in mathematics;
  - Evidence of excellence in teaching;
  - An appreciation for collaborative partnerships in public schools;
  - A familiarity with diverse educational settings;
  - An ability to integrate technology into instruction; and
  - Scholarly interest in teacher education and students' mathematical thinking.

Mathematics Teacher Educators:

- Work with teachers from each end of the spectrum including preservice, inservice, and teacher leaders;
- Provide opportunities for teachers to increase their mathematical content knowledge;
- Help teachers increase their pedagogical content knowledge related to mathematics;

Mathematics Teacher Educators:

- Create experiences in which teachers develop confidence in their mathematics abilities;
- Help teachers to learn how to orchestrate meaningful discourse in the mathematics classroom;
- Provide teachers with the opportunities to experience, develop, and implement worthwhile mathematical tasks.
- Help teachers to confront stereotypes and other beliefs that they may have toward particular groups of students that may impede their ability to move students forward;

Mathematics Educators:

- Help teachers to understand that teaching is a profession that requires constant growth through meaningful experiences;
- Help teachers to understand the importance of getting to know their students and their cultural backgrounds, and then responding accordingly; and
- Help teachers to understand the importance of linking research to practice and practice to research.

EMERGING ISSUES AS ELEMENTARY TEACHERS INTERPRET AND IMPLEMENT CCSSM

Jennifer M. Bay-Williams
University of Louisville

PART 1: CONSIDERATIONS RELATED TO INTERPRETING THE STANDARDS

A Quiz

PART 1: CONSIDERATIONS RELATED TO INTERPRETING THE STANDARDS

K: Decompose numbers less than or equal to 10 into pairs in more than one way, e.g., by using objects or drawings, and record each decomposition by a drawing or equation (e.g., 5 = 2 + 3 and 5 = 4 + 1).

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1. **Decompose (circle all that are true statements):**
   a. **Means number is deteriorating (science connection).**
   b. **Means to take a number apart into addends that equal that number.**
   c. **Is a word Kindergartners should learn.**

PART 1: CONSIDERATIONS RELATED TO INTERPRETING THE STANDARDS

K: Write numbers from 0 to 20. Represent a number of objects with a written numeral 0-20 (with 0 representing a count of no objects).

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2. Numbers and numerals:

a. **Mean the same thing.**
b. **Mean something different – a numeral is the symbol for the quantity.**
c. **Are words that K students should be able to distinguish as different.**

PART 1: CONSIDERATIONS RELATED TO INTERPRETING THE STANDARDS

GR1: Understand subtraction as an unknown-addend problem. *For example, subtract 10 – 8 by finding the number that makes 10 when added to 8.*

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3. Unknown addend problems are:

a. **The same as missing addend problems.**
b. **Different than missing addend because missing addend would have been written as 10 – ■ = 8.**
c. **An attempt to incorporate algebra language earlier in the curriculum.**
d. **Language students should be able to understand and use.**

PART 1: CONSIDERATIONS RELATED TO INTERPRETING THE STANDARDS

GR2: Fluently add and subtract within 20 using mental strategies. By end of Grade 2, know from memory all sums of two one-digit numbers.

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4. Fluency and memorization:

a. Mean the same thing.
b. Are different – Fluently means quick use of strategies and memorization means fact is just known for recall.
c. Only fluency is needed for subtraction, but not memorization.
d. Students should memorize addition and subtraction facts, since subtraction is connected to the addition facts.

PART 1: CONSIDERATIONS RELATED TO INTERPRETING THE STANDARDS

GR3: Use multiplication and division within 100 to solve word problems in situations involving equal groups, arrays, and measurement quantities, e.g., by using drawings and equations with a symbol for the unknown number to represent the problem.1

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5. Within 100 means:

a. Factors are less than 100.
b. Divisor is within 100 (2-digit divisors).
c. Products are less than 100.
d. All of the above.

PART 1: CONSIDERATIONS RELATED TO INTERPRETING THE STANDARDS

GR3: Use multiplication and division within 100 to solve word problems in situations involving equal groups, arrays, and measurement quantities, e.g., by using drawings and equations with a symbol for the unknown number to represent the problem.

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6. Measurement quantities are:

a. Distances you measure (repeated lengths measured for multiplication).
b. Problems that use measurement units (time, length, area, etc.).
c. Situations where one factor is being compared to a product.
d. All of the above.

PART 1: CONSIDERATIONS RELATED TO INTERPRETING THE STANDARDS

GR4: Multiply or divide to solve word problems involving multiplicative comparison, e.g., by using drawings and equations with a symbol for the unknown number to represent the problem, distinguishing multiplicative comparison from additive comparison.

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7. Multiplicative comparisons are:

a. Situations where two values are being compared and the task is to find the factor between the two values.
b. Comparing answers to drawings to see if they are correct
c. Problems that involve division but are worded as missing factor problems.
d. All of the above.

PART 1: CONSIDERATIONS RELATED TO INTERPRETING THE STANDARDS

GR5: Use place value understanding to round decimals to any place.

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8. Rounding using place value understanding means:

a. Students round to the correct place when asked (e.g., round to nearest 1000 and know which place that means.
b. Apply the rounding rules across different place values (4 and under round down, 5 and higher round up)
c. Analyze the overall size of number to determine if number is closer to the [thousand] that is above or below it.
d. All of the above.

PART 1: CONSIDERATIONS RELATED TO INTERPRETING THE STANDARDS

SMP: 6-Attend to precision.

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9. This means (circle all that apply):

a. Show all your steps.
b. Students use mathematical terminology at all grade levels (e.g., decompose for K).
c. Include labels on graphs, units for measurements, etc.
d. Careful use of mathematical terminology (use circle only when it is a circle, etc.)
e. Measure or compute with appropriate precision for the context.

PART 1: CONSIDERATIONS RELATED TO INTERPRETING THE STANDARDS

SMP: **4-Model with mathematics.**

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10. This means (circle all that apply):

a. Show all your steps.
b. Use a manipulative or picture to show your strategy/answer.
c. Connect a manipulative or picture to the given story problem.
d. Create an equation to represent the given story problem.
e. Use an equation, story, graph, or picture to make a prediction.

PART 2: CONSIDERATIONS RELATED TO IMPLEMENTING THE STANDARDS

From teachers….

1. What to do in the next year or so when the students arriving at the grade do not have the CCSSM from the previous year.
2. What to do when students don't have the knowledge from previous grade levels.
3. Does it matter in what order the topics on the list are taught? Should it be all number, and then move onto next topic or should it be more integrated?
4. What resources are available for teaching (my textbook doesn't have this mathematics in it).
5. What resources are available for learning (I don't understand some of these ideas).

PART 2: CONSIDERATIONS RELATED TO IMPLEMENTING THE STANDARDS

From experiences with Standards-based curriculum (and earlier reform movements)….

1. Content demands – understanding well the mathematics in the curriculum.
2. Keeping the SMP at the center of the implementation
3. Communicating with parents and other stakeholders.
4. An informed and engaged principal (beyond 'supportive').
5. Opportunities for ongoing opportunities to meet and plan with grade-level colleagues.
6. Opportunities for ongoing opportunities to meet and plan with 'experts' to get questions answered.
7. Ways to monitor the success of the implementation.
8. Sharing strategies for how to make the CCSSM content and Standards for Mathematical Practice accessible to ELLs and students with special needs.

IMPLICATIONS FOR PROFESSIONAL DEVELOPMENT

- ✓Content-rich, ongoing, include accountability, etc.,

And…

- ✓Be grade-specific (slice the pizza differently)
- ✓Address depth over breadth – including what it means to focus on big ideas and implications for the "other" topics.
- ✓Focus on the SMP connected to the content
- ✓Include ongoing forums for Q&A (Virtually and face-to-face)
- ✓Involve specialists (e.g., special education, ELL specialists) and administrators
- ✓Include reference materials that are not text-intensive, but example rich.
- ✓Other????

Using the Standards for Mathematical Practice as a Framework in the Mathematics Content Preparation of Teachers

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Standards for Mathematical Practice

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

“The Standards for Mathematical Practice describe ways in which developing student practitioners of the discipline of mathematics increasingly ought to engage with the subject matter as they grow in mathematical maturity and expertise throughout the elementary, middle and high school years.”

-CCSSI, Mathematics, p. 8

Methods vs. Content Courses

- Methods Courses:
  - Study the SMP explicitly
  - Consider how they apply to teaching mathematics
- Content Courses:
  - Develop their MP as learners
  - Experience activities that develop MP

Think beyond problems and consider experiences.

Example: Mathematics Pen Pals

- Course: Geometry
- Process:
  - Meet & Assess
  - Send problem
  - Assess student work
  - Send new problem
  - Assess student work
  - Meet & Assess

(Lampe & Uselmann, 2008)

Example: Mathematics Pen Pals

- SMP:
  - Reason abstractly and quantitatively
  - Construct viable arguments and critique reasoning
  - Model with mathematics
  - Use appropriate tools strategically
  - Attend to Precision

Example: Afterschool tutoring

- Course: Number & Operation
- SMP:
  - Reason abstractly and quantitatively
  - Construct viable arguments and critique reasoning
  - Model with mathematics
  - Use appropriate tools strategically
  - Attend to Precision

(Henry & Breyfogle, 2006; Breyfogle, 2010)

References

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- Henry, S. E., and Breyfogle, M. L. (2006). Toward a new framework of 'server' and 'served': De(and Re)constructing reciprocity in service-learning pedagogy. *International Journal of Teaching and Learning in Higher Education, 18*(1), 27-35.
- Lampe, K. A., & Uselmann, L. (2008). Pen pals: Practicing problem solving. *Mathematics Teaching in the Middle School*, 14(4), 196-201.

Supporting Elementary Preservice Teachers in Learning to Plan and Enact Lessons with the CCSSM

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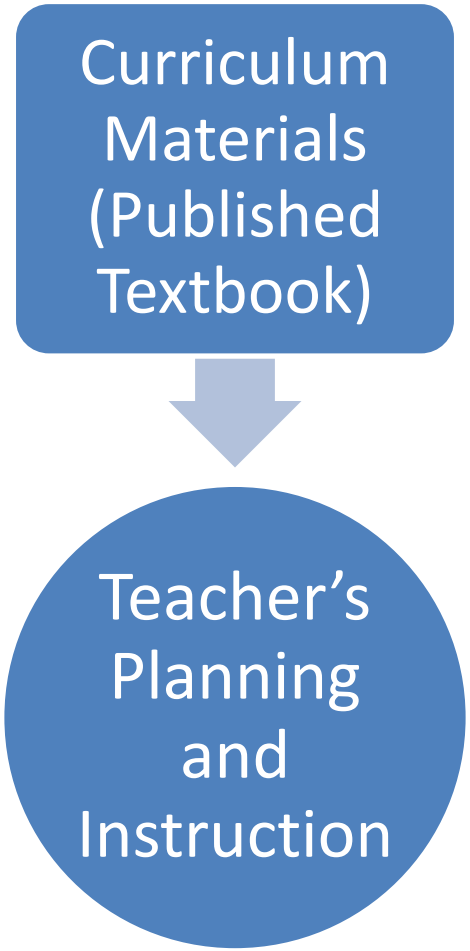
Consider the Practice of Planning and Enacting a Lesson from a Curriculum Perspective



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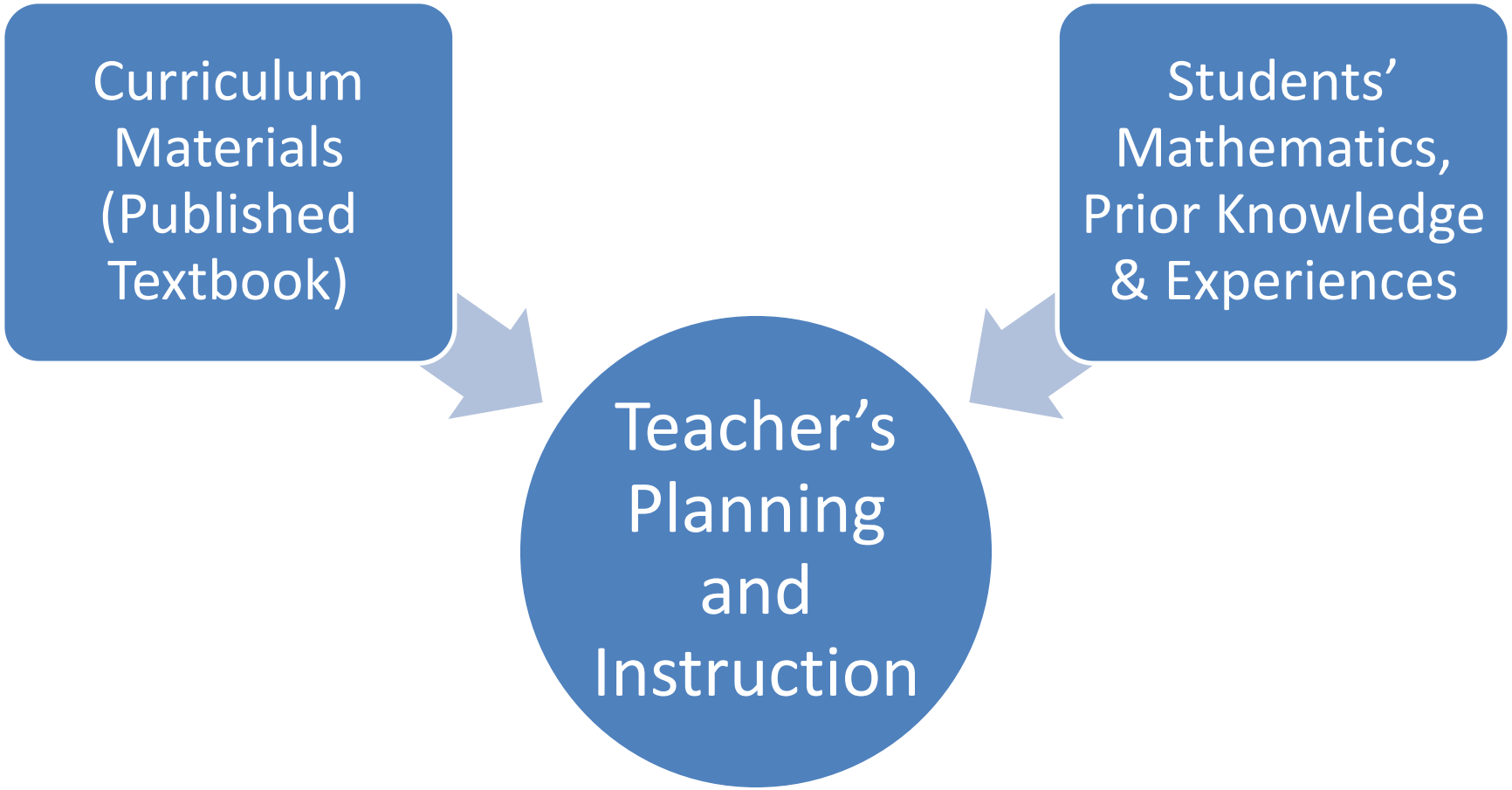
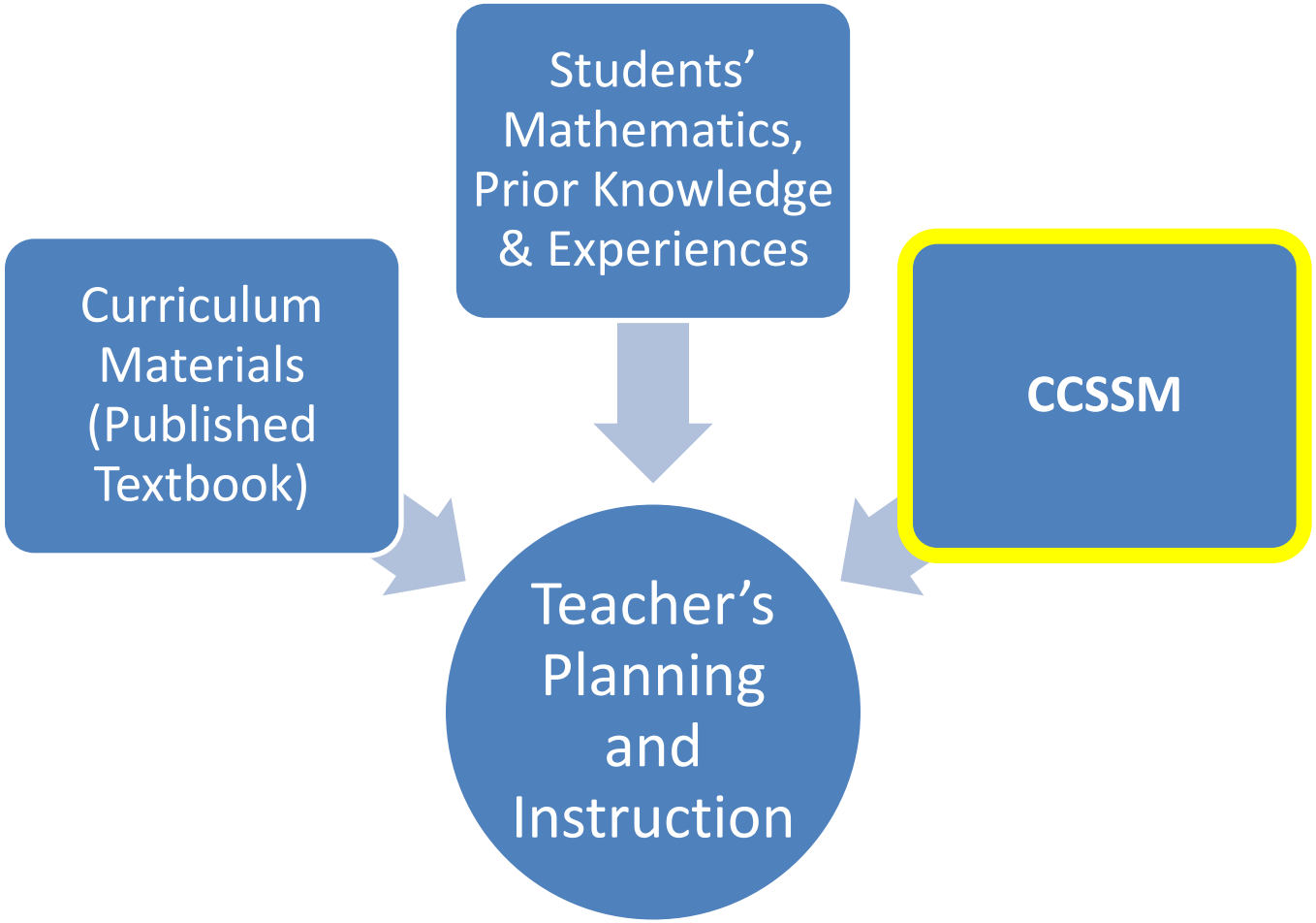


Teachers as Designers

Complexities and demands of planning and enacting lessons increases substantially as teachers take on the role of designers – rather than implementers (Remillard, 2005)

Consider the Practice of Planning and Enacting a Lesson from a Curriculum Perspective



(Roth McDuffie & Mather, 2009)

Teachers need to learn to analyze and consider :

1. What are the primary/central Standards (including Practices) for this grade/unit/lesson? Which CCSS are in the background?
2. Regardless of what students "should know," what prior knowledge and experiences do they bring to the lesson? How can I draw on that? What gaps/ confusions might need to be addressed? (Anticipating, Monitoring – Smith et al. 2009)
3. How do my curriculum materials fit with 1 & 2? Do these materials afford/constrain space for tailoring to needs of students and to relate to CCSS? What adaptations/ supplements/ replacements might be needed? (Drake & Land, in press)

Experiences to develop teachers' planning & enactment practices

From perspectives that focus on a decomposition of practice (Grossman, 2009), and the role of BOTH field-based and university-based experiences (Putnam & Borko, 2000):

- **Planning lessons** as "thought experiments" & enacting with mentor teacher support.
- **Analyzing curriculum** – using a tool aimed at theses issues.
- **Studying examples of practice** with a focus on teachers' intentions, decision making, and outcomes for students' learning (observations, video/written case study, etc.) .
- **Learning about students'** thinking, strategies, role of experiences and background (student interviews/ observations).
- **Learning about learning** – e.g., learning trajectories and how trajectories relate to particular students, CCSSM, curriculum materials (readings & discussions on research and theory).

Preparing teachers in the era of the CCSSM

Opportunities for Middle and Secondary Mathematics Teacher Education

Tim Hendrix, Meredith College

Opportunity 1: A Fresh Bite

- Principle of Perturbation
- Sometimes, just the right "something different" interrupting our "normal operating procedure" can be an infusion of focus and energy
- Potential to change a sense of "pontification" to "important themes", "insight", "reinforcement" and "espousal"

Opportunity 2: Progressions

- Learning progressions, or learning trajectories
- Conceptual development of mathematical ideas situated ***vertically***
- In recent years, from this author's experience, more success in this area has been in K – 8 than in 6 – 12
- Recognition of overlap and efforts across the board

Opportunity 2: Conceptual Progressions

- Moving from numbers to **number systems**
- Moving from operation sense to **algebraic thinking**
- Moving from fraction sense to **proportional reasoning**
- Moving from patterns to **functions**
- Moving from shapes to **properties of shapes**
- Moving from inductive to **deductive reasoning**

Opportunity 2: Conceptual Progressions

- Moving from function computation to **analysis of functions**
- Moving from expressions and equations to **equivalence of expressions**
- Moving from "flips, turns, and slides" to **isometry** as **distance-preserving transformation**
- Moving from data exploration to **drawing conclusions**
- Moving from dealing with uncertainty to **making reasonable inferences**

Opportunity 3: Why… leads to what is…?

- Why do we have to learn X…?
- Why do students need to learn to prove…?
- Prevalent answers are less than satisfying for anything more than the temporary
- CCSSM provides an opportunity to focus on conceptual development vertically which leads to a discussion of ***what mathematics is*** and what ***doing mathematics is***
- ***Standards of Mathematical Practice***

Opportunity 3: Why… leads to what is…?

- "…answers do not address the question of the intellectual tools one should acquire when learning a particular mathematical topic. Such tools…define the nature of mathematical practice." (Harel, 2008, p. 267)

- "One can't do mathematics for more than ten minutes without grappling, in some way or other, with the slippery notion of *equality*." (Mazur, 2008, p.222, emphasis added)

Opportunity 3: Why… leads to what is…?

- Importance of understanding mathematical concepts in multiple ways
- Relationship between ***equivalence*** and ***equality***
- Leads to the notion of ***invariance***, in particular, ***algebraic invariance***
- Helps promote ***functional understanding*** as more than objects, but as a way of ***systematizing and analyzing relationships***

Opportunity 3: Why… leads to what is…?

- Why is this understanding important?
- "*Algebraic invariance* refers to the thinking by which one recognizes that algebraic expressions are manipulated not haphazardly but with the purpose of arriving at a desired form and maintaining certain properties of the expression invariant." (Harel, 2008, p. 279, empahsis added)

Opportunity 3: Why… leads to what is…?

- Caution: ***Ungrounded competence***
- "A student with ungrounded competence will display elements of sophisticated procedural or quantitative skills in some contexts, but in other contexts will make errors indicating a lack of conceptual understanding or qualitative understanding underpinning these skills."
  (Kalchman & Koedinger, 2005, p. 389)

Conclusion: CCSSM fresh bites provide:

- A new opportunity to focus on importance of ***mathematical knowledge for teaching***
- A chance to extend and apply the work of learning progressions and ***vertical conceptual development*** more prominently in the middle and secondary levels
- A valuable opportunity to promote:
  - …discussion of ***what is mathematics***
  - …what it means ***to do mathematics***
  - …the ***importance*** of mathematics

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References:

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- Mazur, B. (2008) When is one thing equal to some other thing? In *Proof & other dilemmas: Mathematics and philosophy* (2008, Gold & Simon, Eds). MAA: Washington, DC

- Kalchman, M. & Koedinger, K. (2005) Teaching and learning functions. In How Students Learn: Mathematics in the Classroom (2005, Donovan & Bransford, Eds). National Research Council: Washington, DC

- Unpublished draft: Progressions in the Common Core—Expressions and Equations (6 – 8). Common Core Writing Team, Draft April 22, 2011 from www.commoncoretools.com

Collaborating *with* teachers in the era of the common core

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Recognize…

- Tammie Cass, Darin Dowling, Patty Gronewold, Jean Krusi, Lana Lyddon Hatten, Jeff Marks, Joe Obrycki, & Angie Shindelar
- 3 HS teachers in northeastern Canada

Social Sciences and Humanities Research Council of Canada

National Science Foundation
WHERE DISCOVERIES BEGIN

Some justifications for CCSS-M

- We need standards to ensure that all students, no matter where they live, are prepared for success in postsecondary education and the workforce. Common standards will help ensure that students are receiving a high quality education consistently, from school to school and state to state. Common standards will provide a greater opportunity to share experiences and best practices within and across states that will improve our ability to best serve the needs of students.
- These standards are a common sense first step toward ensuring our children are getting the best possible education no matter where they live.

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Mathematical practices

- **Make sense of problems and persevere in solving them.**

Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution. They analyze givens, constraints, relationships, and goals. They make conjectures about the form and meaning of the solution and plan a solution pathway rather than simply jumping into a solution attempt. …

- **Construct viable arguments and critique the reasoning of others.**

Mathematically proficient students understand and use stated assumptions, definitions, and previously established results in constructing arguments. They make conjectures and build a logical progression of statements to explore the truth of their conjectures. They are able to analyze situations by breaking them into cases, and can recognize and use counterexamples. They justify their conclusions, communicate them to others, and respond to the arguments of others. They reason inductively about data, making plausible arguments that take into account the context from which the data arose. …

Pedagogical(?) practices

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Typical Professional Development

- Someone other than the teachers (e.g., the curriculum specialist, mathematics specialist, principal, superintendent) decides what to do and who to bring in;
- Typically short-term, disconnected workshops or presentations that focus on telling or showing teachers what they should *do*; and
- Purposes are determined ahead of time, often with little contextual knowledge of the place in which the professional development is happening

After experiencing typical PD after teaching for seven years…

We're just never, ever, ever, ever, ever treated with autonomy

or to think that what we think would be best

or to think about what's important and do it for a long time

or to be supported in what you think is best over a long time.

… that structure [in this discourse project] was so foreign. (Interview, 2008)

Professionals

- are viewed as having specialized knowledge in their field of expertise,
- work in an atmosphere of collegiality in which they work with others in order to produce professional knowledge and to improve their practice and conditions, and
- enjoy a degree of autonomy in their work (from Noddings, 1992).

What might it mean to engage in the enactment of CCSS-M as *professionals*?

NOT…	BUT RATHER…
One-shot workshop PD as usual	Let's work on this together & teaching as lifelong collaborative learning
I know something you don't and what I know is more relevant to good teaching than what you know	We each know important & relevant things, so let's work together to do what's best for students
This is what "best practice" says you should do	How about we talk about this document and what it means for your practice in the context in which you work

Alternatives to typical PD

- Study groups
  - Extended discussion around a topic that is of common interest across a group of participants
  - Typically include activities such as looking at student work, reading professional literature, examining videos of teaching, or some combination of these
- Collaborative action research
  - Cycles of systematic inquiry into one's own practice
  - Leads to generalizations, which are then tested in new situation and further explored
  - Occurs in a community of stakeholders (e.g., teachers, teacher educators, mathematicians, administrators, community members, students)

Alternative Forms of PD related to CCSS-M: Study Groups & Collaborative Action Research

- Provides a way not only to improve their practice but also to develop an understanding of it [**Make sense of problems…**];
- Can develop a sense of agency and control because teachers raise their own questions and generate knowledge. […**and persevere in solving them; Construct viable arguments and critique the reasoning of others**]
- Not only contributes to the development of collegiality within groups of teacher-researchers but also develops relationships among a broader group of stakeholders

Alternative Forms of PD related to CCSS-M: Study Groups & Collaborative Action Research

- Advocates for teachers…

After a year-long study group and two years of collaborative action research…

- *[Study groups and action research] are the only way to actually do it … the only way that it's ever actually gonna have any impact. Like, you can go in and try to tell somebody what they're doing is wrong or they should be doing this and this instead … you're never gonna get anywhere. (Interview, 2008)*

Reconsidering Secondary Mathematics Teacher Preparation in Light of the CCSS

W. Gary Martin

Auburn University

Challenges

- Changes in mathematics content:
  - Different curriculum approaches (e.g., transformational geometry)
  - Emphasis on Standards for Mathematical Practice
- Increased rigor compared to existing state standards:
  - Preparation to help *all* students achieve the standards
- Effective field experiences:
  - Need for alignment between K-12 programs and teacher preparation

Partnerships Are Key

- Partnerships of mathematics teacher educators with:
  - Mathematicians providing the content courses for secondary mathematics teachers
  - Middle and high school mathematics teachers who provide field experiences
- Challenges present opportunities to open serious considerations about how we can collaboratively work to meet the CCSSM.

National Partnerships

- The common vision for mathematics education across states adopting the CCSSM provides new opportunities for collaborative work across institutions and states.

SMTI

Science & Mathematics Teacher Imperative

The Science and Mathematics Teacher Imperative (SMTI) is…

…the nation's most ambitious effort to help public higher education institutions assess and improve the quality, and increase the number and diversity of K-12 science and mathematics teachers.

Science & Mathematics Teacher Imperative

SMTI -- A Brief History

- Initiated in 2008 by the Association of Public and Land-grant Universities (A◆P◆L◆U)
- Now a partnership of 125 public research institutions, 12 university systems across 45 states.
- Includes public IHEs in all states that have adopted Common Core State Standards for Mathematics
- Selected partner for *100kin10* (2011)
- Developed an Analytic Framework to understand current teacher preparation programs (2009-2011)

SMTI

Science & Mathematics Teacher Imperative

- Through an NSF-MSP RETA grant, The Learning Collaborative (TLC) is learning about the factors that need to be in place to create, catalyze and sustain institutional commitment and change related to teacher preparation (2009-2012)
- Now expanding SMTI programs to address teacher preparation in the era of common core math and next generation science standards (2011 and beyond)

SMTI
Science & Mathematics Teacher Imperative

APLU/SMTI Forum: "Higher Education and Common Core Standards"

- Thursday, October 13, 2011
  9:30 am – 11:30 am EDT
  AAAS Auditorium, Washington, DC
  - Release of discussion paper, *Common Core State Standards and Teacher Preparation: The Role of Higher Education*
  - Announcement of a new project focused on mathematics teacher preparation
- More information at www.teacher-imperative.org

Science & Mathematics Teacher Imperative

SMTI – New Focus on Math Teacher Preparation

In order to meet the challenges of CCSS-M and embody research and best practices in the field, SMTI is developing a new **partnership** of IHEs and K-12 school districts to provide a coordinated research and development effort for secondary mathematics teacher preparation programs.

SMTI
Science & Mathematics Teacher Imperative

Plan for Partnership

- Planning grant from NSF to
  - Organize a planning committee and advisory board
  - Form the new partnership by soliciting partners committed to effort
  - Plan a conference to identify guiding principles and priorities for action
  - Select partners to organize an R&D agenda and process that involves the full partnership
- Will seek ongoing funding to support the plan that emerges by Fall 2012

SMTI
Science & Mathematics Teacher Imperative

Next Steps

- October 13, 2011 – A◆P◆L◆U/SMTI announcement
- Early November 2011 – Request for applications to join the partnership
- January 13, 2012 – Applications to join the partnership are due
- March 2012 – Partnership conference

Stay tuned to
www.teacher-imperative.org