Using a Process to Align Curriculum, Assessment and Instructional Practices to the Intent and Rigor of the Mathematics Georgia Standards of Excellence

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GaDOE Instructional Leadership Conference
Thursday, February 25th, 2016

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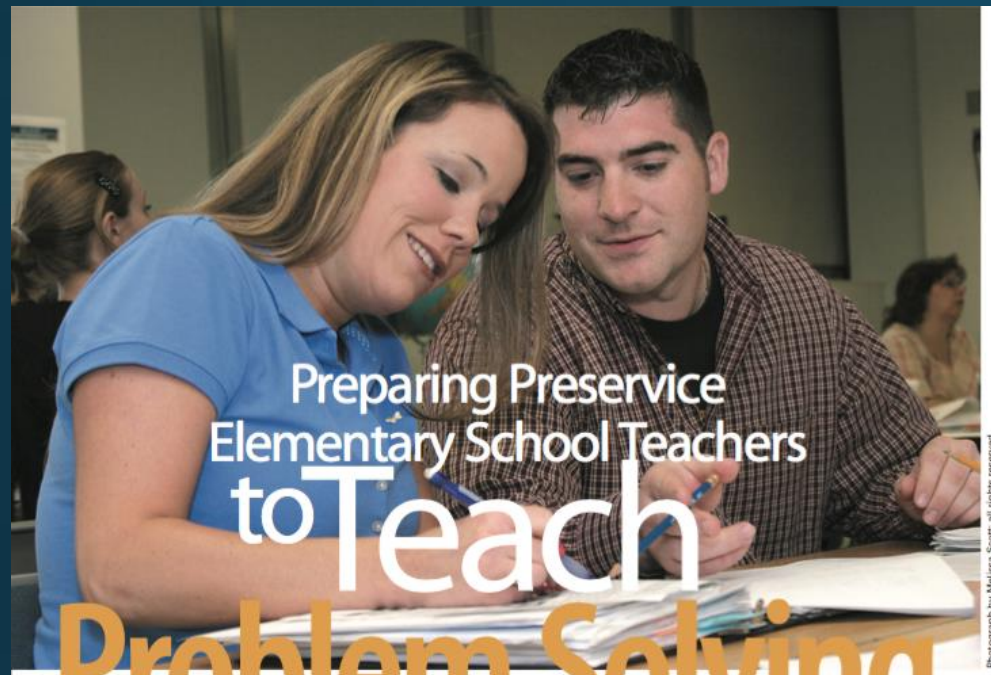


Preparing Preservice Elementary School Teachers to Teach Problem Solving

Photograph by Melissa Scott; all rights reserved

A third-grade teacher recently introduced me to her class as a professor who was there to help them learn how to do problem solving. She added, "You know those word problems we all hate to do—well, she is going to help us learn how to do them better!" I was astounded by this introduction. When I later asked her how often she uses problem-solving activities with her students, she commented, "Very little. I really don't feel comfortable with it [problem solving], and the students just don't know how to do them." I had to wonder what effect this teacher was having on her students' problem-solving abilities and attitudes. How confident and competent did she feel teaching mathematics with problem solving? What experiences with problem solving will help prepare preservice elementary teachers to teach mathematics with a problem-solving approach and feel confident in doing so?

Research shows that elementary school students' lack of success in and fear of problem solving stem from the negative attitudes and incompetence harbored by their teachers (Schoenfeld 1992, p. 359). To teach problem solving effectively, teachers must have the knowledge and dispositions of effective problem solvers (Schoenfeld 1992). *Principles and Standards for School Mathematics* (NCTM 2000, p. 377) states that universities have a significant influence on whether teachers enter the profession with a strong knowledge of mathematics, student learning, and mathematics teaching. The fundamental question is, how can preservice elementary teachers' problem-solving abilities and dispositions improve during their undergraduate experience?

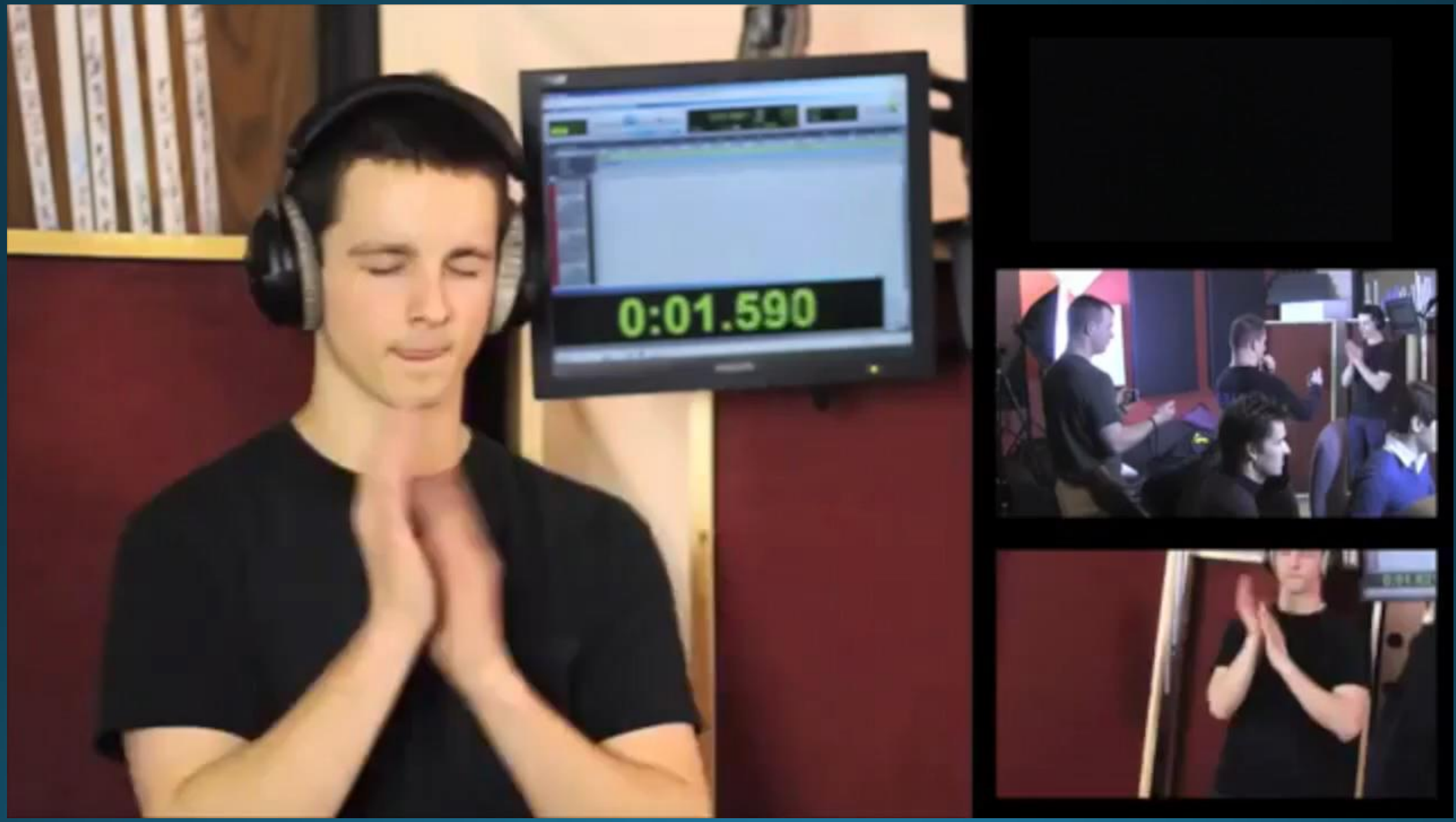
By Jane M. Wilburne

Jane M. Wilburne, jmw41@psu.edu, is an assistant professor of mathematics education at Penn State in Harrisburg, Pennsylvania. She is interested in helping current and future teachers develop their problem-solving abilities and build their confidence with problem solving.

Face to Face

Back to Back

3-ACT Tasks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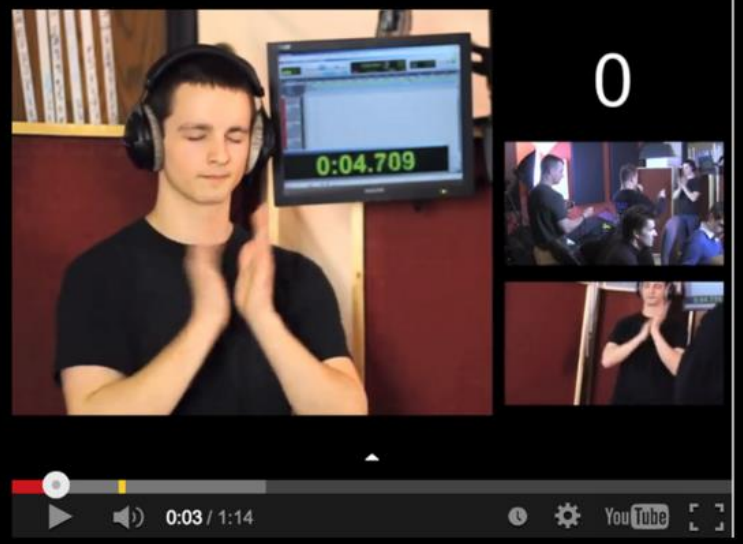

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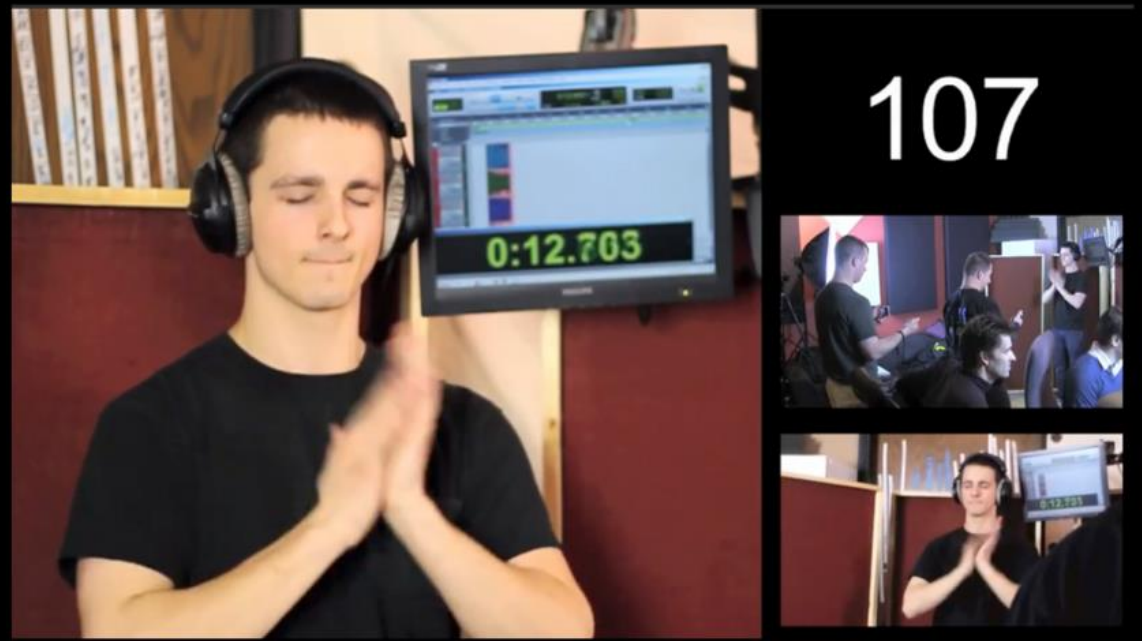

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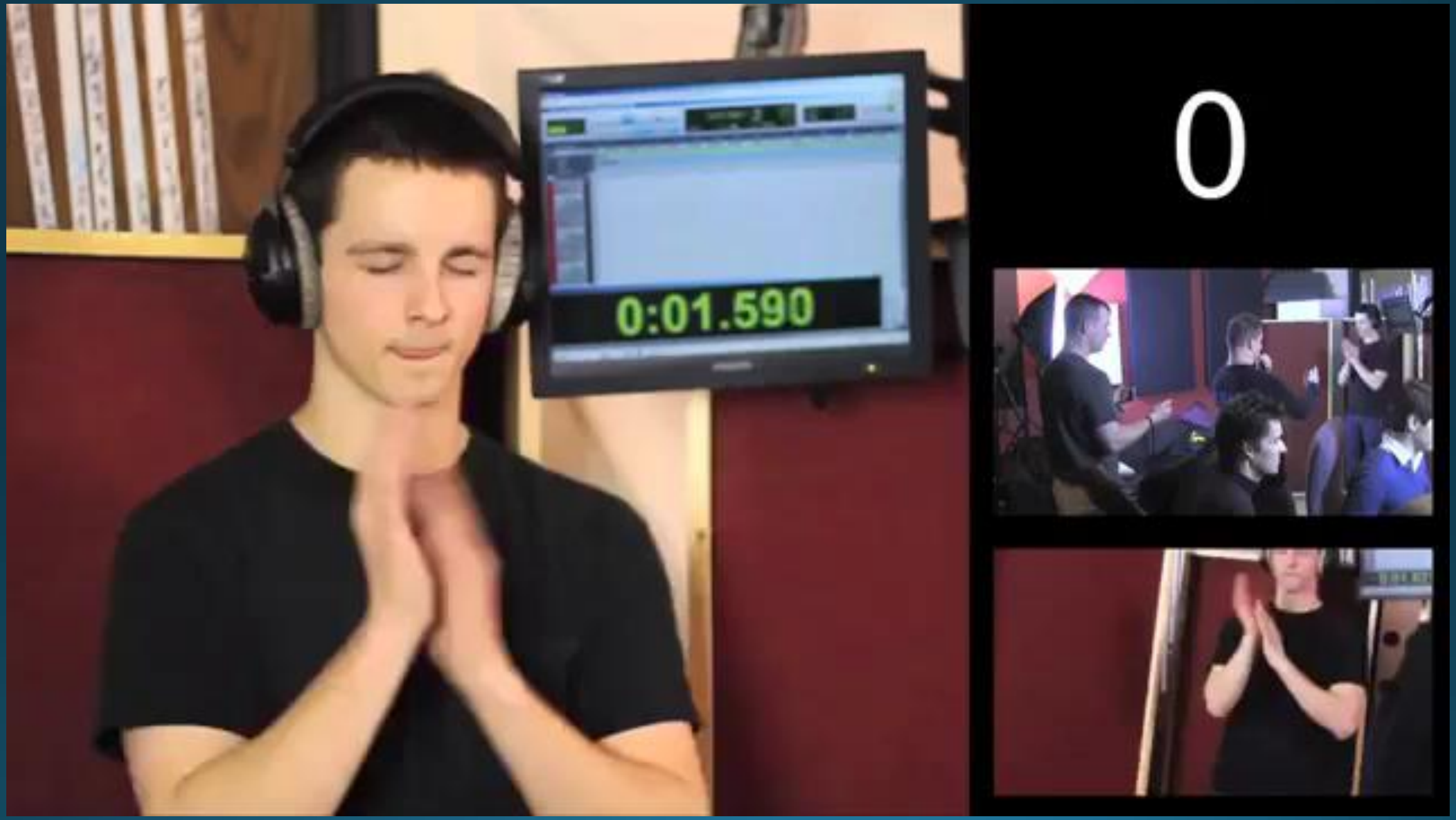
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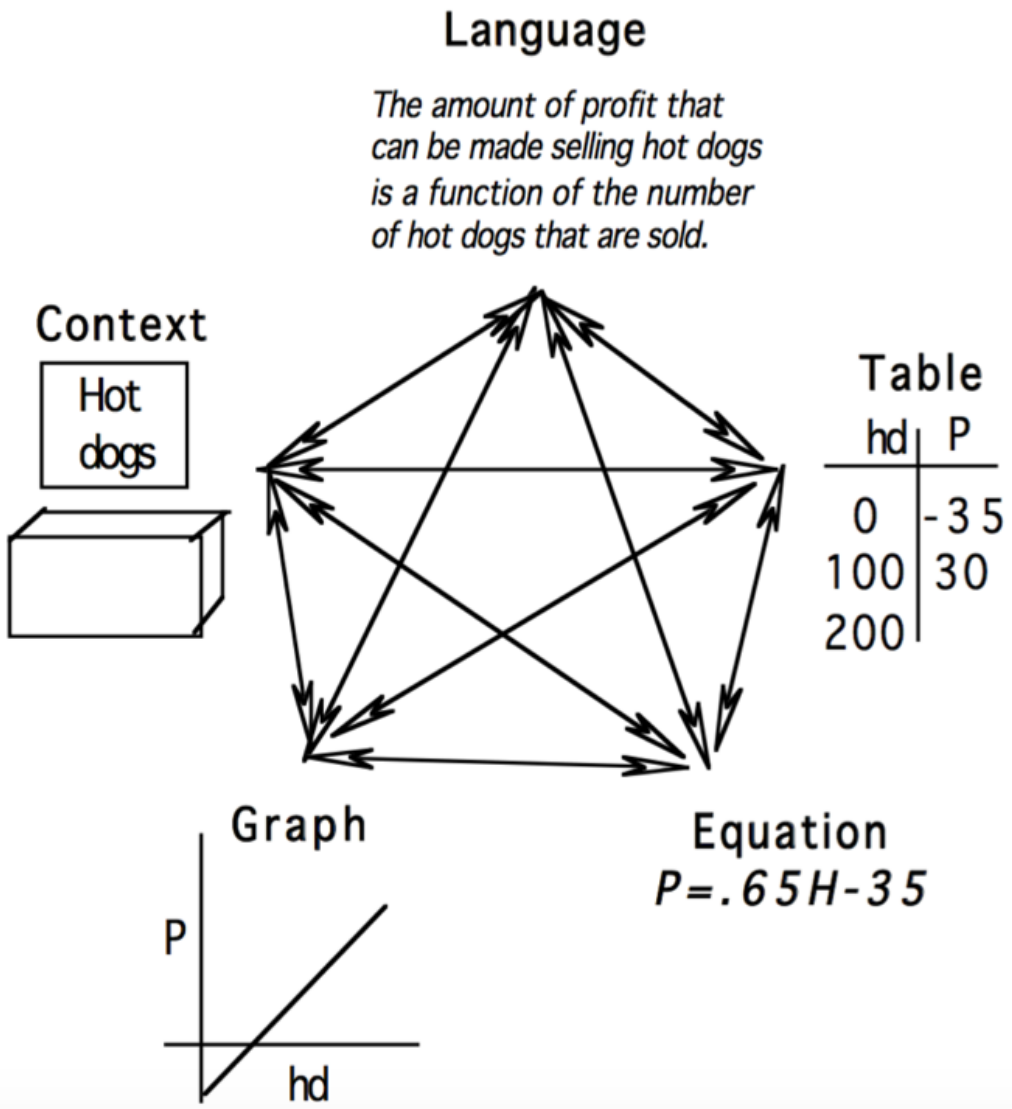


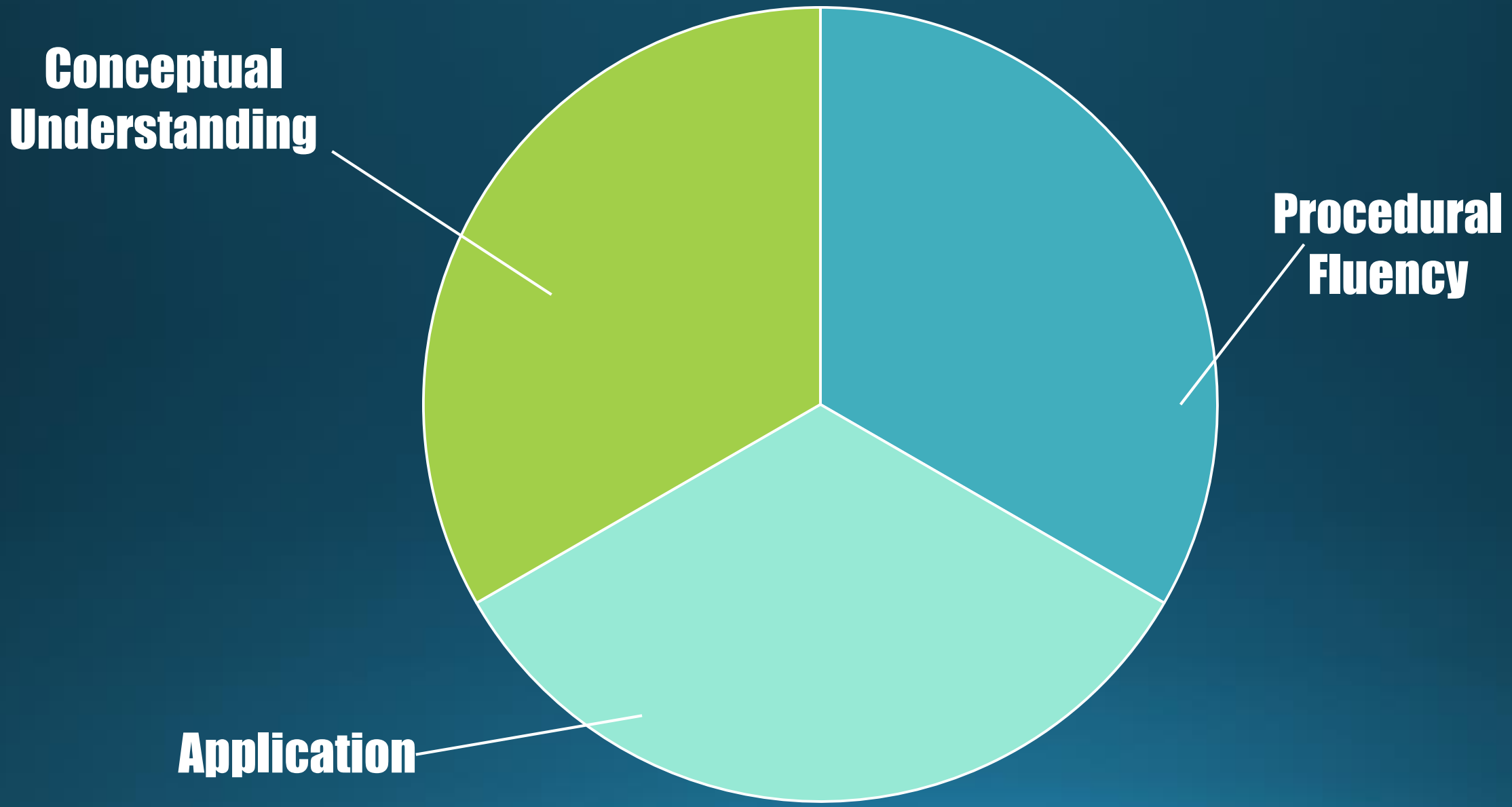
What standards for mathematical practice did we just engage in?

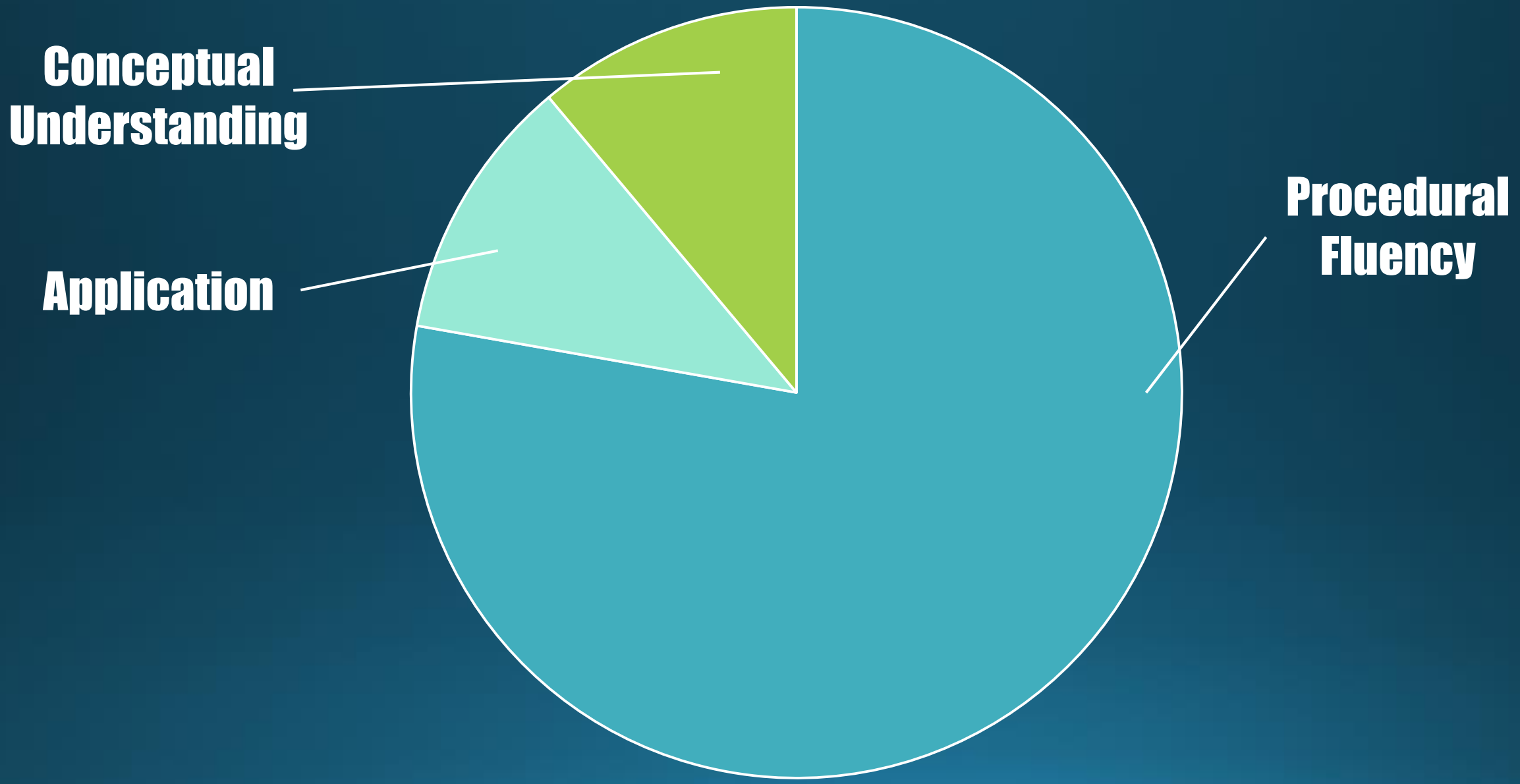
Standards for Mathematical Practice

Mathematically Proficient Students can……

1. **Make sense of problems and persevere in solving them**
   - *-doing mathematics means solving problems and discussing how they solved them*
   - *-plan a solution pathway and adjust as needed as they work through the problem*
   - *-persevere (" First, I drew a diagram, and it didn't help, so I tried to make a table. That worked much better because I found a pattern.")*
   - *-explain thinking through equations, verbal descriptions, tables, graphs, diagrams and search for trends in data*
2. **Reason abstractly and quantitatively**
   - *-numbers represent quantities and these quantities can be represented with symbols*
   - *-generalize based on what they observe*
   - *-"I know that rectangles are parallelograms with four right angles ….so that means this square must be a rectangle because . . ."*
3. **Construct viable arguments and critique the reasoning of others**
   - *-make conjectures with support and reason through the use of objects, drawings, diagrams and actions*
   - *-ask and respond to questions like, "How did you get that?" and "Why is that true?"*
4. **Model with mathematics**
   - *-put mathematics in the context of real world situations and identify those relationships*
   - *-use organizational strategies such as making a table, creating a number line, drawing diagrams, use objects, etc.*
5. **Use appropriate tools strategically**
   - *-use familiar, grade appropriate tools and know when they can be helpful*
   - *-recognize both the strengths and limitations of the tool being used*

6. **Attend to precision**
   - *-communicate precisely to others through my language, models and representations*
   - *-calculate accurately and efficiently, and show flexibility with strategies*
7. **Look for and make use of structure**
   - *-look closely at patterns and structure*
   - *-identify and understand the make-up and inclusion of number (commutative and distributive properties)*
8. **Look for and express regularity in repeating reasoning**
   - *-continually evaluate the reasonableness of intermediate results ("I notice when I divide 4 by 11, I get 0.36, then I keep dividing the same numbers over and over.")*
   - *-students continually check their work by asking themselves, "Does this make sense?"*


Conceptual Understanding
Procedural Fluency
Application


Conceptual Understanding
Application
Procedural Fluency

8 Standards for Mathematical Practice
&
Teacher Keys Evaluation System

STANDARDS FOR MATHEMATICAL PRACTICE

SMP	NEEDS IMPROVEMENT	EMERGING	PROFICIENT	EXEMPLARY
MAKES SENSE OF PROBLEMS AND PERSERVER IN SOLVING THEM	**Task:** □ Is strictly procedural. □ Does not require students to check solutions for errors. **Teacher:** □ Does not allow for wait time; asks leading questions to rush through task. □ Does not encourage students to individually process the tasks. □ Is focused solely on answers rather than processes and reasoning.	**Task:** □ Is overly scaffolded or procedurally "obvious". □ Requires students to check answers by plugging in numbers. **Teacher:** □ Allots too much or too little time to complete task. □ Encourages students to individually complete tasks, but does not ask them to evaluate the processes used. □ Explains the reasons behind procedural steps. □ Does not check errors publicly.	**Task:** □ Is cognitively demanding. □ Has more than one entry point. □ Requires a balance of procedural fluency and conceptual understanding. □ Requires students to check solutions for errors using one other solution path. **Teacher:** □ Allows ample time for all students to struggle with task. □ Expects students to evaluate processes implicitly. □ Models making sense of the task (given situation) and the proposed solution.	**Task:** □ Allows for multiple entry points and solution paths. □ Requires students to defend and justify their solution by comparing multiply solution paths. **Teacher:** □ Differentiates to keep advanced students challenged during work time. □ Integrates time for explicit meta-cognition. □ Expects students to make sense of the task and the proposed solution.
REASON ABSTARCTLY AND QUANTITATIVELY	**Task:** □ Lacks context. □ Does not make use of multiple representations or solution paths. **Teacher:** □ Does not expect students to interpret representations. □ Expects students to memorize procedures with no connection to meaning.	**Task:** □ Is embedded in a contrived context. **Teacher:** □ Expects students to model and interpret tasks using a single representation. □ Explains connections between procedures and meaning.	**Task:** □ Has realistic context. □ Requires students to frame solutions in a context. □ Has solutions that can be expressed with multiple representations. **Teacher:** □ Expects students to interpret and model using multiple representations. □ Provides structure for students to connect algebraic procedures to contextual meaning. □ Links mathematical solution with a question's answer.	**Task:** □ Has relevant realistic context. **Teacher:** □ Expects students to interpret, model, and connect multiple representations. □ Prompts students to articulate connections between algebraic procedures and contextual meaning.
CONSTRUCT VIABLE ARGUMENT	**Task:** □ Is either ambiguously stated. **Teacher:** □ Does not ask students to present arguments or solutions. □ Expects students to follow a given solution path without opportunities to make conjectures.	**Task:** □ Is not at the appropriate level. **Teacher:** □ Does not help students differentiate between assumptions and logical conjectures. □ Asks students to present arguments but not to evaluate them. □ Allows students to make conjectures without justification.	**Task:** □ Avoids single steps or routine algorithms. **Teacher:** □ Identifies students' assumptions. □ Models evaluation of student arguments. □ Asks students to explain their conjectures.	**Teacher:** □ Helps students differentiate between assumptions and logical conjectures. □ Prompts students to evaluate peer arguments. □ Expects students to formally justify the validity of their conjectures.
MODEL THE MATHEMATICS	**Task:** □ Requires students to identify variables and to perform necessary computations. **Teacher:** □ Identifies appropriate variables and procedures for students. □ Does not discuss appropriateness of model.	**Task:** □ Requires students to identify variables and to compute and interpret results. **Teacher:** □ Verifies that students have identified appropriate variables and procedures. □ Explains the appropriateness of model.	**Task:** □ Requires students to identify variables, compute and interpret results, and report findings using a mixture of representations. □ Illustrates the relevance of the mathematics involved. □ Requires students to identify extraneous or missing information. **Teacher:** □ Asks questions to help students identify appropriate variables and procedures. □ Facilitates discussions in evaluating the appropriateness of model.	**Task:** □ Requires students to identify variables, compute and interpret results, report findings, and justify the reasonableness of their results and procedures within context of the task. **Teacher:** □ Expects students to justify their choice of variables and procedures. □ Gives students opportunity to evaluate the appropriateness of model.

Adapted from *Institute for Advanced Study/Park City Mathematics Institute*

STANDARDS FOR MATHEMATICAL PRACTICE

USE APPROPRIATE TOOLS STRATEGICALLY	**Task:** □ Does not incorporate additional learning tools. **Teacher:** □ Does not incorporate additional learning tools.	**Task:** □ Lends itself to one learning tool. □ Does not involve mental computations or estimation. **Teacher:** □ Demonstrates use of appropriate learning tool.	**Task:** □ Lends itself to multiple learning tools. □ Gives students opportunity to develop fluency in mental computations. **Teacher:** □ Chooses appropriate learning tools for student use. □ Models error checking by estimation.	**Task:** □ Requires multiple learning tools (i.e., graph paper, calculator, manipulatives). □ Requires students to demonstrate fluency in mental computations. **Teacher:** □ Allows students to choose appropriate learning tools. □ Creatively finds appropriate alternatives where tools are not available.
ATTEND TO PRECISION	**Task:** □ Gives imprecise instructions. **Teacher:** □ Does not intervene when students are being imprecise. □ Does not point out instances when students fail to address the question completely or directly.	**Task:** □ Has overly detailed or wordy instructions. **Teacher:** □ Inconsistently intervenes when students are imprecise. □ Identifies incomplete responses but does not require student to formulate further response.	**Task:** □ Has precise instructions. **Teacher:** □ Consistently demands precision in communication and in mathematical solutions. □ Identifies incomplete responses and asks student to revise their response.	**Task:** □ Includes assessment criteria for communication of ideas. **Teacher:** □ Demands and models precision in communication and in mathematical solutions. □ Encourages students to identify when others are not addressing the question completely.
LOOK FOR AND MAKE USE OF STRUCTURE	**Task:** □ Requires students to automatically apply an algorithm to a task without evaluating its appropriateness. **Teacher:** □ Does not recognize students for developing efficient approaches to the task. □ Requires students to apply the same algorithm to a task although there may be other approaches.	**Task:** □ Requires students to analyze a task before automatically applying an algorithm. **Teacher:** □ Identifies individual students' efficient approaches, but does not expand understanding to the rest of the class. □ Demonstrates the same algorithm to all related tasks although there may be other more effective approaches.	**Task:** □ Requires students to analyze a task and identify more than one approach to the Problem. **Teacher:** □ Facilitates all students in developing reasonable and efficient ways to accurately perform basic operations. □ Continuously questions students about the reasonableness of their intermediate results.	**Task:** □ Requires students to identify the most efficient solution to the task. **Teacher:** □ Prompts students to identify mathematical structure of the task in order to identify the most effective solution path. □ Encourages students to justify their choice of algorithm or solution path.
LOOK FOR AND EXPRESS REGULARITY IN REASONING	**Task:** □ Is disconnected from prior and future concepts. □ Has no logical progression that leads to pattern recognition. **Teacher:** □ Does not show evidence of understanding the hierarchy within concepts. □ Presents or examines task in isolation.	**Task:** □ Is overly repetitive or has gaps that do not allow for development of a pattern. **Teacher:** □ Hides or does not draw connections to prior or future concepts.	**Task:** □ Reviews prior knowledge and requires cumulative understanding. □ Lends itself to developing a pattern or structure. **Teacher:** □ Connects concept to prior and future concepts to help students develop an understanding of procedural shortcuts. □ Demonstrates connections between tasks.	**Task:** □ Addresses and connects to prior knowledge in a non-routine way. □ Requires recognition of pattern or structure to be completed. **Teacher:** □ Encourages students to connect task to prior concepts and tasks. □ Prompts students to generate exploratory questions based on current task.

TEACHER:_____ **DATE:**_____

NOTES:

Adapted from *Institute for Advanced Study/Park City Mathematics Institute*

Standards for Mathematical Practice Look Fors

Student Behaviors

1. Make sense of problems and persevere in solving them.
Students are:
- Reading the problem carefully (TKES 3.7)
- Drawing pictures, diagrams, tables, or using objects to make sense of the problem (TKES 3.7)
- Discussing the meaning of the problem with classmates (TKES 4.3)
- Making choices about which solution path to take (TKES 5.2)
- Trying out potential solution paths and making changes as needed (TKES 8.2)
- Checking answers and making sure solutions are reasonable and make sense (TKES 6.7)
- Exploring other ways to solve the problem (TKES 8.7)
- Persisting in efforts to solve challenging problems, even after reaching a point of frustration. (TKES 8.5 & 8.6)

2. Reason abstractly and quantitatively.
Students are:
- Using mathematical symbols to represent situations (TKES 3.8)
- Taking quantities out of context to work with them (decontextualizing) (TKES 3.8)
- Putting quantities back in context to see if they make sense (contextualizing) (TKES 3.8)
- Considering units when determining if the answer makes sense in terms of the situation (TKES 3.8)

3. **Construct viable arguments and critique the reasoning of others.**
Students are:
- Making and testing conjectures (TKES 8.7)
- Explaining and justifying their thinking using words, objects, and drawings (TKES 6.2)
- Listening to the ideas of others and deciding if they make sense (TKES 4.5)
- Asking useful questions (TKES 3.7)
- Identifying flaws in logic when responding to the arguments of others (TKES 4.5)
- Elaborating with a second sentence (spontaneously or prompted by the teacher or another student) to explain their thinking and connect it to their first sentence. (TKES 8.6)
- Talking about and asking questions about each other's thinking, in order to clarify or improve their own mathematical understanding. (TKES 4.3)
- Revising their work based upon the justification and explanations of others. (TKES 8.2)

4. Model with mathematics.
Students are:
- Using mathematical models (i.e. formulas, equations, symbols) to solve problems in the world (TKES 3.8)
- Using appropriate tools such as objects, drawings, and tables to create mathematical models (TKES 3.8)
- Making connections between different mathematical representations (concrete, verbal, algebraic, numerical, graphical, pictorial, etc.) (TKES 8.6)
- Checking to see if an answer makes sense within the context of a situation and changing the model as needed (TKES 8.2)

5. Use appropriate tools strategically.
Students are:
- Using technological tools to explore and deepen understanding of concepts (TKES 3.5)
- Deciding which tool will best help solve the problem. Examples may include: (TKES 3.5)
  - Calculator
  - Concrete models
  - Digital Technology
  - Pencil/paper
  - Ruler, compass, protractor
- Estimating solutions before using a tool (TKES 3.4)
- Comparing estimates to solutions to see if the tool was effective (TKES 3.5)

6. Attend to precision.
Students are:
- Communicating precisely using clear language and accurate mathematics vocabulary (TKES 1.4)
- Deciding when to estimate or give an exact answer (TKES 1.5)
- Calculating accurately and efficiently, expressing answers with an appropriate degree of precision (TKES 1.2)
- Using appropriate units; appropriately labeling diagrams and graphs (TKES 1.6)

7. Look for and make use of structure.
Students are:
- Finding structure and patterns in numbers (TKES 1.2)
- Finding structure and patterns in diagrams and graphs (TKES 1.2)
- Using patterns to make rules about math (TKES 1.2)
- Using these math rules to help them solve problems (TKES 1.2)

8. Look for and express regularity in repeated reasoning.
Students are:
- Looking for patterns when working with numbers, diagrams, tables, and graphs (TKES 1.2)
- Observing when calculations are repeated (TKES 8.6)
- Using observations from repeated calculations to take shortcuts(TKES 8.7)

**Please note that most of the teacher and student behaviors listed can be paired with more than one TKES indicator.*

Standards for Mathematical Practice Teacher Behaviors

1. Make sense of problems and persevere in solving them.
Teachers are:
- Providing rich problems aligned to the standards (TKES 1.2)
- Providing appropriate time for students to engage in the productive struggle of problem solving (TKES 8.6)

Teachers ask:
- What information do you have? What do you need to find out? What do you think the answer might be?
- Can you draw a picture? How could you make this problem easier to solve?
- How is ___'s way of solving the problem like/different from yours? Does your plan make sense? Why or why not?
- What tools/manipulatives might help you? What are you having trouble with? How can you check this?

2. Reason abstractly and quantitatively.
Teachers are:
- Providing a variety of problems in different contexts that allow students to arrive at a solution in different ways (TKES 4.1)
- Using think aloud strategies as they model problem solving (TKES 3.4)
- Attentively listening for strategies students are using to solve problems (TKES 5.4)

Teachers ask:
- What does the number ____ represent in the problem? How can you represent the problem with symbols and numbers?
- Can you make a chart, table or graph?

3. Construct viable arguments and critique the reasoning of others.
Teachers are:
- Posing tasks that require students to explain, argue, or critique (TKES 8.6)
- Providing many opportunities for student discourse in pairs, groups, and during whole group instruction (TKES 4.3)

Teachers ask:
- Why or why not? How do you know? Can you explain that? Do you agree?
- How is your answer different than _____'s? What math language will help you prove your answer?
- What examples could prove or disprove your argument? What questions do you have for ____?

4. Model with mathematics.
Teachers are:
- Providing opportunities for students to solve problems in real life contexts (TKES 3.8)
- Identifying problem solving contexts connected to student interests (TKES 4.1)

Teachers ask:
- Can you write a number sentence to describe this situation? What do you already know about solving this problem?
- What connections do you see? Why do the results make sense? Is this working or do you need to change your model?

5. Use appropriate tools strategically.
Teachers are:
- Making a variety of tools readily accessible to students and allowing them to select appropriate tools for themselves (TKES 3.5)
- Helping students understand the benefits and limitations of a variety of math tools (TKES 8.3)

Teachers ask:
- How could you use manipulatives or a drawing to show your thinking?
- Which tool/manipulative would be best for this problem? What other resources could help you solve this problem?

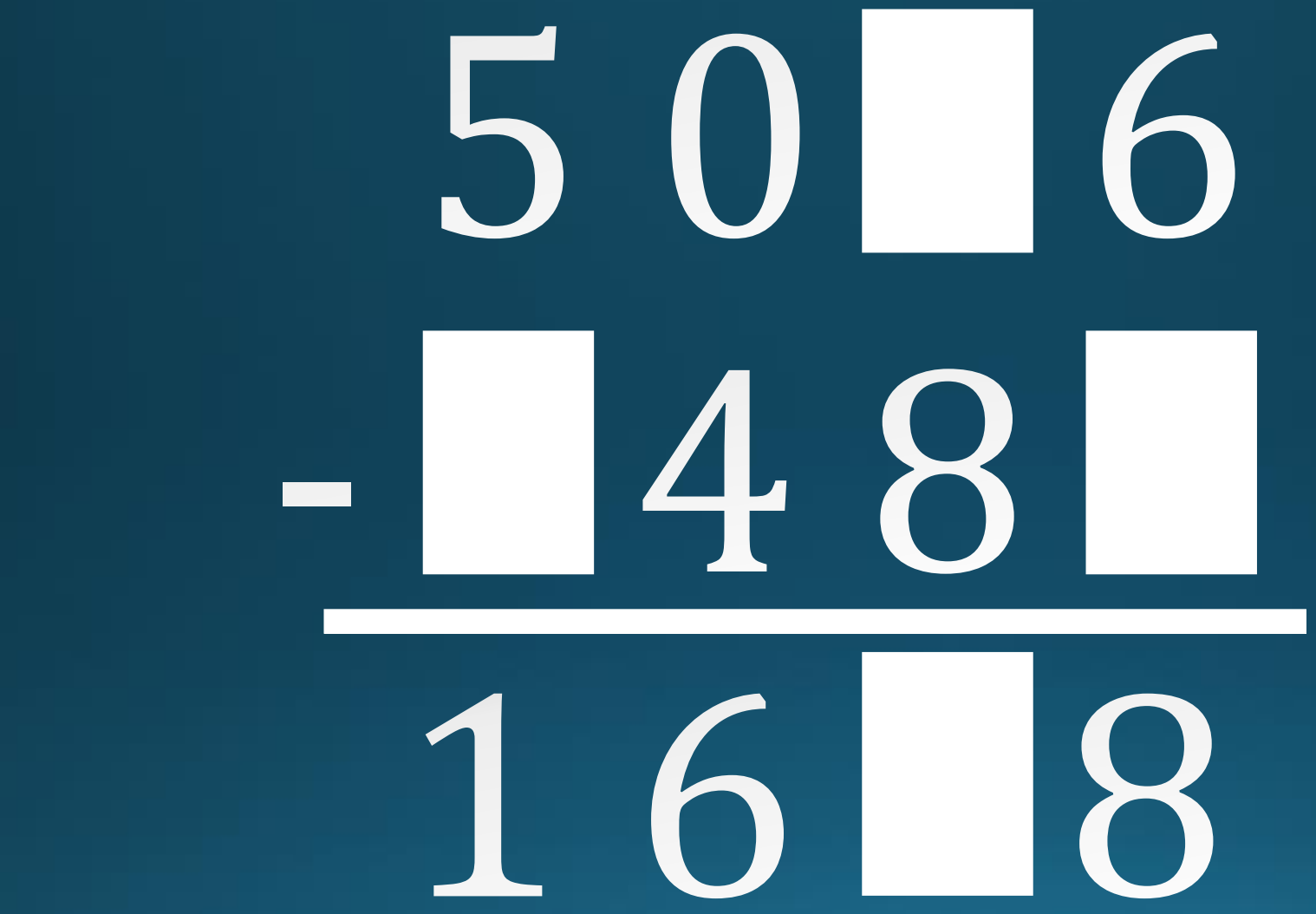
6. Attend to precision.
Teachers are:
- Explicitly teaching mathematics vocabulary (TKES 1.5)
- Insisting on accurate use of academic language from students (TKES 8.5)
- Modeling precise communication (TKES 10.4)
- Requiring students to answer problems with complete sentences, including units (TKES 10.4)
- Providing opportunities for students to check the accuracy of their work (TKES 5.2)

Teachers ask:
- What does the word ____ mean? Explain what you did to solve the problem.
- Compare your answer to _____'s answer What labels could you use?
- How do you know your answer is accurate? Did you use the most efficient way to solve the problem?

7. Look for and make use of structure.
Teachers are:
- Providing sense making experiences for all students (TKES 2.3)
- Allowing students to do the work of using structure to find the patterns for themselves rather than doing this work for students (TKES 8.7)

Teachers ask:
- Why does this happen? How is ____ related to ____? Why is this important to the problem?
- What do you know about ____ that you can apply to this situation? How can you use what you know to explain why this works?
- What patterns do you see?

8. Look for and express regularity in repeated reasoning.
Teachers are:
- Providing sense making experiences for all students (TKES 2.3)
- Allowing students to do the work of finding and using their own shortcuts rather than doing this work for students (TKES 8.7)
- *Teachers ask:*
- What generalizations can you make? Can you find a shortcut to solve the problem?
- How would your shortcut make the problem easier? How could this problem help you solve another problem?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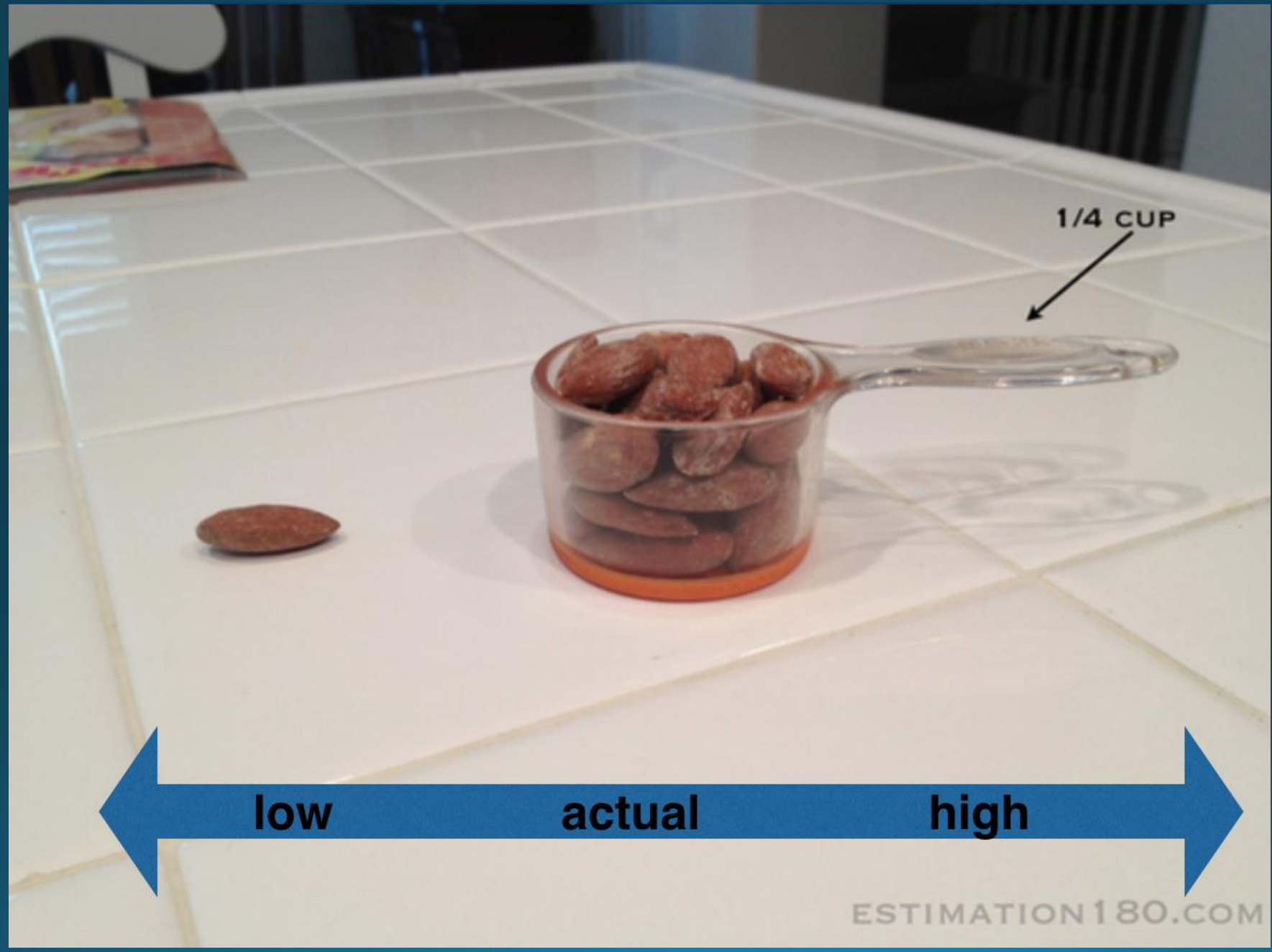
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Building number sense one day at a time.

GOT SMPs?


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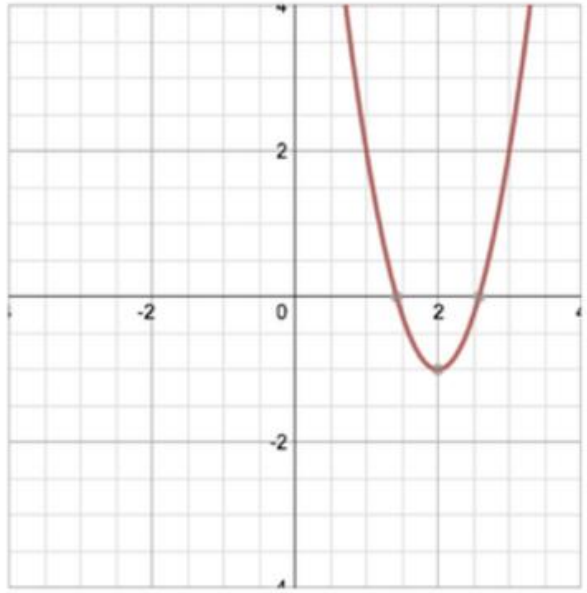
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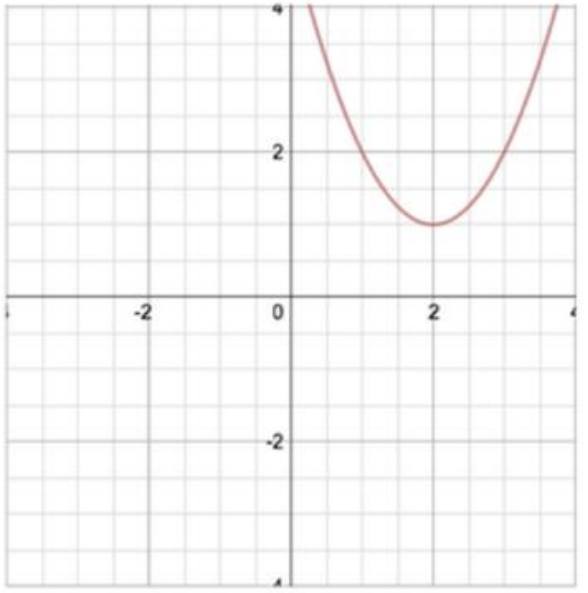
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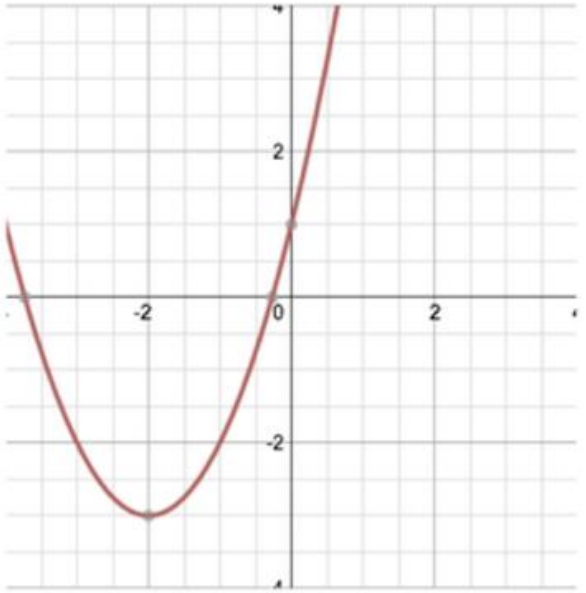
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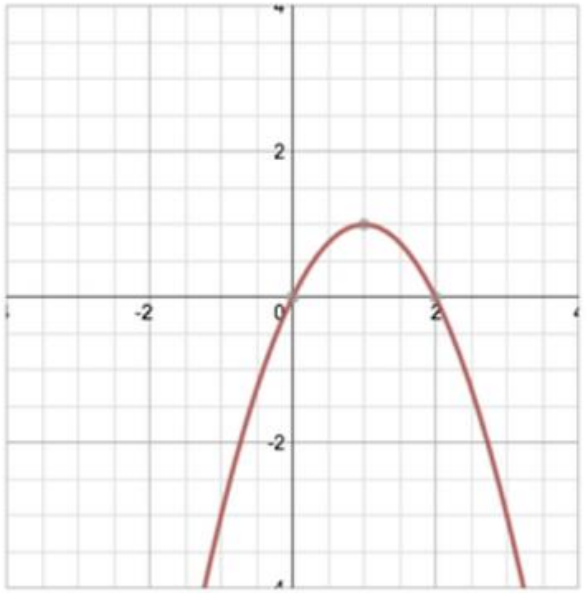
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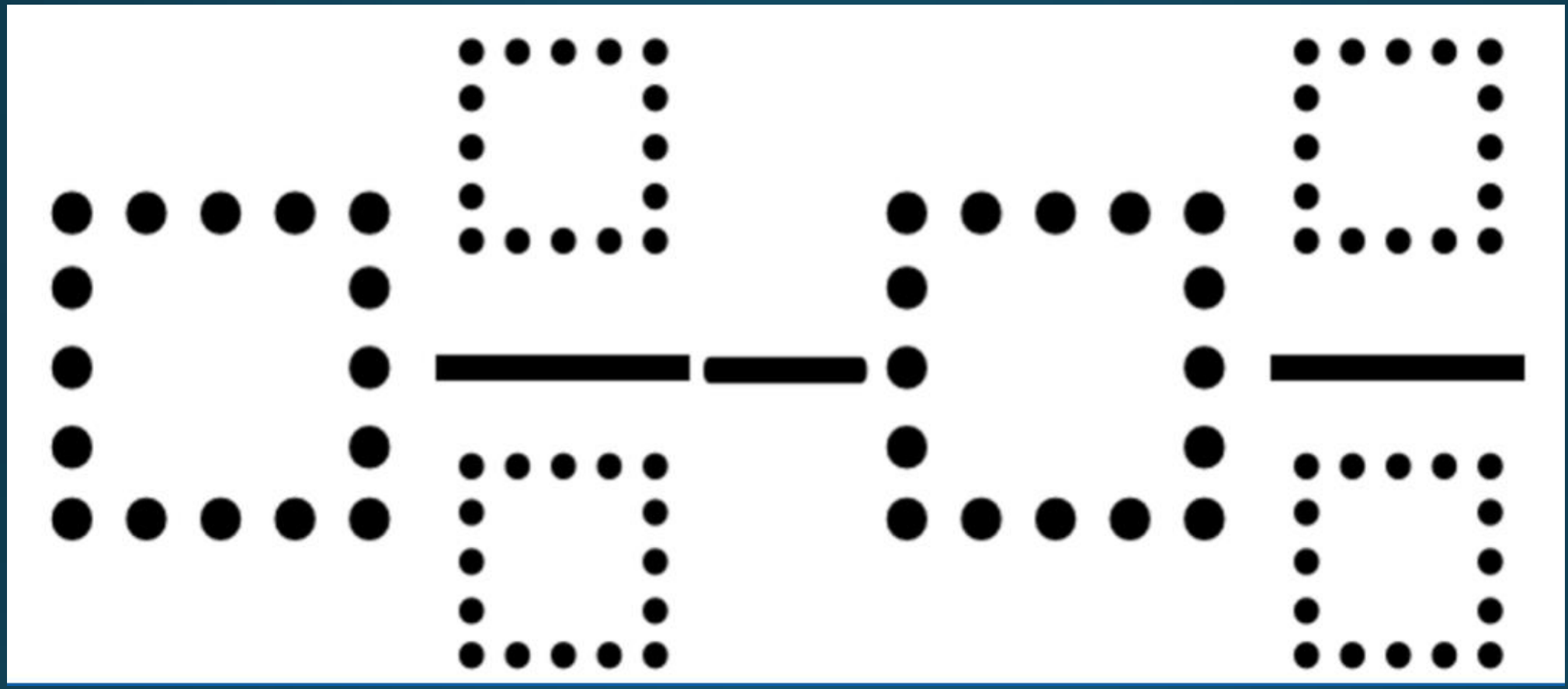

Use the digits 1-9 at most one time to create the smallest difference possible. (difference closest to zero)

GOT SMPs?

BROWSE MATH STANDARDS

Browse Math Standards

- English Language Arts
- Literacy in Social Studies, Science, & CTAE
- **Mathematics**
  - K-5
  - 6-8
  - 9-12
- Archives

Mathematics Georgia Standards of Excellence (GSE)

Highlights

- The Mathematics team has archived the former resources.
- Chris Franklin Statistics Summer 2012 Videos

Georgia Mathematics Teacher Wiki Forums

Visit the Georgia Mathematics Teacher Wiki Forums (No login/password required)

- Elementary School
- Middle School
- High School

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GA Math Wikispaces

☆ home

Edit | 71 | 99 | ...

Welcome to Georgia Mathematics Educator Forum: High School Courses

This wiki has been provided to allow sharing and collaboration among mathematics educators across the state. It is for everyone!

Directions for using this wiki

The 2015-2016 GSE Mathematics Unit Frameworks, Curriculum Maps, and Comprehensive Course Overviews were posted to GeorgiaStandards.org (PDF versions) on July 1, 2015. Word versions of these GSE resources have also been posted here.

For the latest announcements and information from the GaDOE Mathematics Team, join the 9-12 Mathematics listserve at
https://www.georgiastandards.org/Common-Core/Pages/Math.aspx

and follow us on twitter!

Follow @GaDOEMath

Mathematics Frequently Asked Questions

This is the general discussion area for the high school mathematics courses.
Specific course discussions can be found/started on each individual course page.
(To start your own discussion, click on the double word bubble below.)

Subject	Author	Replies	Views	Last Message
Quadratic Formula in GSE Geometry	DPotts5809	2	38	Feb 2, 2016 by DPotts5809
Frameworks for GSE Algebra	mizzbutts	2	1032	Aug 9, 2015 by melissasikes
Foundations of Algebra Frameworks	Onrivers	2	726	Jul 31, 2015 by Onrivers

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2015-2016 GSE Resources
Foundations of Algebra
Algebra I
Accelerated Alg I/Geo A
Coordinate Algebra
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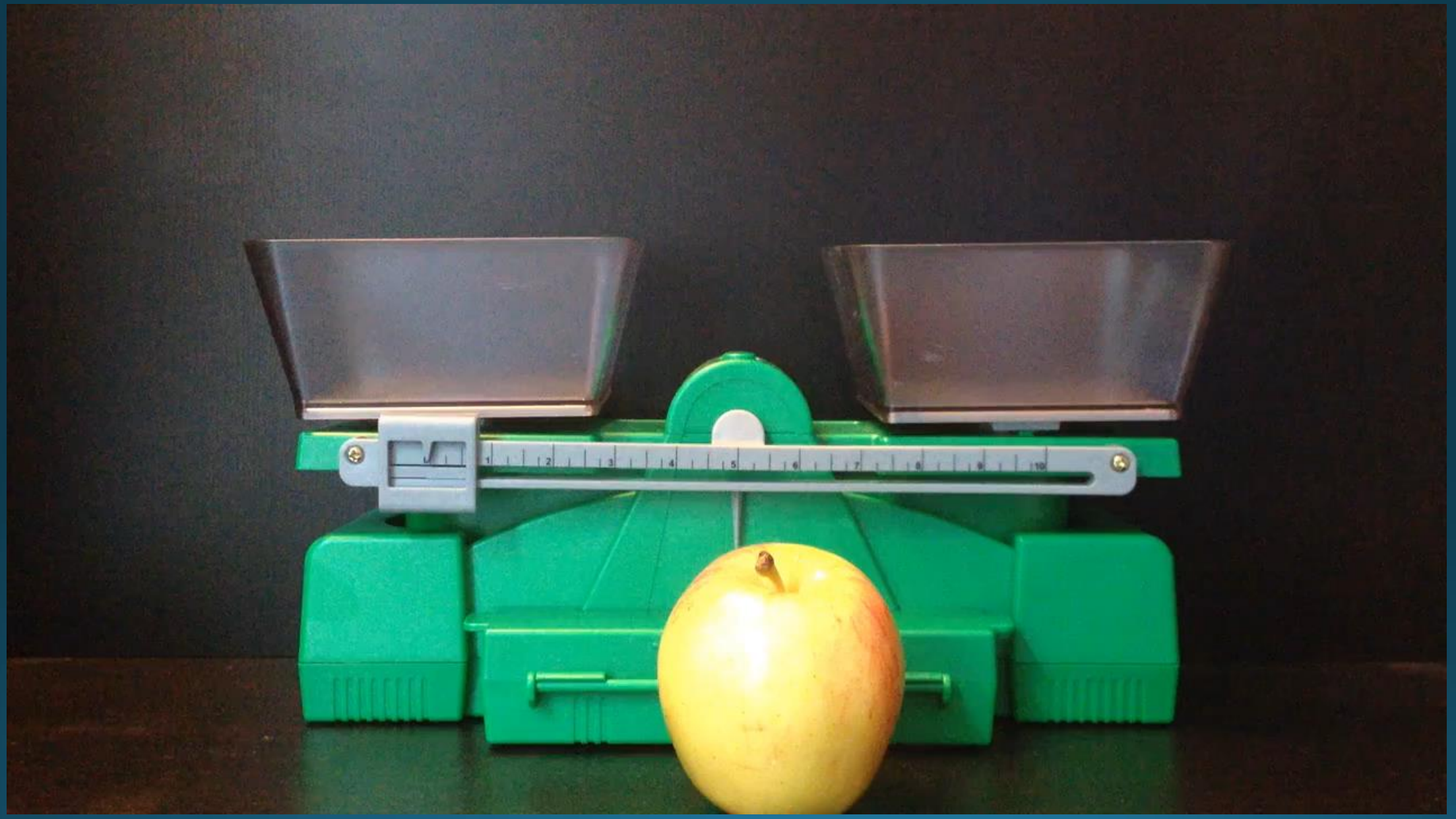
Geometry
Accelerated Geo B/Alg II
Analytic Geometry
Accelerated AG B-AA
Algebra II/Advanced Algebra
4th Mathematics Courses
Blogs/Websites
How to Teach Math
Finding the Right Resources
GloSS/IKAN
Assessment Resources
Grades K-5 Wiki
Grades 6-8 Wiki

What happens when we engage students in non-routine problems?




MATH
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Using a Process to Align Curriculum, Assessment and Instructional Practices to the Intent and Rigor of the Mathematics Georgia Standards of Excellence

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GaDOE Instructional Leadership Conference
Thursday, February 25th, 2016