Deepening Understanding of the Effective Teaching Practices

NCTM Effective Teaching with Principles to Action Institute, 2017

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Learning the Ropes
Mathematics Beliefs Survey

• Reflecting on our beliefs.
• Taking the pulse of the group...
Mathematics Teaching Practices (MTPs)

- Establish mathematical goals to focus learning
- Implement tasks that promote reasoning and problem solving
- Use and connect mathematical representations
- Facilitate meaningful discourse
- Pose purposeful questions
Mathematics Teaching Practices (MTPs) – part 2

• Build procedural fluency from conceptual understanding

• Support productive struggle in learning mathematics

• Elicit and use evidence of student thinking
Establish Mathematics Goals to Focus Learning

- What will teacher be doing?

- What will an observer see or hear from students?
Teacher

- Visual & verbal learning target revisited throughout lesson.
- Checking for understanding, providing feedback & adjust lesson accordingly.

Goals

Students

- Using learning target vocabulary as they are practicing.
- Students engaging in discourse.
- Self assessment of where they are.
Implement Tasks that Promote Reasoning and Problem Solving

• What will teachers be doing?

• What will an observer see or hear from students?
Feedback & adjust lesson accordingly.  

Self assessment of where they are.

Tasks

Relevance and application to real life.

All students can participate—may hear ah ha! moments.

Asking questions

Students are engaged

Purposeful structure to lesson.

Applying prior knowledge

Task addresses higher order thinking skills.

Discovering multiple solution pathways.

Should be many solution pathways.
• What will teachers be doing?

• What will an observer see or hear from students?
Teachers

- Tasks that can be represented in a number of ways
- Allowing time for students to make connections
- Teachers present various forms of representations
- Encourage use of visual support
  Focus attention on meaning of essential features

Students

- Expect students to use multiple forms of representation
- Students communicate, justify/explain the connections
- Students self-select which representation to use
- Students sketch diagrams
- Consider suitability of representations
Facilitate Meaningful Mathematical Discourse

- What will teachers be doing?
- What will an observer see or hear from students?
Facilitate MMD

Meaningful Mathematical Discourse

Teachers will be:

- Using Smith’s 5 practices to plan class discussion during lesson
- Asking Assessing or Advancing questions to promote deeper thinking and/or understanding
- Teacher will ensure student ideas are clarified and summarized (not left ambiguous)

What will an observer see or hear from students?

- Collaborating
- Be able to articulate their thinking and what they are learning
- Reason through their own and others’ mathematical explanations
- Listening to what other students share or explain
- Students valuing other’s strategies and ways of thinking
Pose Purposeful Questions

• What will teachers be doing?

• What will an observer see or hear from students?
## Purposeful Questions

<table>
<thead>
<tr>
<th>Facilitator</th>
<th>Moments for thinking</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Pre-planned</td>
<td>- Visible</td>
</tr>
<tr>
<td>- Initial</td>
<td>- Internal</td>
</tr>
<tr>
<td>- Probing</td>
<td>- ?'s promote student discourse</td>
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<tr>
<td>- Scaffolded w/ ?'s</td>
<td>- Students ask their own purposeful questions</td>
</tr>
<tr>
<td>- Surface → deep</td>
<td>- Articulate their misunderstanding as a result of ?'s</td>
</tr>
<tr>
<td>- Relate to misunderstandings</td>
<td>- Answered the ?</td>
</tr>
<tr>
<td>- Objective to end goal</td>
<td>- Students collaborate to answer the ?'s</td>
</tr>
<tr>
<td>- Listen to student discussions/responses</td>
<td>- Flexible in response to multiple responses</td>
</tr>
<tr>
<td>- ?'s are accessible to all students</td>
<td>- Accepting of unplanned detours</td>
</tr>
</tbody>
</table>

- | - |
Support Productive Struggle in Learning Mathematics

• What will teachers be doing?

• What will an observer see or hear from students?
Productive Struggle

1. Accurately apply current level of learning with differentiation
2. Safe space/environment
3. Define/discuss/model what "productive struggle" is
4. Time is appropriate
5. Teacher recognizes difference between productive struggle & frustration

- Environment/colaborating
- Students are "OK" making mistakes
- Facilitator

Learning Entry

PIT
Elicit and Use Evidence of Student Thinking

• What will teachers be doing?

• What will an observer see or hear from students?
Elicit and use evidence of student thinking

<table>
<thead>
<tr>
<th>What will the teacher be doing?</th>
<th>What will an observer see or hear from students?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determine what is evidence</td>
<td>Show their knowledge through mathematical discourse.</td>
</tr>
<tr>
<td>Check for understanding throughout the lesson</td>
<td>Performance task</td>
</tr>
<tr>
<td>Interpret student-thinking and determine where to go.</td>
<td>Asking ?'s</td>
</tr>
<tr>
<td>Reflect on progress for future instruction or learning environment</td>
<td>Self Monitoring their own progress</td>
</tr>
<tr>
<td>Collaboration w/ Colleagues for other perspectives</td>
<td>Active Participant in support of learning</td>
</tr>
<tr>
<td></td>
<td>Reflected/Refining work</td>
</tr>
<tr>
<td></td>
<td>Team Discussions</td>
</tr>
</tbody>
</table>
Videos are from:

• http://www.learner.org/resources/series34.html
A Look into a Classroom...

• Debriefing Activity
  – In pairs...
    • One person is the teacher
    • The other person is the coach/administrator
    • The coach engages the teacher in reflection and moves the person toward one or two short-term goals tied to MTPs.
A Look into a Classroom... #2

• Debriefing Activity
  – In pairs...
    • One person is the teacher
    • The other person is the coach/administrator
    • The coach engages the teacher in reflection and moves the person toward one or two short-term goals tied to MTPs.
Reflections…

• What are some take-aways that you have from “coaching” your peers around the practices?
A Mathematical Task

With the people at your table, use the image at the right to determine the value of $82^2$ and $93^2$.

Be prepared to share your explanation with another group.
Extensions

• Does this only work for “squares”?
• Can you generalize \((A*10 + B)(C*10 + D)\) with \(A, B, C, D\) integers?
• Can this be extended to \((A + B)(C + D)\) with \(A, B, C, D\) integers?
• Can this be extended to \((A + B)(C + D)\) with \(A, B, C, D\) any rational number?
Four Postulates for Change

1. We are being asked to teach in distinctly different ways from how we were taught.
2. The traditional curriculum was designed to meet societal needs that no longer exist.
3. It is unreasonable to ask a professional to change much more than 10% per year, but it is unprofessional to change by much less than 10% per year.
4. If you don’t feel inadequate, you’re probably not doing the job.

Never Say Anything a Kid Can Say

At your tables,

What part of this article affirms your own thinking or practice?

What part of this article challenges your own thinking or practice?
Charting a Path for Improvement

1. Clearly articulated vision for mathematics learning. (Principles to Action)
2. Time for embedded professional learning.
3. Support for teacher collaboration.
4. Make the learning known.
5. Celebrate successes.
Team Actions for Implementation
Before the Unit

1. Make sense of the agreed upon essential learning standards for the unit.
2. Develop common assessment instruments for the unit.
3. Develop scoring rubrics for the common assessment instruments.
4. Identify high cognitive demand tasks for the unit.
5. Plan common homework assignments for the unit.

Kanold & Larson, in press
Team Actions for Implementation During the Unit

6. Implement high cognitive demand tasks effectively.

7. Use in-class formative assessment processes effectively.

8. Use an instructional design process for lesson planning and collective team inquiry.

Kanold & Larson, in press
9. Ensure evidence-based **student** goal-setting and action for the next unit.

10. Ensure evidence-based **adult** goal setting and action for the next unit.

Kanold & Larson, in press
The National Council of Teachers of Mathematics is a public voice of mathematics education, providing vision, leadership, and professional development to support teachers in ensuring equitable mathematics learning of the highest quality for all students. NCTM’s Institutes, an official professional development offering of the National Council of Teachers of Mathematics, supports the improvement of pre-K-6 mathematics education by serving as a resource for teachers so as to provide more and better mathematics for all students. It is a forum for the exchange of mathematics ideas, activities, and pedagogical strategies, and for sharing and interpreting research. The Institutes presented by the Council present a variety of viewpoints. The views expressed or implied in the Institutes, unless otherwise noted, should not be interpreted as official positions of the Council.
Understanding and Supporting Teachers’ Enactment of the Effective Teaching Practices: Using Tasks
NCTM Effective Teaching Institute, 2017

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Take the Last One

In this mathematical “game” for pairs, each person in the duo chooses a positive whole number initially unknown to the other. At the signal, each member reveals the number to the other simultaneously. Let the chosen numbers each represent a quantity of objects to be taken. Starting with the person who wrote down the larger number, players take turns removing any number of “objects” from either set. A person “wins” the game if they force the other person to take the final object.
Day 2 Outcomes

• Session 1: Identify the characteristics of high cognitive demand tasks and how to support the creation and use of them.

• Session 2: Reflect on the role of productive struggle in mathematics and developing a culture that supports it.
The eight Standards for Mathematical Practice are:

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
A Mathematical Task

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For example:

• For example:
• Player 1: 12 and Player 2: 18
• Start (12, 18)
• Player 2 goes first. Takes 3 from the 12: (9, 18)
• Player 1 takes 5 from the 18: (9, 13)
• Player 2 takes 8 from the 9: (1, 13)
• Player 1 takes 13 from the 13: (1, 0)
• Player 2 must take the 1 and loses.
• Task: Develop a strategy that will guarantee a win.
Mathematics Teaching Practices
(NCTM, 2014)

1. Establish mathematics goals to focus learning.
2. Implement tasks that promote reasoning and problem solving.
3. Use and connect mathematical expressions.
4. Facilitate meaningful mathematical discourse.
5. Pose purposeful questions.
6. Build procedural fluency from conceptual understanding.
7. Support productive struggle in learning mathematics.
8. Elicit and use evidence of student thinking.
1. Makes 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.
What is LEARNING?

• “I learned that yesterday!”

• “I learned that when I was in school but do not remember.”

• “Did we learn anything when I was absent yesterday?”
What is LEARNING?

Think for a moment...

– What *is* learning?

– What conditions are necessary for learning to occur?

– What evidence is necessary to confidently state that learning *has* occurred?
One Look at Learning...
Did Penny Learn?

• Using the conditions you identified prior to the clip, discuss with your neighbor whether Penny learned.

  – Identify what she learned.

  – Identify the evidence you saw for her learning, or the evidence you would like to see.
A Closer Look at Learning

Reflect on a time when you experienced authentic learning...

*What did you learn?*

*What did you go through in order to learn?*

*Where were you?*

*Why do you remember it so well?*
The Cycle of Learning

Existing Knowledge

Disequilibrium

Reasoning and Sense Making

An Experience

Restructuring

Anticipation

Reification

Perturbation
With a partner

• Re-visit your learning experience.

• From what you can recall, narrate your learning experience for your partner identifying the parts of the learning process from the learning cycle.
Over the last 10 years, the graduating class of Leonhard Euler High School has increased by the same amount every year. After the 10 years, a total of 6000 students have graduated from LEHS. How many graduated each year?
Practice 0: Determine learning goal and choose task

Practice 1: Anticipating

Practice 2: Monitoring

Practice 3: Selecting

Practice 4: Sequencing

Practice 5: Connecting
Dimensions and Core Features

- Hiebert et al. (1997, 2000)
  - Nature of Classroom Tasks
  - Role of the Teacher
  - Social Culture of the Classroom
  - Mathematics Tools as Learning Supports
  - Equity and Accessibility
### Dimensions and Core Features

<table>
<thead>
<tr>
<th><strong>Dimensions</strong></th>
<th><strong>Core Features</strong></th>
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</thead>
<tbody>
<tr>
<td>Nature of Classroom Tasks</td>
<td>Make mathematics problematic</td>
</tr>
<tr>
<td></td>
<td>Connect with where students are</td>
</tr>
<tr>
<td></td>
<td>Leave behind something of mathematical value</td>
</tr>
<tr>
<td>Role of the Teacher</td>
<td>Select tasks with goals in mind</td>
</tr>
<tr>
<td></td>
<td>Share essential information</td>
</tr>
<tr>
<td></td>
<td>Establish classroom culture</td>
</tr>
<tr>
<td>Social Culture of the Classroom</td>
<td>Ideas and methods are valued</td>
</tr>
<tr>
<td></td>
<td>Students choose and share their methods</td>
</tr>
<tr>
<td></td>
<td>Mistakes are learning sites for everyone</td>
</tr>
<tr>
<td></td>
<td>Correctness resides in mathematical argument</td>
</tr>
<tr>
<td>Mathematical Tools as Learning Supports</td>
<td>Meaning for tools must be constructed by each user</td>
</tr>
<tr>
<td></td>
<td>Used with purpose—to solve problems</td>
</tr>
<tr>
<td></td>
<td>Used for recording, communicating, and thinking</td>
</tr>
<tr>
<td>Equity and Accessibility</td>
<td>Tasks are accessible to all students</td>
</tr>
<tr>
<td></td>
<td>Every student is heard</td>
</tr>
<tr>
<td></td>
<td>Every student contributes</td>
</tr>
</tbody>
</table>
Task-based instruction

- Make mathematics problematic
- Connect with where students are
- Leave behind something of mathematical value
- Tasks determine the level of thinking in the classroom
As a group, solve the following problem in at least two different ways. Compare and contrast your two solutions.

Three friends went on a fishing trip. After spending the day catching fish, all three agreed to split the catch in the morning and turned in for the night. One of the fishermen woke up in the middle of the night and decided to take his share. He divided the fish into 3 groups. There was one fish left over so he threw it back in the lake. He took his third and left the remaining fish in the tub.

The other two fishermen did exactly the same thing!

When they woke up in the morning, the friends took the fish in the tub and divided it into three equal groups. There was one left over so they threw it back in the lake.

What is the smallest number of fish they could have caught?
What’s the smallest ★ can be?
Total is 4
These 4 came from only 2 groups...
Total is 7

Total is 4
However, these 7 cannot have come from only 2 groups…
What does this mean?
What does this mean?

• The total in a row cannot be odd.

• The numbers in the circles must be odd so that three of them plus one will be even.

• The bottom row cannot start with 1 or any even number.
Let’s try 3...
<table>
<thead>
<tr>
<th>8</th>
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<tbody>
<tr>
<td>5</td>
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<tr>
<td>3</td>
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</table>

Total is 25
Total is 16
Total is 10
Let’s try 3...

...3 didn’t work

We know 5 won’t work – it will lead to 25...
<p>| | | | | | | | | |</p>
<table>
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<tr>
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<td>26</td>
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<td></td>
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</tbody>
</table>

Total is 79

Total is 52

Total is 34

Total is 22
The nature of the tasks that students complete define for them the nature of the subject and contribute significantly to the nature of classroom life (Doyle, 1983, 1988).

The kinds of tasks that students are asked to perform set the foundation for the system of instruction that is created. Different kinds of tasks lead to different systems of instruction.
• Make the MATHEMATICS problematic. That is, is it posed as an interesting problem.
• Connect with where the students are. They have to be able to use their current knowledge and skills to complete the task.
• Engage the students in thinking about important mathematics. They take away something of mathematical value.
• Drive the level of questioning.
Not all tasks provide the same opportunities for student thinking and learning (Hiebert et al. 1997; Stein et al. 2009).

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 and Staples 2009; Hieber and Wearne 1993; Stein and Lane 1996)
What does rigor look like in mathematics classrooms?
MATHEMATICAL RIGOR

- Conceptual Understanding
- Procedural Fluency
- Application
**BLOOM’S TAXONOMY**

**KNOWLEDGE**
The recall of specifics and universals, involving little more than bringing to mind the appropriate material.

**COMPREHENSION**
Ability to process knowledge on a low level such that the knowledge can be reproduced or communicated without a verbatim repetition.

**APPLICATION**
The use of abstractions in concrete situations.

**ANALYSIS**
The breakdown of a situation into its component parts.

**SYNTHESIS AND EVALUATION**
Putting together elements & parts to form a whole, then making value judgments about the method.

**WEBB’S DOK**

**RECALL**
Recall of a fact, information, or procedure (e.g., What are 3 critical skill cues for the overhand throw?)

**SKILL/CONCEPT**
Use of information, conceptual knowledge, procedures, two or more steps, etc.

**STRATEGIC THINKING**
Requires reasoning, developing a plan or sequence of steps; has some complexity; more than one possible answer.

**EXTENDED THINKING**
Requires an investigation; time to think and process multiple conditions of the problem or task.

Can we just look at the verbs to determine the DOK?
Comparing Two Mathematical Tasks

Martha was re-carpeting her bedroom which was 15 feet long and 10 feet wide. How many square feet of carpeting will she need to purchase?

Smith, Stein, Arbaugh, Brown, and Mossgrove, 2004
Ms. Brown’s class will raise rabbits for their spring science fair. They have 24 feet of fencing with which to build a rectangular rabbit pen in which to keep the rabbits.

1. If Ms. Brown's students want their rabbits to have as much room as possible, how long would each of the sides of the pen be?
2. How long would each of the sides of the pen be if they had only 16 feet of fencing?
3. How would you go about determining the pen with the most room for any amount of fencing? Organize your work so that someone else who reads it will understand it.

Smith, Stein, Arbaugh, Brown, and Mossgrove, 2004
Compare the Two Tasks

• Work each task.
• Share solution strategies.
• Discuss:
  How are Martha’s Carpeting Task and the Fencing Task the same and how are they different?
Solution Strategies:
Martha’s Carpeting Task
Martha’s Carpeting Task
Using the Area Formula

\[ A = l \times w \]

\[ A = 15 \times 10 \]

\[ A = 150 \text{ square feet} \]
Martha’s Carpentry Task
Drawing a Picture

10

15
Solution Strategies: The Fencing Task
The Fencing Task
Diagrams on Grid Paper

Area = 32 ft²

Area = 35 ft²

Area = 36 ft²

Area = 35 ft²
## The Fencing Task
### Using a Table

<table>
<thead>
<tr>
<th>Length</th>
<th>Width</th>
<th>Perimeter</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11</td>
<td>24</td>
<td>11</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>24</td>
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<td>6</td>
<td>6</td>
<td>24</td>
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<tr>
<td>7</td>
<td>5</td>
<td>24</td>
<td>35</td>
</tr>
</tbody>
</table>
The Fencing Task
Graph of Length and Area
The Fencing Task
Using Calculus

\[ A = lw \]
\[ A = w(12-w) \]
\[ A = 12w - w^2 \]
\[ A' = 12 - 2w \]
\[ 0 = 12 - 2w \]
\[ 2w = 12 \]
\[ w = 6 \]
Cognitive Level of Tasks

• Lower-Level Tasks
  (e.g., Martha’s Carpeting Task)

• Higher-Level Tasks
  (e.g., The Fencing Task)

The Quasar Project
<table>
<thead>
<tr>
<th>Levels of Demands</th>
<th>Lower-level demands (procedures without connections):</th>
</tr>
</thead>
</table>
| Lower-level demands (memorization):  | • reproducing previously learned facts, rules, formulas, definitions or committing them to memory  
|                                      | • Cannot be solved with a procedure  
|                                      | • Have no connection to concepts or meaning that underlie the facts rules, formulas, or definitions |
| Higher-level demands (procedures with connections): | • use procedure for deeper understanding of concepts  
|                                      | • broad procedures connected to ideas instead narrow algorithms  
|                                      | • usually represented in different ways  
|                                      | • require some degree of cognitive effort; procedures may be used but not mindlessly |
|                                      | • are algorithmic  
|                                      | • require limited cognitive demand  
|                                      | • have no connection to the concepts or meaning that underlie the procedure  
|                                      | • focus on producing correct answers instead of understanding  
|                                      | • require no explanations |
| Higher-level demands (doing mathematics): |
|                                      | • require complex non-algorithmic thinking  
|                                      | • require students to explore and understand the mathematics  
|                                      | • demand self-monitoring of one’s cognitive process  
|                                      | • require considerable cognitive effort and may involve some level of anxiety b/c solution path isn’t clear |

With a Partner:

• Categorize Tasks A – Q into two categories: high level cognitive demand and low level cognitive demand.

• Develop a list of criteria that describe the tasks in each category.
Characterizing Tasks

With a partner,

– Where would the pick-up sticks task from earlier fall?

– Where does the Euler HS task fit?
Reflection and Discussion…

• To what degree are students in mathematics classes engaging in collaborative mathematical tasks on a daily basis?

• To what extent are mathematics teachers using tasks that lead to student articulation of mathematics and mathematical process?
Are there any you want to move?

Lower-Level Tasks

- Memorization
  - C
  - K
- Procedures w/o Connections
  - B
  - D
  - F
  - G
  - H
  - N

Higher-Level Tasks

- Procedures w/ Connections
  - E
  - I
  - L
  - M
  - O
  - Q
- Doing Mathematics
  - A
  - J
  - P
How can you make it better?

• Select 2 lower-level tasks.
• Work with a partner to talk about how you could make these tasks higher-level.
• Record your ideas on the back of the task.
Where do I find these?

• For example, Mathematics Assessment Project: [http://map.mathshell.org/index.php](http://map.mathshell.org/index.php)

• Choose the Tasks Tab

Choose a task and analyze it for the core features of an appropriate task.
Collaborative Classroom Settings

- Students are taught to collaborate
- Tasks require students to work together
- Physical arrangement of classroom communicates the priority of collaboration
- Student-to-student communication is monitored and feedback provided
- Student work as a team is valued, honored, and used to support learning
Moving to Student-centered Classrooms

• Use the class layout and arrangement to convey an acceptance of discussion among students.
• Include student-to-student *structured* talk about mathematics for at least 15 minutes of every lesson.
Resources for Tasks

- Mathematics Assessment Project also MARS (problem solving tasks tab)
- Dan Meyer’s Site (www.tinyurl.com/danmeyerthreect)
- Illustrative Mathematics
- Robert Kaplinsky’s site
- Estimation 180
- CPALMS
- SHMOOP
- Inside Mathematics
- Andrew Stadel’s site
- TI-Inspired site on the front of the PtA book
- ACHIEVE.org
- Desmos
- CarmelSchettino.org
Teaching Mathematics for Understanding Requires Engage in Lesson Planning from the Students’ Point of View
Planning from the SPOV

• Introduction and Learning Target
  – What will I be expected to do that the beginning of the class period? At what cognitive level will I have to engage? What activities will I be doing?
  – How will my teacher know I am ready for today’s lesson? How will I know?
  – How will the opening activity be connected to what I did yesterday or last night? How will it provide me with feedback on where I stand?
Planning from the SPOV

- **Lesson Context: Connecting the Target to an Objective**
  - How or why is this particular lesson important to me? How will I know?
  - Which of the mathematical practices will I be focusing on in this lesson?
  - How will I connect the mathematical skill to the mathematical concept?
  - How will I demonstrate my learning so that I know my teacher sees it as the lesson unfolds?
Planning from the SPOV

• Lesson Process: Student Engagement
  – Do I understand the tasks that I am being asked to complete?
  – Am I on the lookout for my daily “Aha” moment where I make connections among concepts?
  – How will technology help me visualize concepts?
Planning from the SPOV

• Lesson Process: Student Engagement
  – How will I demonstrate that I can reason, conjecture, and create viable arguments?
  – What higher order questions am I seeking to answer?
  – How will my teacher support my work with peers?
  – If I struggle, how will I get support?
Planning from the SPOV

• Lesson Closure
  – How will I summarize the lesson and my learning for today?
  – How will I know if I have reached the target?
  – What do I need to do to close the gap between what is expected of me and what I have learned?
Key concepts / key ideas

• With a shoulder partner, share your insights or thinking about planning from the SPOV.

• What new thoughts do you have about your daily work?
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