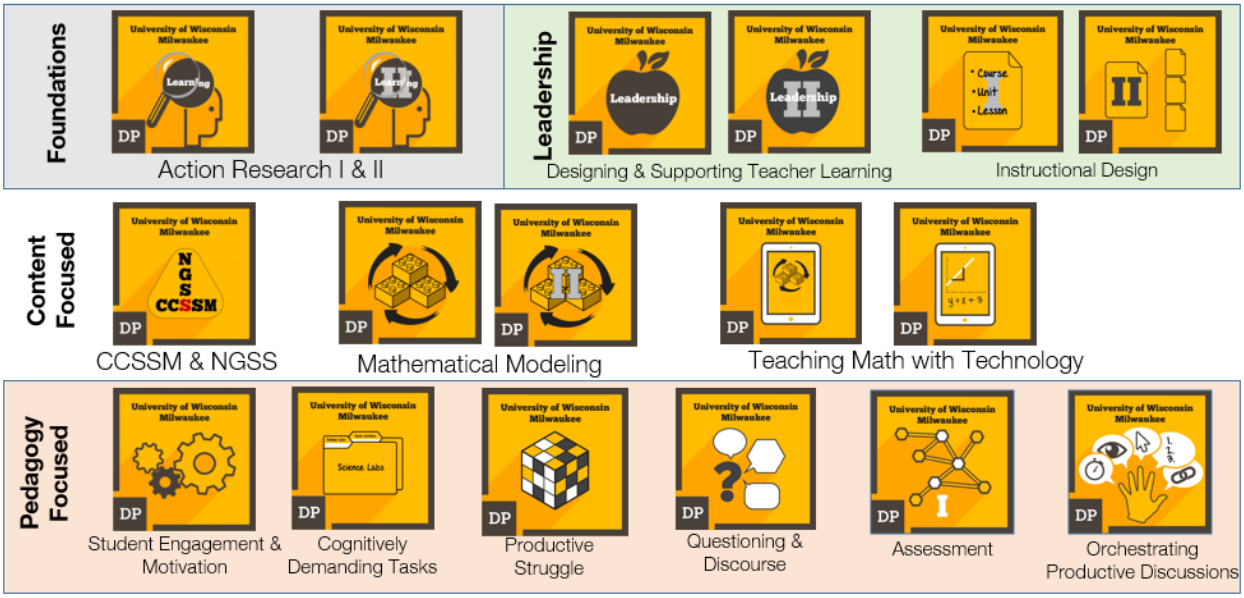
The Milwaukee Master Teacher Partnership:
Enhancing Teacher Practice in Secondary Math & Science

NCTM Annual Meeting • San Diego, CA • 5 April 2019

National Science Foundation Noyce Track 3 Master Teacher Fellows Project

- 24 high school mathematics and science teachers with Masters degrees
- Teachers complete four action research-based microcredentials per year on the Digital Promise platform
- Anticipate changes in teachers' content knowledge for teaching
  (content knowledge, pedagogical knowledge, pedagogical content knowledge)

Sample Microcredentials



Multiple Microcredential Levels

- Conduct action research in your own class
- Engage other teachers in your building or across buildings in action research
- Design and conduct teacher professional development on research topic

More information about the project at http://uwm.edu/mmtp

This project is funded by a grant from the National Science Foundation (awards 1540840 and 1557397) to the University of Wisconsin Milwaukee. The content of this presentation does not necessarily reflect the views of the NSF.

Models and Modeling (Mathematics)

Competency

Educator investigates the use of models and modeling as they pertain to the Common Core State Standards for Mathematics (CCSSM) and investigates resources for use in classrooms, then plans and analyzes a lesson related to such that improves professional practice and student learning outcomes.

Key Method

The educator studies use of models and modeling in the classroom, targeting existing resources for their specific discipline of mathematics, learns about the role of modeling in the teaching of mathematics and the distinctions between mathematical modeling and modeling with mathematics, and focuses on successful implementation of modeling in a mathematics classrooms. They engage in a detailed analysis of the standards related to such, including the analysis of classroom tasks that address modeling. The educator devises a set of criteria for measuring student progress on the standards in that category appropriate to their grade level, designs and teaches a modeling lesson, then analyzes student performance using the created criteria.

Method Components

- Examine your own personal model of teacher decision-making used for planning, teaching, and reflection of lessons
- Use the model of teacher decision-making from Clough, Berg, Olson (2009) to write a reflection of a recent lesson.
- Discuss the distinctions between models, modeling, modeling with mathematics, and mathematical modeling in the context of the Common Core State Standards for Mathematics.
- Engage in a modeling task (The Cruise Ship Task). Examine the task through the lens of mathematical modeling as presented in the GAIMME Report.
- Identify critical features of modeling tasks in mathematics and the progressions related to modeling in high school mathematics using multiple references, including the CCSSM HS Modeling progression, the GAIMME Report, and articles from The Mathematics Teacher.
- Explore pedagogical aspects of modeling, including the reasons for teaching modeling and pedagogical practices that support successful student engagement in modeling.
- Plan and teach a modeling-focused lesson that supports student learning opportunities related to other mathematics content standards.
- Choose or create a measurement tool (rubric, standards-based grading criteria) that capture student performance related to the standards.
- Analyze student performance related to the standards after students engage in the target lessons.
- Write a reflection of the planning, implementation and assessment of the modeling lesson.
- Present results and reflections to the group.

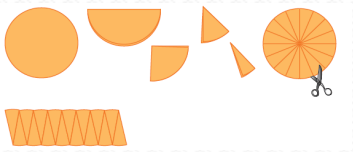
Different Level

Demand Tasks

Lessons on Area

Created by: Michael J. Moore

#1 Area of a circle



Investigation

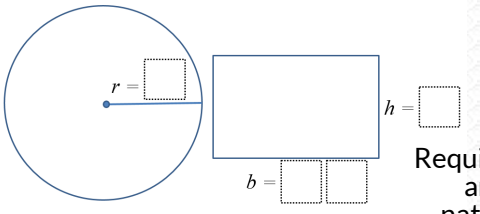
Students complete a series of steps that are provided. Following these steps leads to developing the formula for the area of a circle.

Procedures with Connections Tasks

Focus students' attention on the use of procedures for the purpose of developing deeper levels of understanding of mathematical concepts and ideas.

Open Middle

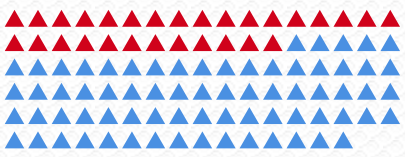
Directions: Find the largest combined area for the rectangle and circle by filling the boxes with numbers 1 through 6. You may use a digit at most once.



Doing Mathematics Tasks

Require students to explore and understand the nature of mathematical concepts, processes, or relationships

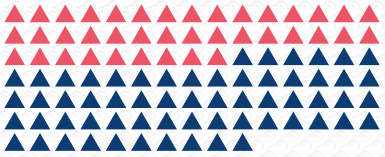
Which activity was more challenging?



Construction Ivestigation (28.60%)

Open Middle Area (71.40%)

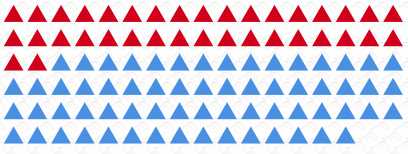
Which activity was more interesting?



Construction Investigation (39.30%)

Open Middle Area (60.70%)

Which activity helped you better understand today's learning intention?



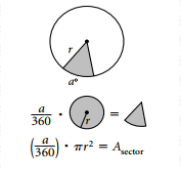
Construction Investigation (35.50%)

Open Middle Area (64.50%)

#2 Sectors, Segments, and Annulus

Think, Pair, Share

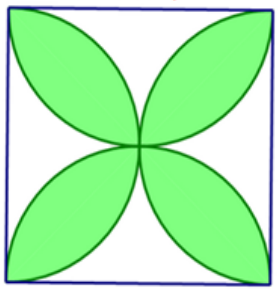
Students work individually on three problems to find the area of a sector, segment, and an annulus. After individual work time students partner with a group and share answers and procedures for each problem.



Procedures without Connections Tasks

Open Middle

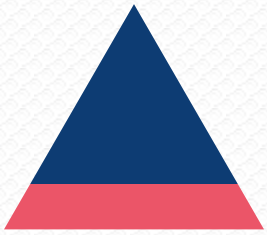
Directions: The diagram shows a square and four semicircles formed using each side of the square as a diameter. What fraction of the square is shaded?



Doing Mathematics Tasks

Require complex and no algorithmic thinking (i.e., there is not a predictable, well-rehearsed approach or pathway explicitly suggested by the task, task instructions, or worked-out example).

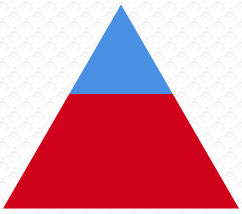
Which activity was more challenging?



Think, Pair, Share (20%)

Open Middle Segments (80%)

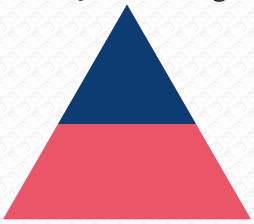
Which activity was more interesting?



Think, Pair,Share (56%)

Open Middle Segments (44%)

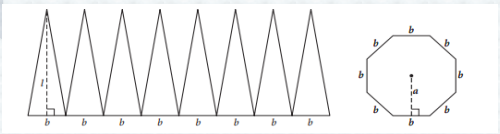
Which activity helped you better understand today's learning intention?



Think, Pair, Share (44%)

Open Middle Segments (56%)

#3 Surface Area



Students complete a series of steps that are provided. Derive formulas for the surface area of a pyramid and a cone.

Procedures with Connections Tasks

Suggest pathways to follow (explicitly or implicitly) that are broad general procedures that have close connections to underlying conceptual ideas as opposed to narrow algorithms that are opaque with respect to underlying concepts.

Open Middle

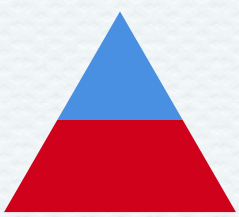
Directions: Using the whole number 1 through 9, at most one time each, list the dimensions of a rectangular prism with the greatest surface area.

☐☐, ☐☐, and ☐☐

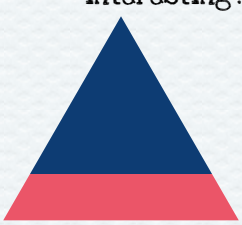
Doing Mathematics Tasks

Demand self-monitoring or self-regulation of one's own cognitive processes.

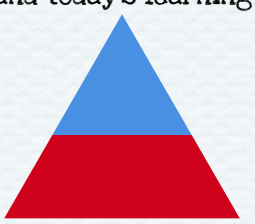
Which activity was more challenging?



Which activity was more interesting?



Which activity helped you better understand today's learning intention?

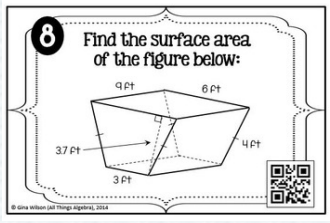


Pyramid and Cone Ivestigation (45.50%) Pyramid and Cone Ivestigation (22.70%) Pyramid and Cone Ivestigation (40.90%)

Rectangular Prism Open Middle (54.50% Rectangular Prism Open Middle (77.30%) Rectangular Prism Open Middle (59.10%)

#4 Surface Area Day 2

Students work in pairs to solve surface area problems. Can scan QR code to find out if they are correct. Rotate to new problem.

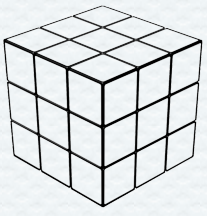


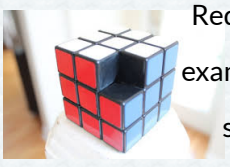
Procedures without Connections Tasks

Require limited cognition demand for successful completion. There is little ambiguity about what needs to be done and how to do it.

Open Middle

Directions: The following prism is made up of 27 identical cubes. What is the greatest possible surface area the prism can have after removing 1 or more cubes from the outside?

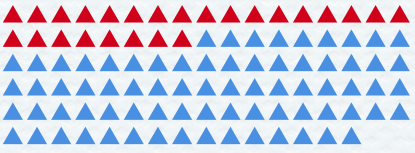




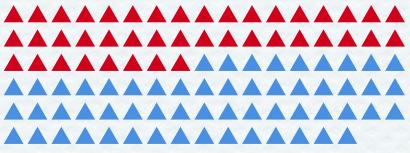
Doing Mathematics Tasks

Require students to analyze the task and actively examine task constraints that may limit possible solution strategies and solutions.

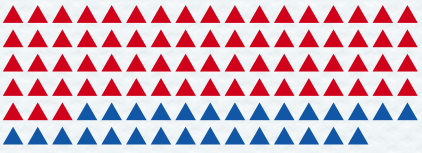
Which activity was more challenging?



Which activity was more interesting?



Which activity helped you better understand today's learning intention?



Task Rotation Activity (25%) Cube S.A. Open Middle (75%)

Task Rotation Activity (41.70%) Cube S.A. Open Middle (58.30%)

Task Rotation Activity (70.80%) Cube S.A. Open Middle (29.20%)

Works Cited

Stein, Mary Kay; Smith, Margaret; Henningsen, Marjorie; Silver, Edward. (2009). *Implementing Standard-based Mathematics Instruction*. New York, NY: Teacher College Press

Serra, Michael. *Discovering Geometry: an Investigative Approach*. Kendall Hunt Publishing Company, 2013.

"All Things Algebra." *Teachers Pay Teachers*, www.teacherspayteachers.com/Store/All-Things-Algebra.

"Open Middle." *Open Middle*, www.openmiddle.com/.

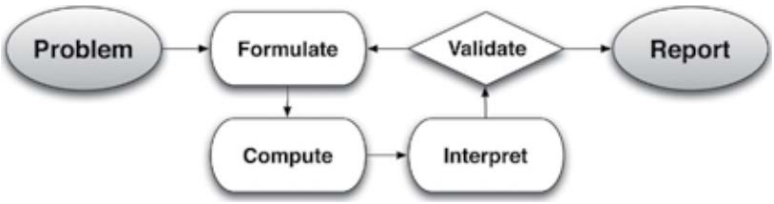
MODELS AND MATHEMATICAL MODELING

MATHEMATICAL MODELING FRAMEWORKS

The models indicate an interative process.

- Start with a big, messy, real world problem;
- Make assumptions;
- Do the math, utilizing different math tools;
- Test the model, and revise if necessary;
- Many different solutions are possible.

Common Core State Standards



GAIMME Report

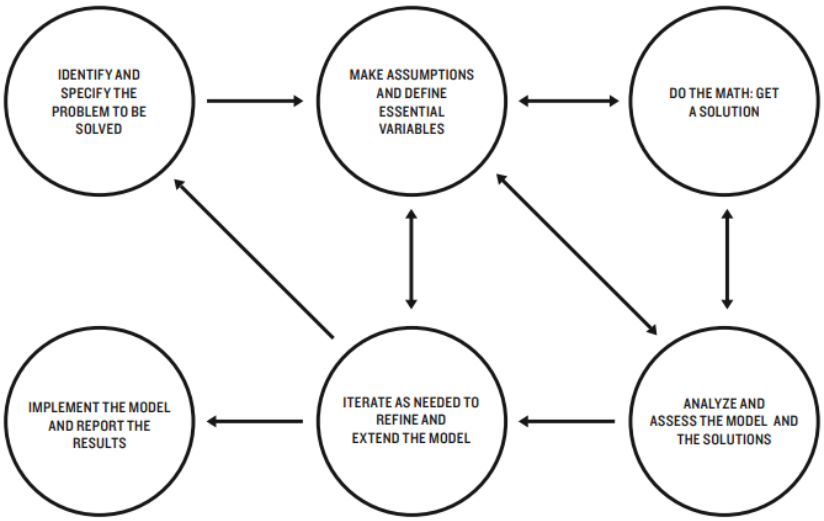


FIGURE I.2: THE MATH MODELING PROCESS

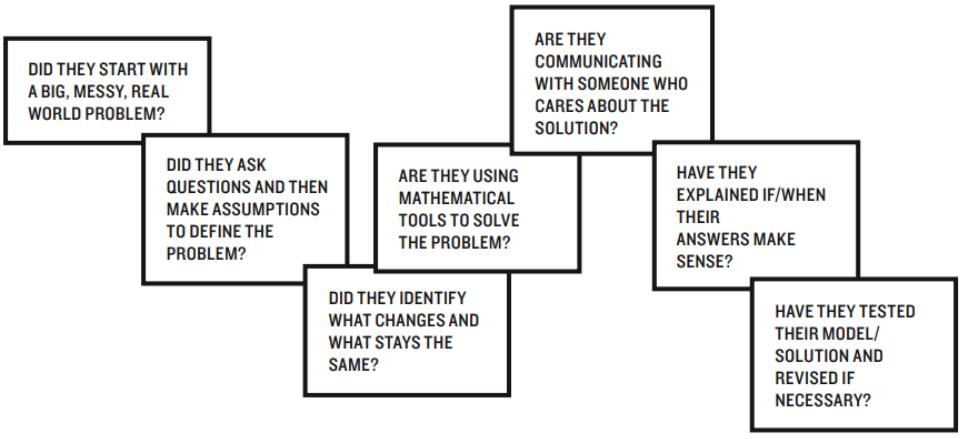


FIGURE 2.9: QUESTIONS TO ASSESS WHETHER STUDENTS ARE MODELING, USED WITH PERMISSION FROM LEVY, IMMERSION

RESEARCH QUESTIONS

This action research investigated the questions:

- What are the key characteristics of a mathematical modeling lesson?
- How can we use mathematical modeling to address student misconceptions and misunderstandings?
- What teacher strategies are used in a modeling lesson?
- What effect does mathematical modeling have on student engagement and learning?
- How do we assess student success in the modeling lesson?

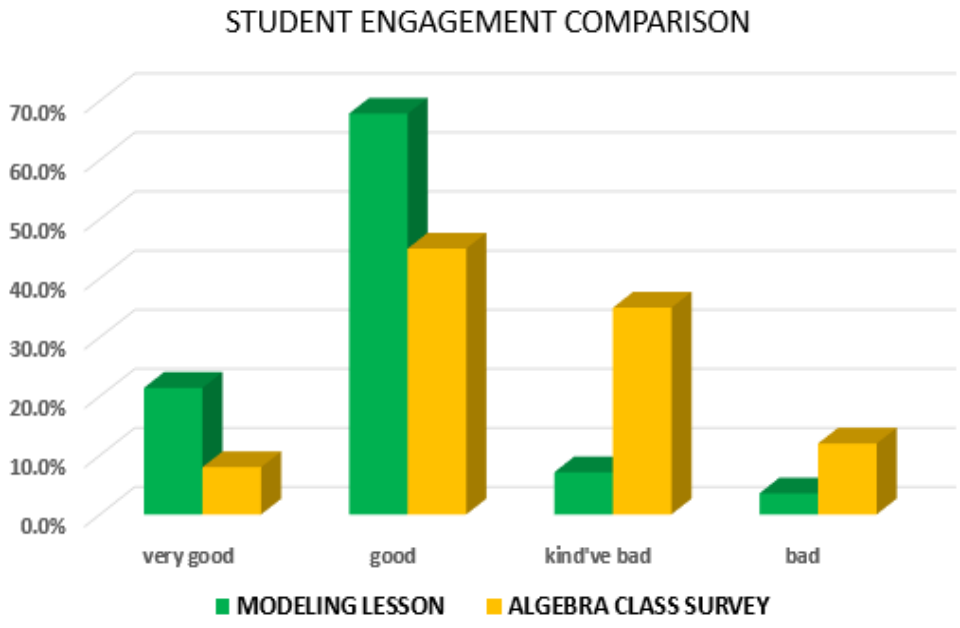
Example: Prior to the modeling task, student work and class discussions were analyzed to identify student misconceptions. Example from inequalities lesson:

MISCONCEPTIONS / LACK OF UNDERSTANDING	TYPE	%
Use of terms "more" "less" "<" or ">" inequality symbols	terminology	30%
Confusion of equality and inequality --- including solution represented as an equality	conceptual	15%
Errors in solving or graphing technique	procedural	30%
Incorrect identification and/or interpretation of the solution of an inequality	conceptual	65%

CONCLUSIONS

When compared to application problems, the mathematical modeling problem resulted in improved:

- student engagement;
- perseverance and the ability to look for entry points into the problem;
- ability to make assumptions and represent the problem mathematically.



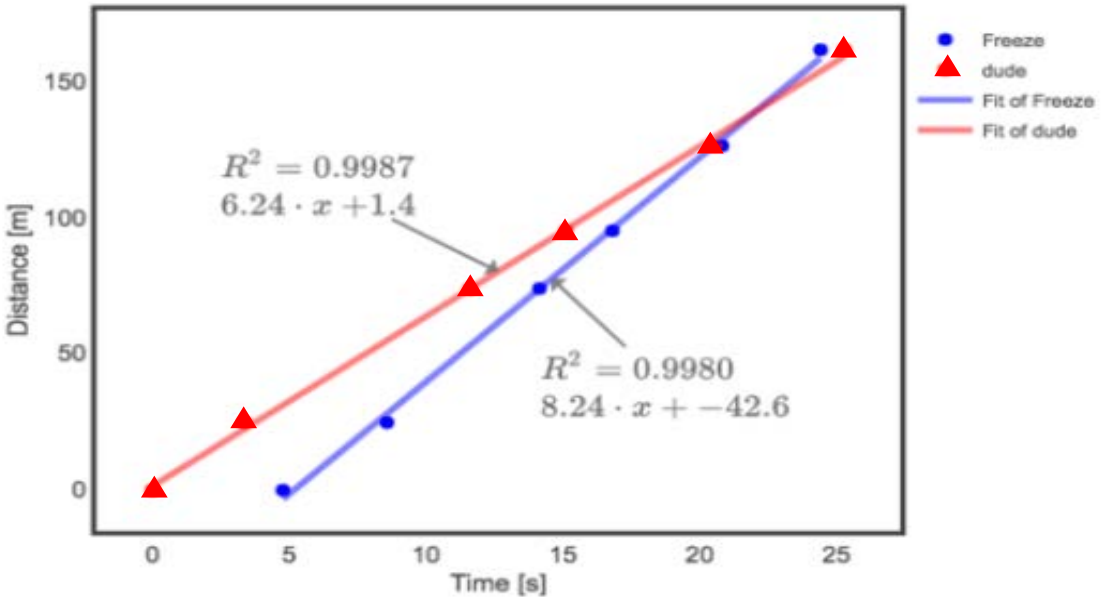
The Freeze

Videos: https://youtu.be/7asw5Vd8lIY https://youtu.be/O-GYh7cQQeY

After watching the video clips, what questions do you have about The Freeze?

Part 1

1. Look at the following graph that was created from the second video.



   a. What do the variables represent? *x*: _____, *y*:_____

   b. Write the equation for The Freeze: *y* = _____.

   c. Write the equation for the Atlanta fan: *y* = _____.

   d. What are their speeds? The Freeze's: _____, the fan's: _____

   e. How much head start did the fan have? Explain how you figured this out.

   f. When and where did The Freeze pass the fan? Explain how you figured this out.

The Question: How much head start should The Freeze give to pass the fan with 2 seconds left in the race?

The questions are adapted from an article, "Physics Explains Why No One Can Beat the Freeze" by Rhett Allain from Wired Magazine.

The Freeze

Part 2

Create your own graph to analyze through this simulation.

The Question: How much of a head start can the 1st walker have so that the 2nd walker will still pass him/her?

1. Make sure all equipment is connected properly.
2. One student will click on the "Collect" button.
3. Two other students will walk 10 floor tiles away from the sensor. One student has a head start. The second student needs to walk faster to pass the first student. The Vernier Lab equipment will collect the data. This will go quickly, so be ready.
4. Do a few trials.
5. When you get a good graph, save it to your Google Drive and share it with your teacher.
6. Keep the graph open to answer the following questions.

    a. What is each walker's speed? 1st: _____, 2nd: _____

    b. At what time do the walker's meet? How do you know?

    c. How far did they walk when they met? How do you know?

    d. How much of a head start did the 1st walker have? Explain how you can figure this out from the graph.

    e. Was this head start enough or too much? Explain.

Part 3

Group Presentations

Your group will share with the class your work both with The Freeze's race and your own simulation. We will use a document camera, so you will not need to create any poster.

Use this table to take notes on the other groups presentations.

	What I noticed:	**What I wondered:**	**What ideas I gained:**
Group 1 Names:			
Group 2 Names:			
Group 3 Names:			

The questions are adapted from an article, "Physics Explains Why No One Can Beat the Freeze" by Rhett Allain from Wired Magazine.

My Journey through Math Intervention

2014-2015

Strategy: Moved into the PBL lab and started teaching the intervention classes. I taught the 9th graders in parallel to their Algebra and Geometry classes. For the second semester, the 10th graders primarily worked on Khan Academy or ST Math due to reduced engagement in class compared to the freshmen.

Results: There was not a lot of improvement from either groups in their screeners at the time (Easy CBM). Many of the students did not attend their other math classes, so there was limited improvement in their Algebra or Geometry grades.

2015-2016

Strategy: We switched to the STAR test as our screener and progress monitoring tool. Using that data, I grouped students and began teaching small groups with the same gaps while the other students in the class worked on ST Math or Khan Academy.

Results: I saw some improvement, but no lasting changes in the students' abilities.

2016-2017

Strategy: After some research in to alternate methods (*Creating a Language Rich Math Class* by Sandra Atkins, *Making Number Talks Matter* by Humpreys &Parker, *Mathematical Mindsets* by Jo Boaler), I decided to try to focus on precise language, conceptual understanding, and extending topics from arithmetic through algebra.

Results: Tremendous improvement in STAR scores, increased understanding of Algebra concepts, improvements in understanding that were sustainable.

2017-2018

Strategy: Continued work with conceptual understanding and precise vocabulary.

Results: Continued improvement in STAR scores, mathematical understanding, and confidence.

Good Resources:

Creating a Language Rich Math Class by Sandra L Atkins

Mathematical Mindsets by Jo Boaler

Making Number Talks Matter by Humphreys and Parker

Good Questions for Math Teaching: Why and What to Ask Grades 4-8 by Schuster and Anderson

Becoming the Math Teacher You Wish You Had by Tracy Johnston Zager

Mathematics for Elementary Teachers with Activities by Sybilla Beckmann

Teaching Math in the Middle School NCTM journal publication

Focus

Specific Topics:

- **Improving the mental number line** – Getting students to think about operations as moving back and forth on a number line improves not only the understanding of how numbers are ordered, but also allows students better conceptual understanding of integers, decimals and fractions. It also allows them to improve estimation skills and understand proportional reasoning.
- **Understanding equality:** Showing students that the equal sign is a relational symbol and not merely telling you to press "enter" on your calculator. Giving students examples of true and false number sentences, for example: 8 + 4 = 7+5 or 5 - 8=3 and having students justify the veracity of each statement. I also change the way I write equations, so the x is not always on the left because not all students are aware that that's "allowed". Do not use or allow the use of running equal signs: ex: (5+3=2-6= -4, those things aren't all equal to each other!)
- **Conceptual Place Value Understanding:** This sounds appallingly low level, most of our students know what the places are called in a number. However, focusing on what it means to move from the tens place to the hundreds place or the ten thousandths place to the tenths place, makes the structure of scientific notation clearer and also prepares students to decompose numbers in a way that eventually makes factoring or multiplying binomials a natural process that makes intuitive sense.
- **Fractions:** This is a big nasty one that many people avoid. Teaching students to be competent with at least understanding what a fraction *is* makes a lot of their mathematical lives so much simpler. Move beyond pizza and procedures. Conceptual understanding of fractions should involve number lines and taking things apart.
- **Distributive Property:** Again, the conceptual understanding of the distributive property, not just the procedure (multiply everything inside by the number outside), but really examine the meaning, for example: $4(2x - 7)$ means that there are 4 sets of $2x - 7$.
- **Precise Vocabulary**:
  - Focus on using correct academic vocabulary (with scaffolding if necessary)
  - Correct names of numbers (1.7 is one and seven tenths, not 1 point 7)
  - Encourage students to employ correct vocabulary
  - Explicitly teach the connections between vocabulary words
  - Learn what students mean with their chosen vocabulary for math work

Methods:

- Metacognition: Teaching students to think about their thinking. The use of number talks is vital for this skill, this pushes students to solidify their understanding and be able to talk to others clearly about their reasoning.
- Constructivist understanding: Students work alone and in small groups to investigate problems, we discuss them in those groups or as an entire class.
- Student centered investigations: I tell the students very little about what happens in math. They make connections and discoveries by talking to each other.
- Group Work: I work on scaffolding the norms and expectations for group work. The group assists each other in their understanding. Explaining topics to others helps students more than just regurgitating information.
- Focus on Problem Solving: Since many of the students are math-phobic, I like to focus on non-traditional problems and then extend them to more traditional methods. It allows me to work to students' strengths while giving them a confidence boost in an area where they struggle.