Designing Instruction for the Science and Engineering Practices in Middle and High School, part 2 (Modeling)

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A Workshop for the Radnor School District

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Goals

Frame science learning as engagement in scientific practices rather than a body of facts to be memorized.

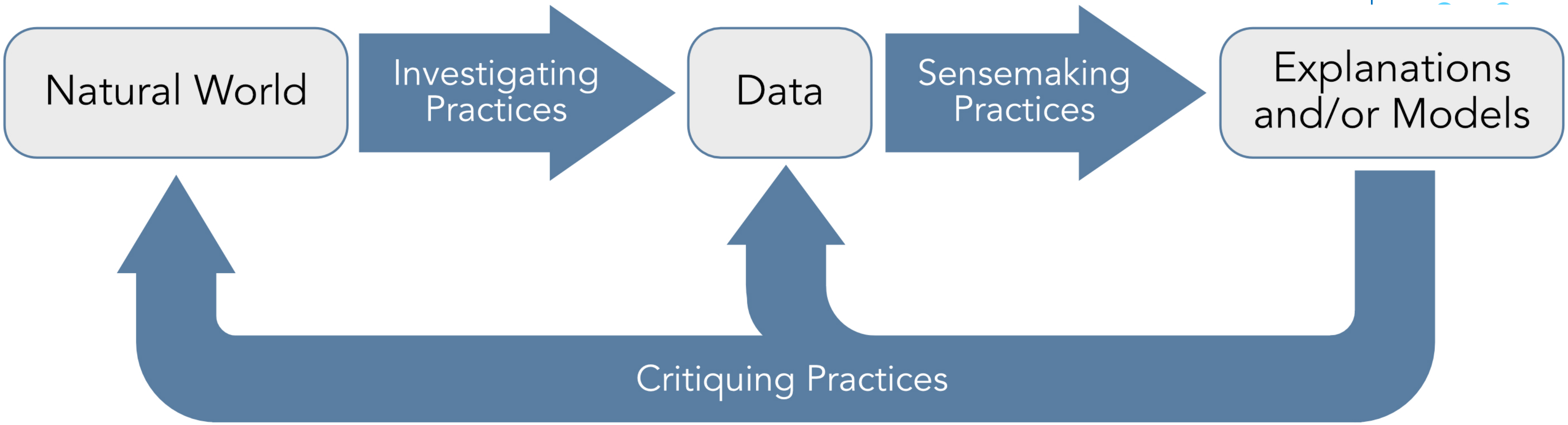
Introduce activities and instructional strategies to incorporate student modeling into your science instruction.

Analyze current curriculum and identify opportunities to scaffold student engagement in modeling.

Agenda

1. *Warm Up*
2. *Student Activity:* Can Implosion
3. *Presentation:* Defining “Developing and Using Models
4. *Video Analysis:* Students Modeling Motion
5. *Application:* Analyze current curriculum
6. *Discussion:* Discuss next steps

Review: Grouping the Practices



Investigating Practices	Sensemaking practices	Critiquing Practices
1. Asking questions 3. Planning and carrying out investigations 5. Using mathematical and computational thinking	2. Developing and using models 4. Analyzing and interpreting data 6. Constructing explanations	7. Engaging in argument from evidence 8. Obtaining, evaluating and communicating information

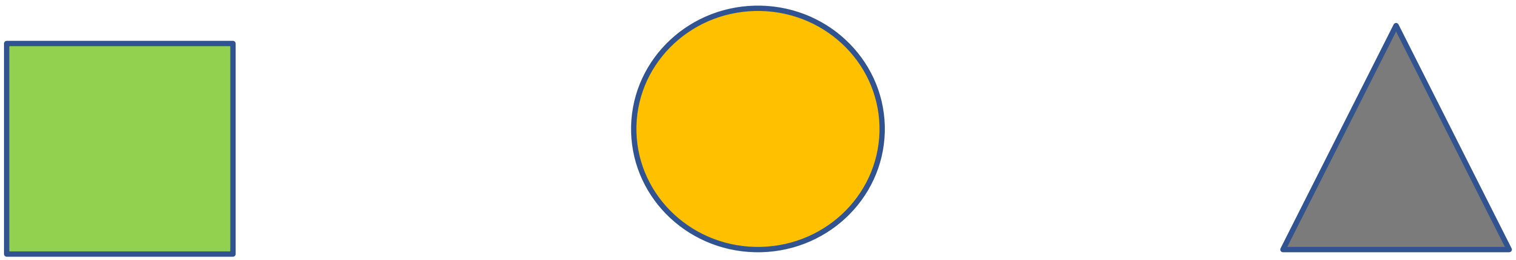
Review: Science Practices Continuum

		Level 1 (Not Present)	Level 2 (Emergent)	Level 3 (Proficient)	Level 4 (Exemplary)
Investigating Practices	**Asking questions**	Students do not ask questions.	Students ask questions, but they are *not typically scientific questions* (i.e., not answerable through the gathering of evidence or about the natural world).	Students ask questions. Students' questions are both *scientific* and *non-scientific* questions.	Students ask questions. Students' questions are typically *scientific* (i.e. answerable through gathering evidence about the natural world).
	Planning and carrying out investigations	Students do not design or conduct investigations.	Students conduct investigations, but these opportunities are typically *teacher-driven*. Students do *not* make decisions about experimental variables or investigational methods (e.g. number of trials).	Students *design or conduct* investigations to gather data. Students make decisions about experimental variables, controls *or* investigational methods (e.g. number of trials).	Students *design and conduct* investigations to gather data. *Students make decisions* about experimental variables, controls *and* investigational methods (e.g. number of trials).
	Using mathematics and computational thinking	Students do not use mathematical skills (i.e., measuring, estimating) or concepts (i.e., ratios).	Students use mathematical skills or concepts but these are *not connected to answering a scientific question.*	Students use mathematical skills or concepts to *answer a scientific question.*	Students *make decisions* about what mathematical skills or concepts to use. Students use mathematical skills or concepts to answer a scientific question.

		Level 1 (Not Present)	Level 2 (Emergent)	Level 3 (Proficient)	Level 4 (Exemplary)
Sensemaking Practices	**Analyzing and interpreting data**	Students may record data, but do not analyze data.	Students work with data to organize or group the data in a table or graph. However, students *do not recognize patterns or relationships* in the natural world.	Students work with data to organize or group the data in a table or graph. Students make sense of data by *recognizing patterns or relationships* in the natural world.	Students *make decisions* about how to analyze data (e.g. table or graph) and work with the data to create the representation. Students make sense of data by *recognizing patterns or relationships* in the natural world.
	Constructing explanations	Students do not create scientific explanations.	Students attempt to create scientific explanations but students' explanations are *descriptive* instead of explaining how or why a phenomenon occurs. Students do *not* use appropriate evidence to support their explanations.	Students construct explanations that focus on explaining *how or why a phenomenon* occurs. Students do *not* use appropriate evidence to support their explanations.	Students construct explanations that focus on explaining *how or why a phenomenon occurs* and *use appropriate evidence* to support their explanations.
	Developing and using models	Students do not create models.	Students create models. Students' models focus on *describing* natural phenomena rather than predicting or explaining the natural world. Students *do not evaluate* the merits and limitations of the model.	Students create models focused on *predicting or explaining* the natural world. Students *do not evaluate* the merits and limitations of the model.	Students create models focused on *predicting or explaining* the natural world. Students *do evaluate* the merits and limitations of the model.

Processing the Science Practices

Get into groups of 3 and share



Something that SQUARED with you

Something that is still CIRCLING around in your head

Something that you see from another ANGLE

Warm Up

The Task:

- We will watch this video as a class 3x
- Create a visual model
- Your model should explain *how* or *why* the can imploded.
- Gallery walk

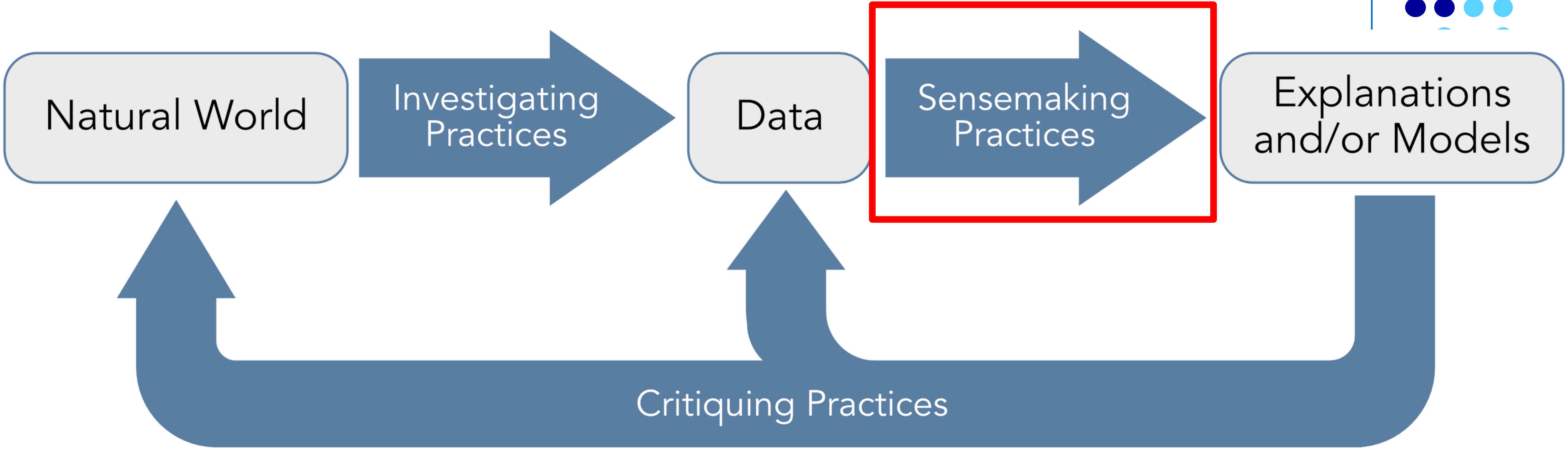
Warm Up

Gallery Walk Discussion:

1. What are the similarities and differences in our models?
2. What are the strengths of our models?
3. How could we collaboratively come up with the best model as a class from what we saw?
4. What questions do we have? (What more do we need to learn to improve our model?)

Can your model explain this?

Which Practices Did You Engage In?



Investigating Practices	Sensemaking practices	Critiquing Practices
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In the previous activity, how did you, as students, engage in modeling?

What did you model?

Developing and using models

A model is an abstract representation of phenomena that is a tool used to ***predict*** *or* ***explain*** *the world.*

Models can be represented as diagrams, 3-D objects, mathematical representations, analogies or computer simulations.

Sample Standards:

Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. (3.1.9-12.D)

Develop and use a model to describe how waves are reflected, absorbed, or transmitted through various materials.(3.2.6-8.R)

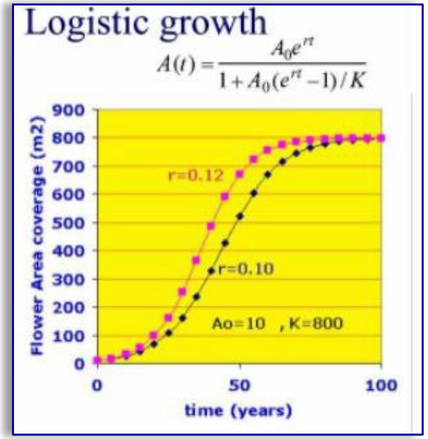
Practices By Grade Band

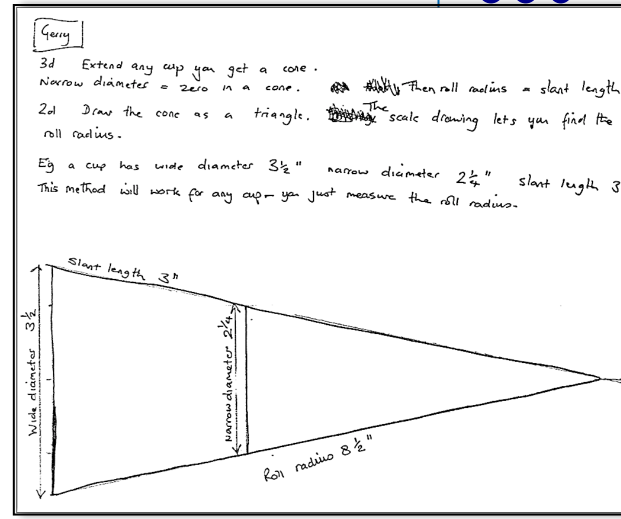
pennsylvania
DEPARTMENT OF EDUCATION

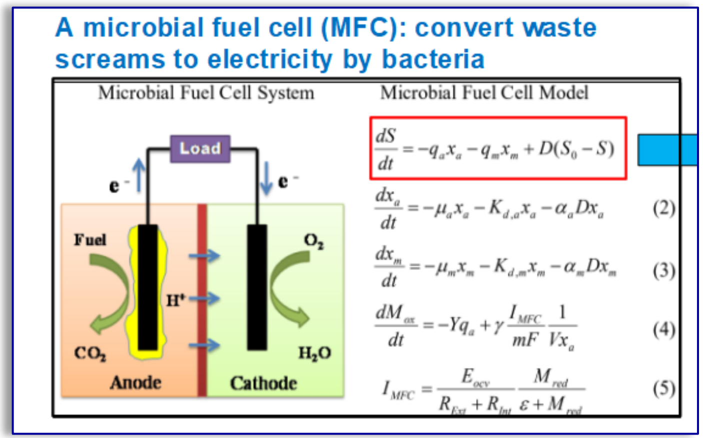
Developing and Using Models			
K – 2	3 – 5	6 – 8	9 – 12
Distinguish between a model and the actual object, process, and/or events the model represents.	Identify limitations of models.	Evaluate limitations of a model for a proposed object or tool.	Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria.
Compare models to identify common features and differences.	Develop a simple model based on evidence to represent a proposed object or tool.	Develop or modify a model—based on evidence – to match what happens if a variable or component of a system is changed.	Design a test of a model to ascertain its reliability.
Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s).	Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events.	Use and/or develop a model of simple systems with uncertain and less predictable factors.	Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.
Intentionally Blank	Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution.	Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.	Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.
Intentionally Blank	Develop and/or use models to describe and/or predict phenomena.	Develop and/or use a model to predict and/or describe phenomena.	Develop a complex model that allows for manipulation and testing of a proposed process or system.
Intentionally Blank	Develop a diagram or simple physical prototype to convey a proposed object, tool, or process.	Develop a model to describe unobservable mechanisms.	Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.
Intentionally Blank	Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.	Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.	*Intentionally Blank*

What are examples of models?

Forms for the Equation of a Line		
Slope-Intercept	$y = mx + b$	m is the slope b is the y-intercept
Point-Slope	$y - y_1 = m(x - x_1)$	m is the slope (x_1, y_1) is a point on the line
Standard Form	$ax + by = c$	a is positive
Intercept Form	$\frac{x}{a} + \frac{y}{b} = 1$	a is the x-intercept b is the y-intercept
Vertical	$x = a$	Vertical line with a as the x-intercept
Horizontal	$y = b$	Horizontal line with b as the y-intercept

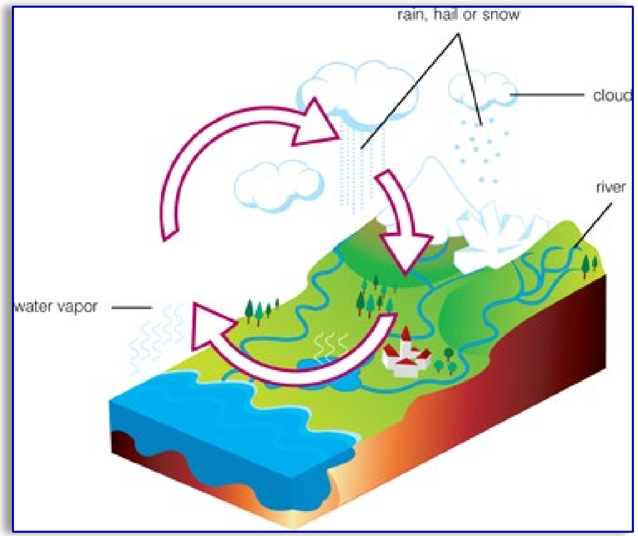


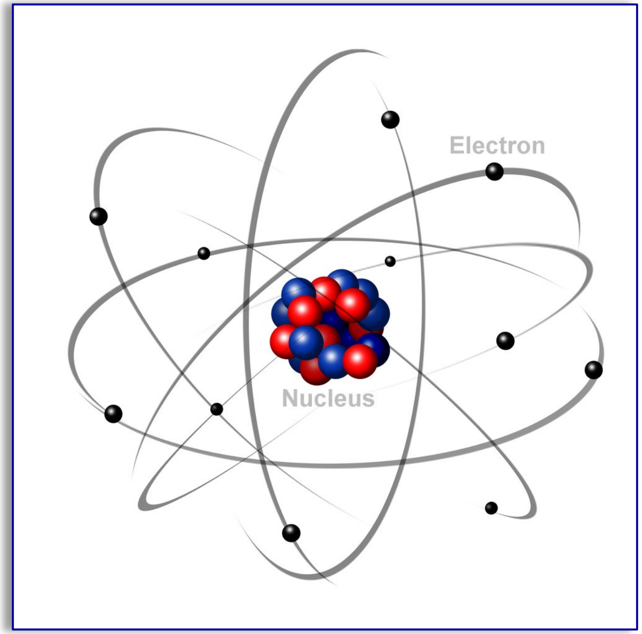


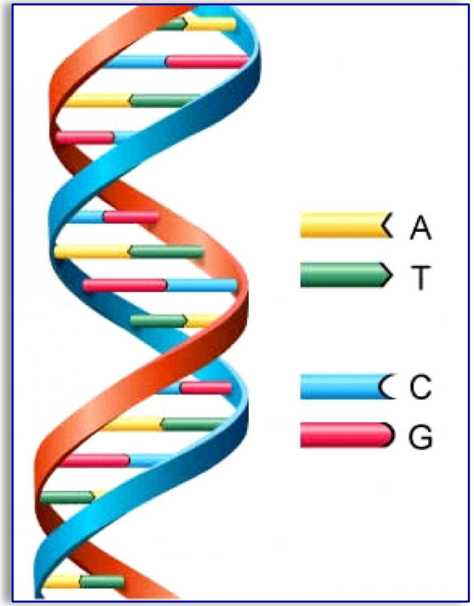


- Do these explain how or why a phenomena occurs?
- Can they be used to predict?

What are examples of models?







- Do these explain how or why a phenomena occurs?
- Can they be used to predict?

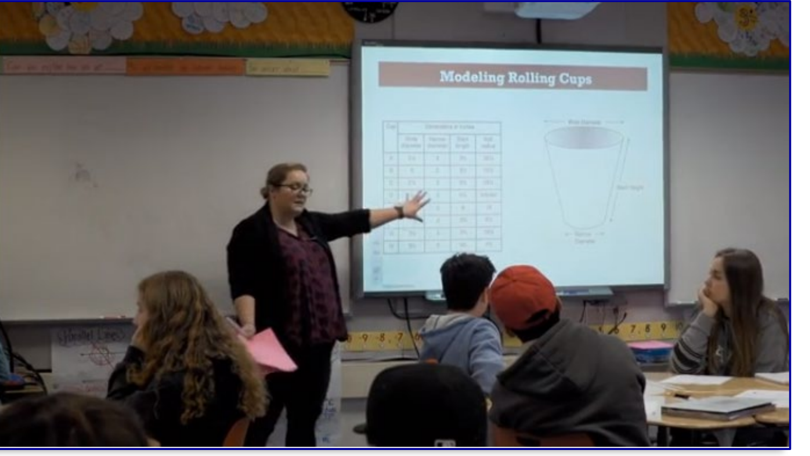
Activity Analysis: Modeling

Think-Pair-Share:

1. How would you rate the imploding can warm-up? Why?
2. As a teacher, what would be your next step to support student modeling?

2. **Developing and using models**	Students do not create or use models.	Students create or use models. The models focus on *describing* natural phenomena rather than predicting or explaining the natural world. Students *do not evaluate* the merits and limitations of the model.	Students create or use models focused on *predicting or explaining* the natural world. Students *do not evaluate* the merits and limitations of the model.	Students create or use models focused on *predicting or explaining* the natural world. Students *do evaluate* the merits and limitations of the model.

Activity: Video Analysis



Classroom Context:

- 9th Grade – Modeling Motion: Circumference of a Cup's Roll

In this lesson, students:

- Work in groups to compare the motion of rolling geometric cup shapes to cups in a computer simulation,
- Predict which cup shapes will generate larger or smaller circles when rolled, as measured by the outer, "drinking" rim of the cup, and
- Share their thinking so far via a visual "status representation" on a large poster.

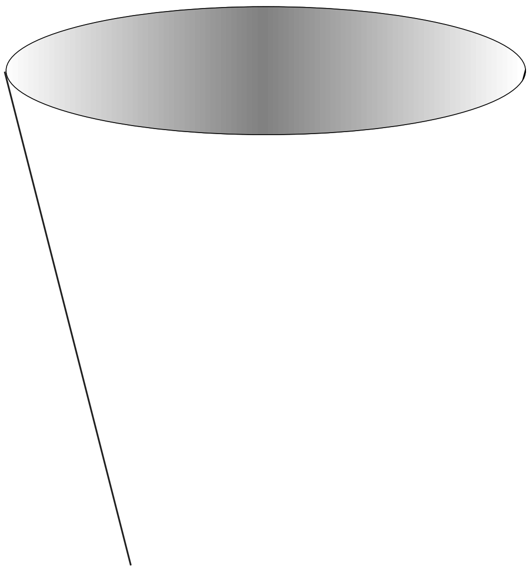
Activity: Video Analysis

Make a prediction: Which cup (or can) will roll in the largest circle? Why?

Video

Activity: Video Analysis

- Can you explain this mathematically?



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Activity: Video Analysis

The Task:

- Watch video (lesson part 1 b); lesson plan also provided
- Use "Modeling Cups Observation" handout
- Take notes with evidence
- Score the lesson excerpt on the math practices checklist
- Think-pair-share for discussion questions on handout.

Student Models

N narrow diameter
W wide diameter
S start height
R roll radius

Fix N=0 and W=4

S	R
1	1
2	2
3	3
4	4
5	5

Fix N=0 and W=5

S	R
1	1
2	2
3	3
4	4
5	5

When N=0 the cup is a cone & R=S. It doesn't matter what W is.

$R = 1{\cdot}5 \times S$

Fix N=1 and W=3

S	R
1	1.5
2	3
3	4.5
4	6
5	7.5

N=1 and W=4

S	R
1	1.25
2	2.75
3	4
4	5.25
5	6.75

N=1 and W=5

S	R
1	1.25
2	2.5
3	3.75
4	5
5	6.25

N=1 and W=6

S	R
1	1.25
2	2.5
3	3.5
4	4.75
5	6

Some of the values are rounded so it's hard to see patterns.

Fix N=2 and W=2

S	R
1	inf
2	inf
3	inf
4	inf
5	inf

Fix N=2 and W=3

S	R
1	3
2	6
3	9
4	12
5	15

Fix N=2 and W=4

S	R
1	2
2	4
3	6
4	8
5	10

$R = 1{\cdot}25 \times S$

$$R = \frac{? \times S}{W - N}$$

When N = W R is infinite ie you have a cylinder that rolls in a straight line.
Formula is something like $R = \frac{?}{W - N}$

Fix N=4 and W=4

S	R
1	inf
2	inf
3	inf
4	inf
5	inf

HEATHER

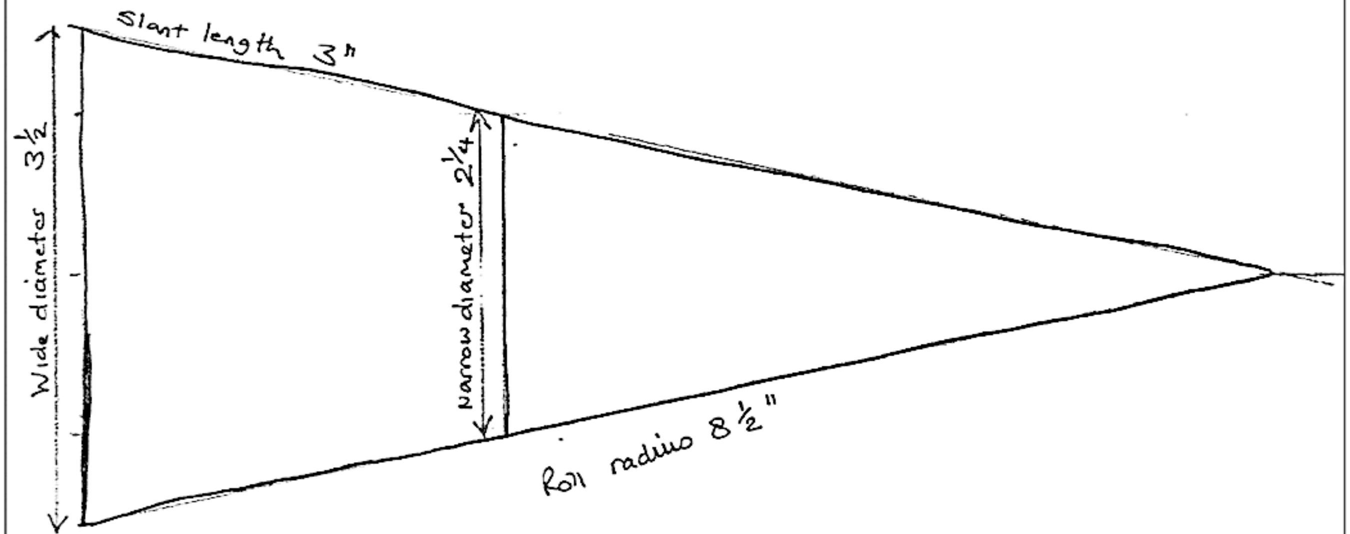
Student Models

Gerry

3d Extend any cup you get a cone.
Narrow diameter = zero in a cone. Then roll radius = slant length.

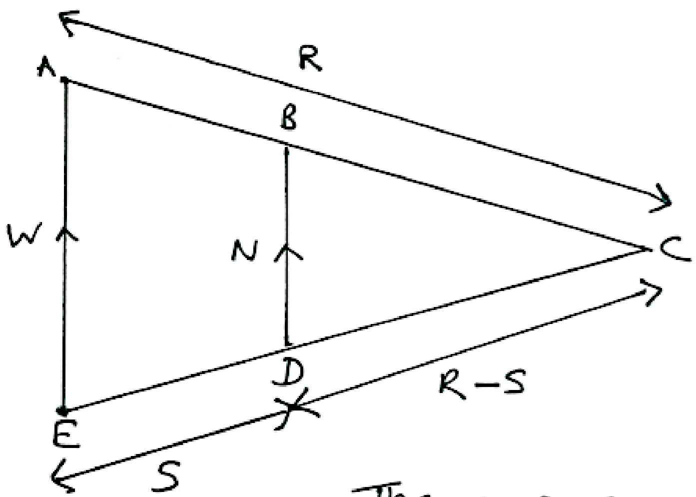
2d Draw the cone as a triangle. The scale drawing lets you find the roll radius.

Eg a cup has wide diameter 3½" narrow diameter 2¼" slant length 3"
This method will work for any cup – you just measure the roll radius.



Student Models

Judi



N = narrow diameter
W = wide diameter
S = slant length
R = roll radius

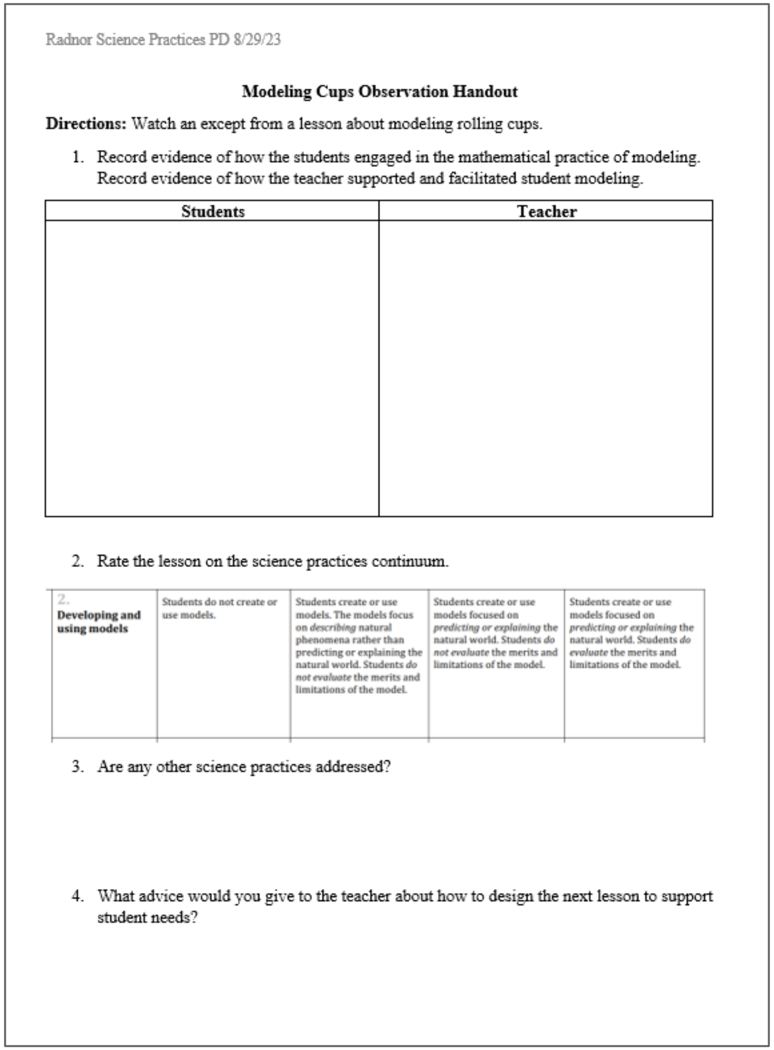
$\triangle ACE$ is similar to $\triangle BCD$

The cup scenario can be modeled using similar triangles.

So $\dfrac{R}{W} = \dfrac{R-S}{N}$

and $RN = WR - S$.

Activity: Video Analysis



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Modeling Cups Observation Handout

Directions: Watch an except from a lesson about modeling rolling cups.

1. Record evidence of how the students engaged in the mathematical practice of modeling. Record evidence of how the teacher supported and facilitated student modeling.

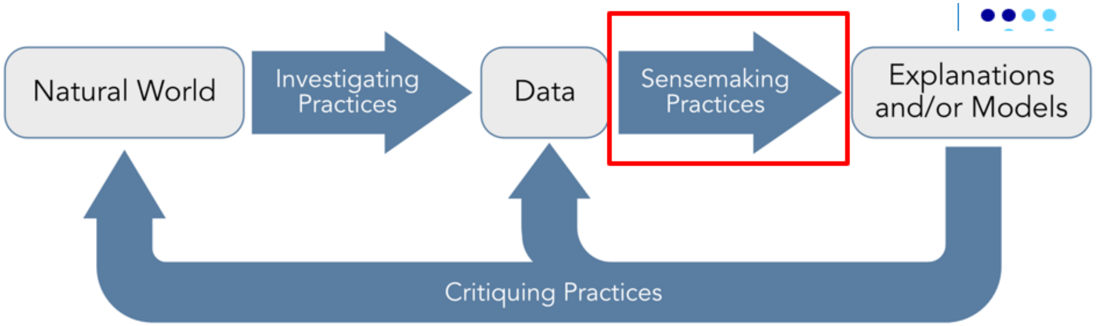
Students	Teacher

2. Rate the lesson on the science practices continuum.

2. **Developing and using models**	Students do not create or use models.	Students create or use models. The models focus on *describing* natural phenomena rather than predicting or explaining the natural world. Students *do not evaluate* the merits and limitations of the model.	Students create or use models focused on *predicting or explaining* the natural world. Students *do not evaluate* the merits and limitations of the model.	Students create or use models focused on *predicting or explaining* the natural world. Students *do evaluate* the merits and limitations of the model.

3. Are any other science practices addressed?

4. What advice would you give to the teacher about how to design the next lesson to support student needs?



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Application

The Task:

- In grade level/discipline-based teams, identify 1 modeling activity to redesign to move up the continuum
- Analyze the lesson and identify strengths/weaknesses
- Identify at least 1 modification to make to the activity and make the necessary changes
- Be prepared to share with the whole group!

Takeaways

Frame science learning as engagement in scientific practices rather than a body of facts to be memorized.

Introduce activities and instructional strategies to incorporate student modeling into your science instruction.

Analyze current curriculum and identify opportunities to scaffold student engagement in modeling.

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