Deepening Understanding of Scientific Modeling in the Secondary Classroom

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California NGSS Rollout Symposium #3

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#NGSS

Outcomes for the Session

- Understand the **importance of modeling** as a science and engineering practice to reveal student thinking.
- Examine how to **support students** in meeting performance expectations around modeling.
- Understand the **characteristics and observable features** of scientific models.
- Use **NGSS Evidence Statements** and a **planning tool** to guide assessment and instruction.

Our Time Together

- **Reflect** on our knowledge of and experience around scientific modeling.
- **Do an activity** to deepen our understanding of scientific modeling.
- **Learn** about how to use NGSS Evidence Statements to plan assessments and guide instruction.
- Collaboratively **plan** student assessments and instruction in which students develop and/or use a scientific model.

Reflecting on Scientific Modeling

1. Walk around the room and read each quote on the wall.
2. Find one quote that resonates or captures your attention.
3. Stand at your quote. Introduce yourself to those who chose the same quote.
4. Discuss the quote.
    a. Highlight a key word or phrase that you think is important.
    b. Circle a word or phrase that brings up a question. Write that question on your poster.
    c. What are the implications of this quote for K-12 science or science in your classroom?
5. Be ready to share out your highlights and question.

Scientific Modeling and the NGSS

- Modeling begins in the earliest grades.
- 24% of the middle school PE's have modeling as the key practice.
- 21% of the high school PE's have modeling as the key practice.

Performance Expectations Associated with SEP2: Developing and Using Models

K-2	3-5	6-8	9-12
K-ESS3-1 2-LS2-2 2-ESS2-2 K-2-ETS1-2	3-LS1-1 4-PS4-1 4-PS4-2 4-LS1-2 5-PS1-1 5-PS3-1 5-LS2-1 5-ESS2-1	MS-PS1-1 MS-PS1-4 MS-PS1-5 MS-PS3-2 MS-PS4-2 MS-LS1-2 MS-LS1-7 MS-LS2-3 MS-LS3-1 MS-LS3-2 MS-ESS1-1 MS-ESS1-2 MS-ESS2-1 MS-ESS2-4 MS-ESS2-6 MS-ETS1-4	HS-PS1-1 HS-PS1-4 HS-PS1-8 HS-PS3-2 HS-PS3-5 HS-LS1-2 HS-LS1-4 HS-LS1-5 HS-LS1-7 HS-LS2-5 HS-ESS1-1 HS-ESS2-1 HS-ESS2-3 HS-ESS2-4 HS-ESS2-6

Source: ngss.sdcoe.net

Scientific Modeling is Progressive through the Grade Bands

K-2	3-5	MS	HS
Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions.	Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.	Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.	Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural
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. Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution. Develop and/or use models to describe and/or predict phenomena.	Develop or modify a model— based on evidence – to match what happens if a variable or component of a system is changed. Use and/or develop a model of simple systems with uncertain and less predictable factors. Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.	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. 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.
	Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.	inputs and outputs, and those at unobservable scales.	Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

The Remainder of This Session

We are going to deepen our understanding of modeling by:

- developing our own model of a science phenomena by DOING a science lesson.
- engage in a process to PLAN assessment and instruction.

Some background for the learning

This is the beginning of a unit on light and color.

MS-PS4-1. Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.

MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

PS4.A: Wave Properties

- A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. (MS-PS4-1)
- A sound wave needs a medium through which it is transmitted. (MS-PS4-2)

PS4.B: Electromagnetic Radiation

- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. (MS-PS4-2)
- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. (MS-PS4-2)
- A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. (MS-PS4-2)
- However, because light can travel through space, it cannot be a matter wave, like sound or water waves. (MS-PS4-2)

Prior Learning

Related PEs in prior grades.

4-PS4-1. Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.

4-PS4-2. Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.

Thinking about How We See Something

1. **Observe** the two objects on your table.
2. **Think** for a minute about how and why you are able to see them.
3. Make a **sketch** (diagrams and words) that captures your initial ideas. Your sketch should include WHY you can see what you can see.
4. When you finish your sketch, **share** with a partner.

Birthday Candles

Imagine you are at a birthday party. A birthday cake with candles is put on a table in the middle of a room. The room is very large. You are standing at the end of the room, 10 meters away from the cake. You can see the candles. Circle the response that best describes how far the light from the candles traveled in order for you to see the flames.

A. The light stays on the candle flames.

B. The light travels a few centimeters from the candle flames.

C. The light travels about 1 meter.

D. The light travels about halfway to where you are standing.

E. The light travels all the way to where you are standing.

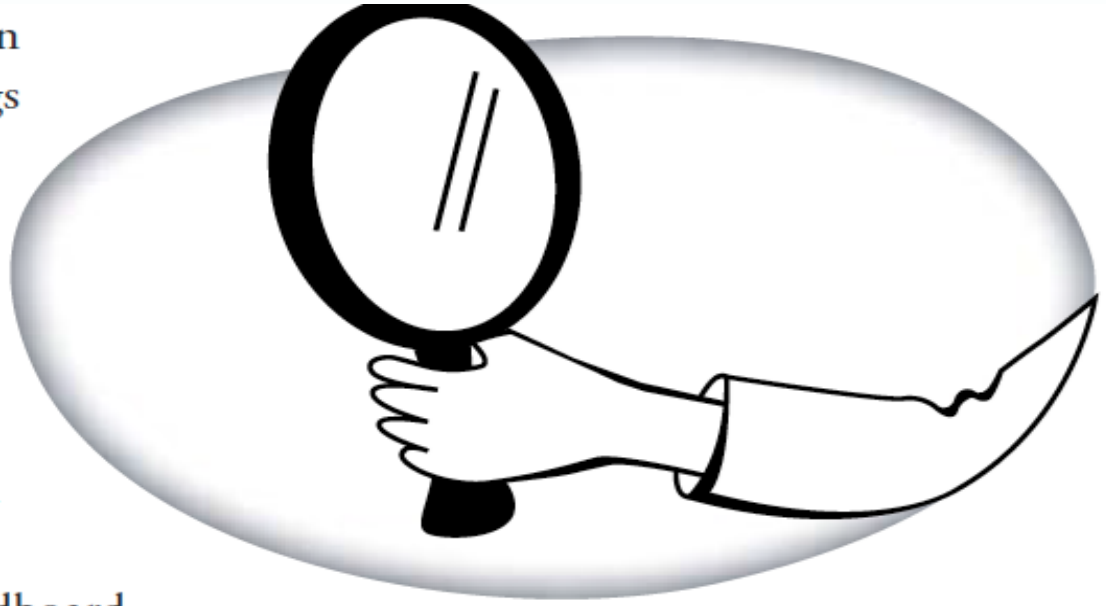
Describe your thinking. Provide an explanation for your answer.

Key Idea #1

Light comes from a source and travels in straight lines to the eye.

Reflecting Light

What types of objects or materials can reflect light? Put an X next to the things you think can reflect light.



___ water
___ gray rock
___ leaf
___ mirror
___ glass
___ sand
___ potato skin
___ wax paper
___ tomato soup
___ crumpled paper
___ shiny metal
___ dull metal
___ red apple
___ rough cardboard
___ the Moon
___ rusty nail
___ clouds
___ soil
___ wood
___ milk
___ bedsheet
___ brand new penny
___ old tarnished penny
___ smooth sheet of aluminum foil

Explain your thinking. Describe the "rule" or the reasoning you used to decide if something can reflect light.

Key Idea #2

In order to see an object, light has to be reflected off the object and travel to the eye.

Apple in the Dark

Imagine you are sitting at a table with a red apple in front of you. Your friend closes the door and turns off all the lights. It is totally dark in the room. There are no windows in the room or cracks around the door. No light can enter the room.

Choose the statement you believe best describes how you would see the apple in the dark:

A. You will not see the red apple, regardless of how long you are in the room.

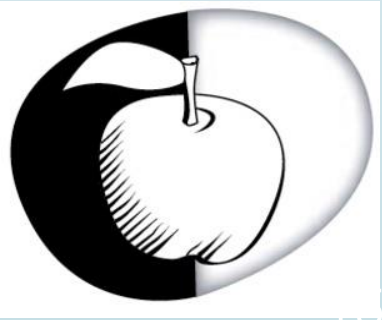
B. You will see the red apple after your eyes have had time to adjust to the darkness.

C. You will see the apple after your eyes have had time to adjust to the darkness, but you will not see the red color.

D. You will see only the shadow of the apple after your eyes have had time to adjust to the darkness.

E. You will only see a faint outline of the apple after your eyes have had time to adjust to the darkness.

Describe your thinking. Provide an explanation for your answer.



Key Idea #3

An object needs to be illuminated by light in order to see it.

Group Consensus

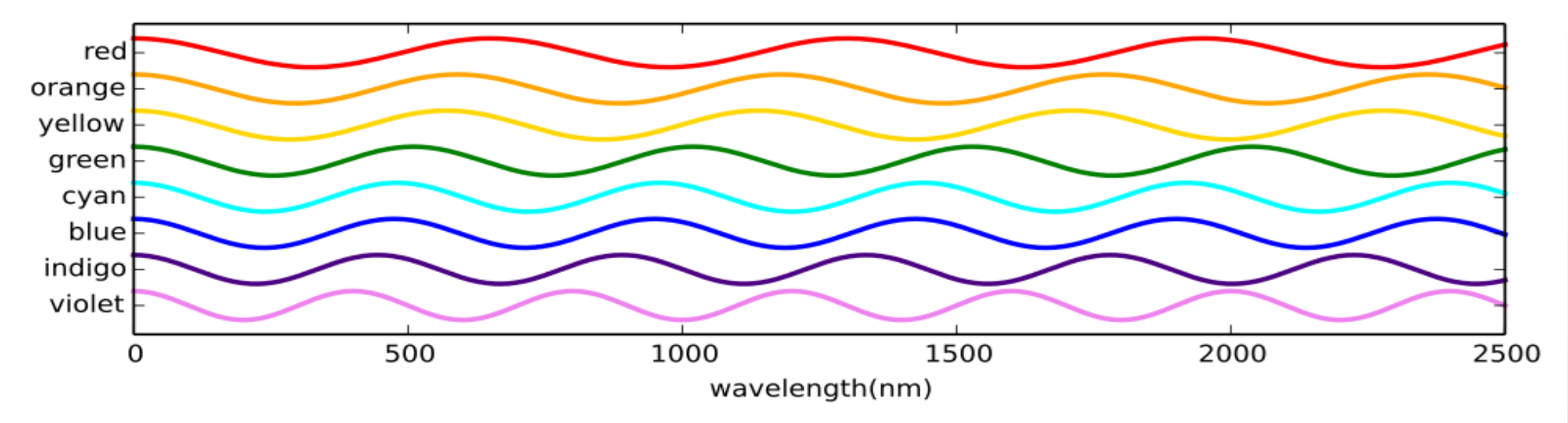
If we were going to make a drawing (model) of how we are able to see something, what would need to be in that drawing (model)?

Develop an Initial Model of Seeing an Object

1. Make a model (drawing) showing how we are able to see the two objects on the table.
2. Be sure your model includes the following components:
   a. Position and source of light
   b. The objects being viewed
   c. Your eye
   d. The path the light travels
3. Label your drawing and explain how the components are related to each other.

What is Color?

Revising Your Initial Model



How did you represent color in your initial model?

Use the idea that the color of light is determined by its wavelength and revise your model if necessary.

How does your model explain what happens to the white light (all the wavelengths combined) that hits an object on your table.

Image source: https://commons.wikimedia.org/wiki/File:Visible_color_wavelengths.svg

Instructional Sequence Next Steps

We have a model of light and color that helps us think about how we are able to see objects and colors of objects.

The next step is to further refine and develop our model to include what happens if we change brightness of the light source.

Debriefing the Lesson

In this lesson:

- What did you DO as a learner?
- What did you LEARN?
- How did the sequence of activities in the lesson support, guide, and push your thinking?

NGSS Performance Expectations and Evidence Statements

- PEs are assessable statements of what students should and be able to do at the end of year
- PEs represent the integration of the three dimensions (SEPs, CCCs, DCIs)
- Both student learning and assessment around NGSS should be three dimensional
- NGSS Evidence Statements are meant to show what it might look like when students are doing the PE

General Observable Features of the SEPs

- In the structure of the PE, the practice dimension provides the means by which students outwardly demonstrate their understanding of the content and concepts.
- The organizing structure created for each practice is listed in the Appendix of the Front Matter document.
- Look at SEP2: Developing and Using Models. What are the general observable features of this practice?
- How were these features used in the lesson we just did?

Sample PE and Evidence Statement

- Look at the Evidence Statement and PE that the lesson was based upon.
- Highlight aspects of the PE that you were building understanding toward.
- Highlight observable features of student performance that were introduced as part of your learning in the activity.
- How might the Evidence Statement and the PE help you think about assessment and instruction?

Debriefing the Planning of the Lesson

Tools D and E

Concept (3D PE)			
Stage	Teacher Does	Student Does	Concept (DCI, SEP, CCC)
Engage			**… then plan concepts through each 5E stage**
Explore			
Explain			
Elaborate			
Evaluate		**Modeling Planning Tool**	**Start here…**

Planning Tool for Developing and Using Models

Step 1: Determine the Observable Features from a Performance Expectation (Evaluate)

Step 2: Identify Possible Student Final Product (Evaluate)

Step 3: Identify Possible Student Initial and Revised Models (Explore, Explain, Elaborate)

Planning Assessment and Instruction Using Evidence Statements

You are now going to have a chance to use a performance expectation, the Evidence Statements, and the *Planning Tool for Developing and Using Models* document to plan assessment and instruction.

Step 1: Determine the Observable Features from a Performance Expectation

Step 2: Identify Possible Student Final Product

Step 3: Identify Possible Student Initial and Revised Models

Step 1: Determine the Observable Features from a Performance Expectation (Part 1)

With your performance expectation in mind, brainstorm what phenomena students could explore or investigate in which a model would be developed. **Note: Tools A, B, C, D, E**

What are the possible components, relationships, and connections for this PE? Write them in Step 1.

Components - What are the essential variables or factors (components) within the system being modeled that students will need to define and clearly label?

Relationships - What are the relationships among the components of the model that students will describe?

Connections - How will students connect their model to causal phenomena or scientific theories using logical reasoning to make explanations or predictions?

Step 1: Determine the Observable Features from a Performance Expectation (Part 2)

Read the NGSS Evidence Statement for the performance expectation. What information from this document might guide assessment and instruction? Add to your observable features (components, relationships, and connections) based on your analysis of the evidence statement.

Components - What are the essential variables or factors (components) within the system being modeled that students will need to define and clearly label?

Relationships - What are the relationships among the components of the model that students will describe?

Connections - How will students connect their model to causal phenomena or scientific theories using logical reasoning to make explanations or predictions?

Step 2: Identify Possible Student Final Product

Based on the observable features of developing and using models, what would a possible student final product look like? Be sure to include the **components of the model**, the **relationships** among the components, and **connections** to causal phenomena or scientific theories.

Draw or describe the student product with as much detail as possible.

Step 3: Identify Possible Student Initial and Revised Models

- What phenomenon will students explore, investigate, or experience in order to create an initial model?
- What initial model(s) might students make after exploring, investigating, or experiencing this phenomenon?
- What evidence will cause students to evaluate and revise their model? How will they gather that evidence?
- What revisions might students make to their model after this additional evidence has been gathered?

Sharing Work

- Join up with another group.
- Share the work you have completed in this session.
- What have been some of the a-ha's/breakthroughs using the planning tool and Evidence Statements?
- What have been some of the struggles/challenges using the planning tool and Evidence Statements?

Returning to the Outcomes

- Understand the **importance of modeling** as a science and engineering practice to reveal student thinking.
- Examine how to **support students** in meeting performance expectations around modeling.
- Understand the **characteristics and observable features** of scientific models.
- Use **NGSS Evidence Statements** and a **planning tool** to guide assessment and instruction.

Closing Discussion

- What new questions or ideas do you have?
- How has your understanding of scientific modeling changed?
- How does the planning tool and Evidence Statements help you think about assessment and instruction around a performance expectation?

Thank You!

Please complete the session evaluation.

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