NGSS Practices in Action

Breakout A: Modeling

Presented by: Cynthia Passmore

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Introducing today’s presenter...

Cynthia Passmore
Associate Professor
School of Education
University of California, Davis
Modeling in the Framework and NGSS
Introductions

• Who am I?
  – Faculty member in science education at University of California Davis
  – Investigate student learning in modeling contexts
  – Investigate teacher learning about how to engage kids in authentic scientific practice
  – Former high school science teacher
What grade levels do you work with?

<table>
<thead>
<tr>
<th>Grade Levels</th>
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<tr>
<td>preK-2</td>
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<tr>
<td>3-5</td>
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<td>6-8</td>
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<td>9-12</td>
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<tr>
<td>College/university</td>
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What subjects do you teach?

<table>
<thead>
<tr>
<th>Subject</th>
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<tbody>
<tr>
<td>Life science</td>
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<tr>
<td>Physical science</td>
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<tr>
<td>Earth/space science</td>
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<tr>
<td>General science</td>
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<tr>
<td>Other</td>
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Goals for our time together

• Explore the modeling practice
  – why is it important?
  – what is it?

• Examine how modeling relates to the other practices

• Experience and imagine what it looks like in the classroom and how to support it
Poll: What is your biggest challenge in implementing modeling?

A. Not sure I understand the practice
B. Not enough curricular resources written from a modeling perspective
C. Not sure how to effectively support students developing and critiquing ideas in my classroom
D. Takes too much time to do it and I’m pressured to cover more material
To begin, let’s imagine two 7th grade lessons focused on moon phases...
The Sun-Moon angle is the angle defined by Sun->Earth->Moon with Earth as the angle vertex. As the Sun-Moon angle increases we see more of the sunlit part of the Moon. If this drawing were to scale, then the Moon would be half this size and its orbit would be 22 times longer in diameter and the Sun would be about 389 times farther away than the Moon.

http://www.moonphases.info/moon_phases.html
Now picture this lesson...
How might we contrast these lessons?
How might we contrast these lessons?

Knowing about
How might we contrast these lessons?

Knowing about versus
How might we contrast these lessons?

Knowing about versus Figuring out
Two Labels to Consider:
Two Labels to Consider:

• **Sense-making frame** for instruction
Two Labels to Consider:

- **Sense-making frame** for instruction
- **Information frame** for instruction
Frames for Science Instruction

Information frame  Sense-making frame
Frames for Science Instruction

Information frame

- Vignette 1

Sense-making frame
Frames for Science Instruction

Information frame

• Vignette 1

• This lesson is centered in an information frame for instruction.

Sense-making frame
Frames for Science Instruction

Information frame

- Vignette 1
- This lesson is centered in an information frame for instruction.
- Students are focused on knowing information.

Sense-making frame
## Frames for Science Instruction

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<th>Sense-making frame</th>
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Frames for Science Instruction

**Information frame**

• Vignette 1

• This lesson is centered in an information frame for instruction.

• Students are focused on knowing information.

• Science is portrayed as a body of established facts.

**Sense-making frame**

• Vignette 2
Frames for Science Instruction

Information frame

• Vignette 1
• This lesson is centered in an information frame for instruction.
• Students are focused on knowing information.
• Science is portrayed as a body of established facts.

Sense-making frame

• Vignette 2
• This lesson is centered in a sense-making frame for instruction.
Frames for Science Instruction

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## Frames for Science Instruction

### Information frame

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- This lesson is centered in an information frame for instruction.
- Students are focused on knowing information.
- Science is portrayed as a body of established facts.

### Sense-making frame

- **Vignette 2**
- This lesson is centered in a sense-making frame for instruction.
- Students are focused on understanding something.
- Science is portrayed as a way to make sense of something.
How might we contrast these lessons?
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Sense-making frame
Information Versus Sense-making
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  – We want students to know stuff.
  – But we also want students to make sense of stuff.
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  – But we also want students to make sense of stuff.

• The interesting thing is, you need to know some stuff in order to make sense of other stuff.

• But the converse is not true, because you can know stuff without making sense of it.
• I can memorize and “know” all the words here, without having any understanding of what this is:

http://www.americanmachinetools.com/how_to_use_a_milling_machine.htm
• Just as I can memorize and “know” all the words here, without having any understanding of what this is:
On any given day in a science class...

Every student in the room should be able to tell an observer what it is they are trying to figure out.
NGSS Performance Expectation aligned to the vignettes

- MS-ESS1-1. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. [Clarification Statement: Examples of models can be physical, graphical, or conceptual.]
Consider the difference between students generating this:
Consider the difference between students generating this:

1.

2. The moon phases

3.
Consider the difference between students generating this:

1. 

2. The moon phases

3. 

being given this:

The Sun-Moon angle is the angle defined by Sun → Earth → Moon with Earth (where observer) as the angle vertex. As the Sun-Moon angle increases we see more of the sunlit part of the Moon. Note that if this drawing were to scale, then the Moon would be half this size and its orbit would be about 22 times larger in diameter and the Sun would be about 389 times farther away than the Moon!
Some other examples of knowing about vs. figuring out
Knowing about

\[ \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + \text{O}_2 \]

- Carbon dioxide
- Water
- Chlorophyll
- Sugars
- Oxygen

Sun's energy
Figuring out

http://www.ecobabysteps.com/2010/04/23/%E2%80%99s-a-toy-if-he-says-it-is/

http://www.hay-fever-relief.com/OakPollen.html
Knowing about

http://www.clker.com/clipart-convection-current-model.html
Figuring out
Knowing about

http://www.peoi.org/Courses/Coursesen/chemorg/ch/ch8b.html
Figuring out
Models of Cognition And The Two Frames
Information Frame
Information Frame

http://www.fpsweb.org/clmr/clmrStaff.cfm
Information Frame

http://www.fpsweb.org/clmr/clmrStaff.cfm

http://firegeezer.com/search/daily/page/9/
Sense-making Frame

http://educationaltoysfrombonz.com/buildables_samples.html
Shifting along the Information/ Sense-Making Continuum
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• While both frames for instruction are important, research and personal experience show us that most teachers are very good at the information frame for instruction.
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• What most teachers need help with is the sense-making frame for instruction.
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• What most teachers need help with is the sense-making frame for instruction.

Sense-making is the core of the NGSS focus on practices
This is not about *tweaking* the system.
This is not about *tweaking* the system.

It is a complete *overhaul*!

FUNDAMENTALLY WE WANT STUDENTS TO 

ENGAGE IN SCIENCE TO LEARN IT
SO WHERE DOES “DEVELOPING AND USING MODELS” FIT IN?
What is a model?

*Few terms are used in popular and scientific discourse more promiscuously than “model.”*

- Goodman 1976, p.171, as cited in Odenbaugh 2009
What is a model?
What is a model?

- Models are **sets of ideas** about how some feature of the natural world works.
What is a model?

• Models are **sets of ideas** about how some feature of the natural world works.

• These sets of ideas (i.e. models) can be used to explain, predict, and make sense of phenomena.
Two main points
Two main points

1. Models are defined by the context of their use

Two main points

1. Models are defined by the context of their use

2. Models are distinct from the representational forms they take
   (Knuutilla 2005; c.f. Harrison & Treagust 2000)
Models are defined by their use

MODELS

Representations OF

PHENOMENA

(Knuutilla, 2005; Passmore, Gouvea & Giere, 2014)
Models are defined by their use

COGNITIVE AGENT

MODELS

Representations OF

PHENOMENA

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Models are defined by their use

Models are defined by their use for making sense of phenomena.

Shift from Dyadic to Triadic

(Knuutilla, 2005; Passmore, Gouvea & Giere, 2014)
Models are defined by their use

The model serves a sense-making purpose for the cognitive agent

(Knuutilla, 2005; Passmore, Gouvea & Giere, 2014)
When most people hear the word ‘model’ in science education they think of these kinds of things:

http://craftsncoffee.com/2012/01/06/out-of-this-world-kids-craft-how-to-make-a-solar-system-model-or-maybe-youll-win-one/

http://newsletter.onlineschool.ca/archives/vol7_edd_022011/student01.html


These are NOT the kinds of models we are talking about:

These are physical replicas or representations that may be useful in communicating about and reasoning with underlying models.

http://craftsncoffee.com/2012/01/06/out-of-this-world-kids-craft-how-to-make-a-solar-system-model-or-maybe-youll-win-one/

What is modeling?
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- Modeling is developing and using a set of ideas that can help us explain a phenomenon/answer a driving question about the world.
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What is modeling?

• Modeling is developing and using a set of ideas that can help us explain a phenomenon/answer a driving question about the world.

• In the moon vignette, the modeling isn’t holding a ball representing the moon, and moving it around a globe.

• The modeling is when students are mentally grappling with a set of ideas which can explain the moon’s changing appearance in the sky. [the props are helpful in this grappling, but it is not the presence of the props that makes this a case of modeling]
Scientific Knowledge Products are Coordinated into and Evaluated against Reasoning about Models

Function to Inform and Structure Scientific Practices that generate

Descriptions
Data Patterns
Questions & Hypotheses
Experimental Design & Procedures
New Concepts
Explanations

For Making Sense of Phenomena

Passmore, Gouvea & Giere, 2014
“Models serve the purpose of being a tool for thinking with, making predictions and making sense of experience.” And further “scientists use models...to represent their current understanding of a system under study, to aid in the development of questions and explanations, and to communicate ideas to others.” (NRC, 2011, pp. 56-7).
Framework Modeling Goals

- “Construct drawings or diagrams as representations and use as the basis for an explanation or prediction
- Use multiple types of models (including simulations)
- Discuss limitations and precision of a model
- Use models to test a design” (p. 58)
Time to Chat!

• Any questions so far?
Models can provide productive anchor for other practices
Questions worth pursuing
Accepted methodology
Standards of evidence
Common language

EXPLANATIONS

MODELS

Data Patterns

Phenomena

Assessment

Empirical criteria
• Model-data fit
• Predictive power

Conceptual criteria
• Consistency with other ideas
• Fruitfulness

(Passmore, Stewart, & Cartier, 2009)
Engaging in Argument from Evidence

Constructing Explanations & Designing Solutions

Obtaining, Evaluating & Communicating Information

Using Mathematics & Computational Reasoning

Planning & Carrying out Investigations

Analyzing and Interpreting Data

Developing & Using Models

Asking Questions/Defining Problems

guides

motivates

guides

constrains the range of appropriate
to inform & communicate about
to explore and evaluate as basis for
guides

provide filters for
to inform & elaborate

informs

informs

to inform & refine
- Asking Questions/Defining Problems
- Using Mathematics & Computational Reasoning
- Engaging in Argument from Evidence
- Constructing Explanations & Designing Solutions
- Obtaining, Evaluating & Communicating Information

**Developing & Using Models**
- Guides inform
- Guides motivate
- Guides constrain the range of appropriate
- Guides to explore and evaluate
- Guides to inform & communicate about
- Guides to inform & elaborate

**Planning & Carrying out Investigations**
- Guides inform
- Guides to inform & refine

**Analyzing and Interpreting Data**
- Guides inform
Engaging in Argument from Evidence

- To explore and evaluate
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Using Mathematics & Computational Reasoning

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Developing & Using Models

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- Motivates
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PHENOMENA

Passmore, Gouvea & Giere, 2014
Time to Chat!

• Any questions so far?
Poll

At what point in your instructional sequence do you typically focus on models?

A. As a review to solidify the main points
B. Throughout the sequence as a way to organize our ongoing work
C. As a way to assess students’ ideas
High School Biology Vignette

Classical genetics
Model-Based Inquiry Unit: Classical Genetics

1. Driving phenomena: Family Histories
2. Construct initial model: Examine and make sense of Mendel’s model of simple dominance
3. Empirical investigations and model elaboration/revision: simulations and model revisions for codominance, multiple alleles, and sex linkage
4. Model evaluation and consensus model development: summarize and return to family histories
5. Model application: novel pedigrees to explain
1 Driving phenomena/question

- Students explore cases written as family histories taken at a genetics counseling clinic. They make pedigrees of each family and note that several patterns of inheritance can been seen across a range of human conditions:
  - sometimes both parents are affected when a child is, sometimes only one and sometimes neither
  - some conditions seem to occur on both sides of the family and others only one
  - some conditions seem to have a gender component

- Driving question: why do different conditions seem to get “passed down” in different ways?
(2) Construct initial model

- Examine Mendel’s data (taken from his original manuscript).
- Find relevant patterns.
- Work with teacher to develop Mendel’s model of simple dominance.
(3, 4) Empirical investigations and model revision

• Students use model to interpret data from fruit fly crosses (simulation).

• They find some data cannot be explained by Mendel’s model and revise the model to account for patterns such as:
  – three or four variations for the trait
  – males affected more frequently than females

• Revised models must fit with other known genetic models/mechanisms (i.e. meiosis)
(5) Consensus model development

• Formalize their model representations, highlighting the key differences between
  – simple dominance
  – codominance
  – multiple alleles
  – sex-linkage

• Apply their new set of models to the initial pedigree data from the family histories.
(6) Apply models to novel phenomenon

I: So you are saying K and L tell you something pretty interesting. What is that?

Paul: That being albino is recessive.

I: How do you know that?

Paul: That is the only way. Because these two are unaffected and they have an affected child. The only way that could happen is if they were both 1,2s [heterozygotes]
What students learned

• The particulars of four different classical genetics models
• They reinforced meiosis model
• They coordinated data/evidence with model revisions
• They engaged in argumentation and communication
TO SUMMARIZE...
Now, we have a *renewed* and clarified *vision*
Let’s embrace the shift from
Let’s embrace the shift from Knowing about information frame
Let’s embrace the shift from Knowing about information frame to
Let’s embrace the shift from

Knowing about

information frame

to

Figuring out

sense-making frame
Modeling is a way to shift our classrooms toward a sense-making frame
Other Modeling Resources

• Book chapters and research articles:

• Helpful websites
Thanks and questions

• I gratefully acknowledge that the ideas presented here have been put together and refined with some amazing collaborators including Julia Gouvea, Rich Hedman, Arthur Beauchamp, Wendell Potter, Brian Reiser and Christina Schwarz

• Contact: cpassmore@ucdavis.edu
Thanks to today’s presenter!

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