Phenomena-Questions-Models

Using phenomena, questions, and models to inform science instruction

Cindy Passmore and Arthur Beauchamp

October, 2016

Sacramento Area Science Project
An Education Partnership • UC Davis and Sacramento State

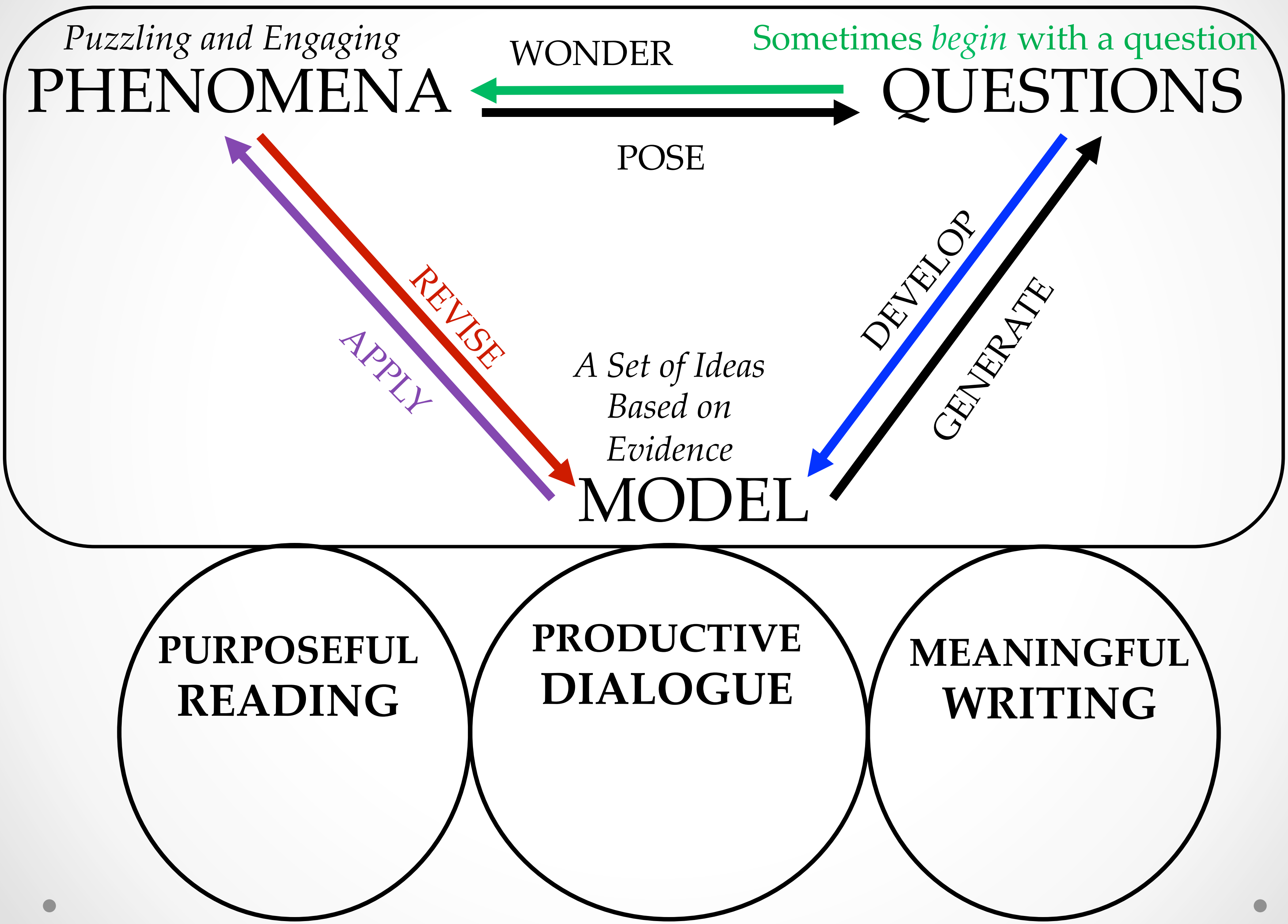
CELEBRATING 50 YEARS
CALIFORNIA SCIENCE TEACHERS ASSOCIATION CSTA
SINCE 1964

P-Q-M

We will investigate a phenomenon:

- Shine the flashlight <u>through</u> the box of water (not in it) – observe closely
- Add 3 or 4 drops of creamer and stir.
- Shine the flashlight <u>through</u> the box of water (not in it) – observe closely

Sense-making and Literacy Framework©



Scientist in the Crib

Alison Gopnik, Andrew N. Meltzoff and Patricia K. Kuhl

- Babies come into this world well equipped for learning. The evidence that children are already born knowing certain things is extensive.
- In a relatively brief span of months babies transform sound waves into individual words, independent of the speaker, turn words into concepts, and concepts into meaning.

Scientist in the Crib

- The authors of “The Scientist in the Crib” advance a hypothesis that a baby is really like a scientist (and a scientist like a baby), forming ideas about the world, doing little experiments to test them, and refining or discarding ideas in light of experimental results. Indeed, the authors believe that babies are driven by a need to explain, to understand, and this drive manifests itself during every stage of baby’s development.

Alison Gopnik, Andrew N. Meltzoff and Patricia K. Kuhl

The Drive to Explain

There is a natural tendency to explain and seek explanation.

Oranges

John McPhee

Curiosity

Curiosity is the very basis of education and if you tell me that curiosity killed the cat, I say only the cat died nobly.

Arnold Edinborough

"Notice all the computations, theoretical scribblings, and lab equipment, Norm. ... Yes, curiosity killed these cats."

Science is simply the word we use to describe a method of organizing our *curiosity*.

Tim Minchin

Phenomena

- Because there is a natural tendency to explain and/or seek explanation, phenomena can act as a starting point for NGSS learning sequences.
- In science education at all levels we can and should be taking advantage of this.
- However, science is often taught as if everything were known.

Phenomena

Phenomena

West shore of Lake Tahoe

Phenomena

Conditions:

1. Bottle on its side.
2. Bottle on road.
3. 6:12 am.
4. Cloud cover.
5. 60°F, no wind.
6. Night was calm.

Phenomena

Bed of pick-up truck, afternoon of hot day, truck had been under a tree

Phenomena

Phenomena

Bottle on side on playground
6:42 am
Clear sky
58˚F, no wind
Night was calm

What makes a good phenomenon for the classroom?

- **Easily observable and likely to spark wonder**

  this does not mean it has to be phenomenal!

- **Would have available Data with Patterns:**

  -From Pictures/Video
  -From Text
  -From Scientists
  -From Student Investigations:
  - Observations
  - Measurements
  - Experiments

- **Connected to the DCI you are working on**

Phenomena can act as a useful starting place for instruction, act as a springboard for curiosity, and ground instructional sequences

BUT, they can only do this if we harness the wonder in specific ways by <u>asking questions.</u>

Questions

- Phenomena are often messy and complex.
- Questions help us refine our wondering and zero in on particular aspects of the phenomenon we are interested in exploring.

About the sunrise:
we might wonder…

- Why is it happening at this specific time today?
- In this location?
- Why is it colored?
- Why isn't it always colored?
- Etc.

Questions

- Return to the light box.
- What are some questions you have?
  - Why can I see the beam after adding creamer?
  - Why does the beam spread out?
  - What is creamer made of?
  - Does the beam heat up the water?
  - Is the beam less intense the further it goes through the water?
  - Will the creamer settle and beam go away if we just let it sit?
  - If we used a different kind of light source would it look the same?
  - Does the temp of the water matter?
  - What do you call this phenomenon?
  - What if you added lots of creamer what might happen to the beam?

Questions

- Return to the light box.
- What are some questions you have?
  - Why can I see the beam after adding creamer?
  - What is creamer made of?
  - Does the beam heat up the water?
  - Does the beam get less intense the further it goes through the water?
  - What do you call this phenomenon?
  - Will the creamer settle and beam go away if we just let it sit?
  - If we used a different kind of light source would it look the same?
  - Why does the beam spread out?
  - Does the temp of the water matter?
  - What is light made of?
  - What if you added lots of creamer what might happen to the beam?

Questions

- Return to the light box.
- What are some questions you have?
  - **Why can I see the beam after adding creamer?**
  - What is creamer made of?
  - Does the beam heat up the water?
  - Does the beam get less intense the further it goes through the water?
  - What do you call this phenomenon?
  - Will the creamer settle and beam go away if we just let it sit?
  - If we used a different kind of light source would it look the same?
  - **Why does the beam spread out?**
  - Does the temp of the water matter?
  - What is light made of?
  - What if you added lots of creamer what might happen to the beam?

Questions

- Return to the light box.
- What are some questions you have?
  - **Why can I see the beam after adding creamer?**
  - ~~What is creamer made of?~~
  - Does the beam heat up the water?
  - Does the beam get less intense the further it goes through the water?
  - ~~What do you call this phenomenon?~~
  - Will the creamer settle and beam go away if we just let it sit?
  - If we used a different kind of light source would it look the same?
  - **Why does the beam spread out?**
  - Does the temp of the water matter?
  - ~~What is light made of?~~
  - What if you added lots of creamer what might happen to the beam?

Questioning

- Two techniques:
  - 5 Whys
  - Question Formulation Technique

Phenomena → Questions

5 Whys –

an iterative interrogative technique for exploring the cause and effect relationships underlying problems or phenomena.

By repeating the question "Why?" each question forms the basis of the next question.

1. Why did this phenomenon occur?

Because ice splits rocks.

2. Why does ice split rocks?

Water gets into small cracks in the rock. The water freezes repeatedly. Ice splits rocks because water expands when it freezes.

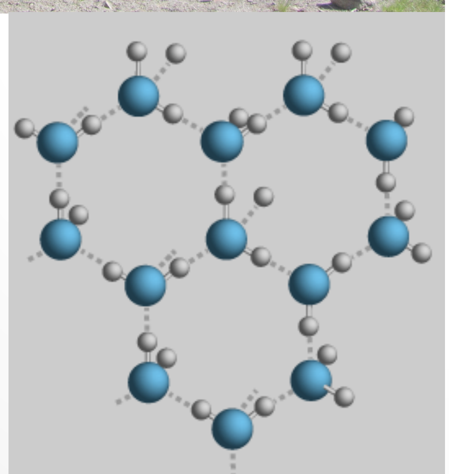
3. Why does ice expand when it freezes?

Because in a liquid state water molecules can move around one another easily and get closer together. As water freezes the molecules move apart.

4. Why do the water molecules move apart?

Because water molecules are sort of a "V" shape and above 0˚C they can move around each other and arrange tightly. When they reach 0˚C they arrange into a configuration that takes up more space.

5. Why does this configuration take up more space?



Because hydrogen bonds form between H and O atoms and hold the molecules in an organized hexagonal lattice. This arrangements means that each H and O in the entire mass of ice must be oriented to their neighboring H and O in an identical repeating pattern held in place by the strength of the hydrogen bonds. And that pattern "spreads out" some to get into this arrangement (called an open crystalline structure).

Do 5 Whys on light boxes

Questioning

- The Right Question Institute

  http://rightquestion.org/education/

Return to the light boxes

- So now we've noticed some interesting things in the world (beams of light):

PHENOMENON

- And we wondered about specific aspects of that thing:

QUESTIONS

- So now we need to figure out what is going on.

If we ask mechanistic questions like:

- WHY does something happen or,
- What CAUSES the phenomenon

Then we are motivated to figure out some ideas about what we are wondering about.

WE NEED A MODEL!

But this begs the question…

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

THINK…

What is your definition of a model?

What definitions of the word model do you think your students have?

Write your thoughts down on your Response Sheet

When finished please put down your writing tool.

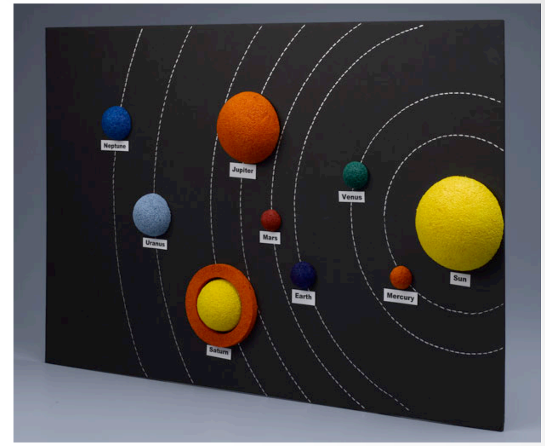
PAIR…

- With an elbow partner, share what you thought about your definition(s) of the word model and talk about what *questions* you might have about models.

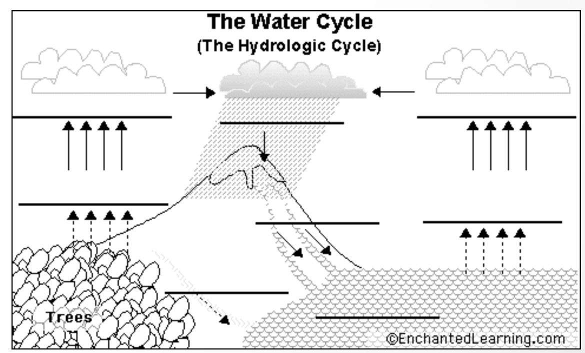
SHARE…

One of your questions about models

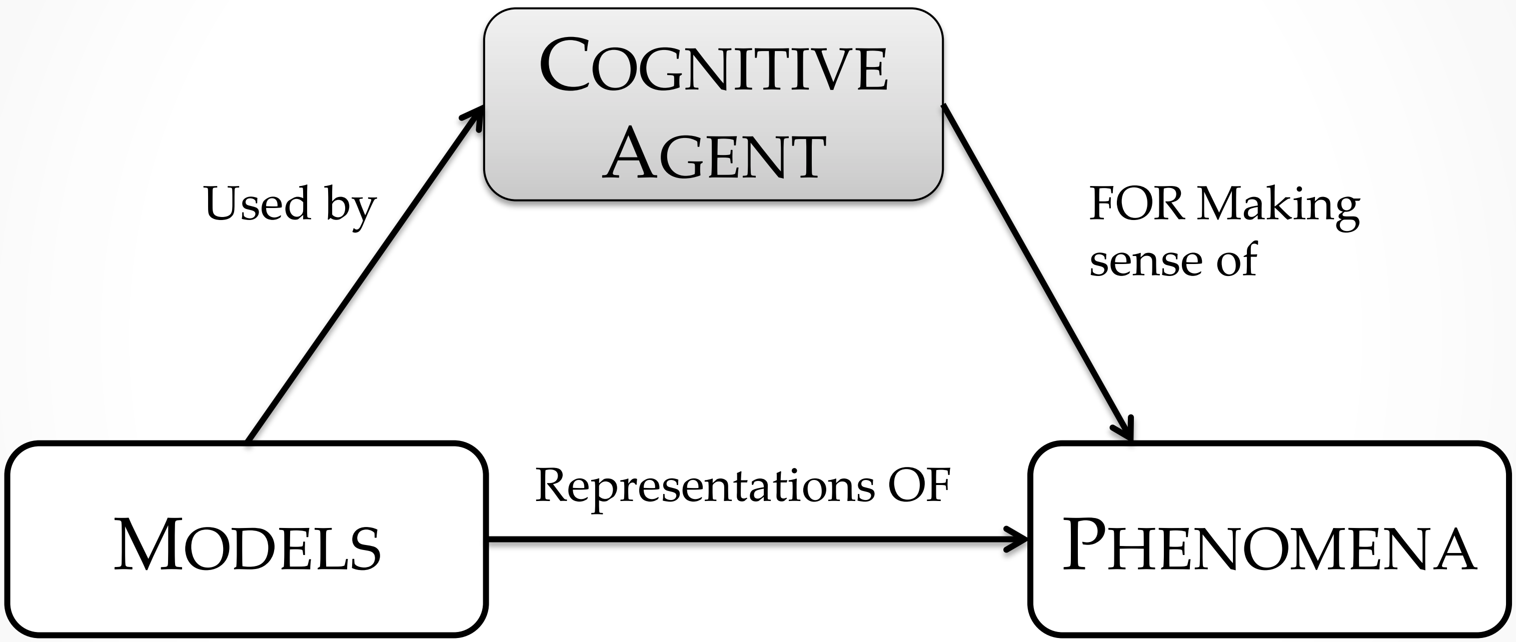
Are these the kinds of things that come to mind when you hear about models in science?



$$\Delta E_{thermal} \quad + \quad \Delta E_{bond} \quad = \quad {}^{+}\mathbf{Q}$$



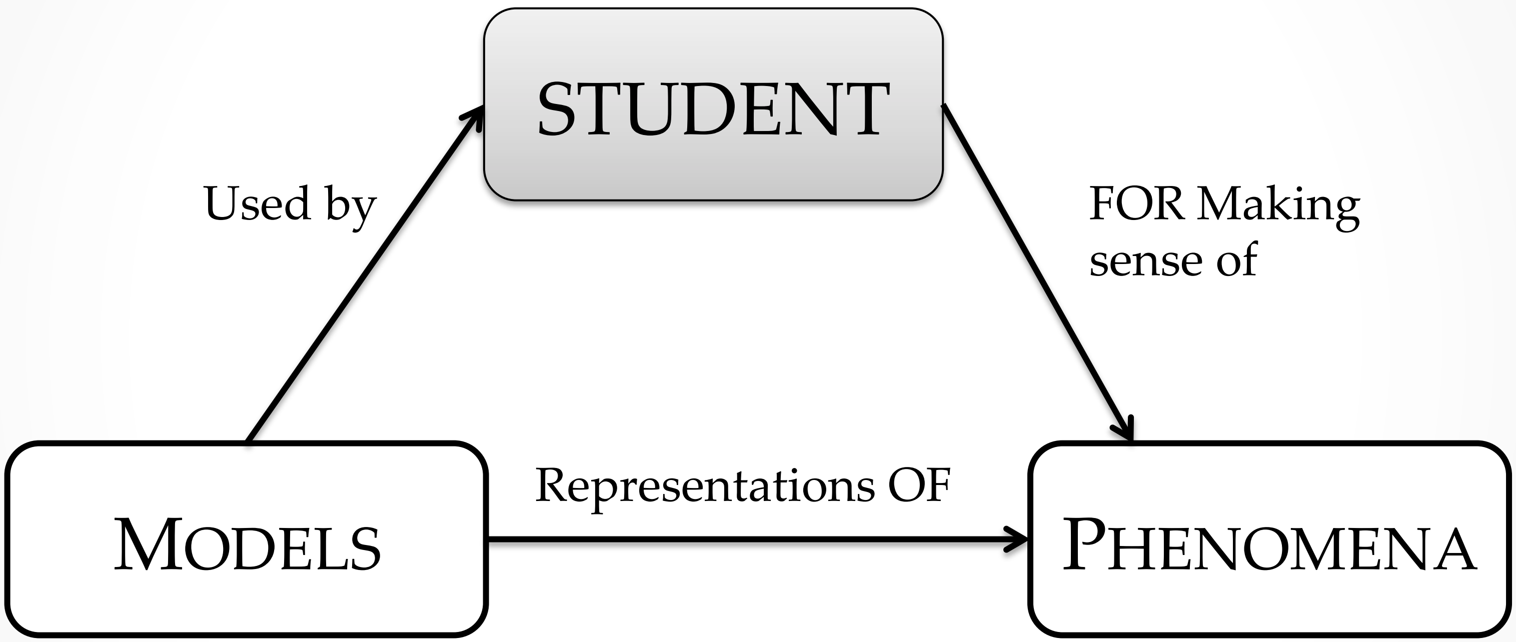
A Shift



Shift from Dyadic to Triadic (Knuuttila, 2005)

The OF/FOR Distinction

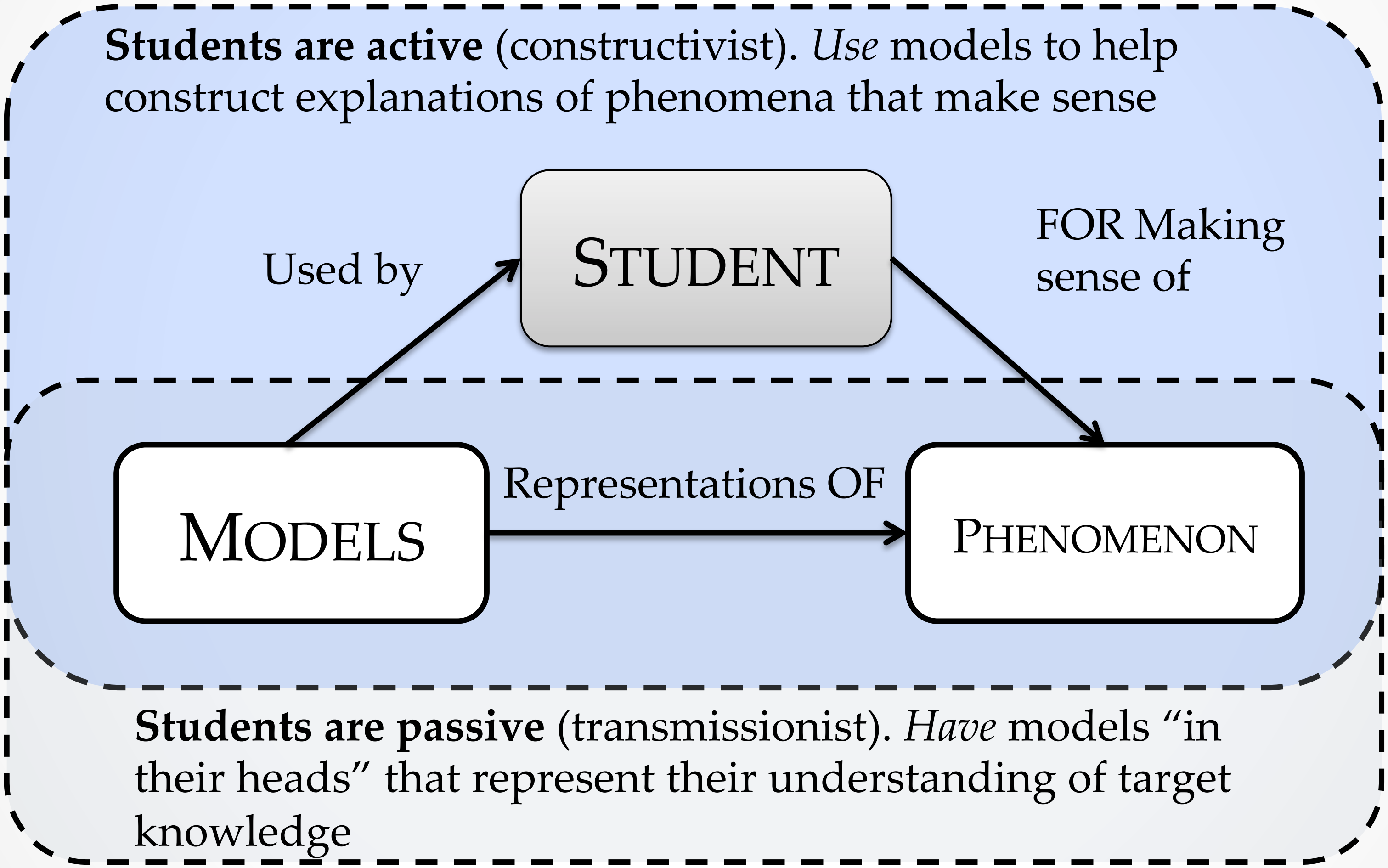
More Shift



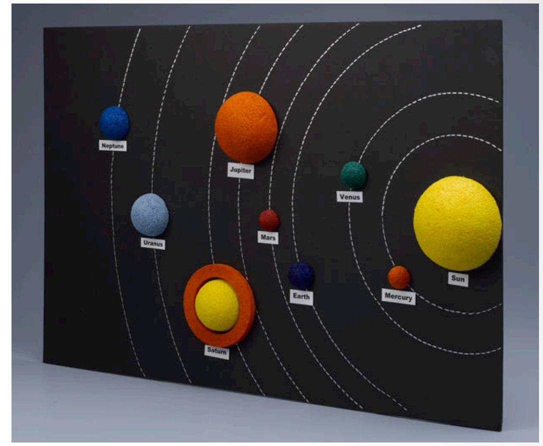
Shift from Dyadic to Triadic (Knuuttila, 2005)

The OF/FOR Distinction

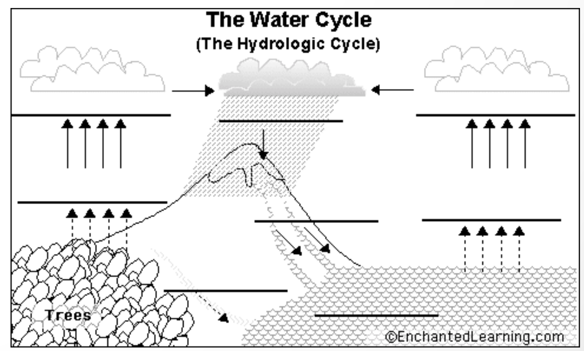
A shift in the instructional paradigm



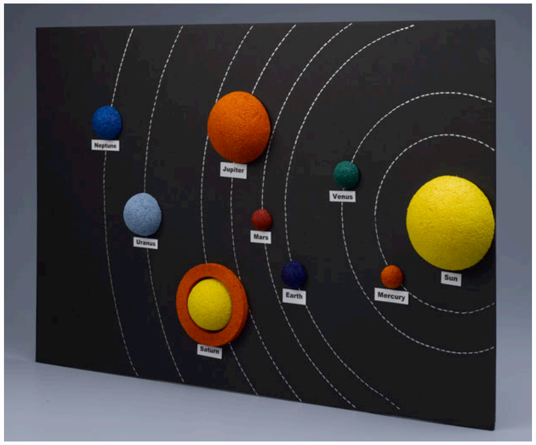
How ‘**MODELS *FOR*’** helps us think about these?

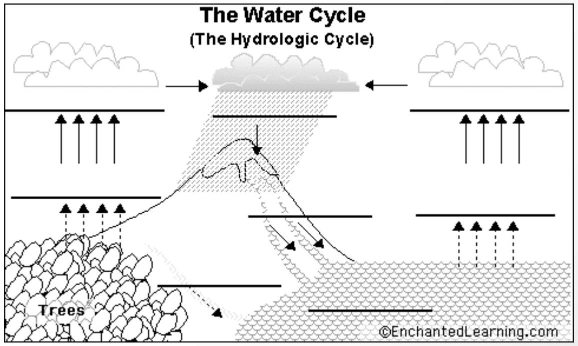


$$\Delta E_{thermal} \quad + \quad \Delta E_{bond} \quad = \quad {}^{+}\mathbf{Q}$$



Try out '***MODELS <u>FOR</u>'*** on these two (hint: think about the PHENOMENA and QUESTIONS)

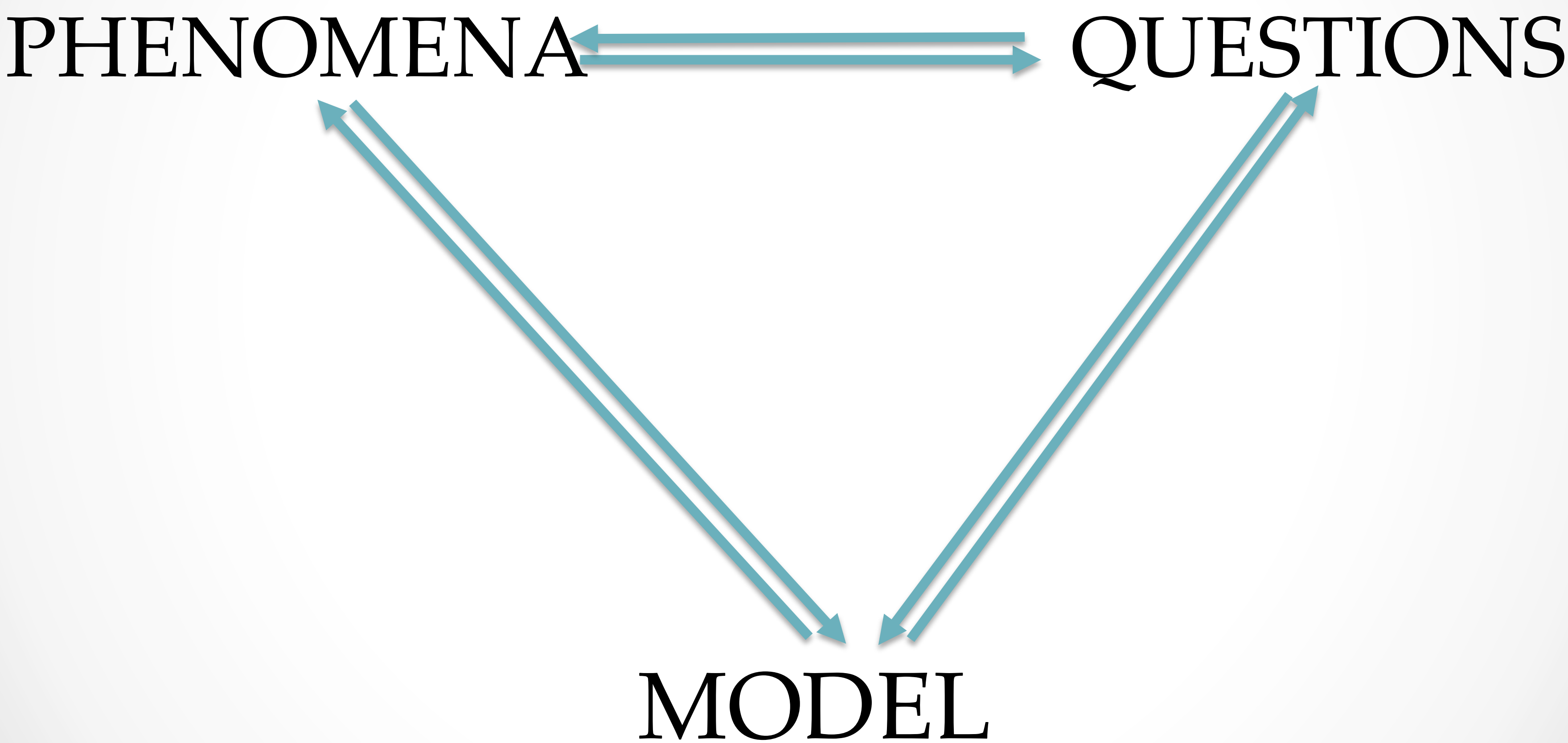




NGSS & MODELS

- Individually, read the NRC Framework regarding the science and engineering practice – Developing and Using Models. Think about the definition, how this practice progresses, and its goals.
- Once you have finished respond to the prompt on your Model Response Sheet

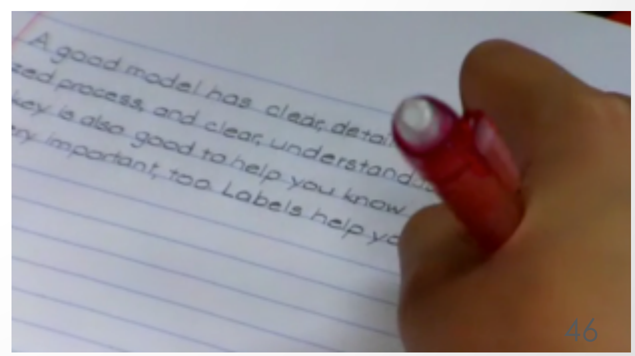
The light boxes



Why models? Modeling as an anchor practice

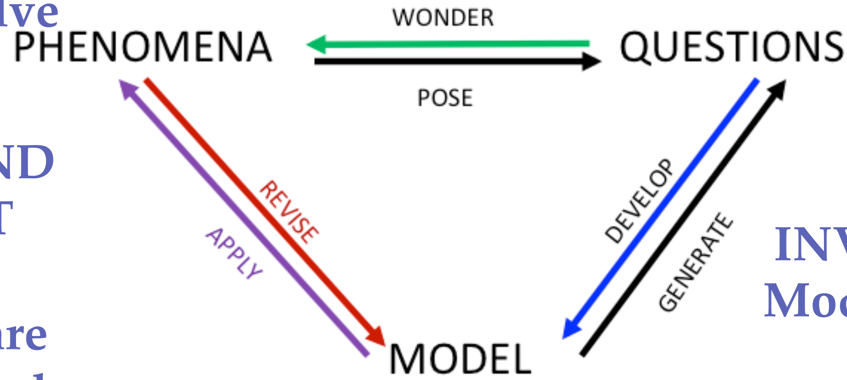
The Framework Says

"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,



DEVELOPING EXPLANATIONS
Models are revised and applied to "answer" or explain, predict, and solve

QUESTIONING
Models help identify questions and predict answers



ANALYZE AND INTERPRET DATA
And models are the filter through which data are interpreted

INVESTIGATIONS
Models help point to empirical investigations

ARGUMENTATION
Argumentation is involved in both developing and evaluating models

MATH AND COMP REASONING
We use mathematics to formulate some models and mathematical reasoning to evaluate models

COMMUNICATING & EVALUATING
Models hold and organize relevant information and become the focus of communicating

Models and theories are the purpose and the outcomes of scientific practices. They are the tools for engineering design and problem solving. As such, modeling guides the other practices.

P-Q-M in curriculum work

- We think if you are really doing a lesson using the practices then you can find yourself on the triangle somewhere.
- We call these learning segments:
  - P → Q
  - Q → M
  - M → Q
  - P → M
  - Q → P
  - M → P

Why does all this really matter?

Rachel Carson's
SENSE OF WONDER

From Zen Pencils

(www.zenpencils.com)

Rachel Carson's
SENSE OF WONDER

- Visit the Zen Pencils web site to see the full illustrated rendition – www.zenpencils.com

It is more important to pave the way for the child to ***want to know*** than to put him on a diet of facts he is not ready to assimilate.

-Rachel Carson

Reflection

Take just a few minutes to write down some of your thoughts about phenomena, questions, and models and using them in your instruction

Once you have finished find a person you haven't spoken with and have a conversation about your thinking

Thank You

- Cindy Passmore

    cpassmore@ucdavis.edu

- Arthur Beauchamp

    acbeauchamp@ucdavis.edu

http:/sasp.ucdavis.edu

Sense-making and Literacy Framework©