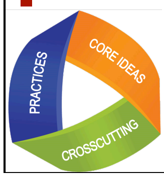
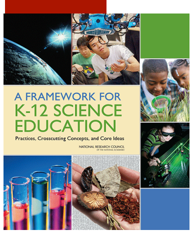
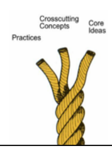


What is 3-Dimensional Learning?

Phenomena, Questions, and Models





The *Framework* supports our understanding that students are **born investigators** who acquire knowledge by integrating scientific and engineering practices, cross-cutting concepts, with core scientific ideas.

This **integration** provides a foundation for applying literacy and mathematical reasoning to answer questions about natural phenomena that are experienced.

Dimension 1: Scientific and Engineering Practices

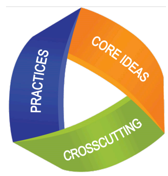
1. Asking questions (science) and defining problems (engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (science) and designing solutions (engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Multiple ways of knowing and doing that scientists and engineers use to study the natural world and design world. The practices work together – they are not separated.

Dimension 2: Crosscutting Concepts

1. Patterns
2. Cause and effect
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter
6. Structure and function
7. Stability and change

These are ideas that cut across and are important to all the science disciplines



Dimension 3 – Disciplinary Core Ideas

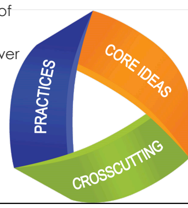
- Physical Sciences
- Life Sciences
- Earth & Space Sciences
- Engineering, Technology and Applications of Science

Disciplinary Significance with Explanatory Power

Generative

Relevant to Peoples' Lives

Useable from K-12



An Analogy between 3-Dimensional Learning and Cooking

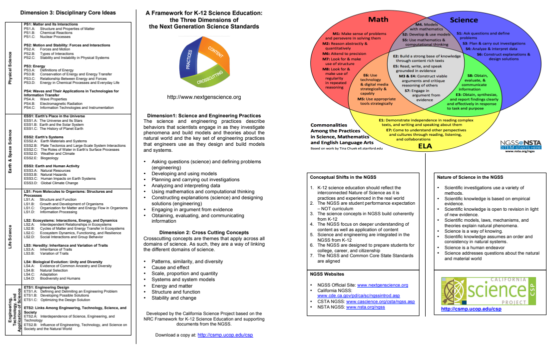
Kitchen Tools & Techniques (Practices)

Basic Ingredients (Core Ideas)

Vegetables, Herbs, Spices, & Seasonings (Crosscutting Concepts)

Preparing a Meal (Three dimensional Learning)

NGSS Cheat Sheet Handout



What is 3-Dimensional Learning?

Three-Dimensional Learning shifts the focus of the science classroom to environments where students use disciplinary core ideas, crosscutting concepts with scientific practices to explore, examine, and explain how and why phenomena occur and to design solutions to problems.

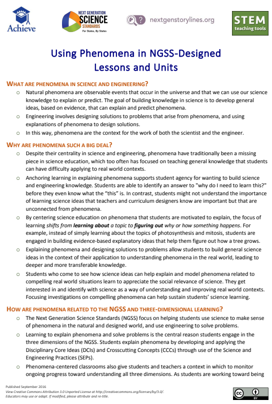
The working together of the three dimensions to make sense of phenomena and design solutions to problems is referred to as 3-dimensional learning.

Joe Krajcik, http://www.activatelearning.com/3-dimensional-learning/

Phenomena

- Natural phenomena are observable events that occur in the universe and that we use our science knowledge to explain and predict. The goal of building knowledge in science is to develop ideas, based on evidence, that can explain and predict phenomena.

Individually read and underline, highlight, or make notes of statements that strike you.



Using Phenomena in NGSS-Designed Lessons and Units

What are phenomena in science and engineering?

- Natural phenomena are observable events that occur in the universe and that we can use our science knowledge to explain or predict. The goal of building knowledge in science is to develop general ideas, based on evidence, that can explain and predict phenomena.
- Engineering involves designing solutions to problems that arise from phenomena, and using explanations of phenomena to design solutions.
- In this way, phenomena are the context for the work of both the scientist and the engineer.

Why are phenomena such a big deal?

- Despite their centrality in science and engineering, phenomena have traditionally been a missing piece in science education, which too often has focused on teaching general knowledge that students can have difficulty applying to real world contexts.
- Anchoring learning in explaining phenomena supports student agency for wanting to build science and engineering knowledge. Students are able to identify an answer to "why do I need to learn this?" before they even know what the "this" is. In contrast, students might not understand the importance of learning science ideas that teachers and curriculum designers know are important but that are unconnected from phenomena.
- By centering science education on phenomena that students are motivated to explain, the focus of learning *shifts from* ***learning about*** *a topic to* ***figuring out*** *why or how something happens*. For example, instead of simply learning about the topics of photosynthesis and mitosis, students are engaged in building evidence-based explanatory ideas that help them figure out how a tree grows.
- Explaining phenomena and designing solutions to problems allow students to build general science ideas in the context of their application to understanding phenomena in the real world, leading to deeper and more transferable knowledge.
- Students who come to see how science ideas can help explain and model phenomena related to compelling real world situations learn to appreciate the social relevance of science. They get interested in and identify with science as a way of understanding and improving real world contexts. Focusing investigations on compelling phenomena can help sustain students' science learning.

How are phenomena related to the NGSS and three-dimensional learning?

- The Next Generation Science Standards (NGSS) focus on helping students use science to make sense of phenomena in the natural and designed world, and use engineering to solve problems.
- Learning to explain phenomena and solve problems is the central reason students engage in the three dimensions of the NGSS. Students explain phenomena by developing and applying the Disciplinary Core Ideas (DCIs) and Crosscutting Concepts (CCCs) through use of the Science and Engineering Practices (SEPs).
- Phenomena-centered classrooms also give students and teachers a context in which to monitor ongoing progress toward understanding all three dimensions. As students are working toward being

Published September 2016

Final Word (Jerome Harste, Indiana University)

1. Once everyone is finished reading, underlining, or highlighting, one person goes first and reads one of their statements without adding any additional comments.
2. The person sitting to their right then makes a comment about the statement that the first person read while other group members listen quietly.
3. Once the second person has commented, the process proceeds around the group until it gets back to the person who read the original statement.
4. The original person then says what they want about the statement and comments (the final word) on what they heard from the other group members.

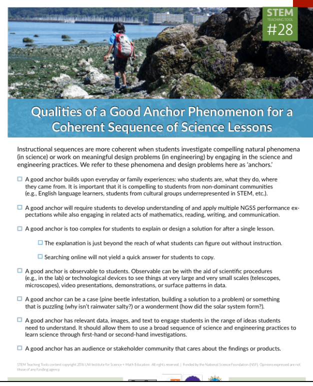
The process repeats with the second person and so on until everyone in the group has had a "final word".

Criteria for Phenomena

- The phenomenon…

1. address the targeted DCI
2. is observable to students, either thorugh firsthand experiences or through someone else's experiences (recording or measurements)
3. is likely to be comprehensible to students
4. is attention-getting thought provoking, and requires some epxlanations so that it is likely to engage all students and motivate them to focus on the DCI
5. is efficient in that the benefits justify any financial costs and time devoted to using the phenomenon with students

Anchor Phenomena

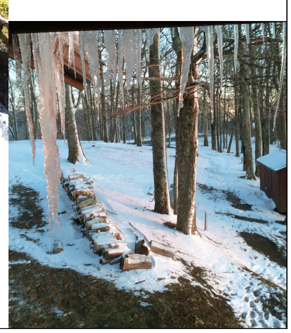

STEM TEACHING TOOLS
#28

Qualities of a Good Anchor Phenomenon for a Coherent Sequence of Science Lessons

Instructional sequences are more coherent when students investigate compelling natural phenomena (in science) or work on meaningful design problems (in engineering) by engaging in the science and engineering practices. We refer to these phenomena and design problems here as 'anchors.'

- ☐ A good anchor builds upon everyday or family experiences: who students are, what they do, where they came from. It is important that it is compelling to students from non-dominant communities (e.g., English language learners, students from cultural groups underrepresented in STEM, etc.).
- ☐ A good anchor will require students to develop understanding of and apply multiple NGSS performance expectations while also engaging in related acts of mathematics, reading, writing, and communication.
- ☐ A good anchor is too complex for students to explain or design a solution for after a single lesson.
  - ☐ The explanation is just beyond the reach of what students can figure out without instruction.
  - ☐ Searching online will not yield a quick answer for students to copy.
- ☐ A good anchor is observable to students. Observable can be with the aid of scientific procedures (e.g., in the lab) or technological devices to see things at very large and very small scales (telescopes, microscopes), video presentations, demonstrations, or surface patterns in data.
- ☐ A good anchor can be a case (pine beetle infestation, building a solution to a problem) or something that is puzzling (why isn't rainwater salty?) or a wonderment (how did the solar system form?).
- ☐ A good anchor has relevant data, images, and text to engage students in the range of ideas students need to understand. It should allow them to use a broad sequence of science and engineering practices to learn science through first-hand or second-hand investigations.
- ☐ A good anchor has an audience or stakeholder community that cares about the findings or products.

Examples



The Power of Phenomena

- Teachers can provide students with a **shared experience** by using a **common phenomena**.
- These phenomena can be used to develop questions, create models (and use other SEPs), and develop new understandings about DCIs as part of a meaningful cycle.
- "They can act as a 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 asking questions." *A. Beauchamp*

A Sequence to Promote Sense Making

NGSS@ NSTA

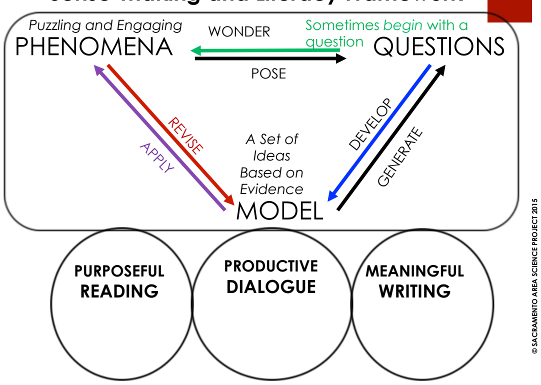
Phenomena
What was the event(s) in the world that happened that we need to explain?

Question
What about the phenomena do we need to explain?

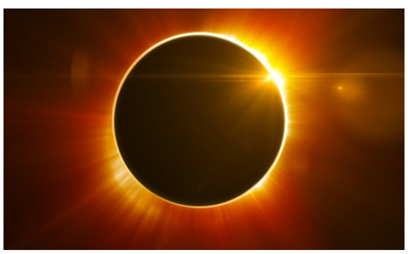
Science and Engineering Practices
How are we modeling, explaining, etc. the phenomena, or designing a solution to solve the problem?

New Ideas
What did we figure out using these practices?
What pieces of the DCIs or CCCs did we figure out?
What new ideas do we have?
What questions do I have?

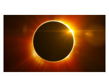
Sense-making and Literacy Framework©



Let's Start with a Shared Phenomena



About the solar eclipse. We might wonder…

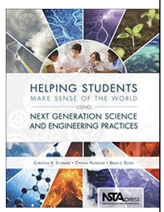


- What causes the solar eclipse?
- Why don't we see at all locations on the Earth at the same time?
- Why don't they occur more often?
- Etc.
- What other questions can you think of?

Key Features of the "Asking Questions" Practice

- Questioning involves developing and revising explanatory questions about how and why phenomena happen.
- Both teachers and students are critical players in asking productive questions.
- Questioning helps identify what about the phenomena needs to be investigated.

Helping Students Make Sense of the World Using Next Generation Science and Engineering Practices. NSTA Press, 2017



How can we help students develop questions?

- The Right Question Institute - Question Formulation Technique – QFT
  - http://rightquestion.org/education/
- 5 Whys
- Wait, What? And Life's Other Essential Questions

Question Formulation Technique

- Use a Focus or Question Focus
- Produce your questions
- Improve your questions
- Prioritize your questions
- Discuss next steps
- Reflect

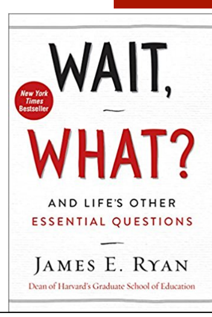
5 Whys

- 5 Whys – an interactive 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.
- Example:
- 1. Why did this phenomenon occur? Try out the 5 Whys with the Solar Eclipse. Record the questions that you come up with.

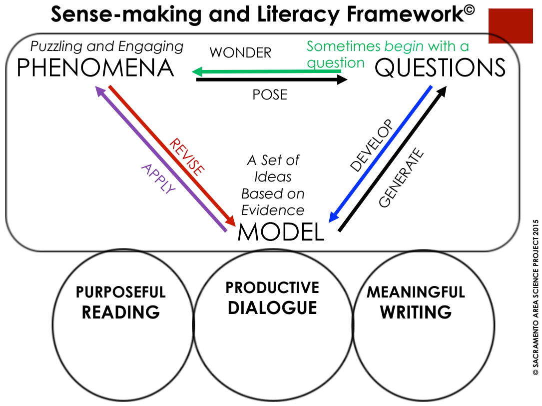
Wait, What?

- By James Ryan

1. Wait, What?
2. I wonder…
3. Couldn't we at least…
4. How can I help?
5. What truly matters?



Sense-making and Literacy Framework©



Return to Reasoning Triangle

- So now we've noticed some interesting things in the world:

PHENOMENON

- And we wondered about specific aspects of that thing:

QUESTIONS

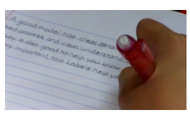
- So now we need to figure out what is going on.

We need a **MODEL**!

The Framework Says

32

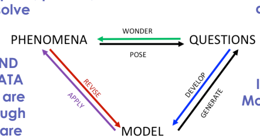
Models serve the purpose of being a tool for thinking with, making predictions and making sense of experience." And further "scientists use models…to represent their current understanding of a system under study, to aid in the development of questions and explanations, and to communicate ideas to others." (NRC, 2011)



The Reasoning Triangle and the SEPs

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

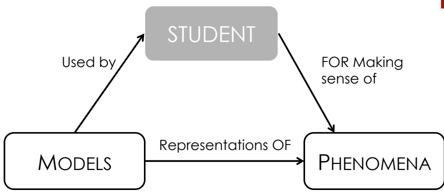
INVESTIGATIONS
Models help point to empirical investigations

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 ideas

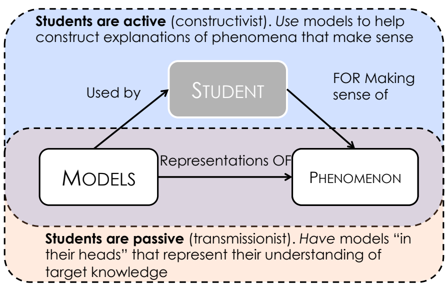
More Shift



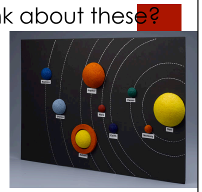
The OF/FOR Distinction

Shift from Dyadic to Triadic (Knuuttila, 2005)

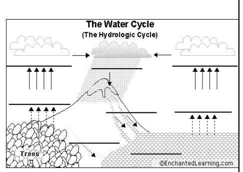
A shift in the instructional paradigm



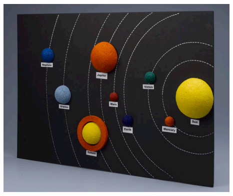
How '**MODELS *FOR***' helps us think about these?

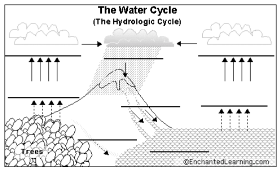


$$Q = m\,c\,\Delta T$$

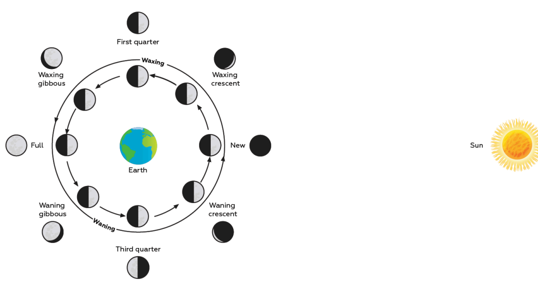


Try out **'MODELS *FOR*'** on these two
(hint: think about the PHENOMENA and QUESTIONS)





A diagram of the Moon phases in relation to the Sun and Earth



Eclipse Reading
Partner A & B read

- In A-B pairs, A Starts – read a paragraph aloud.
- Partner B listens and paraphrases the meaning.
- Partner A then shares a connection he/she can make with the text.
- Next paragraph – switch roles.
- Continue until the entire reading is complete.

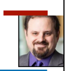
Think-Pair-Share Model for Eclipse

- Based on your observations, reading, and thinking about eclipses – compare and contrast solar and lunar eclipses.
- Create a labeled drawing(s) that represents your understanding of solar and lunar eclipses.

Think – my thoughts or understanding at this time.	**Pair –** what I understand my partner is telling me.
Share – Our common understanding after talking, what we can share with others or what was most important from out dialogue.	

A Sequence to Promote Sense Making

NGSS@ NSTA



Phenomena

What was the event(s) in the world that happened that we need to explain?

Question

What about the phenomena do we need to explain?

Science and Engineering Practices

How are we modeling, explaining, etc. the phenomena, or designing a solution to solve the problem?

New Ideas

What did we figure out using these practices?

What pieces of the DCIs or CCCs did we figure out?

What new ideas do we have?

What questions do I have?

Reflect

- What Science and Engineering Practices did we specifically use during our exploration of eclipses?
- Crosscutting Concepts?
- Disciplinary Core Ideas?
- How did we use
  - Purposeful Reading
  - Productive Dialogue, and
  - Meaningful Writing?