Selecting Phenomena to Motivate Student Sense-making

NSTA Area Conference
Portland
November 10, 2016
The Role of Phenomena in Coherence
Importance of Phenomena

• The word phenomena (or phenomenon) appears 114 times in the Framework.
# EQuIP Rubric

## I. NGSS 3D Design

The lesson/unit is designed so students make sense of phenomena and/or design solutions to problems by engaging in student performances that integrate the three dimensions of the NGSS.

A. **Explaining Phenomena/Designing Solutions:** Making sense of phenomena and/or designing solutions to a problem drive student learning.
   1. Student questions and prior experiences related to the phenomenon or problem motivate sense-making and/or problem solving.
   2. The focus of the lesson is to support students in making sense of phenomena and/or designing solutions to problems.
   3. When engineering is a learning focus, it is integrated with developing disciplinary core ideas from physical, life, and/or earth and space sciences.

B. **Three Dimensions:** Builds understanding of multiple grade-appropriate elements of the science and engineering practices (SEPs), disciplinary core ideas (DCIs), and crosscutting concepts (CCCs) that are deliberately selected to aid student sense-making of phenomena and/or designing of solutions.
   1. Provides opportunities to develop and use specific elements of the SEP(s).
   2. Provides opportunities to develop and use specific elements of the DCI(s).
   3. Provides opportunities to develop and use specific elements of the CCC(s).

A. **Integrating the Three Dimensions:** Student sense-making of phenomena and/or designing of solutions requires student performances that integrate elements of the SEPs, CCCs, and DCIs.

## II. NGSS Instructional Supports

The lesson/unit supports three-dimensional teaching and learning for ALL students by placing the lesson in a sequence of learning for all three dimensions and providing support for teachers to engage all students.

A. **Relevance and Authenticity:** Engages students in authentic and meaningful scenarios that reflect the practice of science and engineering as experienced in the real world.
   1. Students experience phenomena or design problems as directly as possible (firsthand or through media representations).
   2. Includes suggestions for how to connect instruction to the students’ home, neighborhood, community and/or culture as appropriate.
   3. Provides opportunities for students to connect their explanation of a phenomenon and/or their design solution to a problem to questions from their own experience.

B. **Student Ideas:** Provides opportunities for students to express, clarify, justify, interpret, and represent their ideas and to respond to peer and teacher feedback orally and/or in written form as appropriate.

C. **Building Progressions:** Identifies and builds on students’ prior learning in all three dimensions, including providing the following support to teachers:
   1. Explicitly identifying prior student learning expected for all three dimensions
   2. Clearly explaining how the prior learning will be built upon

D. **Scientific Accuracy:** Uses scientifically accurate and grade-appropriate scientific information, phenomena, and representations to support students’ three-dimensional learning.

E. **Differentiated Instruction:** Provides guidance for teachers to support differentiated instruction by including:
   1. Appropriate reading, writing, listening, and/or speaking alternatives (e.g., translations, picture support, graphic organizers, etc.) for students who are English language learners, have special needs, or read well below the grade level.
   2. Extra support (e.g., phenomena, representations, tasks) for students who are struggling to meet the targeted expectations.
   3. Extensions for students with high interest or who have already met the performance expectations to develop deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts.

## III. Monitoring NGSS Student Progress

The lesson/unit supports monitoring student progress in all three dimensions of the NGSS as students make sense of phenomena and/or design solutions to problems.

A. **Monitoring 3D student performances:** Elicits direct, observable evidence of three-dimensional learning; students are using practices with core ideas and crosscutting concepts to make sense of phenomena and/or to design solutions.

B. **Formative:** Embeds formative assessment processes throughout that evaluate student learning to inform instruction.

C. **Scoring guidance:** Includes aligned rubrics and scoring guidelines that provide guidance for interpreting student performance along the three dimensions to support teachers in (a) planning instruction and (b) providing ongoing feedback to students.

D. **Unbiased tasks/items:** Assesses student proficiency using methods, vocabulary, representations, and examples that are accessible and unbiased for all students.
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A. Explaining Phenomena/Designing Solutions:
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i. Student questions and prior experiences related to the phenomenon or problem motivate sense-making and/or problem solving.

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iii. When engineering is a learning focus, it is integrated with developing disciplinary core ideas from physical, life, and/or earth and space sciences.
Definition

• something (such as an interesting fact or event) that can be observed and studied and that typically is unusual or difficult to understand or explain fully
Q&A about Phenomena
Muppets “Phenomena” Song

Phenomena are events in nature
Phenomena: Let’s investigate
Phenomena are events in nature that scientists and students investigate and then try to explain
• **Explanatory ideas** are important so that students are figuring out phenomena and not just learning about facts and details.

• **Science and engineering practices** build explanatory ideas.
Thinking About Coherence

- **Coherence across time**: Building ideas with increasing sophistication across multiple grade bands

- **Coherence between disciplines**: Building explanatory models across disciplines

- **Coherence within a unit**: Building a coherent storyline (an explanatory story) that helps students develop explanations about questions and phenomena using science practices
Elements of Coherence

**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?
Questions about Phenomena

• What are phenomena?
• Why are phenomena such a big deal?
• How are phenomena related to the NGSS and three-dimensional learning?
• How do we use phenomena to drive teaching and learning?
• What makes phenomena effective for instruction?
### Shifts in Thinking

<table>
<thead>
<tr>
<th>Prior Thinking about Phenomena</th>
<th>Thinking about Phenomena Through the NGSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>If it’s something fun, flashy, or involves hands-on activities, it must be engaging.</td>
<td>Authentic engagement does not have to be fun or flashy; instead, engagement is determined more by how the students generate compelling lines of inquiry that create real opportunities for learning.</td>
</tr>
<tr>
<td>Anything students are interested in would make a good “engaging phenomenon”</td>
<td>Students need to be able to engage deeply with the material in order to generate an explanation of the phenomenon using target DCIs, CCCs, and SEPs.</td>
</tr>
<tr>
<td>Explanations (e.g., “electromagnetic radiation can damage cells”) are examples of phenomena</td>
<td>Phenomena (e.g., a sunburn, vision loss) are specific examples of something in the world that is happening—an event or a specific example of a general process. Phenomena are NOT the explanations or scientific terminology behind what is happening. They are what can be experienced or documented.</td>
</tr>
<tr>
<td>Phenomena are just for the initial hook</td>
<td>Phenomena can drive the lesson, learning, and reflection/monitoring throughout. Using phenomena in these ways leads to deeper learning.</td>
</tr>
<tr>
<td>Phenomena are good to bring in after students develop the science ideas so they can apply what they learned</td>
<td>Teaching science ideas in general (e.g., teaching about the process of photosynthesis) may work for some students, but often leads to decontextualized knowledge that students are unable to apply when relevant. Anchoring the development of general science ideas in investigations of phenomena helps students build more usable and generative knowledge.</td>
</tr>
<tr>
<td>Engaging phenomena need to be questions</td>
<td>Phenomena are observable occurrences. Students need to use the occurrence to help generate the science questions or design problems that drive learning.</td>
</tr>
<tr>
<td>Student engagement is a nice optional feature of instruction, but is not required</td>
<td>Engagement is a crucial access and equity issue. Students who do not have access to the material in a way that makes sense and is relevant to them are disadvantaged. Selecting phenomena that students find interesting, relevant, and consequential helps support their engagement. A good phenomenon builds on everyday or family experiences: who students are, what they do, where they came from.</td>
</tr>
</tbody>
</table>
Criteria for Phenomena

The phenomenon...

1. addresses the targeted DCI element

2. is observable to students, either through firsthand experiences or through someone else’s experiences (such as a recording or set of measurements).

3. is likely comprehensible to students. For example:
   - The relationship to the DCI element is clear and easy to comprehend.
   - Any experimental procedure, calculations, and measurements are unlikely to detract from the learning experience.
   - Additional ideas and reasoning skills needed by students are appropriate (given students' grade level and prior experiences).

4. is attention-getting and thought-provoking, and requires some explanation so that it is likely to engage all students and motivate them to focus on the DCI element.

5. is efficient in that the benefits justify any financial costs and time devoted to using the phenomenon with students.
Phenomena as Breadcrumbs
What Are Anchor Phenomena?

Anchor phenomena are puzzling, meaningful phenomena to anchor a unit. What criteria can we use for anchor phenomena?

- They hook student interest and are comprehensible to them.
- They require a number of lessons to study since they are complex (rich in science content).
- They are observable—an event or a process.
- The best are cases of specific events in specific contexts.
- They are introduced to students through an anchoring activity (e.g., a video, demo, firsthand experience, or reading).
- They stimulate a driving question that students will work to answer over the course of the unit.
A Good Anchor Phenomenon...

• builds upon everyday or family experiences and is compelling to students
• requires students to develop understanding of and apply multiple NGSS performance expectations
• Requires engaging in related acts of mathematics, reading, writing, and communication.
• is too complex for students to explain or design a solution for after a single lesson.
• is observable to students.
• can be a case, something that is puzzling, or a wonderment.
• has relevant data, images, and text to engage students in the range of ideas students need to understand.
• has an audience or stakeholder community that cares about the findings or products.
Central Role of Phenomena

- **Driving Question**
- **Anchoring Phenomenon**

**Lesson Level Phenomena**

1. Phenomenon
2. Phenomenon
3. Phenomenon
4. Phenomenon

**Lesson Level Questions**

1. Question
2. Question
3. Question
4. Question

**Investigate and Build Knowledge Through Practices**

1. Investigate, Analyze Data, Explain
2. Explain, Argue, Model
3. Explain, Argue, Model
4. Investigate, Model

**Incrementally Build Models That Explain Phenomena**

1. Initial Model
2. Add to/Revise Model
3. Add to/Revise Model
4. Final Consensus Model

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Reiser, B. 2014. Designing coherent storylines aligned with the NGSS for the K–12 classroom. *NSELA Conference*. Presentation in Boston, MA.
Anchor Phenomena

• **Anchor Phenomenon:** Singer shattering a glass with his voice

• **Driving Question:** Why was the singer able to shatter the glass?
Anchor Phenomena

From *A Private Universe: Minds of Our Own*

- **Anchor Phenomenon:** A grown tree has tremendous mass compared to the seed from which it came.

- **Driving Question:** Where did the mass come from? How could that happen?
Anchor Phenomena

• Anchor Phenomenon: The smell of peppermint oil spreading through a classroom.

• Driving Question: How can we smell odors from across the room?
Anchor Phenomena

- Why are earthquakes more common in some places than in others?
Anchor Phenomena

- Why does a cannon recoil when it’s fired?
Integrating the Three Dimensions

Performance Expectation

Disciplinary Core Idea

Phenomena

How students engage in the phenomena

Practice

Crosscutting Concept
How student ideas affect selecting phenomena
The Earth is flat.
There are two Earths, a flat one that we live on and a spherical one in space.
The Earth is spherical, but people live on a flat surface inside it.
The Earth is spherical, but people live only on the surface of the top hemisphere.
The Earth is spherical, and people live all over the surface (scientifically correct).
Ideas Students Have about “Up” and “Down”

• There is an absolute “down.”

• There is an Earth-referenced “down” to the surface of the Earth (acceptable for students in grades 3-5).

• There is an Earth-referenced “down” to the center of the Earth (scientifically correct).
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Phenomena
Photographs of Earth in Space

Brief Description: Photographs of different parts of the Earth from space show that the Earth appears like a circle. Different photos of different sides of the Earth show different landforms and oceans.

Purpose: This phenomenon can help students see that the Earth is not a flat disk (see Ideas Student Have: The Earth is flat). Photographs of the Earth from several different sides (with different landforms and oceans) show that the Earth always looks like a circle. A sphere is the only shape that looks like a circle from all sides, which students can confirm in the viewing different solids from a variety of angles. (See the activity below). In addition, comparisons of the photos to a globe can show that the globe provides an accurate representation of the Earth. [Note: Avoid photos that show part of the Earth in shadow.]
Phenomena
Photographs of Earth in Space
Photographs of Different Scales of Earth
NASA Goddard Space Flight Center’s Scientific Visualization Studio uses data from several different satellites to produce a film that depicts the view one would have zooming out into space from Atlanta, Chicago, Los Angeles, New York, Orlando, San Francisco, and Washington, DC and many other locations. available at NASA Goddard's Visualization Studio.

http://svs.gsfc.nasa.gov/search/AnimationSeries/GreatZooms.html
Ship at the Horizon

Video from the FOSS *Planetary Science* CD-ROM (Version 2.0)
Chicago from Lake Michigan
Earth’s Shadow in Lunar Eclipse

The images are very vivid...

but do elementary students know enough about light and shadows (and eclipses) to interpret the images?
Representation: Map vs. Globe

Compare nonstop flight travel times between cities to the distances between the cities measured on a map and on a globe.
Representation:
Viewing spheres of increasing size diameter
**Flat Piece of Spherical Melon**

**Brief Description:** When a small plug is removed from a melon, the surface of the rind side appears flat. When the plug is reinserted into the melon, the surface appears curved.

**Purpose:** The purpose is to clarify the counterintuitive notion that a spherical surface can appear flat when viewed up close. The link can then be made to the local flatness of the large spherical Earth.
Representation

“Upside-down” Map