<table>
<thead>
<tr>
<th>Segment 1</th>
<th>8:15-8:45</th>
<th>Welcome! Goals for Science/STEM Learning Targets for This Workshop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Segment 2</td>
<td>8:45 -9:15</td>
<td>What is Sensemaking?</td>
</tr>
<tr>
<td>Segment 3</td>
<td>9:15-11:45</td>
<td>Experience Sensemaking (1a) 15-minute break Experience Sensemaking (1b)</td>
</tr>
<tr>
<td>Lunch</td>
<td>11:45 – 12:45</td>
<td></td>
</tr>
<tr>
<td>Segment 4</td>
<td>12:45 – 2:15</td>
<td>Phenomena-driven Teaching and Learning</td>
</tr>
<tr>
<td>Segment 5</td>
<td>2:15 - 2:30</td>
<td>Science in Action</td>
</tr>
</tbody>
</table>
Welcome!

Making Sense of Three-Dimensional Teaching and Learning - Day 1

Autauga County Technology Center
July 30-31, 2024
Today’s Presenter

Kate Soriano
NSTA Standards Implementation Specialist
ksoriano@nsta.org
**Collection of Resources**

**NSTA**

**Black Belt STEM Institute: Making Sense of Three-Dimensional Teaching and Learning Collection**

- **PRIVATE**
- **20 items**
- Workshop held at Autauga County Technology Center, July 30–31, 2024 (Prattville, AL)

Resources in “Black Belt STEM Institute: Making Sense of Three-Dimensional Teaching and Learning” Collection

<table>
<thead>
<tr>
<th>Title</th>
<th>Resource Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. STEM Teaching Tool 42: Using Phenomena in NGSS-Designed Lessons &amp; Units</td>
<td>Web Page</td>
</tr>
</tbody>
</table>

Meet Our Learning Community

**Alone Zone** (independent thinking time)

❖ Why do you think it is important for all students to learn science?

❖ What are your goals for your students in science?
Meet Our Learning Community

**Alone Zone** (independent thinking time)
- Why do you think it is important for all students to learn science?
- What are your goals for your students in science?

**Small Group**
- Share your thinking with your group.
- What is your group’s top science goal for students in your district(s)?
- After sharing, record your goal and post.
A Framework for K-12 Science Education

The framework is designed to help realize a vision for education in the sciences and engineering in which students, over multiple years of school, actively engage in science and engineering practices and apply crosscutting concepts to deepen their understanding of the core ideas in these fields.

The learning experiences provided for students should engage students with their own fundamental questions about the world and with how scientists have investigated and found answers to those questions.
Learning Goals

● Build an understanding of what three-dimensional teaching and learning looks like, feels like, and sounds like in the classroom.

● Be able to foster a community of evidence-based thinkers and position students as the “knowers” in the classroom.

● Gain strategies to leverage students’ assets (experiences, prior learning, curiosity, etc.) to learn science.

● Be able to apply workshop experience to identify characteristics of high-quality instructional materials.
Meet Ms. Katsanos’ Third-Graders

Students experienced the phenomenon of kidney beans germinating. (The beans look like kidney beans one day and then a few days later some kidney beans look like plants.)

Students have completed an investigation in which kidney beans with water and kidney beans without water were placed in sunny places and dark places.
Elementary Students Sensemaking

Students complete two tasks in this classroom video

Task 1. Reach a consensus using patterns in data on what it means for a seed to germinate (0:24-3:25)

Task 2. Make a claim in answer to the question about the phenomenon, “What do kidney beans need to successfully germinate?” (3:40-6:25)
Alone Zone

1. What are the students doing?

2. What is the teacher(s) doing?

3. Based on what you observed, what is sensemaking?
Alone Zone

1. What are the students doing?

2. What is the teacher(s) doing?

3. Based on what you observed, what is sensemaking?
High school biology students experience the phenomenon of populations changing over time and students’ questions about the phenomenon lead the class to wonder, “Can nature change populations?”

Students have used a computer simulation to “hunt” bacteria moving at different speeds due to differences in physical characteristics (number of flagella).
High School Students Sensemaking

Students complete two tasks in this classroom video.

Task 1: Use a simulation to identify cause-and-effect relationships between an organism’s ability to avoid prey and changes in that organism’s population over time.

Task 2: Construct an explanation(s) using science ideas and cause-and-effect relationships to help answer the question about what causes populations change. (2:53-7:11)
Alone Zone

1. What are the students doing?

2. What is the teacher doing?

3. Based on what you observed, what is sensemaking?
Alone Zone

1. What are the students doing?

2. What is the teacher doing?

3. Based on what you observed, what is sensemaking?
What is Sensemaking?

Small Group

• Discuss with your group members:
  o What were the students doing?
  o What was the teacher doing?

  *Cite specific examples from the classroom video.*

• As a group, describe *sensemaking*.

Set your poster aside; we’ll revisit these ideas later.
Why does a lot of hail, rain, or snow fall at some times and not others?

Lesson adapted from OpenSciEd Unit 6.2 Weather, Climate & Water Cycling.
Why does a lot of hail, rain, or snow fall at some times and not others?

Helium balloon hovering just above the floor
Student Hat: Think like a student.

Student/Teacher Hat: Think like a student, but note teacher guidance.

Teacher “Hat”: Reflect on student experience and educator moves.
Learning Community Norms

- We use and build on other’s ideas.
- We use evidence to support our ideas, ask for evidence from others, and suggest ways to get additional evidence.
- We are open to changing our minds.
- We challenge ourselves to think in new ways.

From OpenSciEd Classroom Norms
### Phenomenon

<table>
<thead>
<tr>
<th>Notice</th>
<th>Wonder</th>
</tr>
</thead>
</table>

Helium balloon hovering just above the floor

[https://youtu.be/Fj0hj_28Iqs?t=133](https://youtu.be/Fj0hj_28Iqs?t=133)
Phenomenon

Helium balloon hovering just above the floor

Partner Talk
Share with your partner
✅ Two observations
✅ One question
Phenomenon

Helium balloon hovering just above the floor

Partner Talk
Share with your partner
✔ Two observations
✔ One question

Be ready to share your question with the whole group and what you observed that caused you to ask that question.
Related Phenomenon: Investigation

We’re going to observe what happens to the soap-bubble film when the bottle is placed in warm water and in cold water.

Don’t forget to observe the bottle before you place it in the warm and cold water.
Related Phenomenon: Model

Create a group consensus model to explain your observations of the soap-bubble film when the bottle is on the table, in hot water, and in cold water.

Alone Zone
Make a “must have” list for this model. Consider

● What absolutely needs to be included in the model to explain your observations? (These are the parts of the model).

● What relationships between parts need to be included to help explain your observations?
Initial Consensus Models (Small Group)

Create a group consensus model to explain your observations of the soap-bubble film when the bottle is on the table, in hot water, and in cold water.

Use words, pictures, symbols, etc. to help communicate your thinking.

bottle in hot water  bottle on the table  bottle in cold water
Gallery Walk

Gather your group members and go on a gallery walk. Stop at each model and look for

- 2 things that are the same or similar compared to your group’s model.

- 2 things that are different compared to your group’s model.
Looking for Patterns

Place 1-3 yellow sticky notes on your own group’s model to identify things that are the same or similar on many or most of the models.

Place 1-3 pink sticky notes on your own group’s model to show things that are different from most of the models.
Gather your group members and join the whole group in a scientist circle.

What might need to happen in the scientists circle for you to feel comfortable sharing an idea?

What might prevent you from sharing an idea?
Where We’re Going Next

Create a model to explain our observations of the balloon (formatively assess students’ understanding).

Connect the bottle with soap-bubble film consensus model and balloon individual models to what happens to air in contact with Earth’s surface as it warms up over the course of a day (weather science idea).
Science and Engineering Practices (SEPs)

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
Developing and Using Models

Scientists use models … to represent their current understanding of a system (or parts of a system) under study, to aid in the development of questions and explanations, and to communicate ideas to others.
Developing and Using Models

Scientists construct mental and conceptual models of phenomena. Mental models are internal, personal, idiosyncratic, incomplete, unstable, and essentially functional. They serve the purpose of being a tool for thinking with, making predictions, and making sense of experience. Conceptual models, the focus of this section, are, in contrast, explicit representations that are phenomena they represent. Conceptual models can visualize and understand a phenomenon without solution to a design problem. Used in science, functional, or behavioral analogs, albeit simplistic, physical replicas, mathematical representations. Although they do not correspond entirely to observed or obscuring others. Because all models come with limitations, the range of validity of their applications, it is important to recognize the conceptual models in some settings that scientists hold and are used to building an understanding of models and constructing and revising mental models of phenomena to a deeper understanding of science.

GOALS

By grade 12, students should be able to:

- Construct drawings or diagrams as representations of events or systems—e.g., draw a picture of an insect with labeled features, represent what happens to the water in a puddle as it is warmed by the sun, or represent a simple physical model of a real-world object and use it as the basis of an explanation or to make predictions about how the system will behave in specified circumstances.
- Represent and explain phenomena with multiple types of models—for example, represent molecules with 3-D models or with bond diagrams—and move flexibly between model types when different ones are most useful for different purposes.
- Discuss the limitations and precision of a model as the representation of a system, process, or design and suggest ways in which the model might be improved to better fit available evidence or better reflect a design’s specifications. Refine a model in light of empirical evidence or criticism to improve its quality and explanatory power.
- Use (provided) computer simulations or simulations developed with simple simulation tools as a tool for understanding and investigating aspects of a system, particularly those not readily visible to the naked eye.
- Make and use a model to test a design, or aspects of a design, and to compare the effectiveness of different design solutions.

PROGRESSION

Modeling can begin in the earliest grades, with students’ models progressing from concrete “pictures” and/or physical scale models (e.g., a toy car) to more abstract representations of relevant relationships in later grades, such as a diagram representing forces on a particular object in a system. Students should be asked to use diagrams, maps, and other abstract models as tools that enable them to elaborate on their own ideas or findings and present them to others [13]. Young students should be encouraged to devise pictorial and simple graphical representations of the findings of their investigations and to use these models in developing their explanations of what occurred.
## K-12 Learning Progression for Developing and Using Models

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modeling in K–2 builds on prior experiences and progresses to include using and developing models (e.g., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions.</strong></td>
<td><strong>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.</strong></td>
<td><strong>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.</strong></td>
<td><strong>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 and designed world(s).</strong></td>
</tr>
<tr>
<td>- Distinguish between a model and the actual object, process, and/or events the model represents.</td>
<td>- Identify limitations of models.</td>
<td>- Evaluate limitations of a model for a proposed object or tool.</td>
<td>- Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism, or system in order to select or revise a model that best fits the evidence or design criteria.</td>
</tr>
<tr>
<td>- Compare models to identify common features and differences.</td>
<td>- Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events.</td>
<td>- Develop or modify a model—based on evidence—to match what happens if a variable or component of a system is changed.</td>
<td>- Design a test of a model to ascertain its reliability.</td>
</tr>
<tr>
<td>- Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s).</td>
<td>- Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution.</td>
<td>- Use and/or develop a model of simple systems with uncertain and less predictable factors.</td>
<td>- 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.</td>
</tr>
<tr>
<td>- Develop a simple model based on evidence to represent a proposed object or tool.</td>
<td>- Develop and/or use models to describe and/or predict phenomena.</td>
<td>- Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.</td>
<td></td>
</tr>
<tr>
<td>- Develop a diagram or simple physical prototype to convey a proposed object, tool, or process.</td>
<td>- Use a model to test cause-and-effect relationships or interactions concerning the functioning of a natural or designed system.</td>
<td>- Develop and/or use a model to predict and/or describe phenomena.</td>
<td></td>
</tr>
<tr>
<td>- Develop a complex model that allows for manipulation and testing of a proposed process or system.</td>
<td>- Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.</td>
<td>- Develop a model to describe unobservable mechanisms.</td>
<td></td>
</tr>
<tr>
<td>- Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Developing and Using Models

Teacher questions we can use to support students in developing models.

• What do you absolutely need to include model (parts/components) to explain the phenomenon?

• What is the relationship or interaction between this component and that component? (Pointing at two components on the model.) How might you represent that?

• How or why are the components interacting (mechanism) in this way? How might you represent that?
# K-12 Learning Progression PS3 Energy

## Disciplinary Core Ideas in Physical Science (continued)

<table>
<thead>
<tr>
<th>Graded K-2</th>
<th>Grades 3–5</th>
<th>Grades 6–8</th>
<th>Grades 9–12</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PS3.B: Conservation of Energy and Energy Transfer</strong></td>
<td><strong>Sunlight warms Earth's surface. (K-PS3-1),(K-PS3-2)</strong></td>
<td><strong>Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2),(4-PS3-3)</strong></td>
<td><strong>When the motion energy of an object changes, there is inevitably some other change in energy at the same time. (MS-PS3-5)</strong>&lt;br&gt;<strong>The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. (MS-PS3-4)</strong>&lt;br&gt;<strong>Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3)</strong></td>
</tr>
<tr>
<td><strong>PS3.C: Relationship Between Energy and Forces</strong></td>
<td><strong>A bigger push or pull makes things go faster. (secondary to K-PS2-1)</strong></td>
<td><strong>When objects collide, the contact forces transfer energy so as to change the objects' motions. (4-PS3-3)</strong></td>
<td><strong>When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. (MS-PS3-2)</strong></td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>------------</td>
<td>------------</td>
<td>-------------</td>
</tr>
<tr>
<td>• Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2), (4-PS3-3)</td>
<td>When the motion energy of an object changes, there is inevitably some other change in energy at the same time. (MS-PS3-5)</td>
<td>• Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1)</td>
<td></td>
</tr>
<tr>
<td>• Light also transfers energy from place to place. (4-PS3-2)</td>
<td>• The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. (MS-PS3-4)</td>
<td>• Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1), (HS-PS3-4)</td>
<td></td>
</tr>
<tr>
<td>• Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (4-PS3-2), (4-PS3-4)</td>
<td>Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3)</td>
<td>• Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1)</td>
<td></td>
</tr>
<tr>
<td>PS3.C: Relationship Between Energy and Forces</td>
<td>• When objects collide, the contact forces transfer energy so as to change the objects’ motions. (4-PS3-3)</td>
<td>When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. (MS-PS3-2)</td>
<td>• The availability of energy limits what can occur in any system. (HS-PS3-1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5)</td>
</tr>
</tbody>
</table>
Continuum of Science Instruction

**Information Frame**
- Teacher is focused on disseminating information.
- Students are focused on knowing information.
- Science is portrayed as a body of established facts.
- Assessments are focused on “right” answers.

**Sensemaking Frame**
- Teacher is focused on developing conceptual understanding.
- Students are focused on understanding something.
- Science is portrayed as a way to make sense of something.
- Assessments are focused on use of evidence to support conclusions/generalizations.

Knowing about...

Figuring out...
Continuum of Science Instruction

Information Frame
- Teacher is focused on disseminating
- Science is portrayed as a body of established facts.
- Assessments are focused on “right” answers.
  Knowing about..

Sensemaking Frame
- Teacher is focused on developing conceptual
- Science is portrayed as a way to make sense of something.
- Assessments are focused on use of evidence to support conclusions/generalizations.
  Figuring out…

From: Cynthia Passmore, NSTA Virtual PD, Nov. 15, 2014
Continuum of Science Instruction

Information Frame
• Teacher is focused on disseminating information.
• Students are focused on knowing information.
• Science is portrayed as a body of established facts.
• Assessments are focused on “right” answers.

Knowing about...

Sensemaking Frame
• Teacher is focused on developing conceptual understanding.
• Students are focused on understanding something.
• Science is portrayed as a way to make sense of something.
• Assessments are focused on use of evidence to support conclusions/generalizations.

Figuring out...
What are phenomena?

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.
Shifting Toward Sensemaking

Students sensemaking in a 4th-grade classroom.
Shifting Toward the Sensemaking

Information Frame  Sensemaking Frame

Less Like  More Like

Soils, Rocks, and Landforms
Shifting Toward the Sensemaking

Information Frame

Sensemaking Frame

Less Like

More Like

Soils, Rocks, and Landforms
Choosing Phenomena

What phenomenon can I put in front of students that will get them to ask questions that require the targeted science ideas to answer?

That is, what phenomenon requires the targeted science ideas to explain *how* or *why* the phenomenon occurs?
Phenomenon: Channeled Scablands

Video clip 02:56 – 04:52

https://vimeo.com/331335155
Phenomenon: Channeled Scablands

Alone Zone
What experiences do you have that might help you think about the Channeled Scablands phenomenon?
Where have you experienced something that reminds you of this phenomenon (the experience is similar but not quite the same)?

Partner Talk
Please share your experience(s) with related phenomena with your partner and tell them how it connects with the Channeled Scablands.
Wonderings

• Review your own observations and the observations shared by the class.
• Think about your own and shared related phenomena.
• Review the questions you recorded in the “I wonder” column of your table.
• Add new questions and/or revise questions you recorded while watching the video of the Channeled Scablands.
• Choose one or two questions to share.
Phenomenon: Channeled Scablands

Video clip 02:56 – 04:52

Our wonderings about the Channeled Scablands

Why is it so flat?!  
Was there water there? Where did it go?

How did the layers get there?  
Is there different matter in the different layers?

Why did the waterfall dry up?  
Where did the boulders come from?

Are there fossils in the rock?  
What kind of wildlife or living organisms are there?

How long did it take to form the Scablands?  
How did the ash get there? Was there a volcanic eruption?
Targeted Disciplinary Core Ideas (ESS)

Disciplinary Core Ideas in Earth and Space Science (continued)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Some events happen very quickly; others occur very slowly, over a time period much longer than one can observe. (2-ESS1-1)</td>
<td>Local, regional, and global patterns of rock formations reveal changes over time due to Earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed. (4-ESS1-1)</td>
<td>The geologic time scale interpreted from rock strata provides a way to organize Earth’s history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. (MS-ESS1-4)</td>
<td>• Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. (HS-ESS1-5)</td>
<td>• Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth’s formation and early history. (HS-ESS1-6)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ESS2: Earth’s Systems</th>
<th>Grades K–2</th>
<th>Grades 3–5</th>
<th>Grades 6–8</th>
<th>Grades 9–12</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Wind and water can change the shape of the land. (2-ESS2-1)</td>
<td>Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. (4-ESS2-1)</td>
<td>All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. This energy is derived from the Sun and Earth’s hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth’s materials and living organisms. (MS-ESS2-1)</td>
<td>• Earth’s systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1), (HS-ESS2-2)</td>
<td>• Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth’s surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, and a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth’s interior and gravitational movement of denser materials toward the interior. (HS-ESS2-3)</td>
</tr>
<tr>
<td>ESS2.A: Earth Materials and Systems</td>
<td>• Earth’s major systems are the geosphere (solid and molten rock, soils, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth’s surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. (5-ESS2-1)</td>
<td>The planet’s systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth’s history and will determine its future. (MS-ESS2-2)</td>
<td>• The geologic record shows that changes to global and regional climate can be caused by interactions among changes in the Sun’s energy output or Earth’s orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (HS-ESS2-4)</td>
<td></td>
</tr>
</tbody>
</table>
Targeted ESS Disciplinary Core Ideas

**ESS1: Earth’s Place in the Universe**

**ESS1.C: The History of Planet Earth**
- Local, regional, and global patterns of rock formations reveal changes over time due to Earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed.

**ESS2: Earth’s Systems**

**ESS2.A: Earth Materials and Systems**
- Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity breaks rocks, soils, and sediments into smaller particles and move them around.
Targeted ESS Disciplinary Core Ideas

ESS1: Earth’s Place in the Universe
ESS1.C: The History of Planet Earth

- Local, regional, and global patterns of rock formations reveal changes over time due to Earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in

Do we need these science ideas to answer our questions about the Channeled Scablands?

ESS2.A: Earth Materials and Systems

- Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity breaks rocks, soils, and sediments into smaller particles and move them around.
**Phenomena**

**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 explorations 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 “why” is. In contrast, students might not understand the importance of learning science ideas that teachers and curriculum designers know are important but that are disconnected 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 competing real-world situations learn to appreciate the social relevance of science. They get interested in and who come to see how science ideas can help explain and model phenomena related to competing real-world situations learn to appreciate the social relevance of science. They get interested in science as a way of understanding and improving real-world contexts. Focusing investigations on competing 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

<table>
<thead>
<tr>
<th>Phenomena (Cause)</th>
<th>Phenomenon (Effect)</th>
</tr>
</thead>
<tbody>
<tr>
<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>
<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., &quot;electromagnetic radiation can damage cells&quot;) are examples of phenomena.</td>
<td>phenomena (e.g., a sunburn, vision loss) are specific examples of something in the world that is happening—is 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) 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 flexible 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 come from.</td>
</tr>
</tbody>
</table>

---

Published September 30, 2019

Creative Commons Attribution 3.0 Unported License (http://creativecommons.org/licenses/by/3.0)

Educators may use, adapt, remix, distribute, and create.
<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>
Phenomenon: Channeled Scablands

Choose one characteristic/description of thinking about phenomena that resonates with you.

How does the Channeled Scablands phenomenon exemplify this characteristic/description?

Be ready to share the connection you made between the description (#) and your experience with Channeled Scablands phenomenon.

**THINKING ABOUT PHENOMENA THROUGH THE NGSS**

1. 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.

2. 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.

3. 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.

4. Phenomena can drive the lesson, learning, and reflection/monitoring throughout. Using phenomena in these ways leads to deeper learning.

5. 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.

6. Phenomena are observable occurrences. Students need to use the occurrence to help generate the science questions or design problems that drive learning.

7. 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.
Choose one characteristic/description of thinking about phenomena that resonates with you.

How does the Channeled Scablands phenomenon exemplify this characteristic/description?

Be ready to share the connection you made between the description (#) and your experience with Channeled Scablands phenomenon.
Phenomena: Equity

• Students have a common experience with the phenomenon (no one student is at an advantage or disadvantage).

• Students connect to the phenomenon through their experience with related phenomena.

• Students’ experience with related phenomena valued by learning community.

• In trying to explain the phenomenon, students recognize gaps in their knowledge which leads to questions they want to answer.
Phenomena

The point of using phenomena to drive instruction is to help students engage in practices to develop the knowledge necessary to explain or predict the phenomena.

It is the **phenomenon plus the student-generated questions** about the phenomenon **that guides the learning and teaching**.

STEM Teaching Tool 42
Sensemaking: Putting the Pieces Together

Alone Zone

Look and listen for evidence that students have been/are currently focused on explaining the phenomenon of the Channeled Scablands.

How is the teacher supporting students in tracking their own progress in explaining the phenomenon over time?

Elementary Science at Beaver Acres
Sensemaking: Putting the Pieces Together
Phenomena and Coherence

Anchor Phenomenon

Investigative Phenomenon

Related Phenomenon

Questions

Phenomena

What We Figure Out

Practices to Engage In

The Story

3D
Students Build Understanding Piece by Piece
As you watch the video, think about:

- What is the **phenomenon** scientists are trying to explain?
- Which **science and engineering practices** (SEPs) do they engage with to build or use **science ideas** (DCIs) to explain how or why the phenomenon occurred?
- What are some of the ways the scientists **share and build on other’s ideas**?
Students making sense of phenomena and scientists making sense of phenomena are almost indistinguishable.
## Collection of Resources

### Black Belt STEM Institute: Making Sense of Three-Dimensional Teaching and Learning Collection

**PRIVATE**

20 items

Workshop held at Autauga County Technology Center, July 30–31, 2024 (Prattville, AL)

**Categories:** Earth & Space Science, Environmental Science, Life Science, Physical Science, Elementary, High School, Kindergarten

### Resources in “Black Belt STEM Institute: Making Sense of Three-Dimensional Teaching and Learning” Collection

<table>
<thead>
<tr>
<th>Title</th>
<th>Resource Type</th>
<th>Open in Library</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. STEM Teaching Tool 42: Using Phenomena in NGSS-Designed Lessons &amp; Units</td>
<td>Web Page</td>
<td></td>
</tr>
</tbody>
</table>

Where We’re Headed Today…

<table>
<thead>
<tr>
<th>Segment 1</th>
<th>8:15 - 8:35</th>
<th>Looking Back/Looking Forward</th>
</tr>
</thead>
<tbody>
<tr>
<td>Segment 2</td>
<td>8:35 - 10:45</td>
<td>Sensemaking Immersion 2 and 3 Dimensions Debrief</td>
</tr>
<tr>
<td>Segment 3</td>
<td>10:45 - 11:45</td>
<td>Productive Talk Goals and Moves</td>
</tr>
<tr>
<td>Lunch</td>
<td>11:45 – 12:45</td>
<td></td>
</tr>
<tr>
<td>Segment 4</td>
<td>12:45 – 2:15</td>
<td>Evaluate Student Artifacts Provide Feedback to Students</td>
</tr>
<tr>
<td>Segment 5</td>
<td>2:15 - 2:30</td>
<td>Reflecting on Ideas about Sensemaking Workshop Wrap-up</td>
</tr>
</tbody>
</table>
Welcome!

Making Sense of Three-Dimensional Teaching and Learning - Day 2

Autauga County Technology Center
July 30-31, 2024
What is Sensemaking?

Small Group
Revisit your initial ideas about sensemaking.

- What ideas are supported?
- What ideas might you want to add to or change?
- What questions can you now answer?

Post any new questions you have about sensemaking.
What is Sensemaking?

Whole Group

Share one thing your group added to or changed and tell why.
# Collection of Resources

![NSTA Logo](https://bit.ly/AUTAUGANSTA)

## Black Belt STEM Institute: Making Sense of Three-Dimensional Teaching and Learning Collection

**PRIVATE**

Workshop held at Autauga County Technology Center, July 30–31, 2024 (Prattville, AL)

- Earth & Space Science
- Environmental Science
- Life Science
- Physical Science
- Elementary
- High School
- Kindergarten

## Resources in “Black Belt STEM Institute: Making Sense of Three-Dimensional Teaching and Learning” Collection

<table>
<thead>
<tr>
<th>Title</th>
<th>Resource Type</th>
<th>Open in Library</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. STEM Teaching Tool 42: Using Phenomena in NGSS-Designed Lessons &amp; Units</td>
<td>📄 Web Page</td>
<td></td>
</tr>
</tbody>
</table>

Sensemaking - High School Example

Lesson Plan

Why Don't the Dishes Move?
Student Hat/Teacher “Hat”

Student Hat: Think like a student.

Student/Teacher Hat: Think like a student, but note teacher guidance.

Teacher “Hat”: Reflect on student experience and educator moves.
Learning Community Discourse Norms

- We use and build on other’s ideas.
- We use evidence to support our ideas, ask for evidence from others, and suggest ways to get additional evidence.
- We are open to changing our minds.
- We challenge ourselves to think in new ways.

From OpenSciEd Classroom Norms
What do you notice? Wonder?

https://youtu.be/o94Pm-Cty3M
What do you notice? Wonder?

Partner Talk
Share at least
✔ Two observations
✔ One question
## Class Notice and Wonder

<table>
<thead>
<tr>
<th>Notice</th>
<th>Wonder</th>
</tr>
</thead>
</table>
| • Both tables have dishes, cups, vases and a teapot.  
• Nothing fell off the table  
• Table setting of right table “mirror”/opposite of left table  
• Everything on the tables moved slightly, in the same direction as the tablecloth moved.  
• The tablecloth is made of a shiny material.  
• The magician pulled the tablecloth fast.  
• Some of the things on the table moved further than others. | • Are all the items on the table empty?  
• Why did everything stay on the table?  
• Why didn’t the tablecloth drag everything off the table?  
• Does the material of the tablecloth matter for the trick?  
• Does how fast he pulls the tablecloth matter?  
• Why did some things move further than others?  
• Did the things that moved further weigh less? (Were they empty?) |

Many of us are wondering why the objects stayed on the table. Should we investigate this first?
Coin in the Cup Investigation

Do you think we can explain the coin in the cup trick using our knowledge of forces?

What forces are acting on the penny in the vertical direction in each of the pictured instances?
### Coin in the Cup Investigation

<table>
<thead>
<tr>
<th>Notice</th>
<th>Wonder</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Both tables have dishes, cups, vases and a teapot.</td>
<td>- Are all the items on the table empty?</td>
</tr>
<tr>
<td>- Nothing fell off the table</td>
<td>- Why did everything stay on the table?</td>
</tr>
<tr>
<td>- Table setting of right table “mirror”/opposite of left table</td>
<td>- Why didn’t the tablecloth drag everything off the table?</td>
</tr>
<tr>
<td>- Everything on the tables moved slightly, in the same direction as the tablecloth moved.</td>
<td>- Does the material of the tablecloth matter for the trick?</td>
</tr>
<tr>
<td>- The tablecloth is made of a shiny material.</td>
<td>- Does how fast he pulls the tablecloth matter?</td>
</tr>
<tr>
<td>- The magician pulled the tablecloth fast.</td>
<td>- Why did some things move further than others?</td>
</tr>
<tr>
<td>- Some of the things on the table moved further than others.</td>
<td>- Did the things that moved further weigh less?</td>
</tr>
</tbody>
</table>
Can we use the cup, index card and penny (coin) to help explain other observations?

<table>
<thead>
<tr>
<th>Notice</th>
<th>Wonder</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Both tables have dishes, cups, vases and a teapot.</td>
<td>• Are all the items on the table empty?</td>
</tr>
<tr>
<td>• Nothing fell off the table</td>
<td>• Why did everything stay on the table?</td>
</tr>
<tr>
<td>• Table setting of right table “mirror”/opposite of left table</td>
<td>• Why didn’t the tablecloth drag everything off the table?</td>
</tr>
<tr>
<td>• Everything on the tables moved slightly, in the same direction as the tablecloth moved.</td>
<td>• Does the material of the tablecloth matter for the trick?</td>
</tr>
<tr>
<td>• The tablecloth is made of a shiny material.</td>
<td>• Does how fast he pulls the tablecloth matter?</td>
</tr>
<tr>
<td>• The magician pulled the tablecloth fast.</td>
<td>• Why did some things move further than others?</td>
</tr>
<tr>
<td>• Some of the things on the table moved further than others.</td>
<td>• Did the things that moved further weigh less?</td>
</tr>
</tbody>
</table>
Change the End Position of the Penny

Scenario 1
Individually
Can you modify the Coin in the Cup trick to end with the penny in each of these three positions?

Ground rules
- Cup remains on the table
- Card may be pushed or pulled
- Card remains parallel to the table

How did you do it?
Identify Patterns

Alone Zone

• Which of the four penny outcomes was closest to what you observed in the tablecloth trick?

• In which case did the sliding card cause the greatest change in the horizontal motion of the penny?

• In which case did the sliding card cause the least change in the horizontal motion of the penny?

• Can you identify a pattern we could use to predict how far the penny will move in the horizontal direction when the card is slid beneath it?
Identify Patterns

Small Group

• Share the pattern you identified that we could use to predict how far the penny will move in the horizontal direction when the card is slid beneath it.

Help clarify and/or build on each other’s ideas
  o What do you mean when you say…? 
  o Are you saying…? That makes me think…

• Reach consensus on a pattern to share with the whole group.
Identify Patterns

Partner Talk

Observe the pattern each group identified that could be used to predict how far the **penny will move** in the **horizontal direction** when the card is slid beneath it.

- What do many or most of our patterns have in common?
- What are areas of disagreement?

Be prepared to share your noticings with the whole group.
Using Mathematics to Represent Patterns

How might we communicate the relationship between the card pulling and the penny moving horizontally mathematically?
Can we use our pattern (mathematical relationship) to explain our observation and answer our question, "Does how fast he pulls the tablecloth matter?"

**Notice**

- Both tables have dishes, cups, vases and a teapot.
- Nothing fell off the table.
- Table setting of right table "mirror"/opposite of left table.
- Everything on the tables moved slightly, in the same direction as the tablecloth moved.
- The tablecloth is made of a shiny material.
- The magician pulled the tablecloth fast.
- Some of the things on the table moved further than others.

**Wonder**

- Are all the items on the table empty?
- Why did everything stay on the table?
- Why didn't the tablecloth drag everything off the table?
- Does the material of the tablecloth matter for the trick?
- Does how fast he pulls the tablecloth matter? Why did some things move further than others?
- Did the things that moved further weigh less?
Using Mathematics to Represent Patterns

The *Real* Physics of the “Tablecloth Trick”
Where We’ve Landed

The pattern your class reaches consensus on may not look quite like this, but the components and relationship between the components will likely be the same.

The pattern your class reaches consensus on may not look quite like this, but the components and relationship between the components will likely be the same.

amount of time the pull is happening

pull (and push?)

change in the horizontal motion

equal to? proportional to?

F \cdot \Delta t \approx \Delta v

F \cdot \Delta t \approx \Delta v

change in the horizontal motion

equal to? proportional to?

F \cdot \Delta t \approx \Delta v
## Class Notice and Wonder

<table>
<thead>
<tr>
<th>Notice</th>
<th>Wonder</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Both tables have dishes, cups, vases and a teapot.</td>
<td>• Are all the items on the table empty?</td>
</tr>
<tr>
<td>• Nothing fell off the table</td>
<td>• Why did everything stay on the table?</td>
</tr>
<tr>
<td>• Table setting of right table “mirror”/opposite of left table</td>
<td>• Why didn’t the tablecloth drag everything off the table?</td>
</tr>
<tr>
<td>• Everything on the tables moved slightly, in the same direction as</td>
<td>• Does the material of the tablecloth matter for the trick?</td>
</tr>
<tr>
<td>the tablecloth moved.</td>
<td>• Does how fast he pulls the tablecloth matter?</td>
</tr>
<tr>
<td>• The tablecloth is made of a shiny material.</td>
<td>• Why did some things move further than others?</td>
</tr>
<tr>
<td>• The magician pulled the tablecloth fast.</td>
<td>• Did the things that moved further weigh less?</td>
</tr>
<tr>
<td>• Some of the things on the table moved further than others.</td>
<td></td>
</tr>
</tbody>
</table>

**How might we investigate?**
Where We’re Headed

Newton’s Second Law (Impulse)

\[ F \cdot \Delta t = m \cdot \Delta v \]
Newton’s Second Law

\[ F = m \cdot \frac{\Delta v}{\Delta t} \]
Does our pattern (mathematical model) predict an object’s change in motion in the vertical direction?
Mathematics and computation offer special ways to propose and investigate scientific relationships and to make predictions.

By exploring how mathematics and computation represent scientific ideas and help them become more precise, students can begin to understand how even the most complex mathematical formulas or computer simulations are fundamentally connected to observations, experiences, and ideas about the world around us and help us explain the natural and designed world.
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
# Building Ownership of Science Ideas

<table>
<thead>
<tr>
<th>Grades K–2</th>
<th>Grades 3–5</th>
<th>Grades 6–8</th>
<th>Grades 9–12</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS2: Motion and Stability: Forces and Interactions</td>
<td>PS2: Motion and Stability: Forces and Interactions</td>
<td>PS2: Motion and Stability: Forces and Interactions</td>
<td>PS2: Motion and Stability: Forces and Interactions</td>
</tr>
<tr>
<td>- Pushes and pulls can have different strengths and directions. (K-PS2-1), (K-PS2-2)</td>
<td>- Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative, addition of forces are used at this level.) (3-PS2-1)</td>
<td>- For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law). (MS-PS2-1)</td>
<td>- Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1)</td>
</tr>
<tr>
<td>- Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. (K-PS2-1), (K-PS2-2)</td>
<td>- The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.) (3-PS2-2)</td>
<td>- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2)</td>
<td>- All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. (MSPS2-2)</td>
</tr>
</tbody>
</table>
## Building Ownership of Science Ideas

<table>
<thead>
<tr>
<th>Interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grades 3–5</strong></td>
</tr>
<tr>
<td>• Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object’s speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative, addition of forces are used at this level.) (3-PS2-1)</td>
</tr>
<tr>
<td>• The patterns of an object’s motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.) (3-PS2-2)</td>
</tr>
</tbody>
</table>

| **Grades 6–8** |
| • For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton’s third law). (MS-PS2-1) |
| • The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2) |

| **Grades 9–12** |
| • Newton’s second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1) |
| • Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. In any system, total momentum is always conserved. (HS-PS2-2) |
| • If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-2),(HS-PS2-3) |
## Disciplinary Core Ideas (DCIs, science ideas)

<table>
<thead>
<tr>
<th>Life Science (LS)</th>
<th>Physical Science (PS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LS1. From Molecules to Organisms: Structures and Processes</td>
<td>PS1. Matter and Its Interactions</td>
</tr>
<tr>
<td>LS2. Ecosystems: Interactions, Energy, and Dynamics</td>
<td>PS2. Motion and Stability: Forces and Interactions</td>
</tr>
<tr>
<td>LS3. Heredity: Inheritance and Variation of Traits</td>
<td>PS3. Energy</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Earth and Space Sciences (ESS)</th>
<th>Engineering and Technology (ETS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESS1. Earth’s Place in the Universe</td>
<td>ETS1. Engineering Design</td>
</tr>
<tr>
<td>ESS2. Earth’s Systems</td>
<td>ETS2. Links Among Engineering, Technology, Science, and Society</td>
</tr>
<tr>
<td>ESS3. Earth and Human Activity</td>
<td></td>
</tr>
</tbody>
</table>
Disciplinary Core Ideas

How this set of big ideas in science and engineering were chosen to include in the national science standards:

• Broad importance within or across science or engineering disciplines

• Provide a key tool for understanding or investigating complex ideas and solving problems

• Relate to societal or personal concerns

• Can be taught over multiple grade levels at progressive levels of depth and complexity.
## Connection to NGSS

**Phenomenon:** Dishes stay on the table when the tablecloth underneath the dishes is removed.

<table>
<thead>
<tr>
<th>Science and Engineering Practices</th>
<th>Disciplinary Core Ideas</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Using Mathematics and Computational Thinking</strong></td>
<td><strong>PS2.A: Forces and Motion</strong></td>
<td><strong>Patterns</strong></td>
</tr>
<tr>
<td>● Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.</td>
<td>● Newton’s Second Law accurately predicts changes in the motion of macroscopic objects.</td>
<td>● Patterns of change can be used to make predictions (Grades 3-5)</td>
</tr>
<tr>
<td><strong>Constructing Explanations</strong></td>
<td></td>
<td><strong>Scale, Proportion and Quantity</strong></td>
</tr>
<tr>
<td>● Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.</td>
<td></td>
<td>● Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).</td>
</tr>
</tbody>
</table>

**Building toward** HS-PS2-1. Analyze data to support the claim that Newton’s Second Law of Motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
Science and Engineering Practices (SEPs)

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
Each of the eight practices, as it is introduced and elaborated and experienced in the classroom, requires that students externalize their reasoning. It requires that they work with the reasoning of other students. …teacher and student talk is the vehicle by which every student can make his or her way into a deep and productive relationship with the science and engineering practices.
Reflecting on Current Science Talk

Alone Zone

- What kinds of science talk happen most frequently in your classroom?
- What kinds of science talk would you like students to engage in within your classroom?
Productive Talk

Being able to identify and support productive talk is an important part of building a culture of equitable sensemaking.

Productive talk allows students to:
- make their thinking public
- reason about complex ideas
- develop arguments and evidence-based explanations
Goals for Productive Talk

● **Goal 1:** Help individual students share, expand, and clarify their own thinking

● **Goal 2:** Help students listen carefully to one another

● **Goal 3:** Help students deepen their reasoning

● **Goal 4:** Help students think with others
Goals and Talk Moves

Alone Zone

- Read through the Goals and Talk Moves Handout.
- Reflect: Have you observed an instance of one or more of these moves in this workshop?
Goals and Talk Moves

Share with a partner:

● Which Goal (1, 2, 3, or 4) is most in use in your own classroom?

● Which Goal (1, 2, 3, or 4) is one you haven’t thought about before?
Using the Talk Goals and Moves
Explore an Interesting Phenomenon

Make a chart on a blank page on the left side of your science notebook and record what you notice and wonder about.

<table>
<thead>
<tr>
<th>Mt. Everest Phenomena</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notice</td>
</tr>
<tr>
<td>Wonder</td>
</tr>
</tbody>
</table>

Watch these videos closely and record things you notice and wonder about.

- [Scary Day on Mt. Everest](#)
Scary Day on Mt. Everest

Michele Battelli
Climber

Smithsonian Channel

- Scientists monitor using satellites (GPS)
- Everest has been moving NE at 4 cm/year
- Earthquake moved it 3 cm SW (same position as 9 months ago)
Read more about the Mt. Everest Phenomenon

- Read with a partner.
- Stop at the end of each paragraph to add noticings and wonderings to your science notebook.
Share Noticings and Wonderings

What did you notice from the video clips?

What did you notice from the reading?

What do you wonder about?
Explain how Everest grows and moves normally

Develop a model to show your thinking:

- How does Mt. Everest get 2 cm taller each year?
- How could Mt. Everest move to the northeast 4 cm each year?

<table>
<thead>
<tr>
<th>Mt. Everest Phenomena</th>
<th>Initial Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notice</td>
<td>Wonder</td>
</tr>
</tbody>
</table>
Classroom Video Context

- Students created their initial model to explain how Mt. Everest grows taller (2 cm/year) and moves northeast (4 cm/year).
- Students shared their initial model with a partner and identified something that is puzzling about their model.
- Students have now moved into a scientist circle to create a class consensus model.
Classroom Video Analysis

Alone Zone

- What talk moves do you notice from this video clip?
- What other strategies do you notice the teacher using?
Teacher: Interesting. Those seem like different ideas. Right. And that’s interesting and puzzling too, right?

https://youtu.be/GKg2OZk5Pwg
Observing Productive Talk

Small Group:

● What talk moves do you notice from this video clip?
● What other strategies did you notice the teacher using?
● How did the talk moves and other strategies support all students in engaging in equitable sensemaking?
Productive Talk Goals and Moves - Teacher
Reflection 1

https://youtu.be/xwQwiMjYgQE
and what I'm thinking is that the magnet isn't the main thing that's making the sound.
Watch 0:47 - 2:26
Equitable Sensemaking PD - 2.3 Teacher Reflection on Classroom Culture
What are talk moves and/or strategies you would like to try to support productive talk in your own classroom? Why?
Student Artifacts of 3D Learning

How did we get here? Unit context:
● Anchoring phenomenon
● Identify conditions in which plants grow
● Matter takes up space and has weight (mass)

What do we want students to show they know and are able to do (through this task)?
Storyline Outline (aka Unit Skeleton)
Unit Context - L1 Anchoring Phenomenon

Related Phenomena

Flat rat
Newborn mouse (see through skin
rat in the street w/bones
fish in grass it was flat
Squished, squirrels in road w/bones
Squirrel on sidewalk could see insides
could see white worms in fur (inside
3 baby birds on sidewalk
big bird at park
Dead chicken on hay
Rat with hole in it, with insides cut
and flies all over
Unit Context - L1 Anchoring Phenomenon

Related Phenomena
- Flat rat
- Newborn mouse / see through skin
- Rat in the street vs bones

Investigation Ideas
(To gather evidence for what happens to the body of a dead animal over a couple days or weeks)
- Field trip - pictures over time
- Bring dead animal into classroom
- Go pio in tree...
- Soil + dead fly in a cup - watch overtime
- Put a rat trap out to catch a rat and observe
- Internet: look for pics + videos safest + legal
- Soil + worms...
Students observe time lapse video of dead badger

Initial Model

Q1: Making Sense: In the space below, draw and label a model to show what is causing the changes you observed.
What other living things besides animals die?

Would you expect to see similar changes in plants or in parts of dead plants that fell to the ground over time?
<table>
<thead>
<tr>
<th>Environment</th>
<th>Plant</th>
<th>Weight of this plant on Week 0</th>
<th>Projected Weight of this plant on Week 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.8g</td>
<td>2.8g</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>1.6g</td>
<td>2.3g</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>2.2g</td>
<td>3.2g</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>1.7g</td>
<td>2.6g</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>2.0g</td>
<td>0.1g</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>1.7g</td>
<td>0.1g</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>1.4g</td>
<td>0.1g</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>2.5g</td>
<td>0.1g</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>1.6g</td>
<td>1.6g</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>1.6g</td>
<td>1.6g</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>2.6g</td>
<td>2.6g</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>1.3g</td>
<td>1.3g</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>2.6g</td>
<td>1.6g</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>2.2g</td>
<td>1.6g</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>1.0g</td>
<td>0.7g</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>1.9g</td>
<td>1.5g</td>
<td></td>
</tr>
</tbody>
</table>
Students figure out that plants require sunlight, water, and air to grow (leaves and roots get longer, weight increases).

Plants do not need soil to grow.
<table>
<thead>
<tr>
<th>Takes up space?</th>
<th>Has weight?</th>
<th>Is it matter?</th>
</tr>
</thead>
<tbody>
<tr>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
</tbody>
</table>
Students figure out that **water** and **air** can provide matter to the plant that it needs to grow (leaves and roots get longer, weight increases).

Sunlight can **not** provide matter to the plant that it needs to grow.
Students figure out that air can be added to a toy basketball from a hand pump and reason that they can represent air using particles (like they have represented small amounts of liquids and solids in previous models) to show that transfer of air.
Phenomenon

This plant is left in this container in a well lit room, and no dirt is added to the container. It is left open to the air, so that water can be added to cover its roots every week.

It is taken out of the container every four weeks, dried off, and weighed, and then put back into the container. These were the results:

<table>
<thead>
<tr>
<th>Plant</th>
<th>Weight of this plant on week 0</th>
<th>Weight of this plant on week 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.8g</td>
<td>2.8g</td>
</tr>
</tbody>
</table>

The person recording this data also notices that the leaves and roots are much longer on week 20 than they were on week 0.
Lesson 12 - Mid Unit Model

**Phenomenon:** After 20 weeks, plants in water (no soil) show visible growth - increase in length of leaves and roots - and a measurable increase in mass.

**Lesson-Level Performance Expectation:** Develop a model to explain why the spider plants that had no soil, but had their roots (structure) in water and leaves (structure) in the air (open system) gained weight and grew over time.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop a model to explain a phenomena</td>
<td>Plants acquire their material for growth chiefly from air and water</td>
<td>Matter is transported into, out of, and within systems. A system can be described in terms of its components and their interactions.</td>
</tr>
</tbody>
</table>
What’s Your Model?

Q3: Develop a model to help explain why the plant in the environment A (from our researcher’s data) kept growing, using the particle representation above.
Plant Matter Student Models

Student Model #1
1. How did we decide to represent different types of really small pieces of matter moving from one thing to another?

2. Develop a model to help explain why the plant in the environment A (from our researcher’s data) kept growing, using the particle representation above.

Student Model #2

Student Model #3
1. How did we decide to represent different types of really small pieces of matter moving from one thing to another?

2. Develop a model to help explain why the plant in the environment A (from our researcher’s data) kept growing, using the particle representation above.

Student Model #4

The Sun gives light to the plant but light does not have matter but light gives the plant energy to grow. The plant needs both air and water to grow.
Review the Plant Matter Model Rubric to become familiar with the organization and descriptions.

Be ready to share observations with the whole group.
Evaluate Student Model 2

1. How did we decide to represent different types of really small pieces of matter moving from one thing another?

- Water
- Air
- Energy
- Piece of matter
- Going into plant

2. Develop a model to help explain why the plant in the environment A (from our researcher’s data) kept growing, using the particle representation above.
Evaluate Student Model 2

Student includes all components that are conceptual aspects used to represent important features of the phenomenon: water particles, air particles, and the plant C

Student shows air going into the plant (arrows). However, no air particles are shown in the plant. R

Student does not communicate by any means (words, pictures and/or symbols) that the plant is growing or has grown. R

Student may understand that water is going into the plant - shows water particles inside and outside the plant - but not explicit. R

Student does not explain why the phenomenon occurs (plant growth is not shown on the model) M
Evaluate Student Model 2

<table>
<thead>
<tr>
<th>Components</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relationships</td>
<td>Level 2</td>
</tr>
<tr>
<td>Mechanism</td>
<td>Level 1</td>
</tr>
</tbody>
</table>

Student includes all components that are conceptual aspects used to represent important features of the phenomenon: water particles, air particles, and the plant C.

Student does not explain why the phenomenon occurs (plant growth is not shown on the model) M.

Student shows air going into the plant (arrows). However, no air particles are shown in the plant. R

Student does not communicate by any means (words, pictures and/or symbols) that the plant is growing or has grown. R

Student may understand that water is going into the plant - shows water particles inside and outside the plant - but not explicit. R
Evaluate Student Models

Individually

Use the Plant Matter Rubric to evaluate **Student Model 1, 3, or 4**.

- Count off “1”, “3”, “4” at your table (continue counting in this way until everyone at your table has an assigned number).
- Use the rubric to evaluate your assigned student model (components, relationships, and mechanism). *Be prepared to support your scores with evidence you can point to on the student model.*
Evaluate Student Models

Small Group - Model groups

- Move to your designated area in the room. Bring your rubric and assigned student model with you.
- Compare your scores (components, relationships, and mechanism) with your group.
- Reach consensus on your scores.
Evaluate Student Models

Small Group - Table Groups

- Return to your tables.
- What patterns do you observe across the four student models?
  - What knowledge (and skills) are students most secure with?
  - What knowledge (and skills) are students still developing (not all-the-way-there)?
  - What questions do you have about noticings that are not accounted for on the rubric?
Plant Matter Student Models

Student Model #1
1. How did we decide to represent different types of really small pieces of matter moving from one thing to another?

2. Develop a model to help explain why the plant in the environment A (from our researcher’s data) kept growing, using the particle representation above.

Student Model #2

Student Model #3
1. How did we decide to represent different types of really small pieces of matter moving from one thing to another?

2. Develop a model to help explain why the plant in the environment A (from our researcher’s data) kept growing, using the particle representation above.

Student Model #4

A model to help explain why the plant in the environment A (from our researcher’s data) kept growing, using the particle representation above.
Plant Matter Student Models

Student Model #1

1. How did we decide to represent different types of really small pieces of matter moving from one thing to another?

2. Develop a model to help explain why the plant in environment A (from our researcher’s data) kept growing, using the particle representation above.

Student Model #3

What is something the students (collectively) can do differently next time they create an explanatory model?
I noticed some of the models showed how the plant changed over time (grew) and some of the models did not.

- What do you like about how some of these models show change over time?
- How might we communicate in the models that some of the particles are causing the change over time (growth)?
Providing Teacher Feedback

I noticed some of the models used only words to explain how plants gained matter.

- How could you show that the particles added the matter to the plant over time using symbols and pictures?
- How could you show that it is the particles causing the leaves and roots to grow?
[The] majority of teacher’s feedback practice is not aligned with the recommendations on effective feedback by researchers. Instead of providing descriptive and prescriptive information, teachers often offered to their students evaluative information either as quantity of work (e.g., “more examples”) or the general level of understanding (e.g., “wow”, “unclear!”, a smiling face, or a question mark) as 20.34% and 40.4%, respectively. Therefore it is not a surprise that due to the lack of information on what can be done next, few students were able to take advantage of teacher comments to modify their work. (Li et al. 2010)
Providing Feedback

[The] majority of teacher’s feedback practice is not aligned with the recommendations on effective feedback by researchers. Instead of providing descriptive and prescriptive information, teachers often offered to their students evaluative information either as quantity of work (e.g., “more examples”) or the general level of understanding (e.g., “wow”, “unclear!”, a smiling face, or a question mark) as 20.34% and 40.4%, respectively. Therefore it is not a surprise that due to the lack of information on what can be done next, few students were able to take advantage of teacher comments to modify their work. (Li et al. 2010)

Explain the strengths and ask questions about weaknesses

Provide suggestions and support for how students can improve their thinking and/or skills.
Peer Feedback

https://youtu.be/M8FKJPpvreY (0:35 -2:35)
Celebrate Sensemaking

What would you add to or change on your “What is Sensemaking” poster?
What questions can you now answer?
What questions remain?

Be prepared to share one “Aha!” on your way out the door.
Transforming Science Learning: OpenSciEd’s Impact in Taunton (MA) Public Schools (these interviews reflect the impact of phenomena-driven, three-dimensional teaching and learning)
High Quality Instructional Materials

[Images and links to instructional materials]

https://www.openscienced.org/curriculum/

https://www.nextgenscience.org/resources/examples-quality-ngss-design?page=0

https://www.colorado.edu/program/inquiryhub/curricula

https://sprocket.educurious.org/home/curriculum
High Quality Instructional Materials (HQIM)

https://www.openscied.org/curriculum/

Quality Examples of Science Lessons and Units

https://www.nextgenscience.org/resources/examples-quality-ngss-design?page=0

Additional high quality instructional materials included in the collection of resources: https://bit.ly/AUTAUGANSTA (all labeled #20)

https://www.colorado.edu/program/inquiryhub/curricula

https://sprocket.educurious.org/home/curriculum
Feedback Survey

Your feedback is valuable to us! We use it to provide follow-up support as well as inform choices about future professional learning opportunities.

Where this workshop took place: **Autauga County Technology Center**

Who was Presenter #1: **Kate Soriano**

skip questions #14-17


OR

[https://www.surveymonkey.com/r/NSTA3DPD](https://www.surveymonkey.com/r/NSTA3DPD)
thank you