Welcome!

Making Sense of Three-Dimensional Teaching and Learning: Developing High-Quality Instructional Materials (HQIM)

July 11, 2024
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### Collection of Resources

#### Clear Creek ISD_Making Sense of 3D Teaching and Learning Collection

- **PRIVATE**
- 4 items

Making Sense of Three-Dimensional Teaching and Learning – Designing High-Quality Instructional Materials.
Workshop for Clear Creek ISD - 7.11.24

- Earth & Space Science
- Engineering
- Life Science
- Physical Science
- High School

- Middle School

#### Resources in “Clear Creek ISD_Making Sense of 3D Teaching and Learning” Collection

<table>
<thead>
<tr>
<th>Title</th>
<th>Resource Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Framework for K-12 Science Education (pdf)</td>
<td>Web Page</td>
</tr>
<tr>
<td>A New Vision for Science Education</td>
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</tr>
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Collection of Resources

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4 items
Earth & Space Science Engineering Life Science Physical Science High School

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bit.ly/NSTAClearCreek
https://my.nsta.org/collection/ySqiJy9O80Y_E
Meet Our Learning Community

Alone Zone (independent thinking time)

❖ Why do you think it is important for all students to learn science/STEM?
❖ What are your goals for your students in science/STEM?
Meet Our Learning Community

**Alone Zone** (independent thinking time)

- Why do you think it is important for all students to learn science/STEM?
- What are your goals for your students in science/STEM?

**Small Group**

- Share your thinking with your group.
- What is your group’s top science/STEM goal(s) for Clear Creek ISD students?
- After sharing, record your goal(s) and post.
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.
6.4 Plate Tectonics & Rock Cycling

What causes Earth’s surface to change?
The Design of OpenSciEd and Other HQIM Curriculums

- **Phenomenon based**: An anchoring phenomenon and related phenomena motivate building ideas over time.
- **Coherent from the Students’ Perspective**: Coherence is grounded in the initial anchoring phenomenon and driven by students’ ideas and questions.
- **Driven by Evidence**: Students seek and use evidence to figure out phenomena as they build new science ideas.
- **Collaborative**: Students figure out ideas together as a classroom community.
- **Equitable**: The class community values the diversity of resources students bring to science class and understand how the learning is relevant to their own lives and communities.
OpenSciEd and other HQIM units are based on a **science storyline**. Each step is driven by students’ questions that arise from phenomena.
All units have an anchoring phenomenon or problem.

This results in student-driven questions, ideas and initial explanations that are then explored in future lessons.
Switching hats

**Student hat:** “Thinking like a kid” What do you anticipate a middle school student might think? What might they say? What experiences, prior learning and resources might students bring into the classroom?

**Teacher hat:** Reflecting on pedagogical approach, instructional routines, classroom culture, logistics/supports, NGSS, etc...

---

### Anchor Phenomenon Routine

This routine positions students to make sense of a phenomenon, grounding all students in a common experience and raising student questions.

- **Element #1:** Explore the phenomenon
- **Element #2:** Attempt to make sense
- **Element #3:** Identify related phenomena
- **Element #4:** Questions and next steps
Switching hats

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**Anchor Phenomenon Routine**

This routine positions students to make sense of a phenomenon, grounding all students in a common experience and raising student questions.

Element #1: Explore the phenomenon
Element #2: Attempt to make sense
Element #3: Identify related phenomena
Element #4: Questions and next steps
Explore a Phenomenon
Mount Everest just grew a couple more feet overnight — at least on paper.

After years of surveys and calculations, China and Nepal have officially revised the elevation of the world's highest peak: to precisely 29,031.69 feet above sea level.

Turn and Talk

What might cause a mountain to grow?
Let's locate where Mt. Everest is on a world map.
Read about the Mt. Everest Phenomenon

In Your Notebook
Add noticings and wonderings from the reading about Mount Everest changing.

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

Students in pairs use a close reading strategy to write their notice and wonders after each paragraph. You would model this with students.
Share Noticings and Wonderings

With Your Class

- What were some of the things you noticed about what happened to Mt. Everest?

In 1856 Mt. Everest was 29,002 feet and in 2021 Mt. Everest was reported at 29,032 feet (grows taller about 2 cm each year).

Mt. Everest is moving about 4 cm each year in the northeast direction.

Satellites are used to measure height and movement.

- What are some of your wonderings?
Brainstorm

With a Partner

Discuss the following:

● Possible causes for the increase in elevation of Mt. Everest

● Possible causes for Mt. Everest moving to the northeast
On your own:

You will develop a model for what you think are:

- Possible causes for the 2 cm/year increase in elevation of Mt. Everest
- Possible causes for Mt. Everest moving 4 cm/year to the northeast
Class Consensus - Scientists Circle

With A Partner

Identify
- two similarities between your models,
- one difference, and
- something on your own model that is puzzling to you.

What we know is happening to Everest:

- Mt. Everest grows about 2 cm taller each year
- In 1856, Mt. Everest was 29,002 feet tall
- In 2021, Mt. Everest was 29,032 feet tall
- Mt. Everest moves about 4 cm/year to the northeast
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.
What we know is happening to Everest:

- Mt. Everest grows about 2 cm taller each year.

- In 1856, Mt. Everest was 29,002 feet tall.
- In 2021, Mt. Everest was 29.032 feet tall.
- Mt. Everest moves about 4 cm/year to the northeast.

Let’s develop a class consensus model for what we think are:

- Possible causes for the 2 cm/year increase in elevation of Mt. Everest.
- Possible causes for Mt. Everest moving 4 cm/year to the northeast.
How Mt. Everest grows and moves

Grows
- Rain, lee makes it taller
- Grows 2 cm/year
- Magma?

Plates?
- Earthquakes move mountains?
- Earthquakes push rocks up?
- Plates shifting?

Plates?
- Gas?

Moves
- Moves NE 4 cm/year
- Rocks move to other side of mountain
- Erosion?
- Water breaks down rock?

Earthquakes and volcanoes move mountains?
Considering Other Mountains

There are a lot of other mountains in the world.

With Your Class

- What are some other mountains or mountain ranges you know about?
- Do you think that they are changing in similar ways too?
- How could investigating other mountain ranges, or the area they are part of, help us figure out what might be happening at Mt. Everest?
Organize a table to record data we find (Patterns?)

In Your Notebook
With your class, develop a table to use to record data you find about different mountains and mountain ranges.

<table>
<thead>
<tr>
<th>Type of data</th>
<th>Data</th>
<th>How this data connects to mountains changing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What are some types of data we would want about other mountains?

What are we trying to figure out?
Mt. Everest is located between Nepal and China in a mountain range called the Himalayas. The Himalayan range is 1,500 miles long. In addition to Nepal and China, it also covers parts of the countries of India, Pakistan, Afghanistan, China, Bhutan and Nepal. Not only is Mt. Everest, the tallest mountain in the world located here, but so is K2, the world's second tallest mountain. The area experiences large active earthquakes.

### Weather and climate
- tropical near the base of the mountains
- snow and ice near the tops of the mountains all year long
- 15,000 glaciers

### Earth materials found here
- sedimentary rock such as shale and limestone
- volcanic rock in some areas
- marine fossils on some of the peaks of the mountains

Many pieces of fossils of crinoids (pictured above), trilobites, brachiopods (lamp shells), and ostracods (small shrimps) are found here.

The name for the Himalayas comes from Sanskrit and translates to “Abode of snow.” The Nepalese people named Mt. Everest Samgarmatha, which is translated as “Goddess of the Universe” or “Forehead of the Sky.” The Tibetan name for Everest is Chomolungma, which means “Goddess Mother of the World.” These mountains are growing in height, with Mt. Everest growing about 2 cm per year.

Image credits: Concord Consortium; CIA World Factbook; Erik Tanghe
Compare different mountain info cards
Compare different mountain info cards

**With Your Small Group**

- Work with your group to analyze your assigned mountain case site card.
- Complete the row for your assigned mountain in the data table.
- As time permits, scan the remaining mountain case site cards and think about
  - Are any other mountains changing either by elevation or location?
  - Why might these other mountains be changing?
Compare different mountain info cards

With Your Small Group

Work with your group to analyze the mountain case site cards. Each person will read ONE card and report back what they learned to their team.

- Are any other mountains changing either by elevation or location?
- Why might these other mountains be changing?
- What patterns of similarities and differences do you notice between the different mountains?
Whole Group

What data did you find for your mountain that could help us explain how mountains can change in height and location?
6.4 Patterns in Mountain Data Jamboard
Add to initial model

We've developed a model for a mountain that is growing, but now we have found out that some are shrinking. Think back to what we have shown that could be causing our mountains to grow. Do we also think these things could be causing our mountains to shrink? Could it be something else?

With Your Small Group

- Choose a location where the data shows that the mountain has been shrinking.
- Develop a consensus model to represent what you think is causing this to happen.
If all mountains aren’t growing, then our initial consensus model won’t explain what is happening to every mountain.

As a class, let’s revise our model to capture the ideas we have for what we think might be causing changes in these other mountains.
How Mountains Shrink

wind and erosion?

rain and water over time break down rock and move it to another place?

snow melts and reduces the height of mountain?

mountain goes down or caves in?

plates moving apart?

plates moving downward?
Related Phenomena

Think back on all your experiences you’ve had over your life where you noticed a change in the surface of the land or landforms. Consider all scales: these changes from the very small to the very large.

On your own

- What are other examples of where you have seen the size or shape of the land or landforms change over time?
- What do you think caused these changes?
Share examples of where you have seen the size or shape of the land or landforms change over time.

Identify any causes for these that you think might also cause the size or shape of some mountains to change over time.
Related Phenomena

With Your Class

Share examples of

○ where we have seen the size or shape of the land or landforms change over time

○ what we think are the causes for these changes

○ whether we think the causes of mountains changing over time are similar to the land changes we see where we live
What questions do you now have?

Take a minute to review the following to identify questions that you have about the phenomena we have explored so far.

➔ Your Notice and Wonder charts about Mt. Everest and the mountain data cards.
➔ Our initial class models.
➔ Our list of related phenomena.

Then write one question per sticky note or card.
Write in marker--big and bold.
Put your initials on the back in pencil.
Driving Question Board (DQB)

Take out your sticky notes with questions. Bring those with you to our Scientists Circle, along with your science notebook.

How to build a Driving Question Board

1. The first student reads his or her question aloud to the class, then posts it on the DQB.
2. Students should raise their hand if one of their questions relates to the question that was just read aloud.
3. The first student selects the next student whose hand is raised.
4. The second student reads his or her question, says why or how it relates, and posts it near the question it most relates to on the DQB.
5. The student selects the next student.
6. We will continue until everyone has at least one question on the DQB.
What additional sources of data might we need to figure out the answers to our questions? What information do we still need?

Small Groups
Add your ideas to a new notebook page titled:
Investigation Ideas (Information/Data We Need)

➔ Be prepared to share these with the whole class.
Driving Question Board (DQB)

Take out your sticky notes with questions. Bring those with you to our Scientists Circle, along with your science notebook.

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5. The student selects the next student.
6. We will continue until everyone has at least one question on the DQB.
Information and Data Needed

What additional sources of data might we need to figure out the answers to our questions? What information do we still need?

Small Groups
Add your ideas to a new notebook page titled:

Investigation Ideas
(Information/Data We Need)

→ Be prepared to share these with the whole class.
Hey, how does your question actually relate to someone else's question?

Play 7:58 to end (Sharing instructions for “Investigation Ideas” task)
https://youtu.be/PMDpNNM33RY?si=zRd1Q2or6u_6cf_8&t=478
Play 0:00 to 3:01 (Students in pairs brainstorming ideas for investigations)
https://youtu.be/Gu-w7GckV4U?si=sAeBaOxsd0x3AjWS
Sixth graders' ideas for investigations

Investigation Ideas (Informations and Data we Need)

- Data chart with data on earthquakes/volcanoes
- Use Google Maps to look at geography around Mt. Everest
- Watch a short video about volcanoes that shrink
- Look at weather patterns over time to now by Mt. Everest to see changes
- Simulate erosion factors: rock with hair dryer and bucket of water
- Use a simulator for mountain growth
- Timelapse video of any mountain growth and mountain shrinking
- Photographs of Earth from 200,000 years ago to see what it looked like (compare to now)
- Pictures of mountains growing/shrinking to see differences
- Use google maps to see distance between oceans and mountains
- Go to Mt. Everest to watch it grow/shrink (observe it as snow falls)
- Videos of mountains growing (Mt. Everest)
- Map where earthquakes are
- Research articles about the changes
- Make a model of a mountain and test our ideas for how the mountain changes (melting, etc.)
What could help us figure out more about why Mt. Everest (and these other mountains) are changing?

Take a moment to look at our questions on our Driving Question Board. Talk with your partner:

What potential causes did we identify as a class for Mt. Everest changing? What seems the most likely cause to you and why?

In our next class, we will think more about these potential causes and begin investigating them.
Anchoring Phenomenon Routine

Element #1: Explore the phenomenon
Element #2: Attempt to make sense
Element #3: Identify related phenomenon
Element #4: Questions and next steps
How do the elements of the Anchoring Phenomenon Routine support all students in figuring things out?

<table>
<thead>
<tr>
<th>Anchoring Phenomenon Routine Tracker</th>
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<tbody>
<tr>
<td><strong>Element 1:</strong> Explore the Phenomenon</td>
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<tr>
<td>What do we notice?</td>
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<tr>
<td>Notes about what you or the students did.</td>
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<td>How does this support figuring out?</td>
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<tr>
<td>How does this support a classroom culture where all students have access?</td>
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</table>
### Anchoring Phenomenon Routine

**Alone Zone**

Jot down some notes about what you did as students in Elements 1, and 2, 3 and 4.

<table>
<thead>
<tr>
<th>Element 1: Explore the Phenomenon</th>
<th>Element 2: Attempt to Make Sense of the Phenomenon</th>
<th>Element 3: Identify Related Phenomena</th>
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</tr>
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<tbody>
<tr>
<td><strong>Notes about what you or the students did.</strong></td>
<td><strong>What do we notice?</strong></td>
<td><strong>How can we explain this? Do our explanations agree?</strong></td>
<td><strong>Where else does something similar happen?</strong></td>
</tr>
<tr>
<td></td>
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</tbody>
</table>

How does this support figuring out?

How does this support a classroom culture where all students have access?
## Anchoring Phenomenon Routine

### Small Group Jigsaw

- **Move into jigsaw groups.**
- **Reflect on your group’s assigned Anchoring Phenomenon Routine element and record key ideas.**
- **Return to your home group and share key ideas.**

### Anchoring Phenomenon Routine Tracker

<table>
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<tr>
<td>What do we notice?</td>
<td>How can we explain this? Do our explanations agree?</td>
<td>Where else does something similar happen?</td>
<td>What should we do to figure out how to explain this?</td>
</tr>
</tbody>
</table>

- 1’s
- 2’s
- 3’s
- 4’s

Notes about what you or the students did.

How does this support figuring out?

How does this support a classroom culture where all students have access?
Anchoring Phenomenon Routine

Whole Group

How does each element of the Anchoring Phenomenon Routine support all students in figuring things out?

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</tr>
<tr>
<td>How does this support a classroom culture where all students have access?</td>
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Connection to Next Generation Science Standards

Phenomenon: Mt. Everest is moving and growing

Lesson Level Performance Expectations:

1.A Develop a model showing what is happening at a scale larger than we can see (patterns) to help explain what happened to the different mountains to (cause) them to change (in elevation and/or location).

1.B Ask questions that arise from our analysis of information showing that Mt. Everest and four other mountain peaks are changing to seek additional information about what caused the changes (effects) we read about.

<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Asking Questions</td>
<td>ESS2.A. Earth’s Materials and Systems</td>
<td>Patterns</td>
</tr>
<tr>
<td>● Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.</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.</td>
<td>• Patterns can be used to identify cause and effect relationships.</td>
</tr>
<tr>
<td>Develop and Use Models</td>
<td></td>
<td>Cause and Effect</td>
</tr>
<tr>
<td>● Develop and/or use a model to predict and/or describe phenomena.</td>
<td></td>
<td>• Cause and effect relationships may be used to predict phenomena in natural or designed systems.</td>
</tr>
</tbody>
</table>

MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.
How Students Experience Sensemaking

- Students experience a **phenomenon**;
- engage in **science and engineering practices** and
- **share ideas** to develop or apply the
- **science ideas** and **crosscutting concepts** (recurring themes and concepts) needed to explain how or why the phenomenon occurs.
Unit Storyline

6.4 Plate Tectonics & Rock Cycling

What causes Earth’s surface to change?
UNIT STORYLINE

Unit Question: What causes Earth's surface to change?

Lesson Question | Phenomena or Design Problem | What we do and figure out | How we represent it
--- | --- | --- | ---
LESSON 1 | 4 days | What is causing Mt. Everest and other mountains to move, grow, or shrink? | We read about how Mt. Everest is getting taller and moving yearly to the northeast. We analyze other mountain peaks around the world and find that other mountains are also getting taller, but others are shrinking. We develop an initial model explaining how mountains grow, move, and shrink. We brainstorm related phenomena, ask questions, and generate a list of data and information we need to better understand how mountain peaks can grow, shrink, and move. We figure out:
- Some mountains move.
- Mountains can get taller.
- Mt. Everest is growing over time - new data shows.
- Mountains can also shrink. |
--- | --- | --- | ---

Navigation to Next Lesson: We identified a variety of possible causes for growth and movement of mountains, one of the main ones were earthquakes. So are there patterns between where earthquakes are found and where mountains are located?

LESSON 2 | 2 days | How are earthquakes related to where mountains are located? |
--- | --- | ---
Investigation | | |
--- | --- | --- | ---
After an earthquake occurred in Ridgecrest, California, a shift in the location and the elevation of the surface was observed. | We look at data sources from Ridgecrest, CA before and after an earthquake. We use Seismic Explorer to determine that there seems to be a pattern with greater earthquake activity at mountains that are increasing in elevation. We figure out:
- The ground moves back and forth in an earthquake.
- Some parts of the surface crack open with a noticeable difference in between the ground on either side of the crack after an earthquake.
- Earthquakes exist on or near almost all mountain ranges.
- There seems to be a correlation between when mountains were highest or growing and where the eqs are the largest or most frequent.
- While earthquakes seem to be correlated to changes in elevation, we are uncertain what is occurring under the surface, and what the land is like under the surface. |

Navigation to Next Lesson: We think that earthquakes are correlated to mountain changes in location and elevation, but want to know what is underground where earthquakes occur.
Plate Tectonics & Rock Cycling Unit Storyline

How well does the storyline reflect our questions and ideas for investigations?

Investigation Ideas

- Data chart with data on earthquakes/volcanoes
- Use Google Maps to look at geography around Mt. Everest
- Watch a short video about volcanoes that shrink.
- Look at weather patterns over time to new by Mt. Everest to see changes.
- Simulate erosion factors: rock with hair dryer and bucket of water
- Use a simulator for mountain growth
- Time-lapse video of any mountain growth and mountain shrinking
- Photographs of Earth, from 200,000 years ago to see what it looked like (compare to now)
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- So to Mt. Everest to watch it grow/shrink (observe it as snow falls).
- Videos of mountains growing (Mt. Everest)
- Map where earthquakes are
- Research articles about the changes
- Make a model of a mountain and test our ideas for how the mountain changes (melting, etc)
Unit Storyline

Alone Zone

Read the unit storyline. Think about the questions on our driving question board.

When you find a lesson that answers or partially answers a posted question

● write the lesson number on sticky dot
● post the sticky dot next to that question on the driving question board.
Coherence from the Students’ Perspective

- We figure out the science ideas
- We figure out where we are going at each step
- We figure out how to put the ideas together over time
Students Build Understanding Piece by Piece
Teacher Reflection

https://youtu.be/ZfRki3muDxk?si=z3VFED_le1i4l-do
Shifting Toward Sensemaking

Students sensemaking in a 4th-grade classroom.
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...**

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

Information Frame
• Teacher is focused on disseminating

Sensemaking Frame
• Teacher is focused on developing conceptual

Less Like
• Science is portrayed as a body of established facts.
• Assessments are focused on “right” answers.

Knowing about...

More Like
• Science is portrayed as a way to make sense of something.
• Assessments are focused on use of evidence to support conclusions/generalizations.

Figuring out…
Continuum of Science Instruction

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- 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...
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.
How We *Design* for Sensemaking

- Students experience a **phenomenon**;
- engage in **science and engineering practices** and
- **share ideas** to develop or apply the
- **science ideas and crosscutting concepts** (recurring themes and concepts) needed to explain how or why the phenomenon occurs.
Shifting Toward Sensemaking

Information Frame  Sensemaking Frame

Less Like  More Like

Soils, Rocks, and Landforms
INVESTIGATIONS GUIDE
Shifting Toward Sensemaking

Information Frame | Sensemaking Frame

Less Like | More Like
Choosing Phenomena

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

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

Video clip 02:56 – 04:52

https://vimeo.com/331335155
Identify Related Phenomena

What experiences do we have that might help us 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)?
Questions

• Review your own observations of the Channeled Scablands and the observations shared.
• Think about the shared related phenomena and the patterns identified.
• 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 your top two questions to share.
Phenomenon: Channeled Scablands

Our wonderings about the Channeled Scablands

- Why is it so flat?!
- Was there water there? Where did it go?
- How did they know the water fall was there?
- Are there fossils in the rock?
- How did the layers get there?
- Is there different matter in the different layers?
- Why did the waterfall dry up?
- How long did it take to the form the Scablands?
- Why was the geologist trying to split the rocks?
- Where did the boulders come from?
- What kind of wildlife or living organisms are there?
- How did the ash get there? Was there a volcanic eruption?
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.
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 explanations of phenomena to design solutions.
- In this way, phenomena are the context for the work of both the scientist and the engineer.

WHY ARE PHENOMENA SUCH A BIG DEAL?
- Despite their centrality in science and engineering, phenomena have traditionally been missing pieces 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 process 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 begin to appreciate the social relevance of science. They get interested in and connected with science as a way of understanding and improving real-world contexts. Focusing investigations on compelling phenomena helps 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

Understanding of DCI ESS1.A, which, at the 5th grade level, focuses on the relationship between star brightness and distance from Earth:
- The process of developing an explanation for a phenomenon should advance students’ understandings. If students already need to know the target knowledge before they can inquire about the phenomenon, then the phenomenon is not appropriate for initial instruction (although it might be useful for assessment).
- Students should be able to make sense of anchoring or investigative phenomena, but not immediately, and not without investigating it using sequences of the science and engineering practices. With instruction and guidance, students should be able to figure out, step by step, how and why the phenomenon works.
- An effective phenomena does not always have to be flashy or unexpected. Students might not be intrigued by an everyday phenomenon right away because they believe they already know how or why it happens. It takes careful teacher facilitation to help students become dissatisfied with what they can explain, helping them discover that they really can’t explain it beyond a simple statement.

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<th>CONS THINKING ABOUT PHENOMENA THROUGH THE NGSS</th>
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<td>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>
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<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>
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<td>Phenomena can drive the lesson, learning, and reflection/monitoring throughout. Using phenomena in these ways leads to deeper learning.</td>
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<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 credible and generative knowledge.</td>
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Engaging phenomena need to be questions:
- Student engagement is an excellent way to encourage students to ask questions and be more active learners.

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.

Published September 2018

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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.
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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.
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
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 building an explanation for the phenomenon over time?
Sensemaking in a 4th-Grade Classroom

https://youtu.be/wmyg7XS6Erc?si=M7RFPGrcoBl_DaQ2
The water picked up and carried away tiny pieces of rock over and over again. Water eroded the rock.
Science and Language Integration

Traditional Views and Contemporary Views

• Vocabulary is a precursor or prerequisite for doing science: Pre-teach and frontload vocabulary
  – Instead, language is a product of use

• Vocabulary is language
  – Instead, language is more than vocabulary and includes using language to engage in disciplinary practices and learn disciplinary content

• Simplify content, simplify language
  – Instead, keep content, amplify language (both support and challenge MLs)
Intentional Sequences of Student Interactions

Foundation for interactions

- Alone zone

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<tr>
<td>- One-to-one</td>
</tr>
<tr>
<td>- One-to-small group</td>
</tr>
<tr>
<td>- One-to-many</td>
</tr>
<tr>
<td>- Small group-to-many</td>
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Explicit beyond the “here” and “now”
Multiple Modalities (Means of Communication)

Students communicate their thinking through multiple modalities. Students need to receive information through multiple modalities.
Phenomena and Coherence

Anchor Phenomenon

Investigative Phenomenon

Related Phenomenon

Questions

Phenomena

Practices to Engage In

What We Figure Out

3D

The Story
Students Build Understanding Piece by Piece
High School Students Sensemaking

B.4 Natural Selection & Evolution of Populations

How does urbanization affect nonhuman populations, and how can we minimize harmful effects?
High School Students Sensemaking

Setting the context

- Students used a simulation to collect population data.
- Students, working in pairs, analyzed their data to identify the cause-and-effect relationships between an organism’s ability to survive and changes in that population of organisms.
- Students next engage in a whole-group consensus discussion.
High School Students Sensemaking

Play 2:53 -7:11
**Connection to NGSS**

**Phenomenon:** Populations change over time

**Lesson Level Performance Expectations:**
Use evidence from a simulation to support an explanation about how different traits (number of flagella) could cause some bacteria to have a competitive advantage affecting the variation of traits within a population.

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<th>Crosscutting Concepts</th>
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<td><strong>PS4.B: Electromagnetic Radiation</strong></td>
<td><strong>Cause and Effect</strong></td>
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<td>• Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena.</td>
<td>• The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population.</td>
<td>• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.</td>
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**Building toward** HS-LS4-3. Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.
Transforming Science Learning: OpenSciEd’s Impact in Taunton (MA) Public Schools
How Students Experience Sensemaking

- Students experience a phenomenon;
- engage in science and engineering practices and
- share ideas to develop or apply the
- science ideas and crosscutting concepts (recurring themes and concepts) needed to explain how or why the phenomenon occurs.
How We Design for Sensemaking

- Students experience a phenomenon;
- engage in science and engineering practices and
- share ideas to develop or apply the
- science ideas and crosscutting concepts (recurring themes and concepts) needed to explain how or why the phenomenon occurs.
Big Ideas in Science*

Core Idea ESS2  Earth’s Systems

How and why is Earth constantly changing?

Earth’s surface is a complex and dynamic set of interconnected geosphere, hydrosphere, atmosphere, and biosphere, with a wide range of temporal and spatial scales. All of Earth’s processes—energy flowing and matter cycling within and among these spheres—involve the motion of tectonic plates, part of the cycles of convection driven by outflowing heat and the downward pull of gravity. Formation and changes of many features of Earth’s land and ocean, the atmosphere, clouds, ice, land, and life forms exchange the makeup of the geosphere, hydrosphere, and atmosphere; conversely, geological events and conditions have a significant role in shaping Earth’s landscape. Water is essential to the dynamic and it plays a significant role in shaping Earth’s landscape.

ESS2.A: Earth Materials and Systems

How do Earth’s major systems interact?

Earth is a complex system of interacting subsystems: the geosphere, atmosphere, and biosphere. The geosphere includes a hot interior core, a mantle of hot, soft, solid rock, and a crust of continents. The atmosphere is the envelope of gas surrounding the planet’s surface: the ice, water vapor, and liquid water in the atmosphere; streams, soils, and groundwater. The presence of living organisms defines the biosphere, life can be found in many parts of the geosphere, and atmosphere. Humans are a part of these activities have important impacts on all of Earth’s systems.

Grade Band Endpoints for ESS2.A

By the end of grade 2. Wind and water can change the shape of the land. The resulting landforms, together with the materials on the land, provide homes for living things.

By the end of grade 5. Earth’s major systems are the geosphere (solid and molten rock, soil, 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 the surface of Earth’s 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 landforms to determine patterns of weather. Rainfall helps 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. Human activities affect Earth’s systems and their interactions at its surface.

By the end of grade 8. 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. 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.

By the end of grade 12. Earth’s systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. A deep understanding of how feedbacks work within and among Earth’s systems is still lacking, thus limiting scientists’ ability to predict some changes and their impacts.

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...
Choosing Phenomena

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

That is, what phenomenon requires the targeted science ideas to explain how or why the phenomenon occurs to the students’ satisfaction?
Choosing Phenomena for Clear Creek ISD

Grade level/subject area groups

1. Identify the “big” ideas students will build collaboratively and own individually. In your Unit 2 support found bit.ly/ClearCreekNSTA Resource #1 (Framework) bit.ly/NSTAClearCreek

2. What phenomenon might be complex enough (need all the targeted big ideas 3 to explain) and will get kids to ask the questions you need (the answers are pieces of targeted big ideas. Resource #10s (Free FAQM) examples
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...**

From: Cynthia Passmore, NSTA Virtual PD, Nov. 15, 2014
Science in Action: How Science Works
Collection of Resources

Clear Creek ISD_Making Sense of 3D Teaching and Learning Collection

PRIVATE
4 items
Making Sense of Three-Dimensional Teaching and Learning – Designing High-Quality Instructional Materials. Workshop for Clear Creek ISD - 7.11.24
Earth & Space Science  Engineering  Life Science  Physical Science  High School
Middle School

Resources in “Clear Creek ISD_Making Sense of 3D Teaching and Learning” Collection

bit.ly/NSTAClearCreek
https://my.nsta.org/collection/ySqiJy9O80Y_E
END OF PRESENTATION