Foundational Services
Science

# Developing and Evaluating Units of Study Aligned to NGSS

## Participant Workbook

The following statements relate to the Science Foundational Service training:

# *Developing and Evaluating Units of Study Aligned to NGSS*

Please indicate your comfort level with the following:

*4 = Fully Agree*
*3 = Agree*
*2 = Somewhat Agree*
*1 = Disagree*
*NA = Not Applicable to this training session*

| Science | Pre | Post |
|---|---|---|
| I can summarize the storylining process used to develop or evaluate a unit of study aligned to the Next Generation Science Standards (NGSS). | | |
| I can accurately apply the phases of the storylining process. | | |
| I can explain the concept of coherence with respect to a unit of study aligned to the Next Generation Science Standards (NGSS). | | |
| I can analyze whether or not lessons in a unit of study fit together coherently targeting a set of performance expectations. | | |
| I can identify and explain the categories of the EQuIP Rubric for Lessons & Units in Science. | | |

**Reflection Questions following post survey:**

1. What areas did you grow the most?

2. What areas do you need further development?

3. What next steps do you plan to take to further develop your knowledge and skills related to NGSS?

# What Can I Take Away?

Foundational Services for Science – *Developing and Evaluating Units of Study Aligned to NGSS* focuses on equipping educators with the tools needed to begin developing and evaluating units of study for alignment to the Next Generation Science Standards. Following each session, we will take a few moments to consider next steps and a plan of action. Use the spaces below each session tile for your reflections.

Session 1

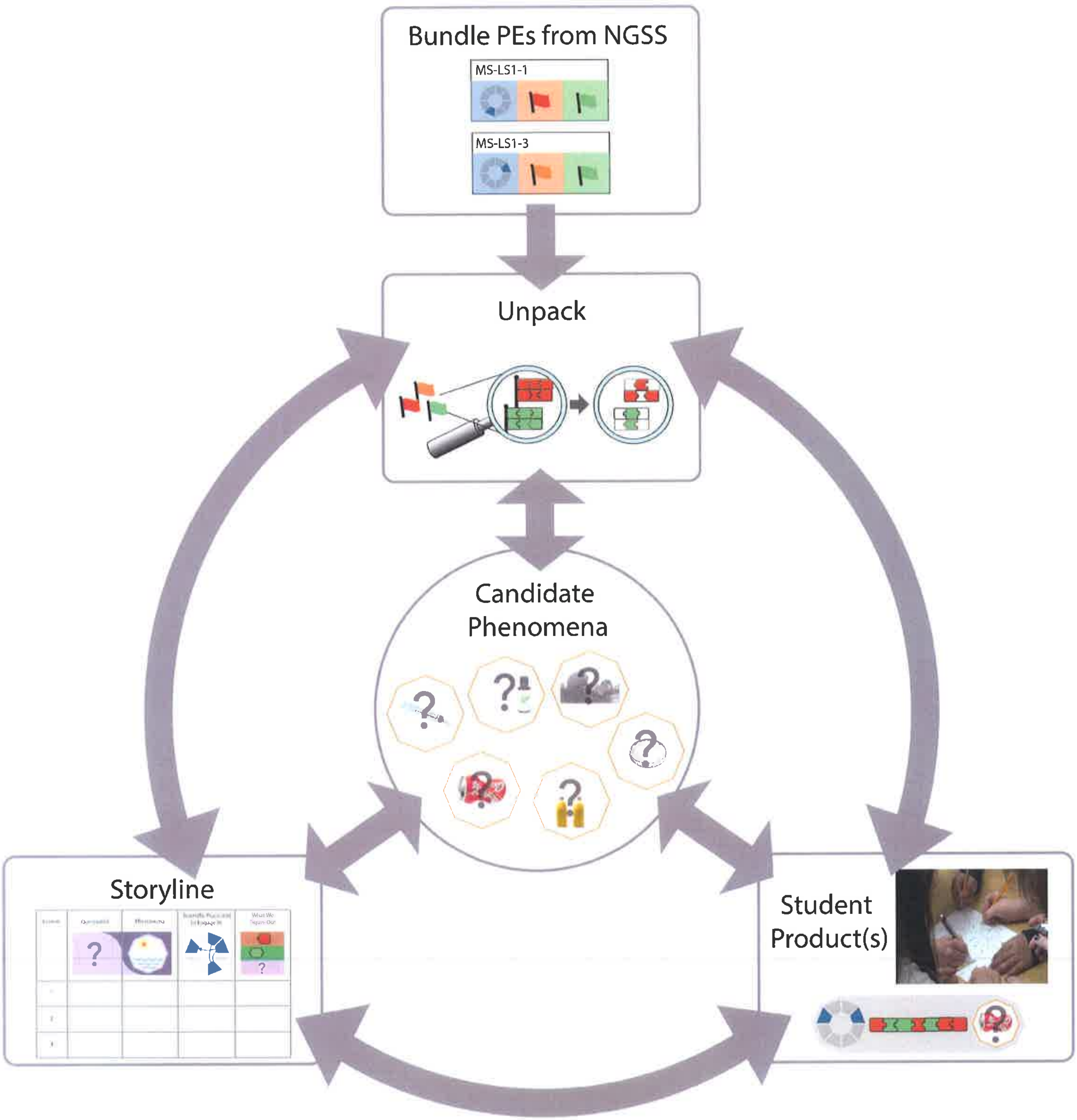
## Session 2

## Session 3

# HOW DO WE DEVELOP A UNIT OF STUDY ALIGNED TO THE NEXT GENERATION SCIENCE STANDARDS?

# Session 1

# NGSS Storyline Process



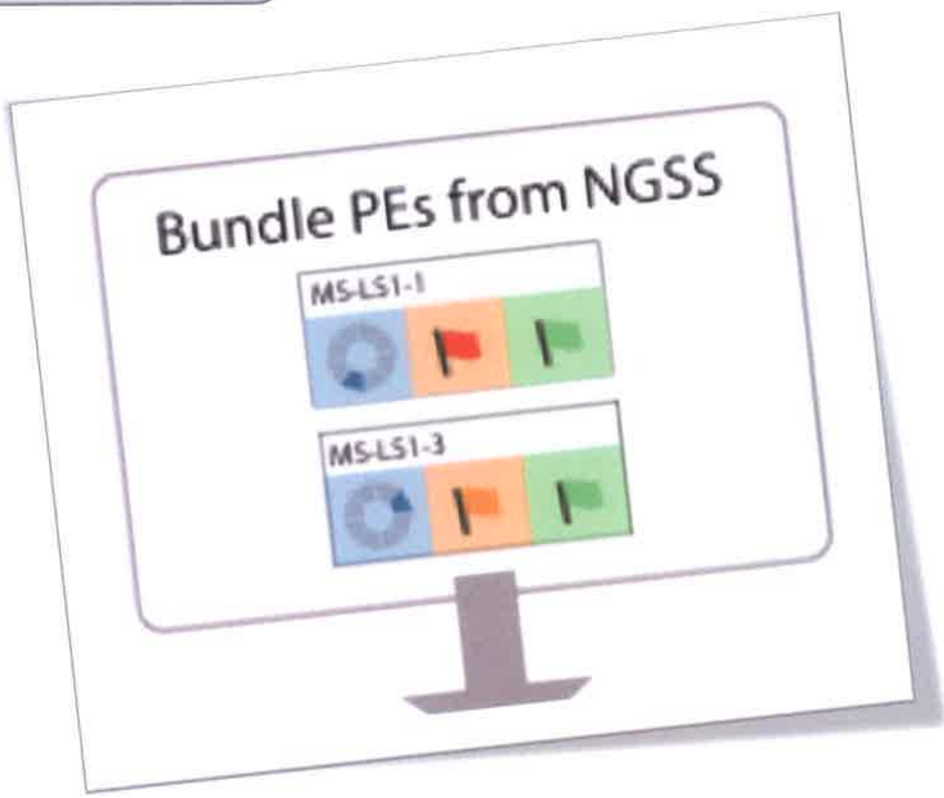


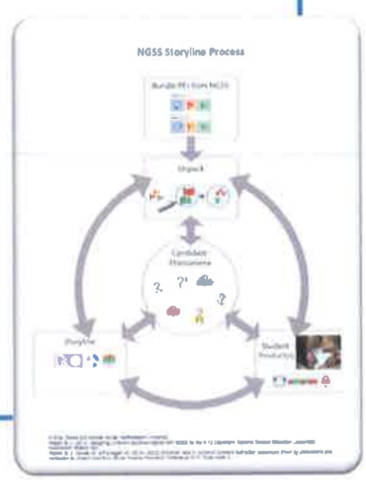

Reiser, B. J. (2014). *Designing coherent storylines aligned with NGSS for the K-12 classroom*. National Science Education Leadership Association, Boston, MA.
Reiser, B. J., Novak, M., & Fumagalli, M. (2015). *NGSS storylines: How to construct coherent instruction sequences driven by phenomena and motivated by student questions*. Illinois Science Education Conference 2015, Tinley Park, IL.

## Understanding the Process

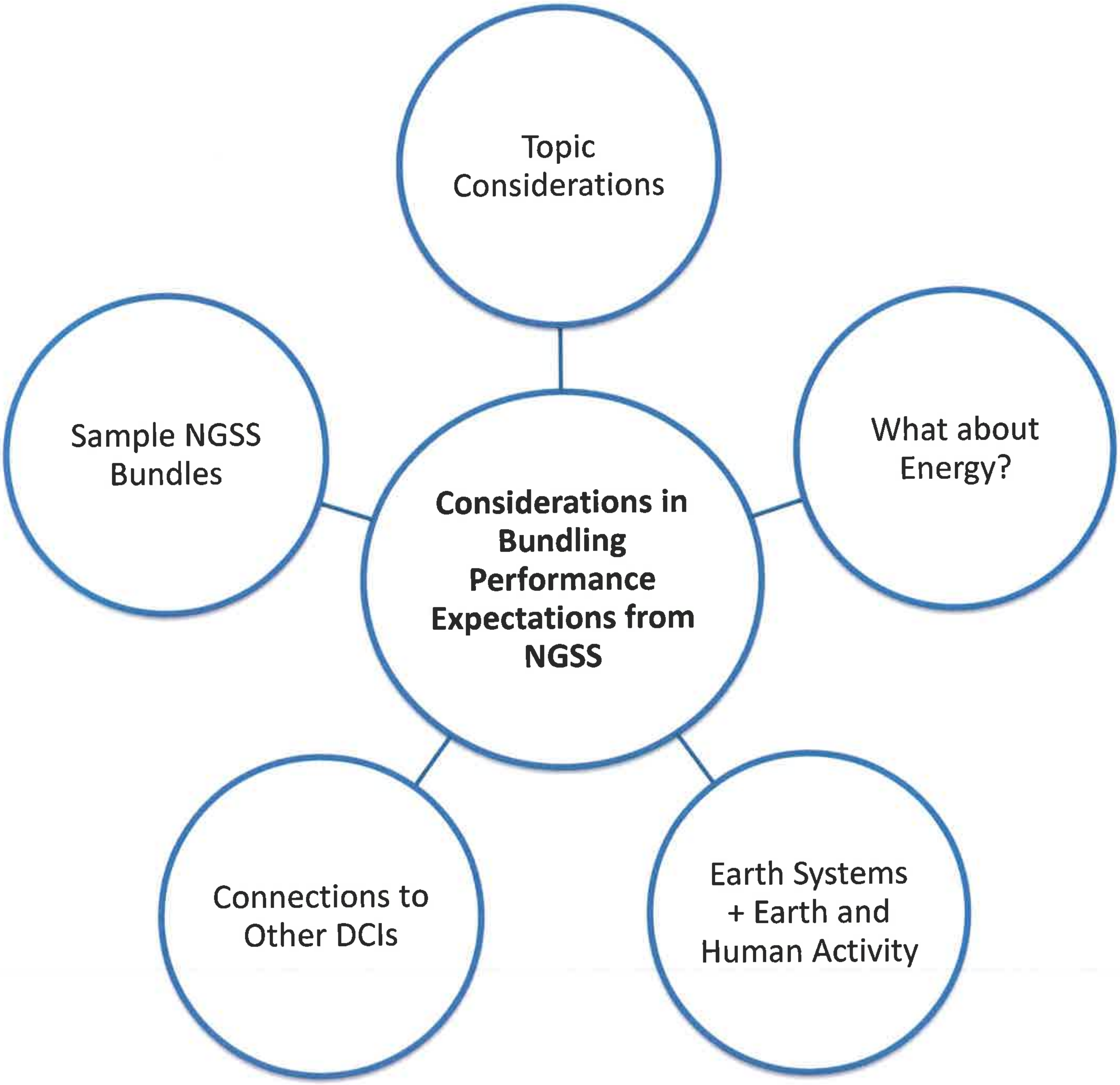
| Phase | Reminders or Notes |
|---|---|
| Bundle PEs from NGSS | |
| Unpack | |
| Candidate Phenomena | |
| Student Product | |
| Storyline | |


HOW DO WE DEVELOP A UNIT OF STUDY ALIGNED TO THE NEXT GENERATION SCIENCE STANDARDS?
Session 1


Bundle PEs from NGSS
MS-LS1-1
MS-LS1-3


NGSS Storyline Process

## Considerations in Bundling Performance Expectations



## Bundle Performance Expectations from NGSS

Working in a small group, bundle performance expectations from the Next Generation Science Standards.

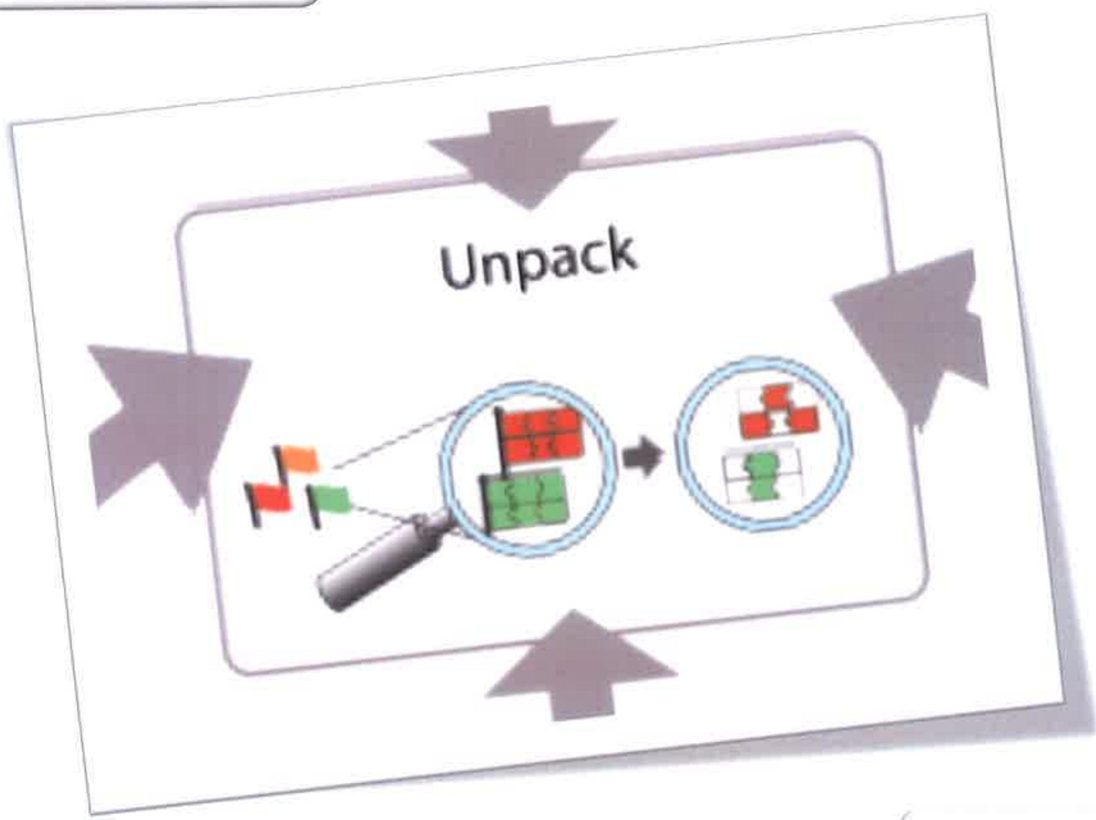
1. Begin by looking through the performance expectations in the NGSS to consider potential performance expectation bundles.
2. Create at least one bundle with your small group.
3. In the chart below, record the performance expectations in the left column. And, explain your rationale for bundling these particular performance expectations in the right column.
4. Be prepared to share with the whole group.

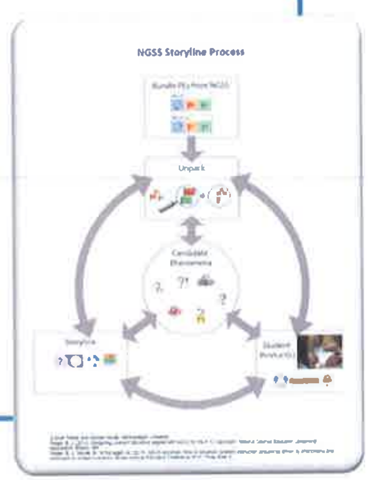
| Bundled Performance Expectations from NGSS | Rationale |
|---|---|
| | |

| Bundled Performance Expectations from NGSS | Rationale |
| --- | --- |
| | |

HOW DO WE DEVELOP A UNIT OF STUDY ALIGNED TO THE NEXT GENERATION SCIENCE STANDARDS?

# Session 1



## The Process of Unpacking to Make Sense of the Science

# 3.Weather and Climate

## 3.Weather and Climate

Students who demonstrate understanding can:

**3-ESS2-1. Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.** [Clarification Statement: Examples of data could include average temperature, precipitation, and wind direction.] [Assessment Boundary: Assessment of graphical displays is limited to pictographs and bar graphs. Assessment does not include climate change.]

**3-ESS2-2. Obtain and combine information to describe climates in different regions of the world.**

**3-ESS3-1. Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.*** [Clarification Statement: Examples of design solutions to weather-related hazards could include barriers to prevent flooding, wind resistant roofs, and lightning rods.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

### Science and Engineering Practices

**Analyzing and Interpreting Data**
Analyzing data in 3–5 builds on K–2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used.

- Represent data in tables and various graphical displays (bar graphs and pictographs) to reveal patterns that indicate relationships. (3-ESS2-1)

**Engaging in Argument from Evidence**
Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).

- Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem. (3-ESS3-1)

**Obtaining, Evaluating, and Communicating Information**
Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluating the merit and accuracy of ideas and methods.

- Obtain and combine information from books and other reliable media to explain phenomena. (3-ESS2-2)

### Disciplinary Core Ideas

**ESS2.D: Weather and Climate**

- Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next. (3-ESS2-1)
- Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years. (3-ESS2-2)

**ESS3.B: Natural Hazards**

- A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts. (3-ESS3-1) *(Note: This Disciplinary Core Idea is also addressed by 4-ESS3-2.)*

### Crosscutting Concepts

**Patterns**

- Patterns of change can be used to make predictions. (3-ESS2-1),(3-ESS2-2)

**Cause and Effect**

- Cause and effect relationships are routinely identified, tested, and used to explain change. (3-ESS3-1)

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***Connections to Engineering, Technology, and Applications of Science***

**Influence of Engineering, Technology, and Science on Society and the Natural World**

- Engineers improve existing technologies or develop new ones to increase their benefits (e.g., better artificial limbs), decrease known risks (e.g., seatbelts in cars), and meet societal demands (e.g., cell phones). (3-ESS3-1)

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***Connections to Nature of Science***

**Science is a Human Endeavor**

- Science affects everyday life. (3-ESS3-1)

*Connections to other DCIs in third grade:* N/A

*Articulation of DCIs across grade-levels:* **K.ESS2.D** (3-ESS2-1); **K.ESS3.B** (3-ESS3-1); **K.ETS1.A** (3-ESS3-1); **4.ESS2.A** (3-ESS2-1); **4.ESS3.B** (3-ESS3-1); **4.ETS1.A** (3-ESS3-1); **5.ESS2.A** (3-ESS2-1); **MS.ESS2.C** (3-ESS2-1),(3-ESS2-2); **MS.ESS2.D** (3-ESS2-1),(3-ESS2-2); **MS.ESS3.B** (3-ESS3-1)

*Common Core State Standards Connections:*

*ELA/Literacy –*

**RI.3.1** Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. *(3-ESS2-2)*
**RI.3.9** Compare and contrast the most important points and key details presented in two texts on the same topic. (3-ESS2-2)
**W.3.1** Write opinion pieces on topics or texts, supporting a point of view with reasons. *(3-ESS3-1)*
**W.3.7** Conduct short research projects that build knowledge about a topic. *(3-ESS3-1)*
**W.3.9** Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories. (3-ESS2-2)

*Mathematics –*

**MP.2** Reason abstractly and quantitatively. (3-ESS2-1),(3-ESS2-2),*(3-ESS3-1)*
**MP.4** Model with mathematics. (3-ESS2-1),(3-ESS2-2), *(3-ESS3-1)*
**MP.5** Use appropriate tools strategically. *(3-ESS2-1)*
**3.MD.A.2** Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem. *(3-ESS2-1)*
**3.MD.B.3** Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step "how many more" and "how many less" problems using information presented in bar graphs. (3-ESS2-1)

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

## ESS2.D: WEATHER AND CLIMATE

*What regulates weather and climate?*

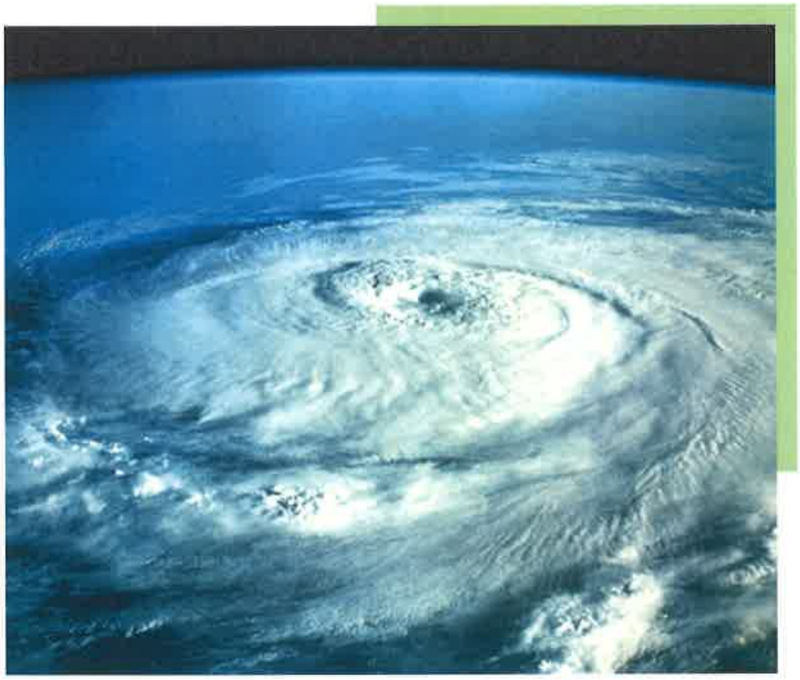
Weather, which varies from day to day and seasonally throughout the year, is the condition of the atmosphere at a given place and time. Climate is longer term and location sensitive; it is the range of a region's weather over 1 year or many years, and, because it depends on latitude and geography, it varies from place to place. Weather and climate are shaped by complex interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions can drive changes that occur over multiple time scales—from days, weeks, and months for weather to years, decades, centuries, and beyond—for climate.

The ocean exerts a major influence on weather and climate. It absorbs and stores large amounts of energy from the sun and releases it very slowly; in that way, the ocean moderates and stabilizes global climates. Energy is redistributed globally through ocean currents (e.g., the Gulf Stream) and also through atmospheric circulation (winds). Sunlight heats Earth's surface, which in turn heats the atmosphere. The resulting temperature patterns, together with Earth's rotation and the configuration of continents and oceans, control the large-scale patterns of atmospheric circulation. Winds gain energy and water vapor content as they cross hot ocean regions, which can lead to tropical storms.

The "greenhouse effect" keeps Earth's surface warmer than it would be otherwise. To maintain any average temperature over time, energy inputs from the sun and from radioactive decay in Earth's interior must be balanced by energy loss due to radiation from the upper atmosphere. However, what determines the temperature at which this balance occurs is a complex set of absorption, reflection, transmission, and redistribution processes in the atmosphere and oceans that determine how long energy stays trapped in these systems before being radiated away. Certain gases in the atmosphere (water vapor, carbon dioxide, methane, and nitrous oxides), which absorb and retain energy that radiates from Earth's surface, essentially insulate the planet. Without this phenomenon, Earth's surface would be too cold to be habitable. However, changes in the atmosphere, such as increases in carbon dioxide, can make regions of Earth too hot to be habitable by many species.

Climate changes, which are defined as significant and persistent changes in an area's average or extreme weather conditions, can occur if any of Earth's systems change (e.g., composition of the atmosphere, reflectivity of Earth's surface). Positive feedback loops can amplify the impacts of these effects and trigger relatively abrupt changes in the climate system; negative feedback loops tend to maintain stable climate conditions.

Some climate changes in Earth's history were rapid shifts (caused by events, such as volcanic eruptions and meteoric impacts, that suddenly put a large amount of particulate matter into the atmosphere or by abrupt changes in ocean currents); other climate changes were gradual and longer term—due, for example, to solar output variations, shifts in the tilt of Earth's axis, or atmospheric change due to the rise of plants and other life forms that modified the atmosphere via photosynthesis. Scientists can infer these changes from geological evidence.



Natural factors that cause climate changes over human time scales (tens or hundreds of years) include variations in the sun's energy output, ocean circulation patterns, atmospheric composition, and volcanic activity. (See ESS3.D for a detailed discussion of human activities and global climate change.) When ocean currents change their flow patterns, such as during El Niño Southern Oscillation conditions, some global regions become warmer or wetter and others become colder or drier. Cumulative increases in the atmospheric concentration of carbon dioxide and other greenhouse gases, whether arising from natural sources or human industrial activity (see ESS3.D), increase the capacity of Earth to retain energy. Changes in surface or atmospheric reflectivity change the amount of energy from the sun that enters the planetary system. Icy surfaces, clouds, aerosols, and larger particles in the atmosphere, such as from volcanic ash, reflect sunlight and thereby decrease the amount of solar energy that can enter the weather/climate system. Conversely, dark surfaces (e.g., roads, most buildings) absorb sunlight and thus increase the energy entering the system.

## Grade Band Endpoints for ESS2.D

*By the end of grade 2.* Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time.

*By the end of grade 5.* Weather is the minute-by-minute to day-by-day variation of the atmosphere's condition on a local scale. Scientists record the patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next. Climate describes the ranges of an area's typical weather conditions and the extent to which those conditions vary over years to centuries.

*By the end of grade 8.* Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. Because these patterns are so complex, weather can be predicted only probabilistically.

The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents. Greenhouse gases in the atmosphere absorb and retain the energy radiated from land and ocean surfaces, thereby regulating Earth's average surface temperature and keeping it habitable.

*By the end of grade 12.* The foundation for Earth's global climate system is the electromagnetic radiation from the sun as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems and this energy's reradiation into space. Climate change can occur when certain parts of Earth's systems are altered. Geological evidence indicates that past climate changes were either sudden changes caused by alterations in the atmosphere; longer term changes (e.g., ice ages) due to variations in solar output, Earth's orbit, or the orientation of its axis; or even more gradual atmospheric changes due to plants and other organisms that captured carbon dioxide and released oxygen. The time scales of these changes varied from a few to millions of years. Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate (link to ESS3.D).

Global climate models incorporate scientists' best knowledge of physical and chemical processes and of the interactions of relevant systems. They are tested by their ability to fit past climate variations. Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and the biosphere. Hence the outcomes depend on human behaviors (link to ESS3.D) as well as on natural factors that involve complex feedbacks among Earth's systems (link to ESS2.A).

## ESS3.B: NATURAL HAZARDS

*How do natural hazards affect individuals and societies?*

Natural processes can cause sudden or gradual changes to Earth's systems, some of which may adversely affect humans. Through observations and knowledge of historical events, people know where certain of these hazards—such as earthquakes, tsunamis, volcanic eruptions, severe weather, floods, and coastal erosion—are likely to occur. Understanding these kinds of hazards helps us prepare for and respond to them.

Natural hazards and other geological events have shaped the course of human history, sometimes significantly altering the size of human populations or driving human migrations.

While humans cannot eliminate natural hazards, they can take steps to reduce their impacts. For example, loss of life and economic costs have been greatly reduced by improving construction, developing warning systems, identifying and avoiding high-risk locations, and increasing community preparedness and response capability.

Some natural hazards are preceded by geological activities that allow for reliable predictions; others occur suddenly, with no notice, and are not yet predictable. By tracking the upward movement of magma, for example, volcanic eruptions can often be predicted with enough advance warning to allow neighboring regions to be evacuated. Earthquakes, in contrast, occur suddenly; the specific time, day, or year cannot be predicted. However, the history of earthquakes in a region and the mapping of fault lines can help forecast the likelihood of future events. Finally, satellite monitoring of weather patterns, along with measurements from land, sea, and air, usually can identify developing severe weather and lead to its reliable forecast.

Natural hazards and other geological events have shaped the course of human history, sometimes significantly altering the size of human populations or driving human migrations. Natural hazards can be local, regional, or global in origin, and even local events can have distant impacts because of the interconnectedness of human societies and Earth's systems. Human activities can contribute to the frequency and intensity of some natural hazards (e.g., flooding, forest fires), and risks from natural hazards increase as populations—and population densities—increase in vulnerable locations.

### Grade Band Endpoints for ESS3.B

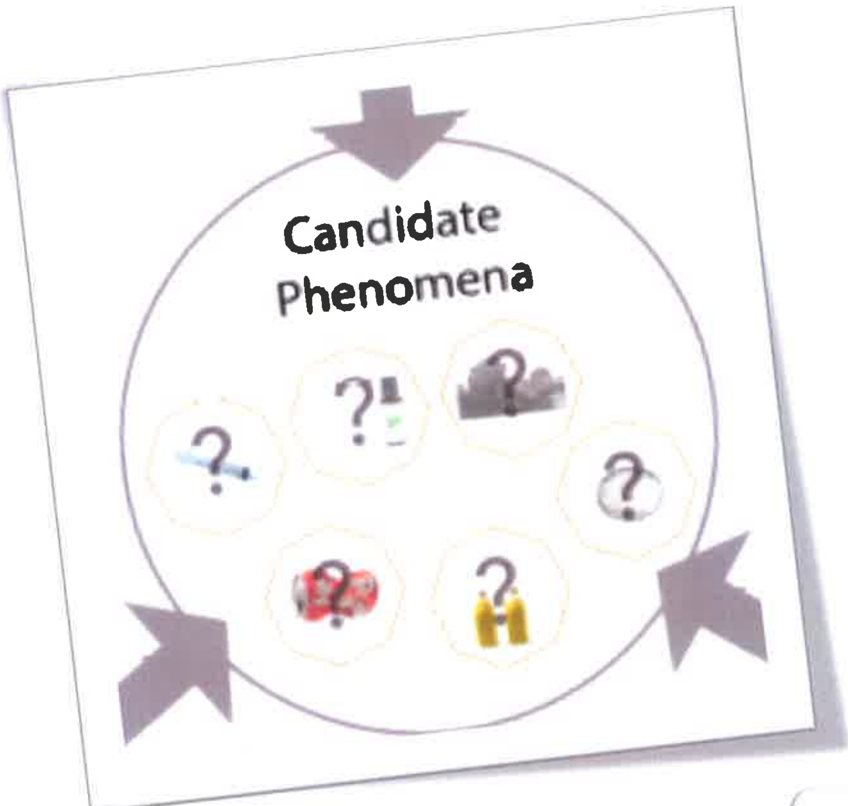
*By the end of grade 2.* Some kinds of severe weather are more likely than others in a given region. Weather scientists forecast severe weather so that communities can prepare for and respond to these events.

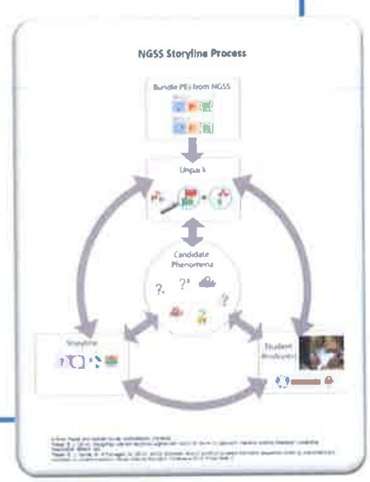
*By the end of grade 5.* A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions, severe weather, floods, coastal erosion). Humans cannot eliminate natural hazards but can take steps to reduce their impacts.

*By the end of grade 8.* Some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions. Others, such as earthquakes, occur suddenly and with no notice, and thus they are not yet predictable. However, mapping the history of natural hazards in a region, combined with an understanding of related geological forces can help forecast the locations and likelihoods of future events.

*By the end of grade 12.* Natural hazards and other geological events have shaped the course of human history by destroying buildings and cities, eroding land, changing the course of rivers, and reducing the amount of arable land. These events have significantly altered the sizes of human populations and have driven human migrations. Natural hazards can be local, regional, or global in origin, and their risks increase as populations grow. Human activities can contribute to the frequency and intensity of some natural hazards.


HOW DO WE DEVELOP A UNIT OF STUDY ALIGNED TO THE NEXT GENERATION SCIENCE STANDARDS?
Session 1


Candidate Phenomena


NGSS Storyline Process

## Phenomena in NGSS

Working independently, consider your experiences from Phase 1 and 2 to brainstorm about phenomena. To brainstorm, follow the directions in the box below.

| | |
|---|---|
| **3** | Write three essential facts regarding phenomena in NGSS.<br>•<br>•<br>• |
| **2** | Write two examples of phenomena.<br>•<br>• |
| **1** | Write one question you have regarding phenomena.<br>• |

# Characteristics of Good Phenomena

from Joe Krajcik, *Three-dimensional instruction: Using a new type of teaching in the science classroom* (NSTA, 2015)

Key characteristics associated with the best types of phenomena and questions to explore in the classroom:

- **Feasible-**Students can design and perform investigations to make sense of the phenomenon.
- **Worthwhile-**By making sense of the phenomenon, students are building understanding toward various performance expectations.
- **Contextualized-**The phenomenon is anchored in real-world issues or local environment of the learner.
- **Meaningful-**Learners will find making sense of the phenomenon interesting and important.
- **Ethical-**By exploring the phenomenon, learners do not harm living organisms or the environment.
- **Sustainable-**Learners can pursue exploration of the phenomenon over time.

# Criteria for Evaluating Phenomena

from Ted Willard, NSTA

According to the Framework for K-12 Science Education and the Next Generation Science Standards (NGSS), teachers should expose students to phenomena and guide them to engage in Science and Engineering Practices in order to explain those phenomena. By carefully selecting phenomena to share with students, teacher can guide them toward the scientific understanding of the world as described by the elements of the Disciplinary Core Ideas (DCIs) in the Framework and NGSS. But some phenomena are much more effective than others at helping all students learn, so it is essential to consider many factors when selecting phenomena. The criteria below are meant as a guide in evaluating the usefulness of phenomena for classroom instruction. Identify the DCI element you wish to target with the phenomena, and then ask the following questions:

1. The phenomenon...
    - addresses **the entire** DCI element (*continue to the next step*)
    - addresses **only part** of the DCI element (*only continue to the next step if the phenomenon address the parts of the DCI Element you wish to address*)
    - **does not** address the DCI element (*end of evaluation, do not use this phenomenon*)
2. The phenomenon is observable to students, either through firsthand experiences or through someone else's experiences (such as a recording or set of measurements).

    **Yes** (*continue to the next step*) **No** (*end of evaluation, do not use this phenomenon*)
3. The phenomenon is likely comprehensible to students. For example, the relationship to the DCI Element is clear and easy to comprehend; any experimental procedure, calculations, and measurements are unlikely to detract from the lesson; or additional ideas and reasoning skills needed by students are appropriate given the students' grade level and prior experiences.

    **Yes** (*continue to the next step*) **No** (*end of evaluation, do not use this phenomenon*)
4. The phenomenon is attention getting, thought provoking, and requires some explanation so that it is likely to engage all students and motivate them to focus on the DCI Element.

    **Yes** (*continue to the next step*) **No** (*end of evaluation, do not use this phenomenon*)
5. Use of the phenomenon is efficient in that the benefits justify any financial costs and/or time devoted to using the phenomenon with students.

    **Yes** (*the phenomenon is promising*) **No** (*end of evaluation, do not use this phenomenon*)

## Anchoring vs. Investigative

Throughout a unit of study, students will engage with phenomena. At the onset of the unit, we look towards engaging the students with anchoring phenomena. This phenomenon should hook the interest of the students and drive students to ask questions that can be investigated in a unit of study. The investigative phenomena are the phenomena that are examined on a lesson level. These phenomena lead to the discovery of scientific principles and towards a greater understanding of the anchoring phenomena.

| Anchoring Phenomena | Investigative Phenomena |
|---|---|
| • Unit Level - Anchors the unit of study and is referred to repeatedly throughout unit<br>• Leads to questions<br>• Can be explained by synthesizing from investigations over a period of time | • Lesson Level<br>• Leads to more questions and discovery of scientific principles |

## Candidate Phenomena – Initial Thoughts

## Candidate Phenomena – Building Towards Lessons

| Scientific Idea | Phenomenon | Apparatus |
|---|---|---|
| This is the "Science."<br>• This is the Scientific Principle students need to learn.<br>• Based on the Disciplinary Core Ideas. | This is reoccurring event that can be observed.<br>• This is: "Wow! How did that happen? "<br>• The event that needs to be explained. | These are the physical materials the students will investigate with and model from in order to explain the phenomenon.<br>• Objects<br>• Lab Equipment |
| | | |
| | | |
| | | |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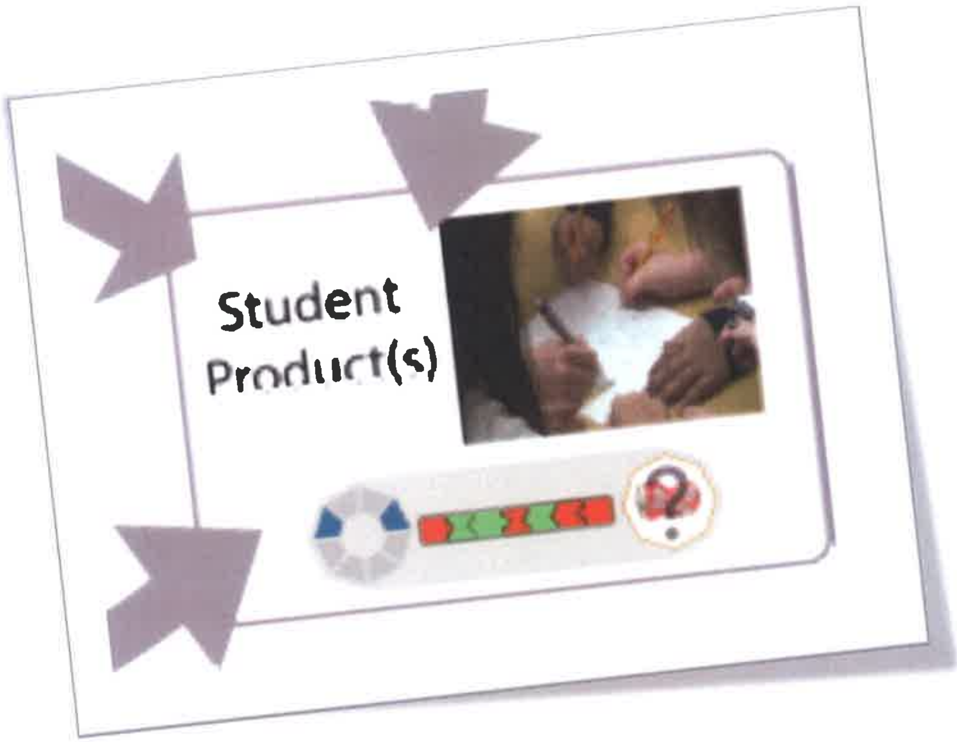
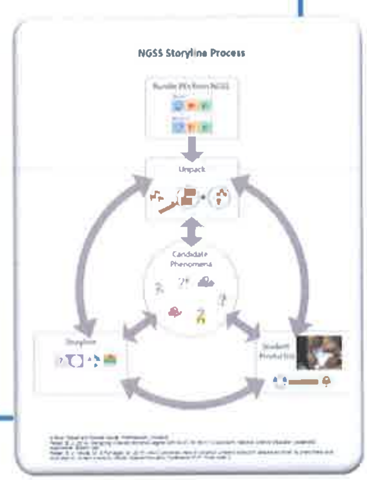
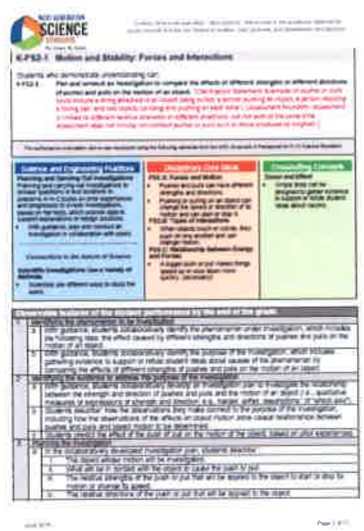

Student
Product(s)


NGSS Storyline Process

## Evidence Statement

| Phase | Reminders or Notes |
|---|---|
| **Purpose of the Evidence Statements** | |
| **Structure of the Evidence Statements** |  SCIENCE<br>K-PS2-1 Motion and Stability: Forces and Interactions |
| **How Evidence Statements can be used** | |
| **Limitations of the Evidence Statements** | |

## Evidence Statement Take-Aways

Working in a small group, review the evidence statements for the Weather and Climate bundle and use this space to record key takeaways from those Evidence Statements.

## Sample Student Product

As you are creating your sample student product, follow the prompts below to guide your work.

Begin by addressing the following questions as a group:

- What are the key aspects of your unpacking that are important to show up in the capstone student product?
- What kind of task might best get students to use these ideas? (e.g., modeling a phenomenon, making sense of data from an experiment, constructing an explanation)

Based on this conversation, determine your performance expectations for the assessment. Your performance expectations may be the same as those in NGSS or they may be a modified version.

Once you have agreed on a general direction, start sketching out a sample student product. Be sure that your sample product makes clear the following:

- What is the phenomenon, and what is the question about it that students will be addressing?
- How are the ideas of your unpacking being used in doing this task?
- What practices are the students engaging in while creating this product?

Put both the question students are addressing and your mocked-up response on chart paper.

When you are finished, display it so that you can report out to other groups.

Modified from NextGen Science Exemplar System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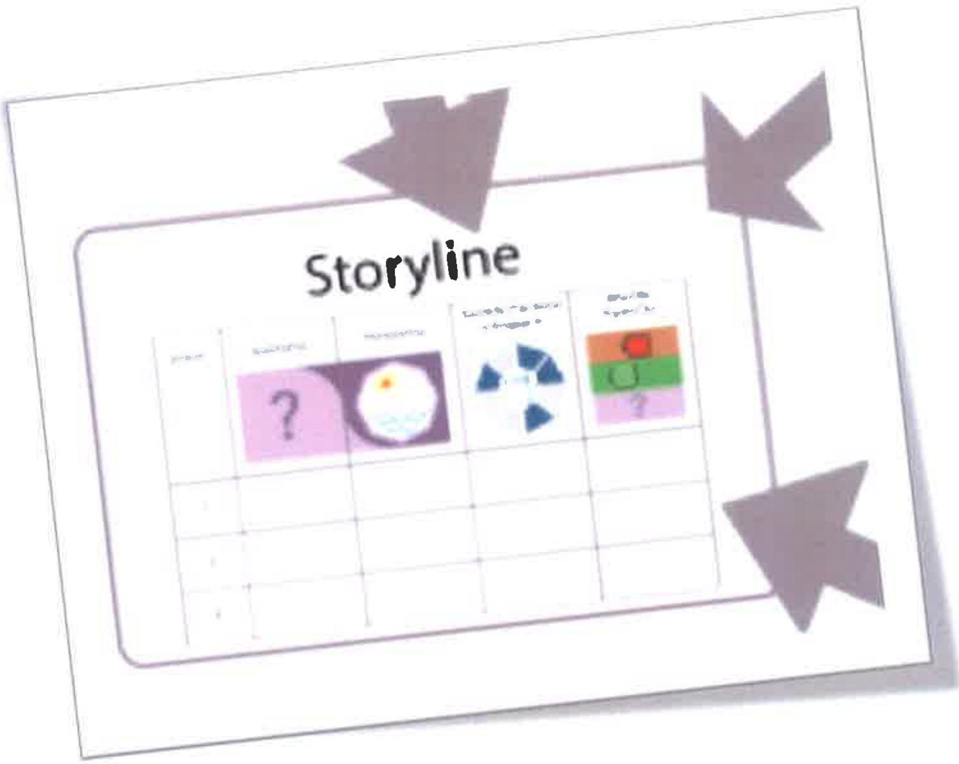
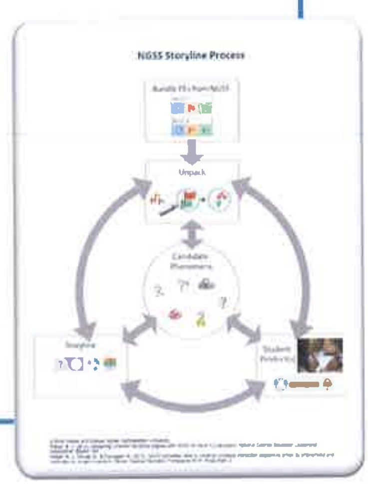
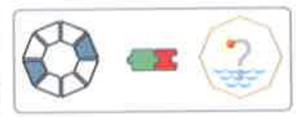
Session 1


Storyline


NGSS Storyline Process

# Understanding the Structure of the Storyline

**Creating NGSS Storylines**

| |  | |  |  |  |
|---|---|---|---|---|---|
| # | Questions | Phenomena | Scientific Practices | What We Figured Out | Lesson Level PE(s) |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |

# Writing a Storyline for Lessons

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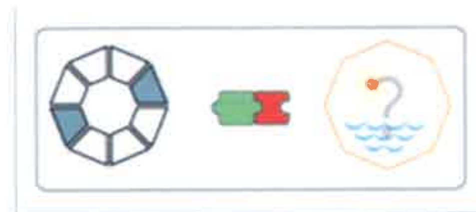
|---|---|---|---|---|---|
| |  | |  |  |  |
| **#** | **Question** | **Phenomena** | **Science & Engineering Practices** | **What We Figured Out** | **Lesson Level Performance Expectation(s)** |
| | • *Does the question come from phenomena related to the driving question or from gaps in what we figured out so far?*<br>• *Does the question ask how & why, and not just about facts?* | • *Can you get students to buy into the question using this phenomenon?*<br>• *Is there something about the phenomenon that needs to be explained?* | • *What practices are they using to investigate and explain the phenomenon?*<br>• *Will this lead to figuring out a piece of the Disciplinary Core Idea?* | • *What part of the Disciplinary Core Idea will students be able to figure out?*<br>• *What Crosscutting Concept lens will they use to make sense of the core idea?*<br>• *What questions come out of the activity to motivate the next step?* | • *How will you articulate the central focus of the three-dimensional learning for this lesson?*<br>• *Where is the heavy lifting for the students and the primary coaching/formative assessment opportunity for the teacher?* |
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# Storyline: Third Grade Weather & Climate

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| **#** | **Question** | **Phenomena** | **Science & Engineering Practices** | **What We Figured Out** | **Lesson Level Performance Expectation(s)** |
| | • *Does the question come from phenomena related to the driving question or from gaps in what we figured out so far?*<br>• *Does the question ask how & why, and not just about facts?* | • *Can you get students to buy into the question using this phenomenon?*<br>• *Is there something about the phenomenon that needs to be explained?* | • *What practices are they using to investigate and explain the phenomenon?*<br>• *Will this lead to figuring out a piece of the Disciplinary Core Idea?* | • *What part of the Disciplinary Core Idea will students be able to figure out?*<br>• *What Crosscutting Concept lens will they use to make sense of the core idea?*<br>• *What questions come out of the activity to motivate the next step?* | • *How will you articulate the central focus of the three-dimensional learning for this lesson?*<br>• *Where is the heavy lifting for the students and the primary coaching/formative assessment opportunity for the teacher?* |
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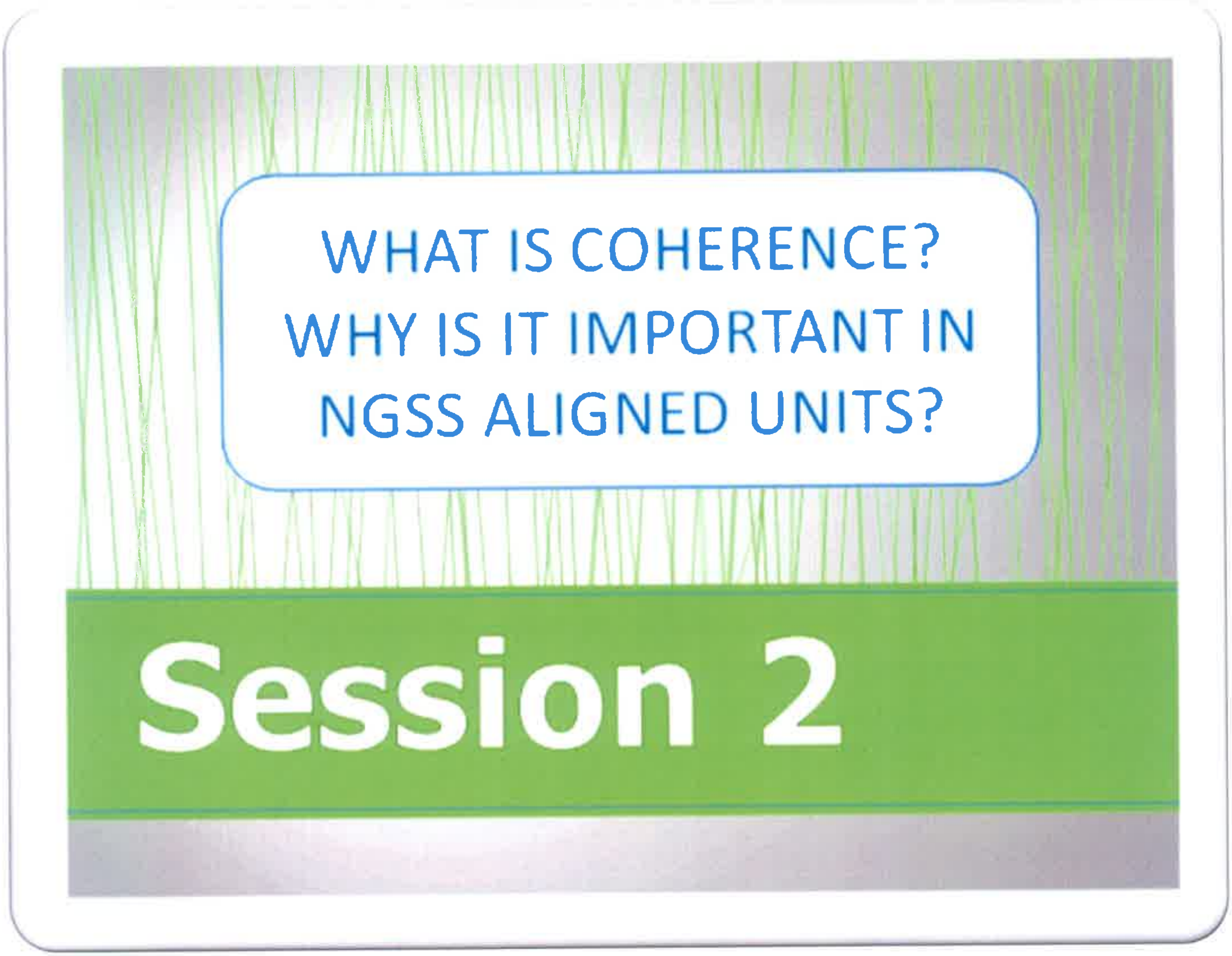
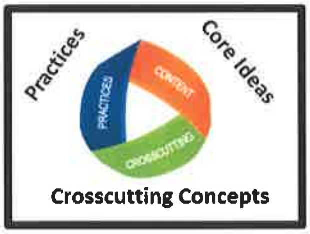
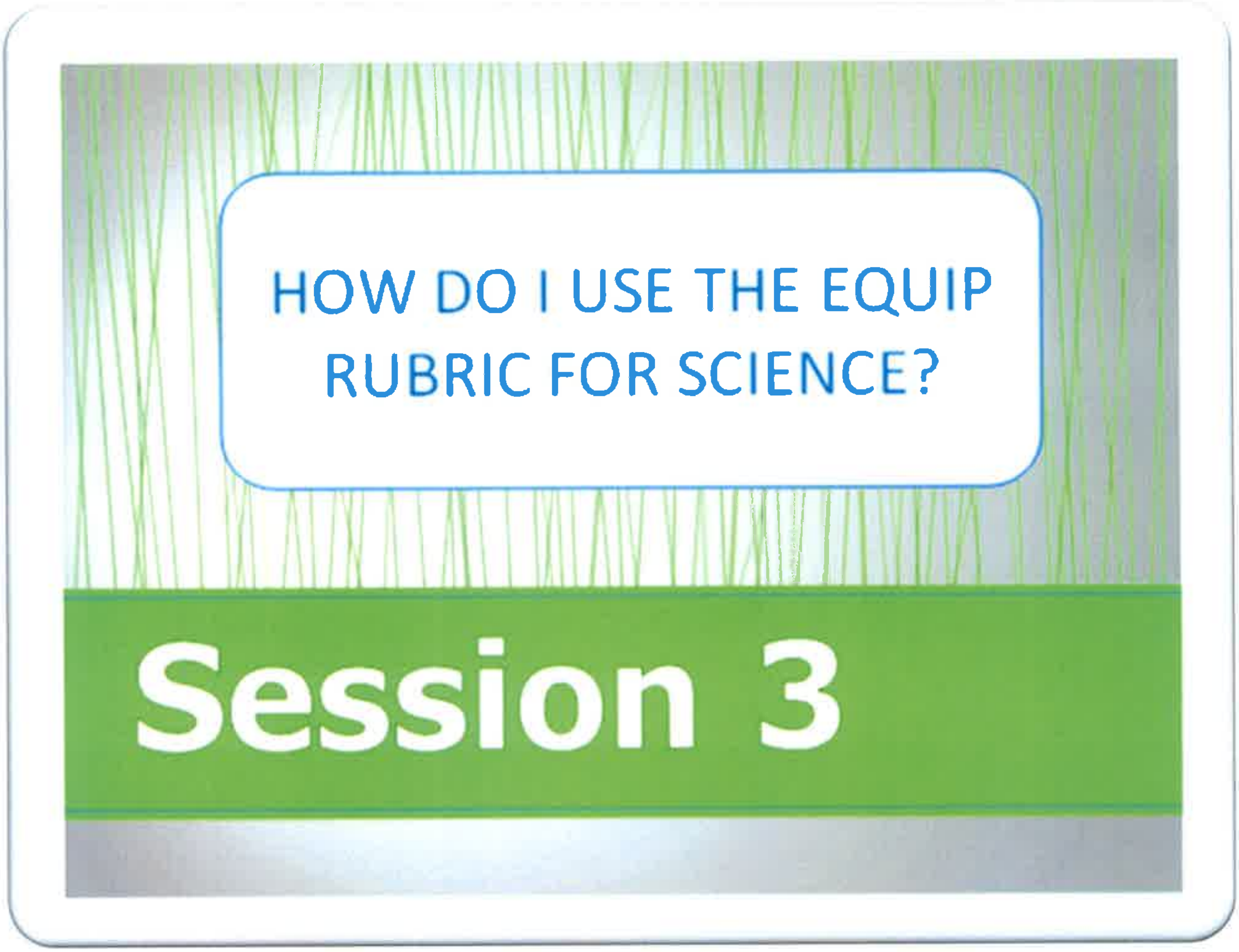

WHAT IS COHERENCE?
WHY IS IT IMPORTANT IN
NGSS ALIGNED UNITS?
Session 2

# Initial Thoughts: Coherence




Consider the term "Coherence." What does this mean? How would you explain this term to students, parents, administrations, and scientists? Take a few minutes to consider what you think coherence might look like in a longer lesson, a series of lessons, or a unit in science. In the space below, write your current working definition for the term "coherence" in regards to NGSS aligned materials.


HOW DO I USE THE EQUIP
RUBRIC FOR SCIENCE?
Session 3

## *EQuIP Rubric for Lessons & Units: Science*

**Introduction**

The Educators Evaluating the Quality of Instructional Products (EQuIP) Rubric for science provides criteria by which to measure the alignment and overall quality of lessons and units with respect to the Next Generation Science Standards (NGSS). The purposes of the rubric and review process are to: (1) review existing lessons and units to determine what revisions are needed; (2) provide constructive criterion-based feedback and suggestions for improvement to developers; (3) identify exemplars/models for teachers' use within and across states; and (4) to inform the development of new lessons and units.

To effectively apply this rubric, an understanding of the National Research Council's *A Framework for K–12 Science Education and the Next Generation Science Standards*, including the NGSS shifts (appendix A of the NGSS), is needed. Unlike the EQuIP Rubrics for mathematics and ELA, there is not a category in the science rubric for shifts. Over the course of the rubric development, writers and reviewers noted that the shifts fit naturally into the other three categories. For example, the blending of the three-dimensions, or three-dimensional learning, is addressed in each of the three categories; coherence is addressed in the first two categories; connections to the Common Core State Standards is addressed in the first category; etc. Each category includes criteria by which to evaluate the integration of engineering, when included in a lesson or unit, through practices or disciplinary core ideas. Another difference between the EQuIP Rubrics from mathematics and ELA is in the name of the categories; the rubric for science refers to them simply as *categories*, whereas the math and ELA rubrics refer to the categories as dimensions. This distinction was made because the Next Generation Science Standards already uses the term *dimensions* to refer to practices, disciplinary core ideas, and crosscutting concepts.

The architecture of the NGSS is significantly different from other sets of standards. The three dimensions, crafted into performance expectations, describe what is to be assessed following instruction and therefore are the measure of proficiency. A lesson or unit may provide opportunities for students to demonstrate performance of practices connected with their understanding of core ideas and crosscutting concepts as foundational pieces. This three-dimensional learning leads toward eventual mastery of performance expectations. In this scenario, quality materials should clearly describe or show how the lesson or unit works coherently with previous and following lessons or units to help build toward eventual mastery of performance expectations. The term *element* is used in the rubric to represent the relevant, bulleted practices, disciplinary core ideas, and crosscutting concepts that are articulated in the foundation boxes of the standards as well as the in the NGSS appendices on each dimension. Given the understanding that a lesson or unit may include the blending of practices, disciplinary core ideas, and crosscutting concepts that are not identical to the combination of practices, disciplinary core ideas, and crosscutting concepts in a performance expectation, the new term *elements* was needed to describe these smaller units of the three dimensions. Although it is unlikely that a single lesson would provide adequate opportunities for a student to demonstrate proficiency on every dimension of a performance expectation, high-quality units are more likely to provide these opportunities to demonstrate proficiency on one or more performances expectations.

There is a recognition among educators that curriculum and instruction will need to shift with the adoption of the NGSS, but there is currently a lack of NGSS-aligned materials. The power of the rubric is in the feedback and suggestions for improvement it provides curriculum developers and the productive conversations educators have while evaluating materials (i.e., the review process). For curriculum developers, the rubric and review process provide evidence on the quality and alignment of a lesson or unit to the NGSS. Additionally, the rubric and review process generate suggestions for improvement on how materials can be further improved and more closely aligned to the NGSS. As more NGSS lessons and units are developed, this rubric may change to meet the evolving needs of supporting both educators in evaluating materials and developers in the modification and creation of materials. Additionally, support materials will be developed to complement the use of this rubric, such as a professional development guide, a criterion discussion guide, and publishers' criteria that will be more focused on textbooks and comprehensive curriculums.

Version 2 – published September 2014

## Directions

The first step in the review process is to become familiar with the rubric, the lesson or unit, and the practices, disciplinary core ideas, and crosscutting concepts targeted in the lesson or unit. The three categories in the rubric correspond to: alignment to the NGSS, instructional supports, and monitoring student progress. Specific criteria within each category should be considered separately as part of the complete review process and are used to provide sufficient information for determination of overall quality of the lesson or unit. For the purposes of using the rubric, a lesson is defined as: a coherent set of instructional activities and assessments aligned to the NGSS that may extend over a few to several class periods or days and a unit is defined as: coherent set of lessons aligned to the NGSS that extend over a longer period of time.

Also important to the review process is feedback and suggestions for improvement to the developer of the resource. For this purpose a set of response forms is included so that the reviewer can effectively provide criterion-based feedback and suggestions for improvement for each category. The response forms correspond to the criteria of the rubric. Evidence for each criterion must be identified and documented and criterion-based feedback and suggestions for improvement should be given to help improve the lesson or unit.

While it is possible for the rubric to be applied by an individual, the quality review process works best with a team of reviewers, as a collaborative process, with the individuals recording their thoughts and then discussing with other team members before finalizing their feedback and suggestions for improvement. Discussions should focus on understanding all reviewers' interpretations of the criteria and the evidence they have found. The goal of the process is to eventually calibrate responses across reviewers and to move toward agreement about quality with respect to the NGSS. Commentary needs to be constructive, with all lessons or units considered "works in progress." Reviewers must be respectful of team members and the resource contributor. Contributors should see the review process as an opportunity to gather feedback and suggestions for improvement rather than to advocate for their work. All feedback and suggestions for improvement should be criterion-based and have supporting evidence from the lesson or unit cited.

*Note: This rubric will eventually have scoring guidelines for each category, as well as for an overall rating. However, given the current lack of NGSS-aligned materials, rather than focusing on ratings at this point in time, the focus should be on becoming familiar with the rubric and using it to provide criterion-based feedback and suggestions for improvement to developers and make revisions to existing materials.*

### Step 1 – Review Materials

The first step in the review process is to become familiar with the rubric, the lesson or unit, and the practices, disciplinary core ideas, and crosscutting concepts targeted in the lesson or unit.

- Review the rubric and record the grade and title of the lesson or unit on the response form.
- Scan to see what the lesson or unit contains, what practices, disciplinary core ideas, and crosscutting concepts are targeted, and how it is organized.
- Read key materials related to instruction, assessment, and teacher guidance.

### Step 2 – Apply Criteria in Category I: Alignment to the NGSS

The second step is to evaluate the lesson or unit using the criteria in the first category, first individually and then as a team.

- Closely examine the lesson or unit through the "lens" of each criterion in the first category of the response form.
- Individually check each criterion on the response form for which clear and substantial evidence is found and record the evidence and reasoning.
- As a team, discuss criteria for which clear and substantial evidence is found, as well as criterion-based suggestions for specific improvements that might be needed to meet criteria.

*If the lesson or unit is not closely aligned to the Next Generation Science Standards, it may not be appropriate to move on to the second and third categories. Professional judgment should be used when weighing the individual criterion. For example, a lesson without crosscutting concepts explicitly called out may be easier to revise than one without appropriate disciplinary core ideas; such a difference may determine whether reviewers believe the lesson merits continued evaluation or not.*

Step 3 – Apply Criteria in Categories II and III: Instructional Supports and Monitoring Student Progress

The third step is to evaluate the lesson or unit using the criteria in the second and third categories, first individually and then as a group.

- Closely examine the lesson or unit through the "lens" of each criterion in the second and third categories of the response form.
- Individually check each criterion on the response form for which clear and substantial evidence is found and record the evidence and reasoning.
- As a team, discuss criteria for which clear and substantial evidence is found, as well as criterion-based suggestions for specific improvements that might be needed to meet criteria.

*When working in a group, teams may choose to compare ratings after each category or delay conversation until each person has rated and recorded input for the two remaining categories. Complete consensus among team members is not required but discussion is a key component of the review process.*

## EQuIP Rubric for Lessons & Units: Science

| I. Alignment to the NGSS | II. Instructional Supports | III. Monitoring Student Progress |
|---|---|---|
| The lesson or unit aligns with the conceptual shifts of the NGSS:<br>A. Grade-appropriate elements of the science and engineering practice(s), disciplinary core idea(s), and crosscutting concept(s), work together to support students in three-dimensional learning to make sense of phenomena and/or to design solutions to problems.<br>i. Provides opportunities to develop and use specific elements of the practice(s) to make sense of phenomena and/or to design solutions to problems.<br>ii. Provides opportunities to develop and use specific elements of the disciplinary core idea(s) to make sense of phenomena and/or to design solutions to problems.<br>iii. Provides opportunities to develop and use specific elements of the crosscutting concept(s) to make sense of phenomena and/or to design solutions to problems.<br>iv. The three dimensions work together to support students to make sense of phenomena and/or to design solutions to problems.<br><br>A unit or longer lesson will also:<br>B. Lessons fit together coherently targeting a set of performance expectations.<br>i. Each lesson links to previous lessons and provides a need to engage in the current lesson.<br>ii. The lessons help students develop proficiency on a targeted set of performance expectations.<br>C. Where appropriate, disciplinary core ideas from different disciplines are used together to explain phenomena.<br>D. Where appropriate, crosscutting concepts are used in the explanation of phenomena from a variety of disciplines.<br>E. Provides grade-appropriate connection(s) to the Common Core State Standards in Mathematics and/or English Language Arts & Literacy in History/Social Studies, Science and Technical Subjects. | The lesson or unit supports instruction and learning for all students:<br>A. Engages students in authentic and meaningful scenarios that reflect the practice of science and engineering as experienced in the real world and that provide students with a purpose (e.g., making sense of phenomena and/or designing solutions to problems).<br>i. The context, including phenomena, questions, or problems, motivates students to engage in three-dimensional learning.<br>ii. Provides students with relevant phenomena (either firsthand experiences or through representations) to make sense of and/or relevant problems to solve.<br>iii. Engages students in multiple practices that work together with disciplinary core ideas and crosscutting concepts to support students in making sense of phenomena and/or designing solutions to problems.<br>iv. Provides opportunities for students to connect their explanation of a phenomenon and/or their design solution to a problem to their own experience.<br>v. When engineering performance expectations are included, they are used along with disciplinary core ideas from physical, life, or earth and space sciences.<br>B. Develops deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts by identifying and building on students' prior knowledge.<br>C. Uses scientifically accurate and grade-appropriate scientific information, phenomena, and representations to support students' three-dimensional learning.<br>D. Provides opportunities for students to express, clarify, justify, interpret, and represent their ideas and respond to peer and teacher feedback orally and/or in written form as appropriate to support student's three-dimensional learning.<br>E. Provides guidance for teachers to support differentiated instruction in the classroom so that every student's needs are addressed by including:<br>i. Suggestions for how to connect instruction to the students' home, neighborhood, community and/or culture as appropriate.<br>ii. Appropriate reading, writing, listening, and/or speaking alternatives (e.g., translations, picture support, graphic organizers) for students who are English language learners, have special needs, or read well below the grade level.<br>iii. Suggested extra support (e.g., phenomena, representations, tasks) for students who are struggling to meet the performance expectations.<br>iv. Extensions for students with high interest or who have already met the performance expectations to develop deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts.<br><br>A unit or longer lesson will also:<br>F. Provides guidance for teachers throughout the unit for how lessons build on each other to support students developing deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts over the course of the unit.<br>G. Provides supports to help students engage in the practices as needed and gradually adjusts supports over time so that students are increasingly responsible for making sense of phenomena and/or designing solutions to problems. | The lesson or unit supports monitoring student progress:<br>A. Elicits direct, observable evidence of three-dimensional learning by students using practices with core ideas and crosscutting concepts to make sense of phenomena and/or to design solutions.<br>B. Formative assessments of three-dimensional learning are embedded throughout the instruction.<br>C. Includes aligned rubrics and scoring guidelines that provide guidance for interpreting student performance along the three dimensions to support teachers in (a) planning instruction and (b) providing ongoing feedback to students.<br>D. Assessing student proficiency using methods, vocabulary, representations, and examples that are accessible and unbiased for all students.<br><br>A unit or longer lesson will also:<br>E. Includes pre-, formative, summative, and self-assessment measures that assess three-dimensional learning.<br>F. Provides multiple opportunities for students to demonstrate performance of practices connected with their understanding of disciplinary core ideas and crosscutting concepts and receive feedback. |

*EQuIP Rubric for Lessons & Units: Science*

**Reviewer Name or ID:** ______________________ **Grade:**__________ **Lesson/Unit Title:** ______________________________

**I. Alignment to the NGSS**

The lesson or unit aligns with the conceptual shifts of the NGSS:

| Criteria | Specific evidence from materials and reviewers' reasoning | Suggestions for improvement |
|---|---|---|
| ☐ A. Grade-appropriate elements of the science and engineering practice(s), disciplinary core idea(s), and crosscutting concept(s), work together to support students in three-dimensional learning to make sense of phenomena and/or to design solutions to problems.<br>i. Provides opportunities to develop and use specific elements of the practice(s) to make sense of phenomena and/or to design solutions to problems.<br>ii. Provides opportunities to develop and use specific elements of the disciplinary core idea(s) to make sense of phenomena and/or to design solutions to problems.<br>iii. Provides opportunities to develop and use specific elements of the crosscutting concept(s) to make sense of phenomena and/or to design solutions to problems.<br>iv. The three dimensions work together to support students to make sense of phenomena and/or to design solutions to problems. | | |

A unit or longer lesson will also:

| Criteria | Specific evidence from materials and reviewers' reasoning | Suggestions for improvement |
|---|---|---|
| ☐ B. Lessons fit together coherently targeting a set of performance expectations.<br>i. Each lesson links to previous lessons and provides a need to engage in the current lesson.<br>ii. The lessons help students develop proficiency on a targeted set of performance expectations. | | |
| ☐ C. Where appropriate, disciplinary core ideas from different disciplines are used together to explain phenomena. | | |
| ☐ D. Where appropriate, crosscutting concepts are used in the explanation of phenomena from a variety of disciplines. | | |
| ☐ E. Provides grade-appropriate connection(s) to the Common Core State Standards in Mathematics and/or English Language Arts & Literacy in History/Social Studies, Science and Technical Subjects. | | |

*If the lesson or unit is not closely aligned to the Next Generation Science Standards, it may not be appropriate to move on to the second and third categories. Professional judgment should be used when weighing the individual criterion. For example, a lesson without crosscutting concepts explicitly called out may be easier to revise than one without appropriate disciplinary core ideas; such a difference may determine whether reviewers believe the lesson merits continued evaluation or not.*

## II. Instructional Supports

The lesson or unit supports instruction and learning for all students:

| Criteria | Specific evidence from materials and reviewers' reasoning | Suggestions for improvement |
|---|---|---|
| ☐ A. Engages students in authentic and meaningful scenarios that reflect the practice of science and engineering as experienced in the real world and that provide students with a purpose (e.g., making sense of phenomena and/or designing solutions to problems).<br>i. The context, including phenomena, questions, or problems, motivates students to engage in three-dimensional learning.<br>ii. Provides students with relevant phenomena (either firsthand experiences or through representations) to make sense of and/or relevant problems to solve.<br>iii. Engages students in multiple practices that work together with disciplinary core ideas and crosscutting concepts to support students in making sense of phenomena and/or designing solutions to problems.<br>iv. Provides opportunities for students to connect their explanation of a phenomenon and/or their design solution to a problem to their own experience.<br>v. When engineering performance expectations are included, they are used along with disciplinary core ideas from physical, life, or earth and space sciences. | | |
| ☐ B. Develops deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts by identifying and building on students' prior knowledge. | | |
| ☐ C. Uses scientifically accurate and grade-appropriate scientific information, phenomena, and representations to support students' three-dimensional learning. | | |
| ☐ D. Provides opportunities for students to express, clarify, justify, interpret, and represent their ideas and respond to peer and teacher feedback orally and/or in written form as appropriate to support student's three-dimensional learning. | | |
| ☐ E. Provides guidance for teachers to support differentiated instruction in the classroom so that every student's needs are addressed by including:<br>i. Suggestions for how to connect instruction to the students' home, neighborhood, community and/or culture as appropriate.<br>ii. Appropriate reading, writing, listening, and/or speaking alternatives (e.g., translations, picture support, graphic organizers) for students who are English language learners, have special needs, or read well below the grade level.<br>iii. Suggested extra support (e.g., phenomena, representations, tasks) for students who are struggling to meet the performance expectations.<br>iv. Extensions for students with high interest or who have already met the performance expectations to develop deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts. | | |

A unit or longer lesson will also:

| Criteria | Specific evidence from materials and reviewers' reasoning | Suggestions for improvement |
|---|---|---|
| ☐ F. Provides guidance for teachers throughout the unit for how lessons build on each other to support students developing deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts over the course of the unit. | | |
| ☐ G. Provides supports to help students engage in the practices as needed and gradually adjusts supports over time so that students are increasingly responsible for making sense of phenomena and/or designing solutions to problems. | | |

## III. Monitoring Student Progress

The lesson or unit supports monitoring student progress:

| Criteria | Specific evidence from materials and reviewers' reasoning | Suggestions for improvement |
|---|---|---|
| ☐ A. Elicits direct, observable evidence of three-dimensional learning by students using practices with core ideas and crosscutting concepts to make sense of phenomena and/or to design solutions. | | |
| ☐ B. Formative assessments of three-dimensional learning are embedded throughout the instruction. | | |
| ☐ C. Includes aligned rubrics and scoring guidelines that provide guidance for interpreting student performance along the three dimensions to support teachers in (a) planning instruction and (b) providing ongoing feedback to students. | | |
| ☐ D. Assessing student proficiency using methods, vocabulary, representations, and examples that are accessible and unbiased for all students. | | |

A unit or longer lesson will also:

| Criteria | Specific evidence from materials and reviewers' reasoning | Suggestions for improvement |
|---|---|---|
| ☐ E. Includes pre-, formative, summative, and self-assessment measures that assess three-dimensional learning. | | |
| ☐ F. Provides multiple opportunities for students to demonstrate performance of practices connected with their understanding of disciplinary core ideas and crosscutting concepts and receive feedback. | | |