NEW MEXICO
Public Education Department

New Mexico Instructional Scope
Fourth Grade Science Guide

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New Mexico STEM Ready! Science Standards Implementation Guide

Overview

A Framework for K-12 Science Education marks a leap forward in how we think about science education and captures the advancements made in understanding how students best learn science that have been made over the last 30 years. The New Mexico Public Education Department and New Mexico public school teachers worked together over the course of June 2021 to construct an Instructional Scope document for the New Mexico STEM Ready! science standards. There are many public schools where high quality instructional materials (HQIM) are present, and these should be used in the teaching of science. In public schools where HQIM may be absent, the New Mexico Instructional Scope for Science (NMIS Science) should be used in conjunction with the New Mexico STEM Ready! Science Standards to plan science instruction.

The following describes the layout of the NMIS Science document and how it has been designed to be implemented. New Mexico science teachers worked collaboratively to identify and construct sample phenomena, classroom assessment items, common misconceptions, multi-layered systems of supports (MLSS), and culturally and linguistically responsive (CLR) instructional strategies for each performance expectation in the New Mexico STEM Ready! Science Standards. The best practice of bundling related standards together to capture multiple aspects of a single phenomenon was not done, as local public schools should determine how best to bundle New Mexico STEM Ready! Science Standards based on their needs.

The standards

What: Each performance expectation begins with links to the *Next Generation Science Standards* and a snapshot of the performance expectation with the relevant Science and Engineering Practices (SEP), Disciplinary Core Ideas (DCI), and Cross Cutting Concepts (CCC). Also captured are the connections across the grade level or band (horizontal), connections across grade levels or bands (vertical), and connections to the *Common Core State Standards* (CCSS) in math and English language arts.

The Performance Expectation describes what a student is expected to be able to do at the completion of instruction. They are intended to guide the development of assessments, but they are not the assessment as such. They are not instructional strategies or instructional objectives, but they should influence and guide instruction. Most performance expectations contain a clarification statement and an assessment boundary statement to provide clarity to the performance expectation and guidance to the scope of the expectation, respectively.[1]

The foundation box, which is located below the performance expectation, contains the learning goals that students should achieve and that will be assessed using the performance expectations. The three parts to the foundation box are the science and engineering practices, the disciplinary core ideas, and the crosscutting concepts. The information contained in the foundation box is taken directly from *A Framework for K-12 Science Education*. Also included in the foundation box, where appropriate, are connections to engineering, technology, and applications of science as well as connections to the nature of science. These supplemental goals are related to the other material in the foundation box and are intended to guide instructions, but the outcomes are not included in the performance expectation.

The connections box identifies connections to other disciplinary core ideas at this grade level that are relevant to the standard, identifies the articulation of disciplinary core ideas across grade levels, and identifies connections to

[1] Pratt, Harold (2013) *The NSTA Reader's Guide to the Next Generation Science Standards.*

the *Common Core State Standards (CCSS)* in mathematics and in English language arts and literacy that align to this standard. The connections box helps support instruction and development of instructional materials.

Why: The first step of any teacher in planning instruction is to deeply understand the end result that is required. The standards section of the NMIS Science document is placed first so that teachers have quick access to these requirements. The *NGSS* describe the essential learning goals and how those goals will be assessed at each grade level or band.

How: It is generally accepted that planning for instruction begins with the selection of the endpoint, or desired results of the instruction, and working backward through an instructional sequence to the beginning knowledge students have coming into the instruction. The description of such a process has been documented by Wiggins and McTighe in *Understanding by Design* (1998).

For the purpose of the NMIS Science document, a process for moving from the New Mexico STEM Ready! science standards to classroom instruction should minimally include the following[2]:

- Read the performance expectation, clarification statement, and assessment boundary.
- Read the disciplinary core idea in the foundation box.
    - Read the applicable disciplinary core idea essay in *A Framework for K-12 Science Education*, located in chapters 5, 6, 7, and 8. As you read, consider the following questions:
        - What are some commonly held student ideas about this topic?
        - How could instruction build on helpful ideas and confront troublesome ideas?
        - What prior ideas or concepts do students need to learn to understand this core idea?
        - What level of abstractness is expected of students?
        - What are some phenomena and experiences that could provide observational or experimental evidence that the DCI is an accurate description of the natural world?
        - What representations or media would be helpful for students to use in making sense of the core idea?
- Read the science and engineering practices associated with the performance expectation.
    - Read the applicable SEP essay in *A Framework for K-12 Science Education* located in chapter 3, consider the following questions:
        - While the PE describes one SEP to be used, others will be needed in the instructional sequence, which ones and in what order will you use them?
        - How will each SEP be used to develop an understanding of the DCI?
        - What practices could students engage in to explore phenomena?
- Read the crosscutting concept associated with the performance expectation.
    - Read the applicable CCC essay in *A Framework for K-12 Science Education* located in chapter 4, consider the following questions:

[2] Bybee, Rodger W. (2013) *Translating the NGSS for Classroom Instruction.*

        - How will the CCC indicated in the PE support the understanding of the core idea?
        - Are there other CCC that could also support learning the core idea?

- Read the connections box
    - When reading the connections to other DCI at this grade level that are relevant to the standard, consider the following question:
        - How can instruction be designed so that students note the connections between the core ideas?
    - When reading the articulation of DCI across grade levels that are relevant to the standard, consider the following questions:
        - Examine the standard at earlier grade levels, do they provide an adequate prior knowledge for the core ideas in the standard being reviewed?
        - Examine the standard at later grade levels, does the standard at this level provide adequate prior knowledge for the core ideas in the later standards?
    - When reading the *CCSS* in mathematics and English language arts (ELA), consider the following questions:
        - Should students have achieved these mathematics and ELA standards to engage in the learning of science, or could they be learned together?
        - In what ways do the referenced mathematics and ELA standards help clarify the science performance expectations?
        - Can any of the science core ideas be included as examples in the mathematics or ELA instruction?
- Create one or more descriptions of the desired results or learning goals for the instruction integrating the three dimensions in the foundation box.
- Determine the acceptable evidence for the assessment of the desired results.
- Create the learning sequence
    - The NMIS Science document includes sample phenomena, classroom assessment items, common misconceptions, general and targeted supports, and CLR considerations that can be used to assist with this process.
- Create the summative assessment and check its alignment with the performance expectation.

Sample Phenomena

What: 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.

<u>Why:</u> Despite their centrality in science and engineering, phenomena have traditionally been a missing piece in science education. 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 "this" is. 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. Explaining phenomena and designing solutions to problems allow students to build general science knowledge in the context of their application to understanding phenomena in the real world, leading to deeper and more transferable knowledge. Students who come to see how science ideas can help explain and model phenomena related to compelling real-world situations learn to appreciate the social relevance of science. They get interested in and identify with science as a way of understanding and improving real-world contexts.

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 DCI and CCC through use of the 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 able to explain phenomena, three-dimensional formative assessment becomes more easily embedded and coherent throughout instruction.

<u>How:</u> We use phenomena to drive instruction to help students engage in practices to develop the knowledge necessary to explain or predict the phenomena. Therefore, the focus is not just on the phenomenon itself. It is the phenomenon plus the student-generated questions about the phenomenon that guides the learning and teaching. The practice of asking questions or identifying problems becomes a critical part of trying to figure something out.

There could potentially be many different lines of inquiry about the same phenomenon. Teachers should help students identify different aspects of the same phenomenon as the focus of their questions. Students also might ask questions about a phenomenon that motivates a line of investigation that isn't grade appropriate or might not be effective at using or building important disciplinary ideas. Teacher guidance may be needed to help students reformulate questions so they can lead to grade appropriate investigations of important science ideas.

It is important that all students – including English language learners and students from cultural groups underrepresented in STEM – are supported in working with phenomena that are engaging and meaningful to them. Not all students will have the same background or relate to a particular phenomenon in the same way. Educators should consider student perspectives when choosing phenomena and should prepare to support student engagement in different ways. When starting with one phenomenon in your classroom, it is always a good idea to help students identify related phenomena from their lives and their communities to expand the phenomena under consideration.

Not all phenomena need to be used for the same amount of instructional time. Teachers could use an anchoring phenomenon as the overall focus for a unit, along with other investigative phenomena along the way as the focus of an instructional sequence or lesson. They may also highlight everyday phenomena that relate investigative or anchoring phenomena to personally experienced situations. A single phenomenon doesn't have to cover an entire unit, and different phenomena will take different amounts of time to figure out.

The most powerful phenomena are culturally or personally relevant or consequential to students. Such phenomena highlight how science ideas help us explain aspects of real-world contexts or design solutions to science-related problems that matter to students, their communities, and society. An appropriate phenomenon for instruction should help engage all students in working toward the learning goals of instruction as described by the DCIs, SEPs, and CCCs in the foundation box of the standard.

The process of developing an explanation for a phenomenon should advance students' understanding. 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. 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. Phenomena do not need 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. With careful teacher facilitation, students can become dissatisfied with what they believe they already know and strive to understand it in the context of the DCI that the teacher is targeting.[3]

Classroom Assessment Items

What: Classroom assessments (sometimes referred to as internal assessments) is used to refer to assessments designed or selected by teachers and given as an integral part of classroom instruction. This category of assessment may include teacher-student interactions in the classroom, observations of students, student products that result directly from ongoing instructional activities, quizzes tied to instructional activities, formal classroom exams that cover material from one or more instructional units, or assessments created by curriculum developers and embedded in instructional materials for teacher use. [4]

Classroom assessments can be designed to guide instruction (formative purposes) or to support decisions made beyond the classroom (summative purposes). Assessments used for formative purposes occur during the course of a unit of instruction and may involve both formal tests and informal activities conducted as part of a lesson. They may be used to identify students' strengths and weaknesses, assist students in guiding their own learning, and foster students' sense of autonomy and responsibility for their own learning. Assessments for summative purposes may be administered at the end of a unit of instruction. They are designed to provide evidence of achievement that can be used in decision making, such as assigning grades, making promotion or retention decisions, and classifying test takers according to defined performance categories. The results of all these assessments are evaluated by the teacher or sometimes by groups of teachers. These assessments play an integral role in students' learning experiences while also providing evidence of progress in that learning.

Why: In *Developing Assessments for the Next Generation Science Standards*, the National Research Council shared the following conclusions regarding assessing three-dimensional learning:[5]

- Measuring the three-dimensional science learning called for in the framework and the NGSS requires assessment tasks that examine students' performance of scientific and engineering practices in the context of crosscutting concepts and disciplinary core ideas. To adequately cover the three dimensions, assessment tasks will generally need to contain multiple components. It may be useful to focus on individual practices, core ideas, or crosscutting concepts in the various components of an assessment task, but, together, the components need to support inferences about students' three-dimensional science learning as described in a given performance expectation.

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[3] Penuel, W. R., Bell, P., Neill, T., Morrison, D., & Tesoriero, G. (2018). *Selecting Anchoring Phenomena for Equitable 3D Teaching*. [OER Professional Development Session from the ACESSE Project] Retrieved from http://stemteachingtools.org/pd/sessione

[4] National Resource Council. (2014). *Developing Assessments for the Next Generation Science Standards.* Committee on Developing Assessments of Science Proficiency in K-12. Board on Testing and Assessments and Board on Science Education, J.W. Pellegrino, M.R. Wilson, J.A. Koenig, and A.S. Beatty, *Editors*. Division of Social Sciences and Education. Washington, DC: The National Academies Press.

[5] National Research Council. (2014). *Developing Assessments for the Next Generation Science Standards.* Committee on Developing Assessments of Science Proficiency in K-12. Board on Testing and Assessment and Board on Science Education. J.W. Pellegrino, M.R. Wilson, J.A. Koenig, and A.S. Beatty, *Editors*. Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

- The Next Generation Science Standards require that assessment tasks be designed so they can accurately locate students along a sequence of progressively more complex understandings of a core idea and successively more sophisticated applications of practices and crosscutting concepts.
- The NGSS places significant demands on science learning at every grade level. It will not be feasible to assess all the performance expectations for a given grade level with any one assessment. Students will need multiple – and varied – assessment opportunities to demonstrate their competence on the performance expectations for a given grade level.
- Effective evaluation of three-dimensional science learning requires more than a one-to-one mapping between the NGSS performance expectations and assessment tasks. More than one assessment task may be needed to adequately assess students' mastery of some performance expectations, and any given assessment task may assess aspects of more than one performance expectations. In addition, to assess both understanding of core knowledge and facility with a practice, assessments may need to probe students' use of a given practice in more than one disciplinary context. Assessment tasks that attempt to test practices in strict isolation from one another may not be meaningful as assessments of the three-dimensional science learning called for by the NGSS. (Developing assessments for NGSS, NRC, pp.44-46)

How: The amount of information that has been generated around designing and creating three-dimensional assessment tasks to meet the conclusions laid out above by the National Research Council has been overwhelming. The following free resources are available through STEM teaching tools to help you navigate this flood of information and translate it into your classroom. You should start by familiarizing yourself with the following STEM Teaching Tools[6]:

- Practice Brief 18 on how teachers can develop formative assessments that fit a three-dimensional view of science learning.
- Practice Brief 26 on how to design formative assessments that engage students in three-dimensional learning.
- Practice Brief 30 on integrating science practices into assessment tasks
- Practice Brief 41 on integrating cross cutting concepts into assessment and instruction
- Practice Brief 33 on designing assessments for emerging bilingual students

In general, one can use the following process to develop classroom assessment tasks:

1. Identify specific learning goals for the desired assessment
2. Brainstorm assessment scenarios that involve phenomena that clearly foreground the identified learning goals
3. Prioritize and select a scenario that best fits the following criteria:
    a. it should allow students from non-dominant communities (e.g., ELLs, students from poverty-impacted communities) to fully engage with the task,
    b. it should involve a compelling phenomenon related to one or more of the DCIs being assessed—and not feel like a test-like task,

[6] STEM Teaching Tools (n.d.), http://stemteachingtools.org/tools accessed on July 7, 2021

   c. it should be quickly understandable by students, and

   d. it should lend itself to a broad range of science and engineering practices.

4. The task formats (practice briefs 30 and 41) provide detailed guidance on how to design assessment components that engage students in the science and engineering practices. Identify the practices that relate to the scenario and use the task formats to craft assessment components

5. Write hypothetical student responses for each prompt: some that reflect limited, partial, and full levels of understanding

6. Share tasks with colleagues and ask for feedback about the alignment of goals, scenarios, and hypothetical student responses

Common Misconceptions

What: This planning support identifies some of the common misconceptions students develop about a scientific topic.

Why: Our brains are highly advanced cause and effect reasoning machines. From birth, we begin to analyze effects to determine causes and provide some sort of reasoning for the whole event. The more events that support our reasoning, the stronger that learning becomes. So, every student in your classroom brings their own unique background knowledge into your classroom. Some of this is aligned to scientific understanding and some of this is misaligned to scientific understanding but aligned to that student's personal experiences. As science educators, we must always create space for students to bring their current understanding about a topic into our classroom so that we can begin to address understandings that are misaligned to scientific understanding. Some of these misunderstandings are not unique to a single student; rather, they are common to many students.

How: When planning with your HQIM look for ways to directly address with students some common misconceptions. The planning supports in this document provide some possible misconceptions and your HQIM might include additional ones. The goal is not to avoid misconceptions, they are a natural part of the learning process, but we want to support students in exploring the misconception and modifying incorrect or partial understandings.

Multi Layered System of Supports (MLSS)

What: The Multi-Layered Systems of Support (MLSS) is designed to support teachers in planning instruction for the needs of all students. Each section identifies general supports (layer 1) for supporting pedagogically sound whole class science instruction and targeted supports (layer 2) for supporting those scholars that teachers identify as not understanding the topic. We recognize there is a need for intensive support (layer 3) for those students needing longer duration or otherwise more intense support with a given topic; however, this was not part of the NM IS Science 1.0 work.

Why: MLSS is a holistic framework that guides educators, those closest to the student, to intervene quickly when students need additional support. The framework moves away from the "wait to fail" model and empowers teachers to use their professional judgement to make data-informed decisions regarding the students in their classroom to ensure academic success with grade level expectations of the New Mexico Science Standards.

How: When planning with your high-quality instructional materials (HQIM) use the suggested universal supports embedded in the sequence of instruction. If you do not have access to HQIM in your school, the universal (layer 1) support in this document can be used in planning your instruction.

Culturally and Linguistically Responsive Instruction

What: Culturally and Linguistically Responsive Instruction (CLRI), or the practice of situational appropriateness, requires educators to contribute to a positive school climate by validating and affirming students' home languages and cultures. Validation is making the home culture and language legitimate, while affirmation is affirming or making clear that the home culture and language are positive assets. It is also the intentional effort to reverse negative stereotypes of non-dominant cultures and languages and must be intentional and purposeful, consistent and authentic, and proactive and reactive. Building and bridging is the extension of validation and affirmation. By building and bridging students learning to toggle between home culture and linguistic behaviors and expectations and the school culture and linguistic behaviors and expectations. The building component focuses on creating connections between the home culture and language and the expectations of school culture and language for success in school. The bridging component focuses on creating opportunities to practice situational appropriateness or utilizing appropriate cultural and linguistic behaviors.

Why: Student understanding of science is shaped by their interactions with phenomena throughout their lives. Science educators must intentionally and purposefully legitimize the home culture and languages of students and validate their ways of knowing and understanding. In addition, create connections between the cultural and linguistic behaviors of the students' home culture and language and the culture and language of scientific understanding.

How: When planning instruction it is critical to consider ways to validate/affirm and build/bridge from your students' cultural and linguistic assets. There has been an overwhelming amount of guidance within STEM education about CLRI. The following STEM teaching tools can be a good place to start wrapping your mind around this topic.[7]

- Practice Brief 15: Promoting equity in science education
- Practice Brief 47: Promoting equitable sensemaking
- Practice Brief 54: Building equitable learning communities
- Practice Brief 11: Indigenous ways of knowing and STEM
- Practice Brief 27: Engaging English language learners in science and engineering practices
- Practice Brief 71: Advancing equity and justice in science education
- Practice Brief 53: Avoiding pitfalls associated with CLRI

The planning supports for each performance expectation provide an example of how to support equity-based teaching practices. Look for additional ways within your HQIM to ensure all students are included in the pursuit of scientific understanding in your classroom.

[7] STEM Teaching Tools (n.d.), http://stemteachingtools.org/tools accessed on July 7, 2021

STANDARDS BREAKDOWN

Physical Sciences	Life Sciences	Earth & Space Sciences	Engineering, Technology, and Applications of Science
Energy 4-PS3-1 4-PS3-2 4-PS3-3 4-PS3-4 Waves and their Applications in Technologies for Information Transfer 4-PS4-1 4-PS4-2 4-PS4-3	From Molecules to Organisms: Structures and Processes 4-LS1-1 4-LS1-2	Earth's Place in the Universe 4-ESS1-1 Earth's Systems 4-ESS2-1 4-ESS2-2 Earth and Human Activity 4-ESS3-1 4-ESS3-2	Engineering Design 3-5-ETS1-1 3-5-ETS1-2 3-5-ETS1-3

Students who demonstrate understanding can:

4-PS3-1. **Use evidence to construct an explanation relating the speed of an object to the energy of that object.** [*Assessment Boundary: Assessment does not include quantitative measures of changes in the speed of an object or on any precise or quantitative definition of energy.*

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Use evidence (e.g., measurements, observations, patterns) to construct an explanation.	**PS3.A: Definitions of Energy** • The faster a given object is moving, the more energy it possesses.	**Energy and Matter** • Energy can be transferred in various ways and between objects.

Connections to other DCIs in fourth grade: N/A

Articulation of DCIs across grade-levels:
MS.PS3.A

Common Core State Standards Connections:
ELA/Literacy -

RI.4.1	Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text. (4-PS3-1)
RI.4.3	Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text. (4-PS3-1)
RI.4.9	Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. *(4-PS3-1)*
W.4.2	Write informative/explanatory texts to examine a topic and convey ideas and information clearly. (4-PS3-1)
W.4.8	Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-PS3-1)
W.4.9	Draw evidence from literary or informational texts to support analysis, reflection, and research. (4-PS3-1)

Grade	NGSS Discipline
4	**Physical Science 3.1**
4.PS3-1	**Sample Phenomena** *When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available.* ● Ramiro recently got a drumset for his birthday. When he hits the cymbal with his drumstick, the cymbal makes noise. Ramiro wants to learn what happens when he hits the cymbal with his drumstick.
	Classroom Assessment Items *When available, you should use your locally selected or created high quality instructional materials. However, the following are example assessment items you can use if you don't have local instructional materials available.* ● Ramiro hits the cymbal by moving the drumstick at two different speeds. First, Ramiro moves the drumstick slowly. Then, he moves the drumstick quickly. Each time Ramiro hits the cymbal, he stops moving the drumstick. Ramiro claims that the drumstick has more energy when it moves quickly than when it moves slowly. ○ Describe what Ramiro should observe that supports his claim. Explain why this would support his claim. *Adapted from STEM Gauge*
	Universal Supports ● Discuss the phenomena and prior knowledge/experience students have with speed and how that relates to the energy of different objects. ● Allow students the opportunity to view a variety of similar examples in picture or video form and possibly construct a visual together that allows students to process these ideas (ex- diagram of a toy car on a ramp will travel further if the ramp is at a steeper incline because it has more potential energy compared to a toy car on a small, nearly horizontal ramp).
	Targeted Supports ● Provide visuals and allow students to work in small groups together to form working definitions. ● Use different examples to help students grasp the concept of how an object's speed relates to its energy (find other examples here). ● Allow students further opportunities to use manipulatives to test this concept. ● Provide sample paragraph and sentence structures for students to aid in the development of a written explanation for their findings.
	Common Misconceptions ● Some students may associate energy only with active, living things (ex- a person might have a lot of energy or only a little energy).

- Some students may think of energy as an ingredient that can be obtained from things in which it is stored (such as food or soil or a battery).
- Some students may believe that energy simply disappears as opposed to being transferred from one form to another.

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

The teacher could use these questions in science classroom discussions to bring out the student's thoughts, ideas and culture.

Validate & Affirm:

- *What are some different words we can use to describe energy and speed? (ex: fast/rápida/o; energía, etc.)*
- *Can you share an example of a time you noticed how the speed of an object affected its energy (e.g. racing toy cars)?*
- *What experiences do you have with speed and energy (e.g. running)?*
- *Do you have any traditions at home that may involve speed and energy (e.g. hitting piñatas at a party, playing sports or games)?*

Build & Bridge:

- *How does your experience compare to the examples we've discussed?*
- *Can you use the knowledge you've gained to define energy and explain how speed is related using an example from your real-life experiences?*

Students who demonstrate understanding can:

4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. [*Assessment Boundary: Assessment does not include quantitative measurements of energy.*]

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.	**PS3.A: Definitions of Energy** • Energy can be moved from place to place by moving objects or through sound, light, or electric currents. **PS3.B: Conservation of Energy and EnergyTransfer** • Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. • Light also transfers energy from place to place. • Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy.	**Energy and Matter** • Energy can be transferred in various ways and between objects.

Connections to other DCIs in fourth grade: N/A

Articulation of DCIs across grade-levels:
MS.PS3.A ; **MS.PS3.B** ; **MS.PS4.B**

Common Core State Standards Connections:
ELA/Literacy -
W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-2),
W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-PS3-2)

Grade	*NGSS Discipline*
4	**Physical Science 3.2**
4.PS3-2	**Sample Phenomena**
	When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available. ● A Stirling engine heats, cools, and recycles the same air (or gas) over and over again to produce useful power that can even power a machine.
	Classroom Assessment Items
	When available, you should use your locally selected or created high quality instructional materials. However, the following are example assessment items you can use if you don't have local instructional materials available. ● Watch this Energy Transfer Video. Pause the video at the following times listed below and select all energy types available.

Energy type	0s 00	15s 04	42s 00	46s 70	54s 36	1m 26s 90
Motion						
Electrical						
Light						
Sound						
Heat						

- Describe how energy is transferred from the wall outlet to the Stirling engine.

Adapted from the Stanford NGSS Assessment Project

Universal Supports

- Brainstorm with students the different types of energy they are familiar with and use daily (keep a list and post for reference).
- As students become more familiar with these concepts, guide them towards examples of common, everyday items that demonstrate the transfer of energy (ex- phone, toaster, car, etc.) and create a class list.
- Provide manipulatives to allow students the opportunity to see first-hand energy transfer taking place (ex- solar panel and battery operated items).
- Use examples that students are most familiar with to model writing sound observations.

Targeted Supports

- Provide further samples of energy transfer occurring by means of videos and pictures and spend time explaining, in detail, the process of energy transfer from beginning to end.
- Prompt students at each step to explain what they believe is happening and provide clarification as needed. (Depending on your examples, some students may need support to understand how mass affects energy transfer. Remind them that objects with a lower mass must increase their speed to increase their energy)
- Provide many examples of how sound, scientific observations are phrased and specific direction in creating meaningful observations.

Common Misconceptions

- Energy simply disappears (or is used up) as opposed to being transferred from one form to another.
- Energy exists in simply one or two forms. Students may be unaware of the variety of forms that exist and the multitude of ways we store, transfer and use energy.
- Energy is an ingredient, or substance, that can be obtained from things in which it is stored (such as food or soil or battery).
- Energy is a tangible material that can flow from place to place. Exposing students to different forms of energy helps develop students' conceptualization of energy as something immaterial, which may be transferred or converted between different forms.
- Only living things have energy.
- Only hot objects can transfer energy.

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

	The teacher could use these questions in science classroom discussions to bring out the student's thoughts, ideas and culture. Validate & Affirm: • *What words come to mind when you think of energy transfer (make sure to allow students time to share, or an opportunity to see key vocabulary words in their native language)?* • *How would YOU describe: light, sound, heat and electricity?* • *Do you have any cultural traditions that use items which exemplify the transfer of energy?* • *Are there any special devices/machines/items in your family that may involve energy transfer?* • *Why are they special?* • *Have you or a family member ever built something that uses energy transfer to help power it?* Build & Bridge: • *Can you make some comparisons with the items you use in your everyday life, or on special occasions, to the Stirling engine? What is similar? What is different?* • *Can you think of any more items you use at home that transfer energy?*

Students who demonstrate understanding can:

4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide. [Clarification Statement: Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact.] [*Assessment Boundary: Assessment does not include quantitative measurements of energy.*]

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in grades 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships. • Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.	**PS3.A: Definitions of Energy** • Energy can be moved from place to place by moving objects or through sound, light, or electric currents. **PS3.B: Conservation of Energy and EnergyTransfer** • Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. **PS3.C: Relationship Between Energy and Forces** • When objects collide, the contact forces transfer energy so as to change the objects' motions.	**Energy and Matter** • Energy can be transferred in various ways and between objects.

Connections to other DCIs in fourth grade: N/A

Articulation of DCIs across grade-levels:
K.PS2.B ; **3.PS2.A** ; **MS.PS2.A** ; **MS.PS3.A** ; **MS.PS3.B** ; **MS.PS3.C**

Common Core State Standards Connections:
ELA/Literacy -
W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-3)
W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-PS3-3)

Grade	*NGSS Discipline*
4	**Physical Science 3.3**
4.PS3-3	**Sample Phenomena** *When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available.* ● Newton's Cradle uses hanging spheres to demonstrate fundamental laws of physics as the spheres collide into one another. **Classroom Assessment Items** *When available, you should use your locally selected or created high quality instructional materials. However, the following are example assessment items you can use if you don't have local instructional materials available.* ● To complete this task, you will be asking questions about energy. Use the table to write as many questions as you can for BEFORE, DURING, and AFTER the Newton's Cradle device is in use. ● Imagine you are given access to a Newton's cradle device and you are able to investigate one of the questions you asked. ○ What is your testable question? (Be sure it's related to energy transfer) ○ Sketch and describe how your investigation would work? ○ What do you predict the results would be?

Adapted from the Stanford NGSS Assessment Project

Universal Supports	Targeted Supports
• Use related examples to help students begin looking at "collisions" from a scientific perspective (ex- a car crash, bowling, chopping wood with an axe). • Model asking questions and making predictions for one of these examples as you describe in detail what is happening at each step. Focus on the differences when speed is adjusted. • Work with students to create a list of simple experiments they can perform at home or in the classroom to observe a variety of collisions and how they are affected by changes in speed. • Allow students to perform selected experiments from their self-created list and emphasize the importance of recording all questions, observations and predictions.	• Reinforce key words with pictures and discussion. Vocabulary may include: speed, collision, energy, potential, kinetic, force, transfer, predict. • Allow students many opportunities to ask clarifying questions in a small group setting and supportive environment. • Provide videos/video clips of a variety of collisions between objects as you narrate and model questioning and making observations and predictions. • Provide a list of basic questions and possible predictions for students to start with.

Common Misconceptions

- Students may think that inanimate things don't have energy because they don't move.
- Energy and force are the same thing.
- Energy is lost during a collision as opposed to being transferred.
- Doubling the speed of an object doubles its kinetic energy.

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

The teacher could use these questions in science classroom discussions to bring out the student's thoughts, ideas and culture.

Validate & Affirm:

- *What words come to mind when you think of objects colliding or collisions (make sure to allow students time to share, or an opportunity to see key vocabulary words in their native language)?*
- *Do you have any experience with "collisions"? What happened? (ex- car crash, running into someone on the playground, bowling, etc.)*
- *Do you believe that a collision is always "bad" or "negative"?*
- *Can you think of a situation in which it is perfectly okay for objects to collide (e.g. using a trampoline, jumping into a pool)?*

Build & Bridge:

- *Can you take your experience with collisions and look at it through a scientist's perspective?*

	• *Can you take a friend's experience with collisions and ask some "what if?" questions? (ex- My friend ran into her pet one morning...What would have happened if she had been running more slowly? Or my friend crashed his bike into a fence? What would have happened if the fence was made of a different material?)*

Students who demonstrate understanding can:

4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.* [Clarification Statement: Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and, a passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.] [*Assessment Boundary: Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.*]

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

Science and Engineering Practices

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.

- Apply scientific ideas to solve design problems.

Disciplinary Core Ideas

PS3.B: Conservation of Energy and EnergyTransfer

- Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy.

PS3.D: Energy in Chemical Processes and Everyday Life

- The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use.

ETS1.A: Defining Engineering Problems

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. *(secondary)*

Crosscutting Concepts

Energy and Matter

- Energy can be transferred in various ways and between objects.

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.

Connections to Nature of Science

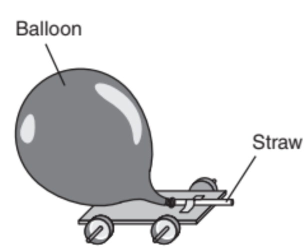
Science is a Human Endeavor

- Most scientists and engineers work in teams.
- Science affects everyday life.

Connections to other DCIs in fourth grade: N/A

Articulation of DCIs across grade-levels:
K.ETS1.A ; **2.ETS1.B** ; **5.PS3.D** ; **5.LS1.C** ; **MS.PS3.A** ; **MS.PS3.B** ; **MS.ETS1.B** ; **MS.ETS1.C**

Common Core State Standards Connections:
ELA/Literacy -
W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-4)
W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-PS3-4)
Mathematics -
4.OA.A.3 Solve multistep word problems posed with whole numbers and having whole-number answers using the four operations, including problems in which remainders must be interpreted. Represent these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding. *(4-PS3-4)*

Grade	*NGSS Discipline*
4	**Physical Science 3.4**
4.PS3-4	**Sample Phenomena** *When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available.* ● A car is a complex machine that is made of many materials and converts energy from one form to another. Examine this simplified model: A team of students designs and builds a balloon-powered car, as shown.  **Balloon-Powered Car**

Classroom Assessment Items

When available, you should use your locally selected or created high quality instructional materials. However, the following are example assessment items you can use if you don't have local instructional materials available.

- Using materials that you have available, use the engineering design process to build a vehicle that is powered by converting one form of energy to another. Can you adjust your design to make your vehicle go further? Faster?

Universal Supports

- Introduce and teach students how the engineering design process works. Highlight certain steps that are particularly relevant to your students and areas where they may struggle.
- Allow students an opportunity to familiarize themselves with more than one type of energy conversion to allow for an abundance of ideas during discussion periods.
- Provide constant feedback on designs by posing questions that will guide student thinking and progress. Encourage students to make mistakes and then find a way to solve the problems they may encounter. Be supportive and offer commendation at each step so that students can truly feel comfortable with their mistakes and learn to embrace them.
- Provide an array of visual aids to guide students through the construction of their devices and as reminders of the engineering design process.
- You may allow students time to work as a large group or in smaller groups to identify their materials and how each may be used as well as acknowledging the constraints they will be bound by.

Targeted Supports

- Provide small group instruction or 1:1 help for students struggling to understand and implement the design process.
- Allow opportunities to view and discuss a variety of devices that students are already familiar with as you explicitly detail how the device functions.
- Use questions to determine where students are struggling and address these areas as needed.
- As necessary, limit materials and options and provide step-by-step instructions(including visual aids/references) for a specific device to allow students to experience success through a guided and structured approach. Some students may not be ready to embrace the ambiguity of the design process.

Common Misconceptions

- Some students may believe that a design is completed after the first attempt and would not benefit from revisions/redesigns/refinements.
- Designs are simply coming up with good ideas. But, ideas also need to be realized and evaluated.
- Students may easily ignore the concept of constraints. In each situation, the constraints will be unique.
- Students may focus on one solution and stop considering alternatives ideas.
- The design process is linear. In doing so, the cyclical process of testing, revising and redesigning may be ignored.

Culturally and Linguistically Responsive Instruction

	Guiding Questions and Connections
	The teacher could use these questions in science classroom discussions to bring out the student's thoughts, ideas and culture. Validate & Affirm: ● *What words come to mind when you think of engineering and design (make sure to allow students time to share, or an opportunity to see key vocabulary words in their native language)?* ● *Have you or anyone in your family ever built something? What was it, how did it work, and why was it built?* ● *What do you believe makes something a “good” building material? Why?* ● *What kinds of ideas do you have for a new invention?* ● *How many times do you revise/tweak/redesign your ideas?* ● *Can you tell me about items you use everyday that convert energy? How important are these items to you?* ● *What kinds of foods do you eat that provide YOU with energy?* Build & Bridge: ● *Can you find some similarities and differences between different designs you’ve seen throughout this lesson?* ● *What can you use from what you’ve learned about the engineering design process to help your family? Your classmates? Yourself?*

Students who demonstrate understanding can:

4-PS4-1. Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. [Clarification Statement: Examples of models could include diagrams, analogies, and physical models using wire to illustrate wavelength and amplitude of waves.] [*Assessment Boundary: Assessment does not include interference effects, electromagnetic waves, non-periodic waves, or quantitative models of amplitude and wavelength.*]

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Develop a model using an analogy, example, or abstract representation to describe a scientific principle. - - - - - - - - ***Connections to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** • Science findings are based on recognizing patterns.	**PS4.A: Wave Properties** • Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach. *(Note: This grade band endpoint was moved from K–2.)* • Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks).	**Patterns** • Similarities and differences in patterns can be used to sort, classify, and analyze simple rates of change for natural phenomena.

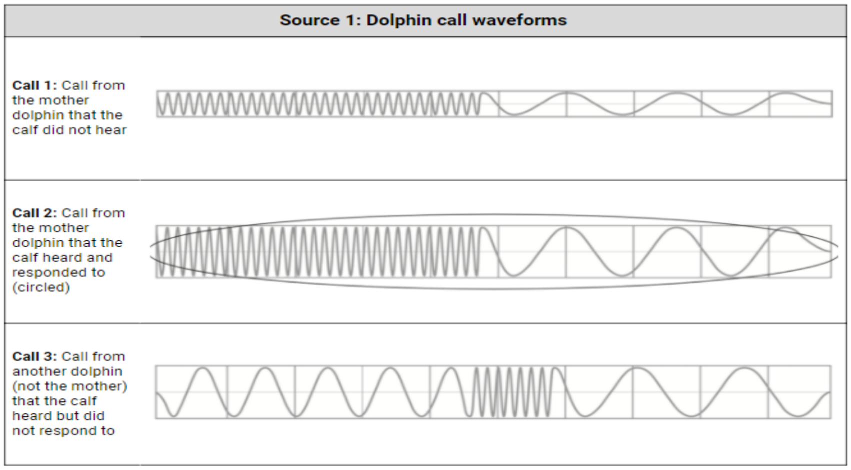
Connections to other DCIs in fourth grade:
4.PS3.A ; **4.PS3.B**

Articulation of DCIs across grade-levels:
MS.PS4.A

Common Core State Standards Connections:
ELA/Literacy -
SL.4.5 Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes. *(4-PS4-1)*
Mathematics -
MP.4 Model with mathematics. *(4-PS4-1)*
4.G.A.1 Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures. *(4-PS4-1)*

Grade	*NGSS Discipline*
4	**Physical Science 4.1**
4.PS4-1	**Sample Phenomena** *When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available.* ● Waves can move objects. We can see transverse waves in a bottle using oil, water, food coloring, and a plastic building brick by viewing a teacher model or video demonstration. **Classroom Assessment Items** *When available, you should use your locally selected or created high quality instructional materials. However, the following are example assessment items you can use if you don't have local instructional materials available.* ● The superintendent of Stellwagen Bank Marine Sanctuary, Maya Martinez, was piloting a boat near a pod of dolphins, and listened as a mother dolphin called twice for her calf, who was very far away. The calf did not hear the first call, but heard and responded to the second call. Maya also heard other dolphins making other calls too after that. She looked at waveforms of dolphin calls, and wants to know two things: ○ Why did the dolphin calf hear the second call from his mother, but not the first? ○ How did the dolphin calf know that the call was from his mother?

- Look at the waveforms below and read the information about them. Write a scientific explanation for the superintendent.



Adapted from Amplify Science

Universal Supports	Targeted Supports
• KWL chart written or projected on board, teach with visuals (show a picture of a wave, show a video about properties of a wave), project reading material and have students follow along as the teacher reads the text aloud. • Use a variety of materials, such as an assortment of ropes, long springs, measuring tape, stopwatch, and string to provide hands-on exploration with creating waves • Reiterate academic language (*i.e. waves in scientific vocabulary versus conversational*).	• More experimentation and more guidance on waves (use a spring coil toy and string to demonstrate compression and rarefaction. • Use sentence stems and word banks to provide students with multiple opportunities to engage with Tier 2 vocabulary. • Provide students with multiple opportunities to reflect on changing thinking and to ask questions.

Common Misconceptions

- Waves are in the ocean. You can see them. (Students may confuse ocean waves with all waves).
- Waves look the same. They do not differ in height or wavelength (spacing).
- Students may think that matter is a barrier to waves or that denser matter can stop sound. The particles that makeup solid materials or any other materials do not simply block sound, but can muffle it because part of it is reflected.
- Soundwaves can change.
- Students may confuse the movement of energy versus the movement of matter.
- Students may not know that waves can be used for communication or geographical purposes.
- The wave can move forward but the particles in the wave have no motion.

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

	The teacher could use these questions in science classroom discussions to bring out the student's thoughts, ideas and culture. Validate & Affirm: ● *What types of bodies of water are you familiar with?* ● *Where have you seen/experienced waves?* ● *What would happen if you were to move around in the water? What would the water produce? Do the waves move?* Build & Bridge: ● *Can the waves carry objects in them and allow them to move?* ● *Have you ever seen a human "wave" before? How does it compare to waves in the ocean?*

Students who demonstrate understanding can:

4-PS4-2. **Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.** [*Assessment Boundary: Assessment does not include knowledge of specific colors reflected and seen, the cellular mechanisms of vision, or how the retina works.*]

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Develop a model to describe phenomena.	**PS4.B: Electromagnetic Radiation** • An object can be seen when light reflected from its surface enters the eyes.	**Cause and Effect** • Cause and effect relationships are routinely identified.

Connections to other DCIs in fourth grade: N/A

Articulation of DCIs across grade-levels:
1.PS4.B ; **1.PS4.C** ; **MS.PS4.B** ; **MS.LS1.D**

Common Core State Standards Connections:
ELA/Literacy -
SL.4.5 Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes. *(4-PS4-2)*
Mathematics -
MP.4 Model with mathematics. *(4-PS4-2)*
4.G.A.1 Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures. *(4-PS4-2)*

Grade	*NGSS Discipline*
4	**Physical Science 4.2**

4.PS4-2

Sample Phenomena

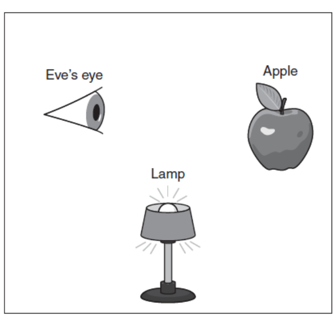
When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available.

- Reflections can cause objects to melt, such as the Walkie Talkie skyscraper in London.

Classroom Assessment Items

When available, you should use your locally selected or created high quality instructional materials. However, the following are example assessment items you can use if you don't have local instructional materials available.

- The diagram shows Eve looking at the apple. Make a model, using the diagram, that explains why Eve can see the apple.



- Explain why turning off the lamp would affect Eve seeing the apple, using your model in Part A.
- Explain why placing a large box between the apple and Eve's eyes would affect Eve seeing the apple, using your model in Part A.
- Explain why closing her eyes would affect Eve seeing the apple, using your model in Part A.

Adapted from STEM Gauge

Universal Supports	Targeted Supports
• Project a visual (video of the Walkie Talkie skyscraper and "the hot spot.") Discuss what the students notice together. Make a list of connections with what the students are familiar with and what they see in the video. (Provide supplemental pictures of the phenomena). • Address misconception(s) (*i.e. allow students to experiment with different kinds of opaque or translucent fabrics to see the levels of light they are experiencing, or have students experiment in blocking out all light to understand light vs little light vs no light*). • Vocabulary activities (layers of paint to showcase translucent and opaque meaning; room darkening curtains; etc.). Vocabulary may include: *light, absorb, refract, reflect, pupil, etc.*	• Provide supplemental examples of pictures (pictures of reflection), review lesson vocabulary, allow students time to discuss and process new information, include scaffolded questions to guide students in the direction you want them to go. Provide more examples/models to deepen understanding. • Use sentence stems and word banks to provide students with multiple opportunities to engage with Tier 2 vocabulary. • Provide students with multiple opportunities to reflect on changing thinking and to ask questions.

Common Misconceptions

- Not all students are aware that the pupil is a hole in the eye. They may think of it as a black dot on the surface of the eye.
- Students may believe that objects cannot absorb and reflect light, not both.
- Students may not think of light as an active, traveling entity, but rather as a source (like a light bulb), an effect (like an observable patch of light on the floor), or a state (like the current brightness or dimness as in the expression "it's lights out").
- Students may often think of light illuminating a space or object and our eyes seeing an object as two separate processes.
- Students may think that it is possible to see when no light is present, based on their experiences of being able to make out objects in very dark rooms.

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

The teacher could use these questions in science classroom discussions to bring out student's thoughts, ideas and cultures:

Validate & Affirm:

- *What do you associate the term "light" with? What about the term "dark"?*

	• *Have you ever seen light hit a mirror or piece of glass? (on a skyscraper, window, mirror, glass bottle, phone display, TV, computer monitor) What happens?* Build & Bridge: • *How does the reflection of light help us see?* • *When is it important that we see clearly with lots of light?*

Students who demonstrate understanding can:

4-PS4-3. **Generate and compare multiple solutions that use patterns to transfer information.*** [Clarification Statement: Examples of solutions could include drums sending coded information through sound waves, using a grid of 1's and 0's representing black and white to send information about a picture, and using Morse code to send text.]

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.	**PS4.C: Information Technologies and Instrumentation** • Digitized information can be transmitted over long distances without significant degradation. High-tech devices, such as computers or cell phones, can receive and decode information—convert it from digitized form to voice—and vice versa. **ETS1.C: Optimizing The Design Solution** • Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. *(secondary)*	**Patterns** • Similarities and differences in patterns can be used to sort and classify designed products. - - - - - - - - - - ***Connections to Engineering, Technology, and Applications of Science*** **Interdependence of Science, Engineering, and Technology** • Knowledge of relevant scientific concepts and research findings is important in engineering.

Connections to other DCIs in fourth grade:
4.ETS1.A

Articulation of DCIs across grade-levels:
K.ETS1.A ; **2.ETS1.B** ; **2.ETS1.C** ; **3.PS2.A** ; **MS.PS4.C** ; **MS.ETS1.B**

Common Core State Standards Connections:
ELA/Literacy -
RI.4.1 Write opinion pieces on topics or texts, supporting a point of view with reasons and information. *(4-PS4-3)*
RI.4.9 Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. (4-PS4-3)

Grade	*NGSS Discipline*
4	**Physical Science 4.3**
4.PS4-3	**Sample Phenomena**
	When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available. • The Arecibo Message is a message that contains information on our planetary system, genetic information, human dimensions, and the Arecibo telescope. It was sent to outer space in hopes of making contact with other life forms.
	Classroom Assessment Items
	When available, you should use your locally selected or created high quality instructional materials. However, the following are example assessment items you can use if you don't have local instructional materials available. • In 1974 the Arecibo Message was sent by astronomers to a group of stars 25,000 light years away. It contained basic information about humans. The message was encoded as a group of 1s and 0s and sent using a radio telescope. You will be given a secret question in an envelope. The questions will contain only letters and numbers and will be no longer than 30 characters. (e.g. What is your name?)

- Your task is to successfully send a digitized message across the room to your partner. Your partner will reply with an appropriate digitized response.
- Constraints: no talking, 20 foot separation, digitized message, materials (paper, flashlight, craft materials (e.g. cardboard, tape, string, crayons, etc.), Makey Makey Invention Kit, safety concerns
- After the designs are tested, evaluate two other solutions in the classroom:
    - How well did it meet the criteria?
    - How well did it meet the constraints?
    - How were the patterns of transmission alike?
    - How were the patterns of transmission different?

Adapted from the Stanford NGSS Assessment Project

Universal Supports	Targeted Supports
• Use of graphic organizers, including KWL charts, for students to organize developing thinking. • Use multiple modes of media (*ex: text, video, audio, etc.*) to provide opportunities for students to engage with content. • Provide students opportunities to create their own message using a secret code (*i.e. flashlights, emojis, numbers, symbols, etc).* and explain how it can be sent securely then trade with a partner to crack the code	• Ask guiding questions (*i.e. Can your code be sent without anyone hearing it? Can your code send messages quickly?*) • Use sentence stems and word banks to provide students with multiple opportunities to engage with Tier 2 vocabulary. • Provide students with multiple opportunities to reflect on changing thinking and to ask questions.

Common Misconceptions

- Students may have no background knowledge of binary code.
- Students may not realize that communication can happen through patterns and numbers.
- Students may think that communication is finite (that it begins and ends in a certain time frame).

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

The teacher could use these questions in science classroom discussions to bring out the student's thoughts, ideas and culture.

Validate & Affirm:

- *What are some ways you communicate with your loved ones at home?*
- *Is all communication verbal? What about your friends or family that may live far away from you?*
- *What are some ways you can think of that humans share information?*
- *Are there any types of alternative communication in your culture or family? (i.e. Codetalkers, ASL, drums, programmers, coding, etc.)*

Build & Bridge:

- *How does sharing information look different across the globe?*
- *What are the many different ways humans can communicate with one another?*

	• *How can we share information with someone next to you, in another room, in another house, in another city, state, or country?* • *What if that person spoke a different language?* • *How would you get them to understand what you wanted to say? What about if we wanted to communicate with someone in another world who may not be able to speak any language?*

Students who demonstrate understanding can:

4-LS1-1. **Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.** [Clarification Statement: Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, and skin.] [*Assessment Boundary: Assessment is limited to macroscopic structures within plant and animal systems.*]

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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). • Construct an argument with evidence, data, and/or a model.	**LS1.A: Structure and Function** • Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.	**Systems and System Models** • A system can be described in terms of its components and their interactions.

Connections to other DCIs in fourth grade: N/A

Articulation of DCIs across grade-levels:
1.LS1.A ; **1.LS1.D** ; **3.LS3.B** ; **MS.LS1.A**

Common Core State Standards Connections:
ELA/Literacy -
W.4.1 Write opinion pieces on topics or texts, supporting a point of view with reasons and information. (4-LS1-1)
Mathematics -
4.G.A.3 Recognize a line of symmetry for a two-dimensional figure as a line across the figure such that the figure can be folded across the line into matching parts. Identify line-symmetric figures and draw lines of symmetry. *(4-LS1-1)*

Grade	*NGSS Discipline*
4	**Life Science 1.1**

4.LS1-1

Sample Phenomena

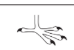
When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available.

- A cactus has small barbs on it as a form of protection.

Classroom Assessment Items

When available, you should use your locally selected or created high quality instructional materials. However, the following are example assessment items you can use if you don't have local instructional materials available.

- Andrew learns about 4 birds. He puts information about the birds into a chart, as shown.

Type of Bird	Shape of Foot	Shape of Beak	Where Bird Lives	What Bird Eats
Bluebird			Open lands on the edges of forests	Small insects, fruits, and berries
Hummingbird			Forests and meadows	Sap in flowers
Pelican			Along the coast, lakes, and rivers	Fish
Eagle			Along the coast, lakes, and rivers	Fish, ducks, and snakes

- Make a claim about how one of the body parts of a bird in the chart helps the bird survive. Explain how evidence you found in the chart supports your claim.
- Make a claim about how one of the body parts of another bird helps that bird to survive. Explain how evidence found in the chart supports your claim.

Adapted from STEM Gauge

Universal Supports	Targeted Supports
• Use graphic organizers, including KWL charts, to organize students' developing thinking and questions about animal and plant functions and structures (both internal and external) • Use multiple modes of media (ex: print, audio, video, etc.) to provide students opportunities to engage with content. • Explicit introduction and modeling of Tier 2 vocabulary (*ex: structure, function, internal, external, survival, reproduction, behavior*).	• Students often think that all plants and animals have the same basic needs which is not always the case. Review how animals and plants may have different needs. • Provide extra diagrams/pictures to allow students to demonstrate what they already know and determine where students are getting confused.

Common Misconceptions

- Students may think that eyes are the only functions that play a role in seeing a threat whereas the brain has to process that information from the eyes.
- Plant classification- if a plant doesn't grow in the soil, they may not classify it as a plant. Plants only grow in the soil.
- The needs of plants- students tend to give plants human characteristics (breathe, keep plants warm, need to eat).
- All living things are either plants or animals.
- All seeds will produce a plant.
- Plants cannot create their own food.
- Some parts of some plants have no purpose (e.g. thorns).

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

The teacher could use these questions in science classroom discussions to bring out the student's thoughts, ideas and culture.

Validate & Affirm:

- *What are some structures of the human body that help us survive?*
- *What body parts help humans grow, behave? What do each of those parts do? What about our insides? What about our emotions?*
- *What kinds of plant and animal life have you seen at home? (In your backyard, community, on vacation, etc.)*
- *Are there any plants and animals in your life that have special significance?*
- *What words come to mind when you think of plant and animal structures (give students time to share, or an opportunity to see key vocabulary words in their native language)?*

.Build & Bridge:

- *Why do some of the same types of animals look slightly different (i.e. polar bear vs. black bear)?*
- *What types of plants or animals have you encountered that have a **specific appearance** that help them survive?*
- *What were the structures that helped them survive? Grow? Behave? Reproduce?*
- *What types of plants or animals that you have seen might have **structures inside of them** to help them survive? Grow? Behave? Reproduce?*
- *Can you compare what we've learned about plants and animals to what you already knew?*

**Teacher Thoughts*: Be aware that there may be some sensitivity around the topic of reproduction. Include native plants and animals as examples

Students who demonstrate understanding can:

4-LS1-2. **Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.** [Clarification Statement: Emphasis is on systems of information transfer.] [*Assessment Boundary: Assessment does not include the mechanisms by which the brain stores and recalls information or the mechanisms of how sensory receptors function.*]

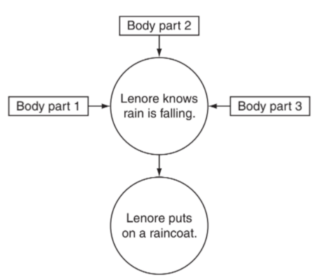
The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Use a model to test interactions concerning the functioning of a natural system.	**LS1.D: Information Processing** • Different sense receptors are specialized for particular kinds of information, which may be then processed by the animal's brain. Animals are able to use their perceptions and memories to guide their actions.	**Systems and System Models** • A system can be described in terms of its components and their interactions.

Connections to other DCIs in fourth grade: N/A

Articulation of DCIs across grade-levels:
MS.LS1.A ; **MS.LS1.D**

Common Core State Standards Connections:
ELA/Literacy -
SL.4.5 Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes. *(4-LS1-2)*

Grade	*NGSS Discipline*
4	**Life Science 1.2**
4.LS1-2	**Sample Phenomena** *When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available.* ● Worms can use their senses to avoid danger. **Classroom Assessment Items** *When available, you should use your locally selected or created high quality instructional materials. However, the following are example assessment items you can use if you don't have local instructional materials available.* ● Lenore is standing outside when rain begins to fall. Lenore uses her senses to know that it is raining. This model can be used to explain why Lenore puts on a raincoat. 

- Identify three sensory body parts that could help Lenore know that rain is falling. Describe the sensory information that each body part gives her.
- Explain how Lenore's body uses the information from her senses to put on a raincoat.
- Explain another way Lenore might behave when she knows that rain is falling on her. Explain why she might behave this way instead of putting on a raincoat.

Adapted from STEM Gauge

Universal Supports	Targeted Supports
● Review the five senses. Emphasize that humans have 5 senses but not all animals do. (*note: not all humans have five senses*) ● Use graphic organizers to take notes on how humans respond to certain stimuli in regards to their senses. ● Review the criteria needed to create a model.	● Provide more visual models such as diagrams or pictures to showcase how the different senses are used to reinforce the concept. ● Use of word banks and sentence starters/stems to provide students opportunities to practice using academic vocabulary. ● Allow students an opportunity and extra time to process the importance of each of our senses and how they work.

Common Misconceptions

- An animal can only find its ways by seeing with its eyes. Students don't understand the complex ways that we receive and interpret information through multiple senses.
- Animals cannot adapt.
- Animals cannot remember.
- Humans are not animals.
- Animals and humans do not have that much in common.
- Having all of our senses is not that important, and missing a sense wouldn't be a great loss.

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

The teacher could use these questions in science classroom discussions to bring out the student's thoughts, ideas and culture.Validate & Affirm:

- What are the five human senses?
- How do humans process information through those senses?
- How does processing this information into our brains help keep us alive?
- Have you ever had an encounter at home or in your community in which something happened and your senses protected you?
- What information do you get from your senses when you visit a friend's house? How does it compare to your home?

Build & Bridge:

- Do you think that a plant or animal in the same situation would react in the same way you would?
- How would different animals or plants act differently?
- How do instincts, reflexes, and memory play a part?

Students who demonstrate understanding can:

4-ESS1-1. **Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.** [Clarification Statement: Examples of evidence from patterns could include rock layers with marine shell fossils above rock layers with plant fossils and no shells, indicating a change from land to water over time; and, a canyon with different rock layers in the walls and a river in the bottom, indicating that over time a river cut through the rock.] [*Assessment Boundary: Assessment does not include specific knowledge of the mechanism of rock formation or memorization of specific rock formations and layers. Assessment is limited to relative time.*]

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Identify the evidence that supports particular points in an explanation.	**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.	**Patterns** • Patterns can be used as evidence to support an explanation. *Connections to Nature of Science* **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes consistent patterns in natural systems.

Connections to other DCIs in fourth grade: N/A

Articulation of DCIs across grade-levels:
2.ESS1.C ; **3.LS4.A** ; **MS.LS4.A** ; **MS.ESS1.C** ; **MS.ESS2.A** ; **MS.ESS2.B**

Common Core State Standards Connections:

ELA/Literacy -

W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-ESS1-1)

W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-ESS1-1)

W.4.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. *(4-ESS1-1)*

Mathematics -

MP.2 Reason abstractly and quantitatively. *(4-ESS1-1)*

MP.4 Model with mathematics. *(4-ESS1-1)*

4.MD.A.1 Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table. *(4-ESS1-1)*

Grade	*NGSS Discipline*
4	**Earth and Space Science 1.1**

4.ESS1-1

Sample Phenomena

When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available.

- A fossil of an ocean creature was discovered in a rocky outcrop in Grand Canyon National Park.

Classroom Assessment Items

When available, you should use your locally selected or created high quality instructional materials. However, the following are example assessment items you can use if you don't have local instructional materials available.

- Monica and her classmates went to the natural history museum, where they saw real fossils on display. One fossil looked like it had a plant pressed into it. Another looked like it had a giant shell frozen inside of it. Monica asked her teacher if one fossil was older than the other, and if the fossils were formed in the same kind of environment. Her teachers said they would need more information from the scientists who discovered them to know which fossil was older, and whether they were formed in the same environment.

- Using your knowledge of how fossils are formed, explain what other information Monica would need to determine if these fossils were the same age, or if they formed in the same environment. In your response, be sure to describe how these fossils were formed, and explain what other information Monica would need to get from the scientists who found them, in order to answer her questions about them.

Adapted from Amplify Science

Universal Supports	Targeted Supports
• As students begin to think about fossil evidence, emphasize the importance of identifying and using patterns as evidence. • Review signal words with students (*first, earlier, last, before, after*) to ensure students can verbalize and describe an order of events. • Support students in grasping the concept of horizontal patterns in rock layers by providing strong visuals that exemplify these rock patterns overtime. Relate this to something they are familiar with (*i.e. layers in a cake*) • Allow for opportunities for students to interact and compare rocks/fossils from different regions or geographical locations.	• Remind students of the three main types of rocks (igneous, metamorphic, and sedimentary) and explain that an important condition for fossil formation is the quick burial of an organism in mud or other solid materials (i.e. sediments), so most organisms do not form fossils. • Have students discuss scaffolded questions that will guide their understanding- *how do different types of rocks form? Which type of rock is related to fossil formation?* • Extensions could include having students collaborate to create an illustrated flow chart to highlight the sequence of events/formation of a familiar landform.

Common Misconceptions

- Students may believe that landforms/rocks have always existed in their present form.
- Rock layers do not reflect different time periods.
- Students may likely have a lot of experience with rocks outside of school, largely shaping their conceptions about them. Students might be interested and surprised to find the variation in different kinds of rocks.
- Students may confuse the rock layers. They might think the oldest layers are in the center or that the top layers form first.
- Students might misunderstand how the rock cycle explains the formation of rocks.
- Fossils are formed quickly and not over long periods of time.

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

The teacher could use these questions in science classroom discussions to bring out the student's thoughts, ideas and culture.

Validate & Affirm:

- *What words do you associate with different kinds of rocks?*
- *Do rocks have any special significance in your family/culture?*
- *Where in our community have you seen a rock that has intrigued you?*

	• *What special rock formations do we have around our state?* Build & Bridge: • *How does your family document change over time? (ex. Photo albums, recordings, storytelling, social media)* • *What patterns do you notice in rocks found in our community, or that you have seen in your travels, that help us determine changes over time?* • *How might we find evidence of changes in a landscape over time?*

Students who demonstrate understanding can:

4-ESS2-1. **Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.** [Clarification Statement: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.] [*Assessment Boundary: Assessment is limited to a single form of weathering or erosion.*]

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.	**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 break rocks, soils, and sediments into smaller particles and move them around. **ESS2.E: Biogeology** • Living things affect the physical characteristics of their regions.	**Cause and Effect** • Cause and effect relationships are routinely identified, tested, and used to explain change.

Connections to other DCIs in fourth grade: N/A

Articulation of DCIs across grade-levels:
2.ESS1.C ; **2.ESS2.A** ; **5.ESS2.A**

Common Core State Standards Connections:

ELA/Literacy -

W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-ESS2-1)

Mathematics -

MP.2 Reason abstractly and quantitatively. (4-ESS2-1)

MP.4 Model with mathematics. (4-ESS2-1)

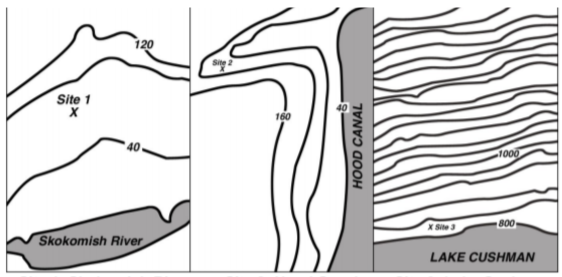
MP.5 Use appropriate tools strategically. (4-ESS2-1)

4.MD.A.1 Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table. *(4-ESS2-1)*

4.MD.A.2 Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale. *(4-ESS2-1)*

Grade	*NGSS Discipline*
4	**Earth and Space Science 2.1**
4.ESS2-1	**Sample Phenomena** *When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available.* ● The Grand Canyon is a mile deep and was carved by the Colorado River over millions of years. ● Tent Rocks in Cochiti Pueblo, NM formed over millions of years. **Classroom Assessment Items** *When available, you should use your locally selected or created high quality instructional materials. However, the following are example assessment items you can use if you don't have local instructional materials available.* ● The Evergreen Development Company has found 3 sites in the area where they could build affordable apartments in the Skokomish River area. When completed, 25 families could live there. However, flooding in the Skokomish River area is a major problem. The flooding is partly due to ways that people have used the land in the past. People's use of the land has caused erosion of gravel, soil, and sand. The gravel, soil and sand has washed into the Skokomish River and been deposited on the bottom of the river, making the flooding much, much worse.

- Mason County does not want the apartments to make the flooding problem worse in the Skokomish River area. So, before Evergreen Development Company can build in the Skokomish area, their plan must be looked at and approved by the Mason County government. There are three possible sites for the new apartments: 1. The Skokomish River, 2. Hoodsport, and 3. Lake Cushman.
  - Examine the topographic maps for each of the 3 sites below.



Site 1: Skokomish River Site 2: Hood Canal Site 3: Lake Cushman

  - Using what you can observe in each of the 3 maps, along with what you know about flooding, erosion, and deposition, make a recommendation to the Mason County government about which, if any, of the three sites to build on.
  - Write down the criteria for a successful solution about where to build the apartments in your own words.
  - What observations would you need to make at each site to determine whether the site meets the criteria?
  - Using the maps as a guide, which site would you expect erosion caused by the new apartments to be greatest?

Adapted from How People Learn

Universal Supports	Targeted Supports
• Show students a visual(s) that provides multiple examples of different landforms. • Engage students in discussion about what they see and how they think these landforms might have formed. Include pictures of various types of rock, including some that have been weathered and eroded. • Emphasize the two types of weathering- physical and chemical- and how these happen over a *long* period of time and give examples (potholes in the streets, plants growing in cracks in rocks, etc) Although weathering, erosion, and deposition have very different meanings that students need	• Make connections of long-term effects of weathering/erosion with something that connects with the students (i.e. how a bicycle changes when left outside in the rain and wind.) Help students develop a flowchart to identify the forces and factors that contribute to erosion. • Possible extensions may include challenging students to explore ways to prevent erosion somewhere meaningful to them (school playground, garden, park, etc.)

to understand in depth, students also need to understand the interconnectedness of these terms- spend time discussing how these work together both as a detriment and benefit to our planet.	• Encourage them to propose an idea to their city in ways to prevent/minimize erosion in this area.

Common Misconceptions

- Students may believe that landforms/rocks have always existed in their present form.
- Rock layers do not reflect different time periods.
- Students may use the words weathering and erosion interchangeably.
- Students may view the earth as static and unchanging
- Students have trouble conceptualizing durations of time longer than spans of time they have lived through.
- Students tend to have a gender awareness of major events in geologic history, such as the ice age, and may seriously underestimate how long ago these events occurred.

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

The teacher could use these questions in science classroom discussions to bring out the student's thoughts, ideas and culture.

Validate & Affirm:

- *Include various examples of different geographical references to weathering/erosion endemic to students' native countries or local areas.*
- *Have you ever witnessed signs of weathering and erosion?*

Build & Bridge:

- *What stories/folktales do you know that have to do with weathering/erosion?*
- *What other landforms have you seen or visited that were created through erosion or weathering?*

Students who demonstrate understanding can:

4-ESS2-2. **Analyze and interpret data from maps to describe patterns of Earth's features.** [Clarification Statement: Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.]

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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. • Analyze and interpret data to make sense of phenomena using logical reasoning.	**ESS2.B: Plate Tectonics and Large-Scale System Interactions** • The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features areas of Earth.	**Patterns** • Patterns can be used as evidence to support an explanation.

Connections to other DCIs in fourth grade: N/A

Articulation of DCIs across grade-levels:
2.ESS2.B ; **2.ESS2.C** ; **5.ESS2.C** ; **MS.ESS1.C** ; **MS.ESS2.A** ; **MS.ESS2.B**

Common Core State Standards Connections:

ELA/Literacy -

RI.4.7 Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears. (4-ESS2-2)

W.4.7 Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears. (4-ESS2-2)

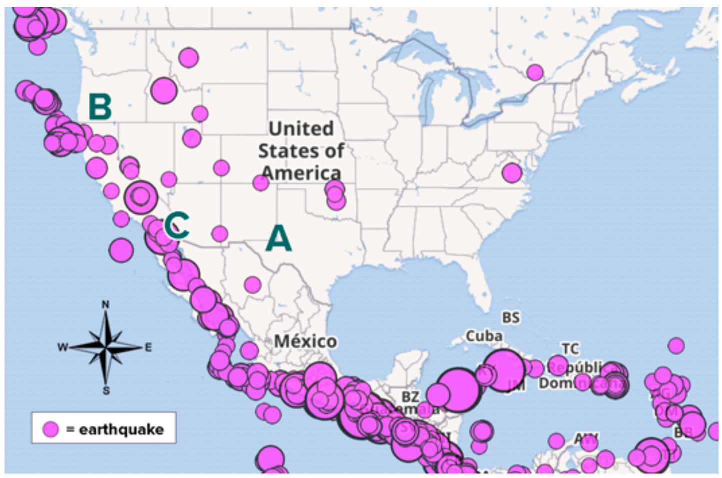
Mathematics -

4.MD.A.2 Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale. *(4-ESS2-2)*

Grade	*NGSS Discipline*
4	**Earth and Space Science 2.2**
	Sample Phenomena
	When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available. ● The Ring of Fire is a region around much of the rim of the Pacific Ocean where many volcanic eruptions and earthquakes occur.
	Classroom Assessment Items

When available, you should use your locally selected or created high quality instructional materials. However, the following are example assessment items you can use if you don't have local instructional materials available.

- Seth's family is preparing to move for his parent's new job. The company has offices in three different cities: A, B, and C. Seth is hoping to move into a home with a swimming pool. His parents say earthquakes can damage pools and make them unsafe. They will not live in a place with a pool if their new home is someplace where earthquakes occur.
- Seth found a map that shows all of the big earthquakes that have happened in the last 10 years. He marked the three cities where the company has offices. Seth wants to predict which of the cities is least likely to have earthquakes.



Map of major earthquakes that happened in the last 10 years.

- How can you use the map to identify where earthquakes have occured in the last 10 years?
- What pattern do you notice about where earthquakes occur?
- Use the pattern you have identified and described to select the best city for Seth's family to move to if he wants a pool.
- Use the patterns you noticed in the map to describe why you chose the city in Question 3.

Adapted from Next Generation Science Assessment

Universal Supports	Targeted Supports
• Expose students to different types of maps other than the traditional street maps they might be used to seeing (include digital map versions.) Be sure to emphasize that although maps can show different features of an area (topography, resource, population, etc), they can all still show the same location of that area. • Explain that maps are made for different purposes and guide students to think of the different purposes/reasons why we might need different types of maps. • To ensure understanding of how tectonic plates move, use visuals and models to help students fully understand the motions of the plates and how these can form different land features.	• Define the different land features found on earth- use cognates for EL (mountain/montaña, canyon/cañon, ocean/oceano) to help solidify student understanding. • Have students work in small groups to create a physical map of a familiar location. Work with them to highlight the use of legend and scale and to discuss important places to include in their map. • Possible extensions could include challenging students to research two different maps of their hometown- ask them to compare and contrast these maps

	and discuss how certain types of maps serve different purposes.

Common Misconceptions

- Students may have difficulty visualizing how the distance on a map correlates to the actual distance between locations/understanding scale.
- Maps are only used to find your way to a location.
- Students may confuse the meaning of the words fault and plate
- Earthquakes and volcanoes only occur along plate boundaries
- Students may be unaware of the different types of geographic features found within our planet.

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

The teacher could use these questions in science classroom discussions to bring out the student's thoughts, ideas and culture.

Validate & Affirm:

- *What types of maps does your family use?*
- *Have you ever used a map? Who have you seen use a map?*
- *Which type of map do you think is the most helpful in describing patterns of the Earth's features?*

Build & Bridge:

- *What might this be a map of?* (Show students a variety of maps of places/areas that are familiar to them.)
- *Where have you traveled that is really close to our school?*
- *Where have you traveled that is really far away from our school?*
- *What is a route you take when you come to school?*
- *What types of landforms are close to us?*
- *What types of landforms are not found in our state?*

Students who demonstrate understanding can:

4-ESS3-1. **Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.** [Clarification Statement: Examples of renewable energy resources could include wind energy, water behind dams, and sunlight; non-renewable energy resources are fossil fuels and fissile materials. Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning of fossil fuels.]

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluate the merit and accuracy of ideas and methods. • Obtain and combine information from books and other reliable media to explain phenomena.	**ESS3.A: Natural Resources** • Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not.	**Cause and Effect** • Cause and effect relationships are routinely identified and used to explain change. ***Connections to Engineering, Technology, and Applications of Science*** **Interdependence of Science, Engineering, and Technology** • Knowledge of relevant scientific concepts and research findings is important in engineering. **Influence of Engineering, Technology, and Science on Society and the Natural World** • Over time, people's needs and wants change, as do their demands for new and improved technologies.

Connections to other DCIs in fourth grade: N/A

Articulation of DCIs across grade-levels:
5.ESS3.C ; **MS.PS3.D** ; **MS.ESS2.A** ; **MS.ESS3.A** ; **MS.ESS3.C** ; **MS.ESS3.D**

Common Core State Standards Connections:
ELA/Literacy -
W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic. *(4-ESS3-1)*
W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-ESS3-1)
W.4.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. *(4-ESS3-1)*
Mathematics -
MP.2 Reason abstractly and quantitatively. *(4-ESS3-1)*
MP.4 Model with mathematics. *(4-ESS3-1)*
4.OA.A.1 Interpret a multiplication equation as a comparison, e.g., interpret $35 = 5 \times 7$ as a statement that 35 is 5 times as many as 7 and 7 times as many as 5. Represent verbal statements of multiplicative comparisons as multiplication equations. (4-ESS3-1)

Grade	*NGSS Discipline*
4	**Earth and Space Science 3.1**
4.ESS3-1	**Sample Phenomena** *When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available.* ● Vegetable oil can be used as fuel in both diesel cars and heating oil burners. **Classroom Assessment Items** *When available, you should use your locally selected or created high quality instructional materials. However, the following are example assessment items you can use if you don't have local instructional materials available.*

- Uranium is a common metal found in rock all over the world. A nuclear energy power plant uses one ton of uranium to make the same amount of electricity as burning 16,000 tons of coal or 80,000 barrels of oil. Like coal and oil, uranium is not a renewable energy resource. The following two articles are about nuclear energy.
    - *Article 1-* The energy for a nuclear energy power plant comes from uranium. A small amount of uranium contains a lot of energy. Energy is given off when a tiny piece of uranium is split apart. This energy is used to heat water and make steam. The steam spins a machine that changes the motion energy of spinning into electrical energy. Because uranium is not burned, a nuclear energy power plant does not give off greenhouse gases like burning coal and oil does. Many scientists think that greenhouse gases in the atmosphere lead to climate change.
      —adapted from "A Student's Guide to Global Climate Change: Nuclear Energy," U.S. Environmental Protection Agency website
    - *Article 2-* Waste from a nuclear energy power plant gives off harmful, tiny particles called radiation. Some of the waste (high-level) is more harmful to living things than other waste (low-level). Low-level waste can be packed in boxes and buried in the ground. The amount of radiation given off by the waste in the ground is always being measured to make sure it is safe. High-level waste is stored in a deep, steel-lined concrete pool of water at the power plant. People and the environment must be protected from high-level waste for thousands of years.
      —adapted from "The Harnessed Atom: Waste from Nuclear Power Plants," U.S. Department of Energy website
- Explain why scientists are not worried about running out of uranium even though it is not a renewable energy resource.
- Describe one possible harmful effect of nuclear energy on the environment.
- Describe one way using uranium to make electricity may be better for the environment than using coal or oil.

Universal Supports

- Create a KWL chart with students and encourage students to contribute what they already know about energy (where it comes from and what it's used for). Be intentional in connecting this standard to what students already know about how energy causes changes in motion.
- Use visuals/models to explain how coal can be mined from the ground and converted into energy.
- Hands-on activities are beneficial in deepening the understanding of how energy and fuel can affect the environment.
- Create visuals/flow charts to help students form a concrete picture of the coal (or gas/oil) formation/mining process.
- Show different examples of renewable/nonrenewable resources that are relatable to your specific group of students.
- Review the harmful effects versus the benefits of obtaining and using fuel.

Targeted Supports

- Create a two-column chart and label it "sources and uses." Guide students in researching sources of energy and the different uses these sources provide. Have students make a Venn diagram to compare coal and petroleum.
- Collaborate with a small group to create a cause and effect organizer to identify the cause/effect of different environmental impacts.
- Possible extensions could include having students collaborate in a small group to create a flowchart that shows the process of converting energy from the sun (or wind, water, etc) into fuel. Have students work in partners to create a 30 second infomercial about wind or solar energy.

Common Misconceptions

- Students may not realize where our energy sources come from.

- Students are not aware of the different types of energy sources (wind, water, thermal.)
- Grasping the concept of nonrenewable resources might be difficult for some.
- Students may think that energy needs have remained constant over time.
- May not be aware of the effects of using these resources/carbon footprint.

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

The teacher could use these questions in science classroom discussions to bring out the student's thoughts, ideas and culture.

Validate & Affirm:

- What kinds of fuel do you and your family use in your everyday life?
- What do you and your family use fuel for?
- Have you seen renewable resources around our state?
- Do you know of anyone that works to help create energy for our state?

Build & Bridge:

- Discuss in small groups the different fuels and their purposes you are familiar with. What are some alternate fuel sources you have heard about?
- What can you tell us about solar powered or electric powered machines?

Students who demonstrate understanding can:

4-ESS3-2. **Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.*** [Clarification Statement: Examples of solutions could include designing an earthquake resistant building and improving monitoring of volcanic activity.] [*Assessment Boundary: Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions.*]

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.	**ESS3.B: Natural Hazards** • A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts. *(Note: This Disciplinary Core Idea can also be found in 3.WC.)* **ETS1.B: Designing Solutions to Engineering Problems** • Testing a solution involves investigating how well it performs under a range of likely conditions. *(secondary)*	**Cause and Effect** • Cause and effect relationships are routinely identified, tested, and used to explain change. - - - - - - - - - - - - - - - - ***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, to decrease known risks, and to meet societal demands.

Connections to other DCIs in fourth grade:
4.EST1.C

Articulation of DCIs across grade-levels:
K.ETS1.A ; **2.ETS1.B** ; **2.ETS1.C** ; **MS.ESS2.A** ; **MS.ESS3.B** ; **MS.ETS1.B**

Common Core State Standards Connections:
ELA/Literacy -
RI.4.1 Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text. (4-ESS3-2)
RI.4.9 Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. (4-ESS3-2)
Mathematics -
MP.2 Reason abstractly and quantitatively. *(4-ESS3-2)*
MP.4 Model with mathematics. *(4-ESS3-2)*
4.OA.A.1 Interpret a multiplication equation as a comparison, e.g., interpret 35 = 5 × 7 as a statement that 35 is 5 times as many as 7 and 7 times as many as 5. Represent verbal statements of multiplicative comparisons as multiplication equations. *(4-ESS3-2)*

Grade	*NGSS Discipline*
4	**Earth and Space Science 3.2**

4.ESS3-2

Sample Phenomena

When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available.

- According to eyewitnesses a group of elephants heard the infrasound of an approaching tsunami and moved to safety. There are numerous accounts of animals sensing natural hazards, through sound waves or vibrations.

Classroom Assessment Items

When available, you should use your locally selected or created high quality instructional materials. However, the following are example assessment items you can use if you don't have local instructional materials available.

- A large pile of soil and rock sliding down a steep slope is called a landslide. Heavy rainfall may start a landslide. People are in danger when landslides hit houses and move onto roads.
  - Explain why a heavy rainfall can start a landslide.

- A plan to protect people from a landslide may meet one or both of these criteria (goals):
  - Stop a landslide from happening.

- Warn people when a landslide will likely happen.

- Describe two plans that would meet one or both of the listed criteria goals.
- Compare how well each plan described in part (b) meets the criteria goals.

Adapted from STEM Gauge

Universal Supports	Targeted Supports
• Review the terms *cause* and *effect* with students, reiterating that a cause is what makes something happen and the effect is what happens. • Ask students to share their experiences and knowledge about natural hazards. • Show students videos of natural processes to expose students to events they might not be familiar with (tsunami, volcano, earthquake, hurricane) and discuss possible causes and effects. • Expose students to vocabulary terms to depict ways to lessen effects of disaster *(ex: stilts, sandbags, seawalls, levee, structure, wetlands, etc.)*	• Reteach content by creating a two column chart and choosing a natural process, guide students in identifying the effects of that process on humans and then some ways to minimize those effects. Model how to incorporate science vocabulary when verbally describing causes/effects. Explicitly state that a process may have more than one cause and more than one effect. • Possible extension activities may include having students work in groups to choose a natural Earth process and think about the factors that could increase the amount of damage to humans and factors that could decrease the amount of damage. Students may also create a list of safety tips for different natural hazard

Common Misconceptions

- Students may think that humans can prevent natural processes from occurring.
- Certain natural processes are always deadly (volcanoes, earthquakes) Students might associate volcanoes with a spectacular explosion.
- Humans have no impact on natural processes occurring.
- Students may be limited in their understanding of the causes/effects of natural processes.
- Students might not be aware of the fault lines in New Mexico and the possibility of earthquakes.
- Students might not know that there are volcanoes in New Mexico.

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

The teacher could use these questions in science classroom discussions to bring out the student's thoughts, ideas and culture.

Validate & Affirm:

- *Have you been in a natural process?*
- *What is your family's plan in case of an emergency?*

	● *What natural processes have you witnessed or seen?* ● *What do cities do to protect humans from the effects of these natural processes?* Build & Bridge: ● *Do you have any stories/folktales/legends that explain why natural processes occur?*

Students who demonstrate understanding can:

3-5-ETS1-1. **Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.**

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships. • Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.	**ETS1.A: Defining and Delimiting Engineering Problems** • Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.	**Influence of Science, Engineering, and Technology on Society and the Natural World** • People's needs and wants change over time, as do their demands for new and improved technologies.

Connections to 3-5-ETS1.A: Defining and Delimiting Engineering Problems include:
Fourth Grade: 4-PS3-4

Articulation of DCIs across grade-levels:
K-2.ETS1.A ; **MS.ETS1.A** ; **MS.ETS1.B**

Common Core State Standards Connections:
ELA/Literacy -

W.5.7	Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. (3-5-ETS1-1)
W.5.8	Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. *(3-5-ETS1-1)*
W.5.9	Draw evidence from literary or informational texts to support analysis, reflection, and research. *(3-5-ETS1-1)*

Mathematics -

MP.2	Reason abstractly and quantitatively. *(3-5-ETS1-1)*
MP.4	Model with mathematics. *(3-5-ETS1-1)*
MP.5	Use appropriate tools strategically. *(3-5-ETS1-1)*
3-5.OA	Operations and Algebraic Thinking *(3-ETS1-1)*

Grade	*NGSS Discipline*
3-5	**Engineering, Technology, and Applications of Science 1.1**

3-5-ETS1-1

Sample Phenomena

When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available.

- Newton's Cradle uses hanging spheres to demonstrate fundamental laws of physics as the spheres collide into one another.

Classroom Assessment Items

When available, you should use your locally selected or created high quality instructional materials. However, the following are example assessment items you can use if you don't have local instructional materials available.

- To complete this task, you will be asking questions about energy. Use the table to write as many questions as you can for BEFORE, DURING, and AFTER the Newton's Cradle device is in use.
- Imagine you are given access to a Newton's cradle device and you are able to investigate one of the questions you asked.
  - What is your testable question? (Be sure it's related to energy transfer)
  - Sketch and describe how your investigation would work?

- What do you predict the results would be?

Adapted from the Stanford NGSS Assessment Project

Universal Supports	Targeted Supports
• Use related examples to help students begin looking at "collisions" from a scientific perspective (e.g. a car crash, bowling, chopping wood with an axe). • Model asking questions and making predictions for one of these examples as you describe in detail what is happening at each step. Focus on the differences when speed is adjusted. • Work with students to create a list of simple experiments they can perform at home or in the classroom to observe a variety of collisions and how they are affected by changes in speed. • Allow students to perform selected experiments from their self-created list and emphasize the importance of recording all questions, observations and predictions.	• Reinforce key words with pictures and discussion. Vocabulary may include: speed, collision, energy, potential, kinetic, force, transfer, predict. • Allow students many opportunities to ask clarifying questions in a small group setting and supportive environment. • Provide videos/video clips of a variety of collisions between objects as you narrate and model questioning and making observations and predictions. • Provide a list of basic questions and possible predictions for students to start with.

Common Misconceptions

- Some problems are too big to be solved, or cannot be solved.
- A problem has one *true* solution.
- *Designing* is the same thing as *inventing* so unique solutions must be found.
- A solution can be perfect, with no limitations or drawbacks.
- Solutions do not have to meet criteria or constraints.
- The design steps (define, develop, improve) must be followed once and in a specific order.
- A solution does not need to be revised.

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

The teacher could use these questions in science classroom discussions to bring out the student's thoughts, ideas and culture.

Validate & Affirm:

- *What words come to mind when you think of objects colliding or collisions (make sure to allow students time to share, or an opportunity to see key vocabulary words in their native language)?*
- *Do you have any experience with "collisions"? What happened? (e.g. car crash, running into someone on the playground, bowling, etc.)*
- *Do you believe that a collision is always "bad" or "negative"?*
- *Can you think of a situation in which it is perfectly okay for objects to collide (e.g. using a trampoline, jumping into a pool)?*

Build & Bridge:

	- *Can you take your experience with collisions and look at it through a scientist's perspective?* - *Can you take a friend's experience with collisions and ask some "what if?" questions? (e.g. My friend ran into her pet one morning...What would have happened if she had been running more slowly? Or my friend crashed his bike into a fence? What would have happened if the fence was made of a different material?)*

Students who demonstrate understanding can:

3-5-ETS1-2. **Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.**

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem.	**ETS1.B: Developing Possible Solutions** • Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. • At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.	**Influence of Science, Engineering, and Technology on Society and the Natural World** • Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.

Connections to 3-5-ETS1.B: Developing Possible Solutions Problems include:
Fourth Grade: 4-ESS3-2

Articulation of DCIs across grade-levels:
K-2.ETS1.A ; **K-2.ETS1.B** ; **K-2.ETS1.C** ; **MS.ETS1.B** ; **MS.ETS1.C**

Common Core State Standards Connections:
ELA/Literacy -

RI.5.1	Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. *(3-5-ETS1-2)*
RI.5.1	Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. *(3-5-ETS1-2)*
RI.5.9	Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. (3-5-ETS1-2)
Mathematics -	
MP.2	Reason abstractly and quantitatively. *(3-5-ETS1-2)*
MP.4	Model with mathematics. *(3-5-ETS1-2)*
MP.5	Use appropriate tools strategically. *(3-5-ETS1-2)*
3-5.OA	Operations and Algebraic Thinking *(3-ETS1-2)*

Grade	*NGSS Discipline*
3-5	**Engineering, Technology, and Applications of Science 1.2**
3-5-ETS1-2	**Sample Phenomena** *When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available.* • Ramiro recently got a drumset for his birthday. When he hits the cymbal with his drumstick, the cymbal makes noise. Ramiro wants to learn what happens when he hits the cymbal with his drumstick. **Classroom Assessment Items** *When available, you should use your locally selected or created high quality instructional materials. However, the following are example assessment items you can use if you don't have local instructional materials available.* • Ramiro hits the cymbal by moving the drumstick at two different speeds. First, Ramiro moves the drumstick slowly. Then, he moves the drumstick quickly. Each time Ramiro hits the cymbal, he stops

moving the drumstick. Ramiro claims that the drumstick has more energy when it moves quickly than when it moves slowly.

- Describe what Ramiro should observe that supports his claim. Explain why this would support his claim.

Adapted from STEM Gauge

Universal Supports	Targeted Supports
• Discuss the phenomena and prior knowledge/experience students have with speed and how that relates to the energy of different objects. • Allow students the opportunity to view a variety of similar examples in picture or video form and possibly construct a visual together that allows students to process these ideas (e.g. diagram of a toy car on a ramp will travel further if the ramp is at a steeper incline because it has more potential energy compared to a toy car on a small, nearly horizontal ramp).	• Provide visuals and allow students to work in small groups together to form working definitions. • Use different examples to help students grasp the concept of how an object's speed relates to its energy (find other examples here). • Allow students further opportunities to use manipulatives to test this concept. • Provide sample paragraph and sentence structures for students to aid in the development of a written explanation for their findings.

Common Misconceptions

- Some problems are too big to be solved, or cannot be solved.
- A problem has one *true* solution.
- *Designing* is the same thing as *inventing* so unique solutions must be found.
- A solution can be perfect, with no limitations or drawbacks.
- Solutions do not have to meet criteria or constraints.
- The design steps (define, develop, improve) must be followed once and in a specific order.
- A solution does not need to be revised.

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

The teacher could use these questions in science classroom discussions to bring out the student's thoughts, ideas and culture.

Validate & Affirm:

- *What are some different words we can use to describe energy and speed? (ex: fast/rápida/o; energía, etc.)*
- *Can you share an example of a time you noticed how the speed of an object affected its energy (e.g. racing toy cars)?*
- *What experiences do you have with speed and energy (e.g. running)?*
- *Do you have any traditions at home that may involve speed and energy (e.g. hitting piñatas at a party, playing sports or games)?*

	Build & Bridge: ● *How does your experience compare to the examples we've discussed?* ● *Can you use the knowledge you've gained to define energy and explain how speed is related using an example from your real-life experiences?*

Students who demonstrate understanding can:

3-5-ETS1-3. **Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.**

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.	**ETS1.B: Developing Possible Solutions** • Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. **ETS1.C: Optimizing the Design Solution** • Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.	

Connections to 3-5-ETS1.B: Developing Possible Solutions Problems include:
Fourth Grade: 4-ESS3-2
Connections to K-2-ETS1.C: Optimizing the Design Solution include:
Fourth Grade: 4-PS4-3

Articulation of DCIs across grade-levels:
K-2.ETS1.A ; **K-2.ETS1.C** ; **MS.ETS1.B** ; **MS.ETS1.C**

Common Core State Standards Connections:
ELA/Literacy -

W.5.7	Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. (3-5-ETS1-3)
W.5.8	Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. *(3-5-ETS1-3)*
W.5.9	Draw evidence from literary or informational texts to support analysis, reflection, and research. *(3-5-ETS1-3)*

Mathematics -

MP.2	Reason abstractly and quantitatively. *(3-5-ETS1-3)*
MP.4	Model with mathematics. *(3-5-ETS1-3)*
MP.5	Use appropriate tools strategically. *(3-5-ETS1-3)*

Grade	*NGSS Discipline*
3-5	**Engineering, Technology, and Applications of Science 1.3**
3-5-ETS1-3	**Sample Phenomena** *When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available.* ● Ramiro recently got a drumset for his birthday. When he hits the cymbal with his drumstick, the cymbal makes noise. Ramiro wants to learn what happens when he hits the cymbal with his drumstick. **Classroom Assessment Items** *When available, you should use your locally selected or created high quality instructional materials. However, the following are example assessment items you can use if you don't have local instructional materials available.* ● Ramiro hits the cymbal by moving the drumstick at two different speeds. First, Ramiro moves the drumstick slowly. Then, he moves the drumstick quickly. Each time Ramiro hits the cymbal, he stops

moving the drumstick. Ramiro claims that the drumstick has more energy when it moves quickly than when it moves slowly.

- Describe what Ramiro should observe that supports his claim. Explain why this would support his claim.

Adapted from STEM Gauge

Universal Supports	Targeted Supports
• Discuss the phenomena and prior knowledge/experience students have with speed and how that relates to the energy of different objects. • Allow students the opportunity to view a variety of similar examples in picture or video form and possibly construct a visual together that allows students to process these ideas (e.g. diagram of a toy car on a ramp will travel further if the ramp is at a steeper incline because it has more potential energy compared to a toy car on a small, nearly horizontal ramp).	• Provide visuals and allow students to work in small groups together to form working definitions. • Use different examples to help students grasp the concept of how an object's speed relates to its energy (find other examples here). • Allow students further opportunities to use manipulatives to test this concept. • Provide sample paragraph and sentence structures for students to aid in the development of a written explanation for their findings.

Common Misconceptions

- Some problems are too big to be solved, or cannot be solved.
- A problem has one *true* solution.
- *Designing* is the same thing as *inventing* so unique solutions must be found.
- A solution can be perfect, with no limitations or drawbacks.
- Solutions do not have to meet criteria or constraints.
- The design steps (define, develop, improve) must be followed once and in a specific order.
- A solution does not need to be revised.

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

The teacher could use these questions in science classroom discussions to bring out the student's thoughts, ideas and culture.

Validate & Affirm:

- *What are some different words we can use to describe energy and speed? (ex: fast/rápida/o; energía, etc.)*
- *Can you share an example of a time you noticed how the speed of an object affected its energy (e.g. racing toy cars)?*
- *What experiences do you have with speed and energy (e.g. running)?*
- *Do you have any traditions at home that may involve speed and energy (e.g. hitting piñatas at a party, playing sports or games)?*

	Build & Bridge: ● *How does your experience compare to the examples we've discussed?* ● *Can you use the knowledge you've gained to define energy and explain how speed is related using an example from your real-life experiences?*

Section 3: Resources

Science is not just a body of knowledge that reflects current understanding of the world; it is also a set of practices used to establish, extend, and refine that knowledge. [8] Our core science instruction must also allow for students to develop their science and engineering practices over time in addition to disciplinary core ideas. We know that children enter kindergarten with a surprisingly complex way of thinking about the world.[9] We know that students need sustained opportunities to work with and develop the underlying ideas and to appreciate those ideas' interconnections over a period of years rather than weeks or months.[8] We know that in order for students to develop a sustained attraction to science and for them to appreciate the many ways in which it is pertinent to their daily lives, classroom learning experiences in science need to connect with their own interests and experiences.[9] To this end, the National Research Council lays out a three-dimensional framework that is foundational to the development of the *Next Generation Science Standards (NGSS)*.

Dimension 1 describes the scientific and engineering practices (SEP). Dimension 2 describes the crosscutting concepts (CCC). Dimension 3 describes the core ideas (DCI) in the science disciplines and the relationships among science, engineering, and technology. All three of these dimensions must be interwoven in curriculum, instruction, and assessment.[9]

Engaging in the Practices of Science

Students provided sustained opportunities to engage in the practices of science and engineering better understand how knowledge develops and provides them an appreciation of the diverse strategies used to investigate, model, and explain the world.[9] The practices for K-12 science classrooms are:

1. Asking questions (science) and defining problems (engineering)
    a. Science asks:
        i. What exists and what happens?
        ii. Why does it happen?
        iii. How does one know?
    b. Engineering asks:
        i. What can be done to address a particular human need or want?
        ii. How can the need be better specified?
        iii. What tools or technologies are available, or could be developed, for addressing this need?
    c. Both ask:
        i. How does one communicate about phenomena, evidence, explanations, and design solutions?
2. Developing and using models
    a. Mental models: functional, used for thinking, making predictions, and making sense of experiences.
    b. Conceptual models: allow scientists and engineers to better visualize and understand phenomena and problems.

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[8] National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

[9] National Research Council. (2007). *Taking Science to School: Learning and Teaching Science in Grades K-8.* Committee on Science Learning, Kindergarten through Eighth Grade. R.A. Duschl, H.A. Schweingruber, and A.W. Shouse (Eds.). Board of Science Education, Center for Education. Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

   c. Are used to represent current understanding of a system (or parts of a system) under study, to aid in the development of questions or explanations, and to communicate ideas to others.
3. Planning and carrying out investigations
   a. Used to systematically describe the world and to develop and test theories and explanations of how the world works.
4. Analyzing and interpreting data
   a. Once collected, data are presented in a form that can reveal any patterns and relationships and that allows results to be communicated to others.
5. Using mathematics and computational thinking
   a. Enables the numerical representation of variables, the symbolic representation of relationships between physical entities, and the prediction of outcomes.
6. Constructing explanations (science) and designing solutions (engineering)
   a. Explanations are accounts that link scientific theory with specific observations or phenomena.
   b. Engineering solutions must include specifying constraints, developing a design plan, producing and testing models/prototypes, selecting among alternative design features to optimize achievement, and refining design ideas based on prototype performance.
7. Engaging in argument from evidence
   a. Scientists and engineers use reasoning and argumentation to make their case concerning new theories, proposed explanations, novel solutions, and/or fresh interpretations of old data.
8. Obtaining, evaluating, and communicating information
   a. Being literate in science and engineering requires the ability to read and understand their literature. Science and engineering are ways of knowing that are represented and communicated by words, diagrams, charts, graphs, images, symbols, and mathematics.

STEM teaching tools develop briefs to assist STEM teachers with issues that arise in the teaching of STEM. Here are some briefs that address scientific practices. All of these can be found at www.stemteachingtools.org/tools

Why focus on science and engineering practices – and not "inquiry?" Why is "the scientific method" mistaken? - STEM teaching tool #32

For decades science education has engaged students in a version of science inquiry that reduces the investigation of the natural world to a fixed, linear set of steps—sometimes devoid of a deep focus on learning and applying science concepts. Rigid representations of a single "scientific method" do not accurately reflect the complex thinking or work of scientists. The new vision calls for engaging students in multifaceted science and engineering practices in more complex, relevant, and authentic ways as they conduct investigations.

Practices should not stand alone: how to sequence practices in a cascade to support student investigations – STEM teaching tool #3

Science and engineering practices should strongly shape instruction—and be integrated with disciplinary core ideas and cross-cutting concepts. Some people might treat the practices as "stand alone" activities to engage students, but research shows that it is more effective to think about designing instruction as a cascade of practices. Practices should be sequenced and intertwined in different ways to support students in unfolding investigations.

What is meant by engaging youth in scientific modeling? - STEM teaching tool #8

A model is a representation of an idea or phenomenon that otherwise may be difficult to understand, depict, or directly observe. Models are integral to the practice of science and are used across many disciplines in a variety of ways. Scientists develop, test, refine, and use models in their research and to communicate their findings. Helping students develop and test models supports their learning and helps them understand important aspects of how science and engineering work.

Beyond a written C-E-R: supporting classroom argumentative talk about investigations – STEM teaching tool #17

Argumentation, a central scientific practice, relies on the coordination of claims, evidence, and reasoning (C-E-R). C-E-R scaffolds can help students compose a written argument for an investigation. However, there are additional important dimensions to argumentation beyond individually written claims. Classroom discussions that require students to make evidence-based claims and collectively build understanding also reflect argumentation. Several types of discussions can be used and can help build a supportive classroom culture.

Why should students learn to plan and carry out investigations in science and engineering? - STEM teaching tool #19

The NRC Framework for K-12 Science Education specifies eight science and engineering practices to be incorporated into science education from kindergarten through twelfth grade. One of these is planning and carrying out investigations. Although many existing instructional models and curricula involve engaging students in planned investigations, this tool will help you think about ways you can promote student agency by having them plan and conduct science investigations.

How can assessments be designed to engage students in the range of science and engineering practices? - STEM teaching tool #26

The new vision for K-12 science education calls for engaging students in three-dimensional science learning. This approach requires us to figure out new ways to assess student learning across these multiple dimensions—including the eight science and engineering practices. But there aren't many assessment tasks that require students to apply their understanding of core ideas using practices. In this tool, we describe how to use "task formats" to guide the development of such items. The formats can also spark ideas for designing classroom instruction.

Integrating science practices into assessment tasks – STEM teaching tool #30

This detailed and flexible tool suggests activity formats to help teachers create three-dimensional assessments based on real-world science and engineering practices. In response to this felt need being expressed among educators, researchers at the Research + Practice Collaboratory has developed a series of "task format" tables, which suggest different possible templates for student activities that integrate real-world science and engineering practices with disciplinary core ideas. This tool also combines two of the Research + Practice Collaboratory's major focuses: formative assessment and engaging learners in STEM practices. This tool offers between four and eight possible task formats for each of the science and engineering practices listed in the Next Generation Science Standards. It can be a great way for educators to brainstorm new activities or to adapt their existing lesson plans to this new three-dimensional vision.

Engaging students in computational design during science investigations – STEM teaching tool #56

Inquiry in science has become increasingly computational over the past several decades. The broad availability of computational devices, sensor networks, visualizations, networking infrastructure, and programming have revolutionized the way science and engineering investigations are carried out. Computational thinking practices enable unique modes of scientific inquiry that allow scientists to create models and simulations to generate data, and to understand and predict complex phenomena. K-12 science classrooms are natural contexts in which students can engage in computational thinking practices during their investigations.

Designing productive uncertainty into investigations to support meaningful engagement in science practices – STEM teaching tool #60

We want students to engage from the earliest ages in science and engineering practices with sincere curiosity and purpose. Science investigations can be viewed as "working through uncertainty." However, 3D instructional materials often try to support engagement in science practices by making them very explicit and scaffolding the process to make it easy to accomplish—arguably, too easy. An alternative approach that emphasizes productive uncertainty focuses on how uncertainty might be strategically built into learning environments so that students establish a need for the practices and experience them as meaningful ways of developing understanding.

Crosscutting concepts

A Framework for K-12 Education identifies seven concepts that bridge disciplinary boundaries. These concepts provide students with an organizational framework for connecting knowledge from the various disciplines into a coherent and scientifically based view of the world.[1] These crosscutting concepts are:

1. Patterns – guide organization and classification, prompt questions about relationships and the factors that influence them.
2. Cause and effect: mechanisms and explanations – a major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across contexts and used to predict and explain events in new contexts.
3. Scale, proportion, and quantity – in considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.
4. Systems and system models – Defining systems under study provides tools for understanding and testing ideas that are applicable throughout science and engineering.
5. Energy and matter: flows, cycles, and conservation – Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.
6. Structure and function – The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.
7. Stability and change – conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

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Prompts for integrating crosscutting concepts into assessment and instruction – STEM teaching tool #41

This set of prompts is intended to help teachers elicit student understanding of crosscutting concepts in the context of investigating phenomena or solving problems. These prompts should be used as part of a multi-component extended task. These prompts were developed using the Framework for K-12 Science Education and Appendix G of the Next Generation Science Standards, along with relevant learning sciences research.

The planning and implementation of instruction in your classroom should allow your students multiple and sustained opportunities to learn disciplinary core ideas through the science and engineering practices, as well as using appropriate crosscutting concepts as lenses to understand the disciplinary core idea and its relationship to other core ideas.

Planning Guidance for Culturally and Linguistically Responsive Instruction

"Equity in science education requires that all students are provided with equitable opportunities to learn science and become engaged in science and engineering practices; with access to quality space, equipment, and teachers to support and motivate that learning and engagement; and adequate time spent on science. In addition, the issue of connecting to students' interests and experiences is particularly important for broadening participation in science[1]"

In order to ensure our students from marginalized cultures and languages view themselves as confident and competent learners and doers of science within and outside of the classroom, educators must intentionally plan ways to counteract the negative or missing images and representations that exist in our curricular resources. The guiding questions below support the design of lessons that validate, affirm, build, and bridge home and school culture for learners of science:

> **Validate/Affirm:** How can you design your classroom to intentionally and purposefully legitimize the home culture and languages of students and reverse the negative stereotypes regarding the science abilities of students of marginalized cultures and languages?
>
> **Build/Bridge:** How can you create connections between the cultural and linguistic behaviors of your students' home culture and language and the culture and language of school science to support students in creating identities as capable scientists that can use science within school and society?

STEM Teaching tools highlight ways of working on specific issues that arise during STEM teaching. Here are some tools that have been created to guide STEM instruction around the concept of culturally and linguistically responsive instruction. All of these can be found at www.stemteachingtools.org/tools

How can we promote equity in science education? - STEM teaching tool #15

Equity should be prioritized as a central component in all educational improvement efforts. All students can and should learn complex science. However, achieving equity and social justice in science education is an ongoing challenge. Students from non-dominant communities often face "opportunity gaps" in their educational experience. Inclusive approaches to science instruction can reposition youth as meaningful participants in science learning and recognize their science-related assets and those of their communities.

Building an equitable learning community in your science classroom – STEM Teaching Tool #54

Equitable classroom communities foster trusting and caring relationships. They make cultural norms explicit in order to reduce the risk of social injuries associated with learning together. Teachers are responsible for disrupting problematic practices and developing science classroom communities that welcome all students into safe, extended science learning opportunities. However, this is tricky work. This tool describes a range of classroom activities designed to cultivate communities that open up opportunities for all students to learn.

How can you advance equity and justice through science teaching? - STEM teaching tool #71

Inequities are built into the systems of science education such that "students of color, students who speak first languages other than English, and students from low-income communities… have had limited access to high-quality, meaningful opportunities to learn science." Intersecting equity projects can guide the teaching and learning of science towards social justice. Science educators who engage in these projects help advance Indigenous self-determination (details) and racial justice by confronting the consequences of legacies of injustice and promoting liberatory approaches to education.

Focusing science and engineering learning on justice-centered phenomena across PK-12 – STEM Teaching tool #67

In the Framework vision for science education, students engage in active investigations to make sense of natural phenomena and analyze and build solutions to problems. Basing these investigations on justice-centered phenomena can be a powerful and rightful way to support science and engineering learning. Justice-centered investigations can open up important opportunities for students to engage in projects that support equity for communities and to see how the application of science and engineering are fundamentally entwined with political and ethical questions, dimensions, and decisions.

Teaching STEM in ways that respect and build upon indigenous peoples' rights – STEM teaching tool #10

Indigenous ways of knowing are sometimes thought to be in opposition to and detrimental to the learning of Western Science or STEM. Consequently, indigenous ways of knowing are rarely engaged to support learning. If STEM learning is to be meaningful and transformative for Indigenous youth, respecting Indigenous peoples' rights and related critical issues, including Indigenous STEM, settler-colonialism, and decolonization, must be understood and explicitly addressed in Indigenous youths' informal and formal STEM learning experiences.

How can formative assessment support culturally responsive argumentation in a classroom community? - STEM teaching tool #25

Argumentation has long been seen as an important practice in science and thus in science education. Formative assessment can be used to help students value the contributions and perspectives of others as they engage in argumentation to make sense of natural phenomena. Educators can use these strategies to help foster argumentation that is culturally responsive, meaning it draws from and respects students' cultural resources, backgrounds, and personal experiences. Culturally responsive formative assessment happens within a community of learners where the teacher has cultivated explicit norms for increasing student-centered discourse, making decisions for their own purposes through democratic processes, and using clear guidelines for maintaining mutual respect.

Engaging English learners in science and engineering practices – STEM teaching tool #27

Routinely engaging all students in the practices of science and engineering is a crucial fixture of the new vision for K-12 science education. The practices can be seen as a barrier to participation for English Learners (ELs), or they can be viewed as an opportunity to provide rich instruction that builds science-related competencies and identities. Certain elements of the practices and related instructional approaches can be beneficial for students learning science while also learning the language of instruction.

How can I promote equitable sensemaking by setting expectations for multiple perspectives? - STEM teaching tool #47

In a phenomena-focused, 3D approach to science learning, students use science practices to consider each other's ideas based on available interpretations and evidence. To promote deep and equitable learning, plan purposefully to ensure that the various perspectives that students bring to making sense of phenomena are solicited, clarified, and considered. It is important to support students as they develop a shared understanding of the different perspectives in the group.