Chapter 3
Kindergarten Through Grade Two

2016 Science Framework

FOR CALIFORNIA PUBLIC SCHOOLS
Kindergarten Through Grade Twelve

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To view the remaining sections of the 2016 California Science Framework on the CDE website, go to: https://www.cde.ca.gov/ci/sc/cf/casciencefreamework2016.asp

Items in this document that relate to crosscutting concepts are highlighted in green and followed by the abbreviation CCC in brackets, **[CCC]**, with a number corresponding to the concept. The same items that correspond to the science and engineering practices are highlighted in blue and followed by the abbreviation SEP in brackets, **[SEP]**, with a number corresponding to the practice.

The Web links in this document have been replaced with links that redirect the reader to a California Department of Education (CDE) Web page containing the actual Web addresses and short descriptions. Here the reader can access the Web page referenced in the text. This approach allows CDE to ensure the links remain current.

Kindergarten Through Grade Two

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Introduction to Kindergarten Through Grade Two

Students in kindergarten through fifth grade begin to develop an understanding of the four disciplinary core ideas: physical sciences; life sciences; Earth and space sciences; and engineering, technology, and applications of science. In the earlier grades, students begin by recognizing patterns and formulating answers to questions about the world around them.

The performance expectations in elementary school grade bands develop ideas and skills that will allow students to explain more complex phenomena in the four disciplines as they progress to middle school and high school. While the performance expectations shown in kindergarten through fifth grade couple particular practices with specific disciplinary core ideas, instructional decisions should include use of many practices that lead to the performance expectations.

— NGSS Lead States, *Next Generation Science Standards for States By States*.

When children arrive on the first day of school in kindergarten, they are already scientists and engineers. Children are naturally curious about the world, motivated to learn about it, and anxious to find ways to make it better. Early elementary teachers cultivate this curiosity and give students foundations for implementing the **science and engineering practices (SEP)** in later grades. The SEPs, like all three dimensions of the California Next Generation Science Standards (CA NGSS), build in complexity in an age-appropriate manner and look very different in K–2 than they do in high school. Appendixes E, F and G of the national version of the Next Generation Science Standards (NGSS) outline these progressions for each dimension and table 3.1 shows one way to interpret the SEPs for grades K–2. Children use these practices to understand everyday life events (*phenomena*), and CA NGSS-aligned instruction should begin with and be based around these real-world experiences. In particular, K–2 instruction focuses on recognizing **patterns [CCC-1]** in what students observe. Under the learning progressions in the CA NGSS, these patterns will be explained in later years, leaving early elementary students to focus on exuberant exploration with their senses and early attempts at making sense of what they discover.

The CA NGSS do not specify which phenomena to explore or the order in which to address topics because phenomena need to be relevant to the students that live in each community and should flow in an authentic manner. This chapter illustrates one possible set of phenomena that will help students achieve the CA NGSS performance expectations (PEs). The phenomena chosen for this statewide document will not be ideal for every classroom in a state as large and diverse as California. Teachers are therefore encouraged to select phenomena that will engage their students and use this chapter's examples as inspiration for designing their own instructional sequence.

In this framework, overarching phenomena that frame entire sequences of instruction are called *anchoring phenomena* while smaller and more focused phenomena are called *investigative phenomena*. While all phenomena ideally should be relevant to students' lives, cultures, and experiences, sometimes instruction draws attention to specific events that occur as *everyday phenomena*. Some phenomena introduce challenges that require engineering solutions, and in these cases it makes sense to focus on the anchor, investigative, or everyday problem rather than the phenomenon itself.

In this chapter's examples, each year is divided into instructional segments (IS) centered on questions about observations of a specific anchoring phenomenon. Different phenomena require different amounts of investigation to explore and understand, so each instructional segment should take a different fraction of the school year. As students achieve the performance expectations within the instructional segment, they uncover **disciplinary core ideas (DCIs)** from the different disciplines of science (physical science, life science, and Earth and space science) and engineering. Students engage in multiple practices in each instructional segment, not only those explicitly indicated in the performance expectations. Students also focus on one or two **crosscutting concepts (CCCs)** as tools to make sense of their observations and investigations; the CCCs are recurring themes in all disciplines of science and engineering and help tie these seemingly disparate fields together.

The SEPs, DCIs, and CCCs grow in sophistication and complexity throughout the K–12 sequence. While this chapter calls out examples of the three dimensions in the text using color-coding, each element should be interpreted with this grade-appropriate complexity in mind (appendix 1 of this framework clarifies the expectations at each grade span in the developmental progression).

Table 3-1. Age Appropriate Science and Engineering Practices

AS STATED IN STANDARDS	ADAPTED FOR K–2
Asking questions (science)/Defining problems (engineering)	Wondering (science)/Deciding the "rules" (engineering)
Developing and using models	Drawing diagrams and building models to represent how things work.
Planning and carrying out investigations	Doing "exploriments"
Analyzing and interpreting data	Comparing and looking for patterns
Using mathematical and computational thinking	Counting and measuring
Constructing explanations (science)/ Designing solutions (engineering)	Describing what happened (science)/ Tinkering (engineering)
Engaging in argument from evidence	"I think ____ because I see or know ____."
Obtaining, evaluating, and communicating information	Writing, drawing, or talking (acting out) about what we know, read, and understand about new discoveries (things) (ELA connections)

How can science fit into an early elementary teacher's busy agenda? This document explicitly illustrates strategic connections across the disciplines (mathematics, English language arts, history/social science, arts, and health). While these integrations are crucial, specific time must be devoted to science itself as students directly engage in the SEPs to explore their world. The common experiences students share provide a platform that supports language development and motivates mathematics, accelerating progress in those fields rather than detracting from them.

As teachers design their own instructional segments, they should consider the amount of observable data students need to collect across a certain time period in order to observe relevant **patterns [CCC-1]** from the data. For example, IS4 in kindergarten focuses on weather and climate investigations. To be successful, weather observation should be carried out over different times during the year to allow for some variability in weather conditions. To broaden the scope of data, teachers can creatively engage families and expanded-learning programs to build upon classroom learning experiences.

Kindergarten

Kindergarten may be students' first experience with classroom learning of science, but they have been exploring the world around them since birth. Students' natural curiosity and questions are the initial basis for science instruction and must be used, developed, and refined. Each of the instructional segments in this grade-level description is framed around phenomena that students can directly experience, observe, and question: What do plants and animals need to survive? Why do certain plants and animals live in our community? Will it be hot tomorrow? What happens when two toy trucks crash?

Table 3.2 shows one possible sequence for arranging science instruction in kindergarten. Teachers and districts can plan any sequence that meets their local needs, but there are some constraints to consider. The first two instructional segments are closely related and discuss the relationship between organisms and their environment. The instructional segment on weather, IS3, requires periodic weather observations prior to the instructional segment. Instructional segment 3 must therefore be placed late enough in the school year that students have recorded a variety of weather conditions. Collecting weather data also allows teachers to emphasize the importance of water for living things as they discuss IS1 and IS2. Instructional segment 4 asks students to relate the motion of objects to pushes and pulls. While very tangible, talking about these forces requires the most sophisticated language and this segment is saved for later in the year when students are ready to face this challenge.

Table 3-2. Overview of Instructional Segments for Kindergarten

	**1 Plant and Animal Needs** Students observe plants and animals directly and through books and media to discover patterns in what they need to survive. They distinguish between plants and animals based on these needs. They describe how organisms meet their needs using resources from their surroundings.
	**2 Plants and Animals Change Their Environment** Students gather evidence about how organisms can directly change their environment. They focus especially on human impacts by gathering information about ways to reduce those impacts. They communicate their solutions.
	**3 Weather Patterns** Students observe the weather to spot patterns in the rhythm of the seasons and of the day. They investigate the effects of the Sun on the Earth and design a shelter for shade.
	**4 Pushes and Pulls** Students explore how pushes and pulls speed objects up, slow them down, or change their direction. They design solutions to schoolyard challenges such as moving heavy boxes and protecting a block structure from an oncoming ball.

Sources: Labuda 2014; Nightingale 2009; Hodan n.d.; Virginia State Parks 2011

IS1

Kindergarten Instructional Segment 1: Plant and Animal Needs

When children come to kindergarten, they recognize that living things differ from nonliving ones, that plants differ from animals, and that certain plants and animals belong in certain places on Earth. When pressed to describe or explain these differences, however, their responses are often inconsistent and not aligned with scientific ideas. Kindergarten science instruction helps children make sense of these categories by employing their keen eye for detail and passionate desire to observe. While observing the bodies and behaviors of plants and animals, children notice patterns in what living things need to survive and grow. During the instructional segment, they develop the language tools to articulate what they see and collaboratively refine what they know.

KINDERGARTEN INSTRUCTIONAL SEGMENT 1: PLANT AND ANIMAL NEEDS

Guiding Questions

- How do we know that something is alive?
- What do animals and plants need to survive?
- Does what they need affect where they live?

Performance Expectations

Students who demonstrate understanding can do the following:

K-LS1-1. Use observations to describe patterns of what plants and animals (including humans) need to survive. [Clarification Statement: Examples of patterns could include that animals need to take in food but plants do not; the different kinds of food needed by different types of animals; the requirement of plants to have light; and, that all living things need water.]

K-ESS3-1. Use a model to represent the relationship between the needs of different plants or animals (including humans) and the places they live. [Clarification Statement: Examples of relationships could include that deer eat buds and leaves, therefore, they usually live in forested areas; and, grasses need sunlight so they often grow in meadows. Plants, animals, and their surroundings make up a system.]

K-ESS3-3. Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.* [Clarification Statement: Examples of human impact on the land could include cutting trees to produce paper and using resources to produce bottles. Examples of solutions could include reusing paper and recycling cans and bottles.]

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a practice or disciplinary core idea.

The bundle of performance expectations above focuses on the following elements from the NRC document *A Framework for K–12 Science Education*:

Highlighted Science and Engineering Practices	Highlighted Disciplinary Core Ideas	Highlighted Crosscutting Concepts
[SEP-2] Developing and Using Models [SEP-4] Analyzing and Interpreting Data [SEP-8] Obtaining, Evaluating, and Communicating Information	LS1.C: Organization for Matter and Energy Flow in Organisms ESS3.A: Natural Resources	[CCC-1] Patterns [CCC-4] Systems and System Models

Highlighted California Environmental Principles and Concepts:

Principle I The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services.

Principle II The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services.

KINDERGARTEN INSTRUCTIONAL SEGMENT 1: PLANT AND ANIMAL NEEDS
Principle IV The exchange of matter between natural systems and human societies affects the long-term functioning of both.
CA CCSS Math Connections: MP. 2, 4, K.CC.1–3, K.MD.2–3
CA CCSS for ELA/Literacy Connections: MP. 2, 4, K.CC.1–3, K.MD.2–3
CA ELD Standards Connections: ELD.PI.K.3

The DCIs for this segment are developmentally appropriate for kindergarten. Students learn that plants need water and light to live and grow and that animals need food. Animals obtain food from plants or other animals. Students also learn that organisms survive and thrive in places that have the resources they need. Simply knowing these core ideas is not sufficient for meeting the performance expectation; K-LS1-1 requires that students identify **patterns [CCC-1]** in the needs of different organisms. It is not possible to identify a pattern unless students observe and compare multiple observations of living things. The process of integrating multiple observations and looking for patterns constitutes **analyzing data [SEP-4]** in the K–2 grade band.

Students can observe living things directly in the classroom, on the schoolyard, and through media. Media (including books, print articles, and digital resources) expose students to a wide variety of organisms. Classroom pets such as birds, rodents, reptiles, fish, or even ant farms allow students to notice consistent patterns over time (i.e., the fish needs to be fed every day or the rodent spends most of its waking time eating). With pets, teachers must be mindful of district policies and allergies. Students can observe plants, insects, and other critters on their schoolyard. They can also grow their own seeds in cups or in an outdoor garden space.

Opportunities for ELA/ELD Connections

After students observe plants and animals in a variety of settings (e.g., ant farms, fish in an aquarium, plants growing, insects in a jar), the teacher asks them to share their thoughts about what the plants and animals need using expressions like, "I think..." and "I agree with...." To help summarize **patterns [CCC-1]** in the needs of plants and animals, teachers can list all of the needs the class has discussed on the board using words and pictures/symbols (e.g., sun, water, food). Students, individually or with a partner, draw a picture of a plant on one half of a piece of paper, and an animal on the other half. Then they draw and/or write the needs of the plant and of the animal next to each picture. Students can verbally complete the sentence frame, "Plants are different from animals because __________." This concept is important because scientists distinguish plants from animals based on what they need: animals need to consume food while plants do not, although plants do need nutrients. Students can represent this idea with a Venn diagram.

CA CCSS for ELA/Literacy Standards: W.K.2, 8; SL.K.1, 4, 5; L.K.5c

CA ELD Standards: ELD.PI.K.3

Once students have identified patterns about what plants need to survive, they can test out their idea by taking several identical plants that have already sprouted and deprive them of water, light, both, or neither. Based on their **model [SEP-2]** of what plants need, which do they predict will survive? Students will plan their own investigation of this question in grade two (2-LS2-1).

Mathematics Connections

Kindergarten students use attributes to sort objects (CA CCSSM K.MD.3). For example, a large portion of IS1 involves sorting plants and animals based on patterns in their needs. Students can sort organisms based on whether they are a plant or an animal, whether they live on water or land, and whether an animal eats only plants, only animals, or both.

CA CCSSM: MP. 2, K.CC.1-3, K.MD.2-3

While all plants and all animals share common features, there are also important differences between types of organisms. Different plants require different amounts of water (such as a fern that requires lots of water versus a cactus that requires very little). Different animals prefer different types of foods. For example, some animals only eat plants while others only eat animals, and others eat both. Students can use their background knowledge and observations from media to match specific animals to the food sources that they eat. Teachers can then ask questions such as, What will happen if a deer that eats only grass tries to live in a desert where cacti are the main plants?

Kindergarten Snapshot 3.1: Matching Environment and Needs

Anchoring phenomenon: Rivers have a wide variety of plants and animals that live near them (observed on a virtual field trip from videos and photographs).

Mrs. J took her students on a virtual field trip of California's notable river and lake habitats using videos and photographs. Mrs. J guided the students in a collaborative discussion about what they already know about rivers and lakes and recorded their comments. The class then observed features of these habitats on alphabet cards called *R is for River and L is for Lake* from the California Education and the Environment Initiative (EEI) curriculum unit *The World Around Me*.

Students imagined they were explorers traveling down a river and observing a variety of plants, animals, and human activities on their River and Lake information cards (1–10). Working in pairs, they **obtained and evaluated information [SEP-8]** about the animals and plants, as well as the places they live. Students then **communicated [SEP-8]** their findings with the whole class. Mrs. J asked follow-up questions: What do the animals and plants need to survive? If it is an animal, does it eat plants or other animals? Where does it live? (e.g., in a river, lake, or on the land nearby.) Why do you think it lives in that spot? Would it be able to survive somewhere else? She ensured that each student could **explain [SEP-6]** how the place a plant or animal lives is related to its specific needs for survival (K-ESS3-1). After all students shared, Mrs. J asked students to describe **patterns [CCC-1]** in the needs (K-LS1-1). Is there any need that every single one of the plants and animals shared? Students recognized water as a common link, and that the plants and animals can all get it by living near the river or lake. Mrs. J inquired, "Do people need water?" Even though the children do not live near a river or lake, Mrs. J described that they rely on water from natural systems to survive (California's Environmental Principles and Concepts [EP&C I]). Mrs. J had students draw pictures showing that our faucets take water from rivers or lakes to meet our needs, and that our drains and toilets eventually return that water back to natural systems after it is cleaned in a water treatment plant (EP&C IV).

Mrs. J asked two follow-up questions: When we traveled down the river did you see any places that were changed by people's activities? Do you think that those changes affect the animals and plants that live there? She explained that many things people do affect the places where plants and animals get what they need to survive (EP&C II).

Resources:

California Education and the Environment Initiative. 2013. *The World Around Me*. Sacramento: Office of Education and the Environment. https://www.cde.ca.gov/ci/sc/cf/ch3.asp#link1

This snapshot is part of a multi-day lesson sequence available online at: California Education and the Environment Initiative. 2016. "Kindergarten Vignette: Needs of Animals and Plants and their Environment." Sacramento: Office of Education and the Environment. https://www.cde.ca.gov/ci/sc/cf/ch3.asp#link2

Students should begin to group plants and animals together based upon their similar environmental needs (water, sunlight) and the availability of their preferred food sources. For example, students might read a story about the grasslands of Africa where a gazelle eats grass and then a lion eats the gazelle. Students should be able to **explain [SEP-6]** why each animal lives in that particular spot in Africa. Their answers should identify a specific need that is met by that location (either an environmental condition such as the grass lives there because it gets the sunlight and water that it needs, or a food source such as the lion lives there because it eats the gazelles there). Once students master the relationships of simple groups of organisms like the African grassland, teachers can focus on living things close to their school. What plants grow well in the weather in their city? What animals will eat those plants, and what animals will eat those animals? Teachers and students can decorate the four corners of their classrooms to look like the landscape of regional environments. They can read stories (fictional and informational) set in those environments. They can modify the decorations as the seasons change (connecting to IS3).

Students will build on their model of the relationship between the needs of organisms and their environmental conditions in grade three when they explore what happens when the environment changes (3-LS4-4) and in grade five when they examine the specific flow of energy and matter (5-LS2-1).

IS2 Kindergarten Instructional Segment 2: Animals and Plants Can Change Their Environment

Even though all organisms rely on the environment to get the things they need, many organisms also have the power to change their environment to make it even better at meeting their needs. Since everything is connected in systems, changes by one organism affect all the others. The content in this segment flows from IS1, but is split apart as a separate segment partly to emphasize humans as an agent of change (ESS3.C).

KINDERGARTEN INSTRUCTIONAL SEGMENT 2: ANIMALS AND PLANTS CAN CHANGE THEIR ENVIRONMENT

Guiding Questions

- How do animals and plants change their environment to survive?
- What do we (humans) do that changes our environment?
- What can we do to modify our impact on the environment?

Performance Expectations

Students who demonstrate understanding can do the following:

K-ESS2-2. Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs. [Clarification Statement: Examples of plants and animals changing their environment could include a squirrel digs in the ground to hide its food and tree roots can break concrete.]

K-ESS3-3. Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.* [Clarification Statement: Examples of human impact on the land could include cutting trees to produce paper and using resources to produce bottles. Examples of solutions could include reusing paper and recycling cans and bottles.]

K–2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a practice or disciplinary core idea.

The bundle of performance expectations above focuses on the following elements from the NRC document *A Framework for K–12 Science Education*:

Highlighted Science and Engineering Practices	Highlighted Disciplinary Core Ideas	Highlighted Crosscutting Concepts
[SEP-1] Asking Questions and Defining Problems [SEP-7] Engaging in Argument from Evidence	ESS2.E: Biogeology ESS3.C: Human Impacts on Earth Systems ETS1.A: Defining and Delimiting Engineering Problems ETS1.B: Developing Possible Solutions	[CCC-2] Cause and Effect: Mechanism and Explanation [CCC-4] Systems and System Models

Highlighted California Environmental Principles and Concepts:

Principle I The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services.

KINDERGARTEN INSTRUCTIONAL SEGMENT 2:
ANIMALS AND PLANTS CAN CHANGE THEIR ENVIRONMENT

Principle II The long-term functioning and health of terrestrial, freshwater, coastal and marine ecosystems are influenced by their relationships with human societies.

Principle IV The exchange of matter between natural systems and human societies affects the long-term functioning of both.

CA CCSS Math Connections: K.MD.3

CA CCSS for ELA/Literacy Connections: RI.K.1, 2, 10; SL.K. 2, 3, 5; W.K.2, 7, 8; L.K.1, 2

CA ELD Standards Connections: ELD.PI.K.2, 5, 6; ELD.PII.K.3

Students begin by walking around their schoolyard looking for ways in which plants and animals are changing the ecosystem. Students might notice a squirrel digging in the ground to hide a nut, ants piling up dirt outside a hole, a bird pulling a twig off a branch for its nest, a tree root pushing up a sidewalk, or a large bush blocking the sunlight of a smaller bush.

While animals are active and it is easier for students to think of them as making changes, students should also notice how plants change their environment. Some of the best evidence that plants make changes comes by comparing soil under plants to a patch of soil that does not have plants. Without plants, some soils can blow away in the wind. Plant roots change the environment and prevent soil from blowing or washing away. A patch of dirt might be dry because it lacks plants whose roots draw up moisture from deep below the surface and whose leaves shade the surface from the sunlight that dries it up. But bare dirt is not always loose—it can sometimes get hard and compacted. After a rainstorm, a patch of this hard dirt might be much muddier than soil near plants because it is hard for water to soak into soil that is hard and compacted. Students can notice these differences and **ask questions [SEP-1]** about why some bare dirt is loose and some is hard. A plant's roots sometimes act like a net to hold soft soil together, but other times they break hard soil apart, which allows water to soak in. A few pioneering weeds will be the first to send roots into that hard soil, slowly changing it. To draw attention to plant-related impacts, teachers can ask, Why do you think the sidewalk is raised or broken near the trees on the sidewalk? or After a rainstorm, why does mud run into the gutter from an empty lot, but not from a yard with lawn? Teachers scaffold student responses using simple sentence frames that emphasize the **cause and effect relationships [CCC-2]** (I think the ____ caused the ____). Students can represent the **changes [CCC-7]** by drawing two side-by-side pictures showing a before and after comparison of what the environment looked like before the change and what it looks like now.

Not every schoolyard has abundant nature visible, so teachers will have to do their best by finding short video clips and reading stories that illustrate ways in which animals and plants change their environment. For example, students can watch online videos of woodpeckers pecking holes in trees. Teachers encourage students to **ask questions [SEP-1]** about what they see, encouraging their natural curiosity. To address the question, Why is it pecking?, a teacher can ask students what ideas they have. After recording student responses, teachers emphasize that all of these possibilities relate to meeting the woodpecker's need for survival. It turns out that different woodpecker species peck for different reasons, but students can look for evidence in the videos for different species. A pileated woodpecker stops pecking periodically to eat bugs while an acorn woodpecker pecks a deep hole near several other holes that have acorns stuffed inside because it stores its food for the winter. With all those holes, students wonder, Does it hurt the trees? While some woodpeckers target trees that are already dead, others prefer live trees so that they can eat the sap and insects that feed on the sap. So the answer depends on how many woodpeckers there are and how many holes they drill. This idea allows teachers to transition into issues about human effects on the natural environment (ESS3.C).

Kindergarten Snapshot 3.2: Resource Systems

Many changes that animals make to the environment benefit other organisms, but humans can modify the environment on such a large **scale [CCC-3]** that sometimes the changes affect other organisms including other people. Humans alter the environment when they extract natural resources for making products and when they produce the energy needed to make those items (EP&C II). In this snapshot, students **obtain, evaluate, and communicate information [SEP-8]** about the relationship between everyday objects, the natural resources that are needed to produce them, and how using those resources can affect the natural systems where they are found (EP&Cs I and IV).

Everyday phenomenon: Paper can be recycled.

Ms. W walked over to the blue bin for recycled paper in her classroom and asked what could go in it. She then led a discussion about what students know about the questions: What is paper made of? and What does it mean to recycle it? Ms. W distributed three information cards to students with the labels Paper, Logs, and Trees. Ms. W led a class conversation about the photographs on the cards and students discussed how the objects relate to one another. Ms. W wanted to introduce the concept that paper is a resource that comes from trees that grow in forests. To scaffold this process, she had students arrange the cards in a sequence of which came first and had students use verb phrases (CA ELD PII.K.3) to describe how trees became logs (cut) and how logs became paper (ground up in a factory). To reinforce both the concepts and the language development, she read a poem that used some of these verb phrases with vivid imagery. Students repeated the discussion for cards labeled “Bread-Wheat-Soil” and “School Building-Sand/Concrete-River.” Ms. W emphasized that there is a **pattern [CCC-1]** by asking students to sort the cards into categories (CA CCSSM K.MD.3): “Object I use,” “Material to make the object,” and “Natural system.” People use **materials [CCC-5]** from one category to make another, so each group of cards represents a separate **system [CCC-4]**. Ms. W had students complete a simple sentence describing a **cause and effect relationship [CCC-2]** within each system, such as When we use paper, we affect _____, or When we build _____, we take sand from rivers.

Ms. W asked the students to work in pairs to think about the question, What happens if we cut down too many trees in a forest? As they began to recognize that using things like paper in their daily lives affects the natural systems those resources come from, students started to develop an understanding of the essence of California EP&C II—people influence natural systems.

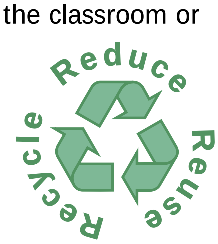
Resources:

California Education and the Environment Initiative. 2013. *A Day in My Life*. Sacramento: Office of Education and the Environment. https://www.cde.ca.gov/ci/sc/cf/ch3asp#link3

Wilson, Fred. 2013. “Sticks, Sticks, Pick up Sticks.” In *A Day in My Life*, edited by California Education and the Environment Initiative. Sacramento: Office of Education and the Environment. https://www.cde.ca.gov/ci/sc/cf/ch3.asp#link4

Engineering Connection — Reduce, Reuse, Recycle

Once students understand that producing everyday objects affects natural systems, they can begin to come up with **solutions [SEP-6]** that reduce the effects (K–2-ETS1-1). For example, students can brainstorm ways that they can save water or paper. Their solutions probably fall into the categories of reducing, reusing, or recycling, so teachers can introduce these terms and help students categorize their suggestions. Students might come up with systems for reusing materials in the classroom or design a way to capture wasted water in their classroom sink. To **communicate [SEP-8]** their solutions (K-ESS3-3), students can draw a picture of one of their ideas and then choose the appropriate label for their suggestion (reduce, reuse, or recycle). Students should be able to identify the natural system that benefits from the action and **explain [SEP-6]** how their solution will help).



Opportunities for ELA/ELD Connections

Select four or five books about different ecosystems to read aloud to the class. For example, the series about living in a biome by Carol L. Linden has numerous topics such as *Life in a Forest*, *Life in an Ocean*, *Life in a Desert*, *Life in a Stream*, *Life in a Rain Forest*, and *Life in a Pond*. As each book is read, prompt student engagement using similar questions about the biome, for example: What does ____ (animal or plant) need to survive? Where does ____ live? How does ____ change their environment? Divide students into small groups, with each group assigned a different book, to compose (through dictation and/or pictures) an explanatory piece about their biome, including some text-based details.

CA CCSS for ELA/Literacy Standards: RI.K.1, 2, 10; SL.K. 2, 3, 5; W.K.2, 7, 8; L.K.1, 2

CA ELD Standards: ELD.PI.K.2, 5, 6

Sample Integration of Science and ELD Standards in the Classroom

Students use pictures, drawings, and observations of natural events to construct an argument based on evidence about how plants and animals (including humans) can change the environment to meet their needs (K-ESS2-2). They sequence events and compare predictions (based on prior experiences, such as having picked fruit from a tree to eat or having collected and used water from different sources for different purposes) to what occurred (observable events), such as seeing birds gathering materials to build nests and drinking water from puddles, squirrels storing food, and tree roots breaking the concrete of sidewalks. As they work as a class and in small groups, they ask questions of one another and respond to others in order to identify details and patterns that support their claims.

CA ELD Standards: ELD.PI.K.5

Source: Lagunoff et al. 2015, 214–215

IS3

Kindergarten Instructional Segment 3: Weather Patterns

Weather is something that every child experiences and can observe. Students are naturally motivated to ask, "Is it too rainy to play outside today?" or "Do I need my hat today?" With this relevance in mind, students can record the weather each day and begin to see **patterns [CCC-1]** over time.

KINDERGARTEN INSTRUCTIONAL SEGMENT 3: WEATHER PATTERNS

Guiding Questions

- What is the weather like today and how it is different from yesterday?
- Can I predict tomorrow's weather?
- What happens when the Sun shines on different objects?
- How can I protect myself from the sunlight?
- How do we prepare for severe weather?

Performance Expectations

Students who demonstrate understanding can do the following:

K-ESS2-1. Use and share observations of local weather conditions to describe patterns over time. [Clarification Statement: Examples of qualitative observations could include descriptions of the weather (such as sunny, cloudy, rainy, and warm); examples of quantitative observations could include numbers of sunny, windy, and rainy days in a month. Examples of patterns could include that it is usually cooler in the morning than in the afternoon and the number of sunny days versus cloudy days in different months.] [*Assessment Boundary: Assessment of quantitative observations limited to whole numbers and relative measures such as warmer/cooler.]*

K-ESS3-2. Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather.* [Clarification Statement: Emphasis is on local forms of severe weather.]

K-PS3-1. Make observations to determine the effect of sunlight on Earth's surface. [Clarification Statement: Examples of Earth's surface could include sand, soil, rocks, and water] [*Assessment Boundary: Assessment of temperature is limited to relative measures such as warmer/cooler.*]

K-PS3-2. Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area.* [Clarification Statement: Examples of structures could include umbrellas, canopies, and tents that minimize the warming effect of the Sun.]

K–2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

K–2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

K–2-ETS1-3. Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a practice or disciplinary core idea.

KINDERGARTEN INSTRUCTIONAL SEGMENT 3: WEATHER PATTERNS

The bundle of performance expectations above focuses on the following elements from the NRC document *A Framework for K–12 Science Education*:

Highlighted Science and Engineering Practices	Highlighted Disciplinary Core Ideas	Highlighted Crosscutting Concepts
[SEP-1] Asking Questions and Defining Problems [SEP-2] Developing and Using Models [SEP-3] Planning and Carrying Out Investigations [SEP-4] Analyzing and Interpreting Data [SEP-6] Constructing Explanations (for science) and Designing Solutions (for engineering) [SEP-8] Obtaining, Evaluating, and Communicating Information	PS3.B: Conservation of Energy and Energy Transfer ESS2.D: Weather and Climate ESS3.B: Natural Hazards ETS1.A: Defining and Delimiting Engineering Problems ETS1.B: Developing Possible Solutions ETS1.C: Optimizing the Design Solution	[CCC-1] Patterns [CCC-2] Cause and Effect: Mechanism and Explanation [CCC-6] Structure and Function

Highlighted California Environmental Principles and Concepts:
Principle I The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services.
Principle III Natural systems proceed through cycles that humans depend upon, benefit from and can alter.
Principle IV The exchange of matter between natural systems and human societies affects the long-term functioning of both.

CA CCSS Math Connections: K.CC.5–6; K.MD.2-3, 10; K.G.1

CA CCSS for ELA/Literacy Connections: L.K.5c, 5d, 6; W.K.2, 3, 8; SL.K.1, 4, 5, 6

CA ELD Standards Connections: PI.K.A.1, PI.K.A3, PI.K.C.9

In the CA NGSS, DCIs are revisited many times at an increasing level of complexity. By the end of high school, students will have developed a model of Earth's energy balance and how it relates to the flow of water and air that drives atmospheric and ocean circulation. But at the beginning of the journey, students are solely expected to notice. They notice that weather varies from day to day and wonder about what causes it. They also recognize that these variations are not random; the consistent rhythms of the day and the seasons show **patterns [CCC-1]** that students can explicitly identify.

Because weather varies, patterns are sometimes hard to recognize in small data sets. Students are much more likely to be able to recognize patterns when they collect data consistently over a long period of time. Teachers must select a weather variable that is locally relevant and have students record observations about it. The data recorded each day should probably be qualitative, such as keeping track of the clothing that is most appropriate for recess each day (e.g., short sleeves, long sleeves, a warm coat, or a rain jacket) or choosing the appropriate weather icon after lunch (e.g., sunny, partly cloudy, foggy, windy, rainy, etc.). Students could also keep track of the number of days that meet a certain locally relevant criteria such as number of foggy mornings (for coastal communities), rainy days (for Northern California), or afternoons above 95°F (for desert communities). These observations need to begin long before the actual instructional segment on weather so that students have accumulated enough data to recognize and describe patterns (K-ESS2-1). Animals have grown to depend on these patterns to survive, so teachers can draw connections to life science concepts from earlier in the course. Humans, too, have built cities depending on these patterns and face challenges when these regular cycles are interrupted (EP&C III).

Opportunities for Mathematics Connections

Students can **count [SEP-5]** and **compare [SEP-4]** (CA CCSSM K.CC.5, K.MD.3) the number of days meeting the criteria within a certain month to recognize seasonal patterns. The California Common Core State Standards for mathematics (CA CCSSM) do not require students to be able to represent data using picture or bar graphs until grade two (CA CCSSM 2.MD.10), but students in kindergarten should be able to look at a picture graph and decide which categories have the most days and the least days that meet the criteria (CA CCSSM K.CC.6).

CA CCSSM: K.CC.5–6

Students can record the temperature at the same time of day, several times a day for a week to spot another important weather **pattern [CCC-1]**. On most days, the temperature at the end of the school day is warmer than the temperature at the beginning of the school day. Students should be able to describe this pattern (K-ESS2-1) and **ask questions [SEP-1]** about what causes it. Students can claim based on past experience that the Sun **causes [CCC-2]** this daily warming, and in kindergarten they now **collect observations [SEP-4]** that support that **argument [SEP-7]** (K-PS3-1). They also undergo a design challenge to reduce the effect of sunlight (K-PS3-2).

KINDERGARTEN VIGNETTE 3.1: MADE FOR THE SHADE

Performance Expectations

Students who demonstrate understanding can do the following:

K-PS3-1. Make observations to determine the effect of sunlight on Earth's surface. [Clarification Statement: Examples of Earth's surface could include sand, soil, rocks, and water] [*Assessment Boundary: Assessment of temperature is limited to relative measures such as warmer/cooler.*]

K-PS3-2. Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area.* [Clarification Statement: Examples of structures could include umbrellas, canopies, and tents that minimize the warming effect of the Sun.]

K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

K-2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

K-2-ETS1-3. Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a practice or disciplinary core idea.

Highlighted Science and Engineering Practices	Highlighted Disciplinary Core Ideas	Highlighted Crosscutting Concepts
[SEP-2] Developing and Using Models [SEP-3] Planning and Carrying Out Investigations [SEP-6] Constructing Explanations (for science) and Designing Solutions (for engineering)	PS3.B: Conservation of Energy and Energy Transfer ETS1.A: Defining and Delimiting Engineering Problems ETS1.B: Developing Possible Solutions ETS1.C: Optimizing the Design Solution	[CCC-2] Cause and Effect: Mechanism and Explanation [CCC-6] Structure and Function

Highlighted California Environmental Principles and Concepts:

Principle I The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services.

CA CCSS Math Connections: K.MD.2, K.G.1

CA CCSS for ELA/Literacy Connections: W.K.2, W.K.8, SL.K.1, SL.K.5, SL.K.6

CA ELD Standards Connections: ELD.PI.K.A.1, PI.K.A.3, PI.K.C.9

KINDERGARTEN VIGNETTE 3.1: MADE FOR THE SHADE

Introduction

What effects does the Sun have on us? How can we minimize the negative effects? Energy from the Sun is at the heart of all components of the Earth system and is revisited throughout the entire K–12 sequence. This kindergarten activity merges scientific understanding of cause and effect with an engineering design challenge. Students design and build a shelter to protect rabbits made out of ultraviolet (UV) sensitive beads.

Day 1: Observe Sun and Shade

Students go outdoors to observe which areas of the schoolyard are in sun and in shade, and how sunny and shady areas change throughout the day. They record their observations at each time of day.

Day 2: Reading in the Sun

Students plan a trip out to the schoolyard to read a book about how different animals stay cool. When they return, they draw and write about how they stay protected from the Sun.

Day 3: Defining the Problem

Students read about the ways that jackrabbits stay cool and then explore with a rabbit made out of UV-sensitive beads. They learn about the design challenge to protect their rabbit from the Sun.

Day 4: Imagine

Students investigate the possible materials for their shelter. They test the performance of ten basic shelters.

Day 5: Plan

Students choose materials and draw a diagram with their shelter plan.

Day 6–8: Create, Improve, Communicate

Students build their shelters, test them in the Sun, make improvements, and share their results.

Day 1: Observe Sun and Shade

Anchoring phenomenon: Some areas of the schoolyard are sunny and some are shady at different times throughout the day.

Mrs. K chose a particularly sunny day to begin this sequence and told students that the next day they were going to read a book outside in the schoolyard. Before that, they needed to gather information so that they could decide the best place to sit and read. To make an informed decision, students went outside to observe which parts of the schoolyard were in the sun and which were in the shade at different times of day. They visited four different locations three times during the day and recorded on a simple chart whether each spot was sunny or shady on each

KINDERGARTEN VIGNETTE 3.1: MADE FOR THE SHADE

visit. They discovered that some places were sunny in the morning and shady in the afternoon, other places just the opposite. Were there places that were always sunny or always shady?

Before their third visit outside, Mrs. K taught students how to read thermometers. Inside the classroom, all the thermometers read about the same temperature. Mrs. K asked the students if they thought the thermometer would read a higher number or a lower number when they were outside (a bit more advanced than CA CCSSM K.CC.7; 1.NBT.3). Would the temperature in the Sun be different than the temperature in the shade? Why did they think that? Students then went outside and made note of whether each spot was sunny or shady and then recorded the temperature at each spot. They **analyzed their data [SEP-4]** by comparing the different measurements and completed the sentence frame, Where it is sunny, the temperature is _____. Mrs. K wanted to know what does the Sun give off? What do we receive from the Sun? What does it mean when we say a spot is sunny or shady? How are sunny places different from shady places? It took a while for Mrs. K to find the questions that inspired students to discuss their wide-ranging ideas about the Sun. After a few minutes, their discussion focused on the light that comes from the Sun. Mrs. K introduced the idea of **cause and effect relationships [CCC-2],** providing a few examples from everyday life. She then asked students to write down as many cause and effect relationships about the Sun (_____ causes _____) that they observed in the activity.

Day 2: Reading Outdoors

On the day for reading outside, Mrs. K told students that she wanted them to be comfortable and able to enjoy the book, so where should they sit? She asked pairs of students to discuss proposals, including a reason why their spot would be the most comfortable place to be. She reminded students to use their observations from yesterday to help them decide. The class eventually reached consensus on a location beneath a tree and they went there to read *Beneath the Sun* by Melissa Stewart (2014). The book shows different ways that animals and people try to stay cool. Mrs. K related what they were reading to the student's own situation, asking if any of them thought it was too bright or too shady, or if they were too warm or cold. She asked them about how trees on the schoolyard could keep them cool (EP&C I). Students returned to the classroom to finish the sentence, I stay protected from the Sun by _______. (CA CCSS for ELA/Literacy: W.K.8)

Day 3: Defining the Problem

Everyday phenomenon: Rabbits spend time in the shade on hot sunny days

In the neighborhood around the school, students sometimes saw rabbits hopping around with their little white tails and big ears. Mrs. K read a text that described a day in the life of a California native, the black-tailed jackrabbit (*Lepus californicus*). It spends most of the hot sunny daytime resting in the shade of bushes. Even in the shade, the rabbit still has its very long ears that help it stay cool.

Mrs. K asked the children to imagine that the class was going to get a jackrabbit for a pet

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and they wanted it to have a place to live outside. There were not any bushes outside the classroom, so students would have to design a shelter to keep their rabbit cool during the hot sunny days. Some light colored rabbits in captivity get sunburned if they sit in the direct sun for too long. While the class would not be getting a real rabbit, she gave each child a tiny rabbit made out of white beads (figure 3.1). She had the students cup them in their hands to protect them as they took them outside for the first time. She had them uncover their rabbits all at once, and the white beads immediately turned vibrant colors. She gave the students time to explore the effects of the Sun on their rabbits, placing them in their shadows, in the shade of a tree, or under their clothing.

Investigative problem: How do we keep a pet rabbit out of the Sun?

She then described the challenge: they would design and build a shelter for their rabbit (K-PS3-2). She invited students to ask questions about the project (K–2-ETS1-1). They decided on a few rules (**defining the problem [SEP-1]**), including that the house must have a front entrance, must protect the rabbit from the Sun, and must be built using the materials that Mrs. K provides.

Figure 3.1. Rabbit Made from UV-Sensitive Beads

Source: Margo's Beadie Critter Collection n.d.

Day 4: Imagine

Investigative phenomenon: Different materials block sunlight better than others.

Mrs. K wanted students to explore the different materials so that they could plan which ones to use for their shelter. She built ten basic shelters using different roof materials (black and white construction paper, wax paper, cardboard, aluminum foil, felt, and clear plastic sheets with and without three different strengths of sunscreen spread over the top). She asked students which roof materials they thought would protect their rabbits the most and least. Several students thought that the cardboard, felt, or foil would work best. Others thought that the clear plastic, regardless of sunscreens, would work the least. When they tested the shelters outside, they also noticed how well, or not, the shelters protected their rabbits. Some rabbits stayed mostly white, while others became multicolored. Mrs. K encouraged students to **explore [SEP-3]** the effects of different roof materials by switching shelters with each other. She had her students discuss how well each material worked

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(**analyzing and interpreting data [SEP-4]**, CA CCSS for ELA/Literacy SL.K.1). The consensus was that the cardboard worked the best because it was thick and prevented sunlight from getting through. The plastic sheet with no sunscreen worked the least because it provided no protection at all. To the students' surprise, the plastic sheet with sun-protection factor (SPF) 50 sunscreen worked very well to keep the rabbits mostly white. One student exclaimed, "Wow, this is why it's so important to wear sunscreen outside!"

Day 5: Plan

Students brainstormed possible shelter designs. They **debated [SEP-7]** the pros and cons of each roof material and explained their reasoning. They then drew their individual design idea and labeled the parts (K–2-ETS1-2, CA CCSS for ELA/Literacy W.K.2, SL.K.5). Mrs. K asked students to describe some of the shapes that were present in their structure (CA CCSSM K.G.1). Each pair shared their designs with another pair of students. They described the parts of each design that they thought would work the best, and the parts that they thought might not work as well, or might cause problems. Each pair decided on the design they wanted to build the next day.

Days 6–8: Create, Improve, Communicate

Finally, the day came to build their rabbit shelters. They could not wait to get started! They built shelters with roofs, walls, and windows so that the rabbit could look out for predators and doors so that the rabbit could quickly escape if it needed to. Some houses even had a soft clump of grass that mimicked the spot where a rabbit in the wild would rest. They shared ideas freely and gave suggestions to each other along the way. During this process, they struggled with making structures that supported the roof while still having room for their rabbit to fit inside and move around (**structure and function [CCC-6]**). They tested their shelters outside in the sunshine and students compared their designs to others (K–2-ETS1-3). Most students made a series of **improvements [SEP-6]**. For example, several students had houses with windows. But when they noticed that the Sun shone through and turned their rabbit multicolored, they decided to add SPF 50 sunscreen to the windows. One student noticed a gap between his roof and walls that allowed the Sun to get in, so he taped the edges together. Another student added a second layer to the roof to make it thicker and block more of the Sun's rays. Mrs. K took lots of pictures to document students' progress through the steps of the engineering design process (figure 3.2). Once they had completed the work, students presented their houses to the class and [redacted] (CA CCSS for ELA/Literacy SL.K.6) what special features kept their rabbits protected from the Sun's heat and harmful rays.

Figure 3.2. Students Testing Their Shade Structures

Source: Kitagawa 2016

KINDERGARTEN VIGNETTE 3.1: MADE FOR THE SHADE

Vignette Debrief

The engineering design challenge in this vignette frames a three-dimensional learning process.

SEPs. Students perform the engineering design process from beginning to end. The exploration outdoors on day 1 and the background reading and discussion of prior experience on days 2–3 ensures that students understand the context of the **problem [SEP-1]**. They **obtain information [SEP-8]** from a variety of texts, including fiction and informative texts (see the Resources section for additional story suggestions). While they never plan an investigation, they engage in several of the components of **conducting investigations [SEP-3]** appropriate for K–2: they collaboratively collect data on day 1 and then compare their qualitative observations with measurements from a thermometer. They make a prediction about where it will be shady enough to read their book. On day 4, they compare different materials. In days 3 and 5–8, students work on **designing solutions [SEP-6]**.

The emphasis of the last two days is on the iterative improvement process. To provide students quick and easy-to-interpret feedback, the UV-sensitive beads allow students to literally see the effectiveness of their shelter. In middle and high school, they will return to solar houses and solar cookers and will collect detailed temperature data, but a quantitative focus is not age-appropriate for kindergarten.

DCIs. This activity lays the groundwork for more detailed understanding of the DCIs about energy transfer, electromagnetic radiation, heat flow, forces, and the properties of materials in later grades. Despite the fact that the primary DCI for this vignette (PS3.B) is called Conservation of Energy and Energy Transfer, the word *energy* never appears because the abstract concept of energy is not age appropriate. At this age, students just need to master the idea that sunlight warms Earth's surface.

CCCs. On days 4–5, the map itself was a form of **analysis [SEP-4]** as students noticed **patterns [CCC-1]** and created categories while they were still in the field. Once students describe the pattern, they then interpreted their observations in terms of **cause and effect [CCC-2]** (day 6).

EP&Cs. On day 1, students focus on how they depend on the natural environment for shade and comfort (EP&C I). They then extend that idea to other living things as they focus on how rabbits need a certain physical environment to survive and thrive. The rabbit's body and behavior are well suited to this physical environment. In the engineering challenge, students actually modify the physical environment on a small scale. The vignette never explicitly introduces this idea, but teachers could emphasize it to introduce EP&C II.

CCSS Connections to English Language Arts and Mathematics. Throughout the activity, students engage in discourse about their observations and solutions. They supplement their direct observations with information from written texts. Mathematically, students work with shapes and comparisons.

Text and images for this vignette come from Kitagawa (2016), which includes more detailed directions and a list of materials. The original lesson uses a lizard instead of a jackrabbit.

KINDERGARTEN VIGNETTE 3.1: MADE FOR THE SHADE

Resources:

Butterfield, Moira. 1999. *In Hot Places*. London: Belitha Press Ltd.

Kitagawa, Laura. 2016. “Made for the Shade.” *Science and Children* 53 (5): 34–40.

Margo’s Beadie Critter Collection. n.d. Bunny 2. https://www.cde.ca.gov/ci/sc/cf/ch3.asp#link5

Stewart, Melissa. 2014. *Beneath the Sun*. Atlanta: Peachtree Publishers.

Students are full of questions about extreme weather and the CA NGSS places emphasis on local forms of severe weather. Students might **wonder [SEP-1]**, Do we have hurricanes in California? How many days in a row has it rained in our city? or When was the last flood on our local stream, and did it cause any damage? Students can use local library books or age-appropriate media to **obtain information [SEP-8]** about one such weather hazard. They can then pretend to be a weather forecaster **communicating [SEP-8]** a warning about an upcoming weather hazard (ELD K.PI.C.9). They can inform their classmates about how to prepare for the event (K-ESS3-2). Given the complexity of K-ESS3-2, this task may benefit from parent involvement during a home project.

Opportunities for ELA/ELD Connections

As part of the introduction to the weather unit to support students building their knowledge of weather terms, the tools used to collect the data, and weather patterns, students can take turns acting as the meteorologist to lead the class in a discussion, with appropriate language support, about weather conditions for that day. In addition to the individual weather journals, a class data collection poster can be used to clarify the recorded weather, adding visual pictures or symbols.

CA CCSS for ELA/Literacy: SL.K.4, 5, 6; W.K.3, 8; L.K.5c, 5d, 6

CA ELD Standards: ELD.PI.K.9, 11

Sample Integration of Science and ELD Standards in the Classroom

Students have been collecting local weather data on a daily calendar. They work as a whole group near a large chart that shows labeled images of various types of severe weather (different from those on the daily calendar) and view a video of severe weather (such as heavy rain and wind, blizzard, or heavy snowstorm). Students explore the phenomena, asking questions about the purpose of weather forecasting and how to respond to severe weather in their locality (K-ESS3-2). For example, students may ask, "What if the forecast were this type of weather for our community? What would be the problems for our community if we had this type of weather? What things could we do to prepare for this type of weather? How can forecasting the weather help us prepare and be ready for severe weather?" The teacher supports English learners at the Emerging and Expanding levels of English language proficiency in asking and answering these questions by providing sentence frames (e.g., If ____, then we could ___. We should ___ if ___). The teacher encourages students to refer to the labeled images of weather when they ask and answer questions. When necessary, the teacher asks probing questions and recasts students' responses, affirming their ideas and helping them use vocabulary and structure their statements in ways appropriate for a science discussion.

CA ELD Standards: ELD.PI.K.1

Source: Lagunoff et al. 2015, 206–207)

IS4

Kindergarten Instructional Segment 4: Pushes and Pulls

Even very young children have an intuitive sense—a mental model—of the way objects move. They express surprise if they see a ball change its direction of motion or suddenly speed up or slow down with no visible reason for the change. They know how to push or pull toys to get them moving, and they are overjoyed by their own body's ability to move large objects. IS4 builds on this intuitive sense of how the world works and develops a language of words and diagrams for talking and thinking about these experiences. The segment includes three activity sequences in which students progressively refine a model of motion:

- We can change the motion of objects (marble track).
- Pushes and pulls cause objects to speed up, slow down, or change direction (kickball and tug of war).
- Pushes and pulls can have different strengths and directions. The bigger the push or pull, the faster the motion (school-yard box challenge).

KINDERGARTEN INSTRUCTIONAL SEGMENT 4: PUSHES AND PULLS

Guiding Questions

- What happens when you push or pull on an object?
- How can you make an object move faster or in a different direction?

Performance Expectations

Students who demonstrate understanding can do the following:

K-PS2-1. Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. [Clarification Statement: Examples of pushes or pulls could include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball, and two objects colliding and pushing on each other.] [*Assessment Boundary: Assessment is limited to different relative strengths or different directions, but not both at the same time. Assessment does not include non-contact pushes or pulls such as those produced by magnets.*]

K-PS2-2. Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.* [Clarification Statement: Examples of problems requiring a solution could include having a marble or other object move a certain distance, follow a particular path, and knock down other objects. Examples of solutions could include tools such as a ramp to increase the speed of the object and a structure that would cause an object such as a marble or ball to turn.] [*Assessment Boundary: Assessment does not include friction as a mechanism for change in speed.*]

K–2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a practice or disciplinary core idea.

The bundle of performance expectations above focuses on the following elements from the NRC document *A Framework for K–12 Science Education*:

Highlighted Science and Engineering Practices	Highlighted Disciplinary Core Ideas	Highlighted Crosscutting Concepts
[SEP-1] Asking Questions and Defining Problems [SEP-3] Planning and Carrying Out Investigations [SEP-4] Analyzing and Interpreting Data	PS2.A: Forces and Motion PS2.B: Types of Interactions PS3.C: Relationship Between Energy and Forces ETS1.A: Defining Engineering Problems	[CCC-2] Cause and Effect: Mechanism and Explanation [CCC-7] Stability and Change

CA CCSS Math Connections: MP.2; K.CC.4–6; K.MD.1-2; K.G.1, 4–6

CA CCSS for ELA/Literacy Connections: L.K.5b–c; L.1e–f; RL.K.10a–b; RI.K.1–10

CA ELD Standards Connections: ELD.PI.K.A1, PI.K.A3, PI.K.B5

Learning and playing are closely related for young children. When given materials and freedom, they **investigate [SEP-3]**, **ask questions [SEP-1]**, and **solve problems [SEP-6]**. Instructional segment 1 begins with students exploring the laws of motion using marbles on a ramp or toy cars on a track. Strips of molding from home improvement stores make low-cost marble ramps that can be supported by blocks or everyday objects around the classroom (University of Northern Iowa n.d.). Even though students individually direct their own investigation, the teacher constantly facilitates learning. Students **ask more questions [SEP-1]** and explore more boldly when their teacher demonstrates his or her own curiosity (Engel 2013). During one-on-one exchanges, teachers can remark, I wonder if the size of the marble matters… or What happens if you make your ramp with three blocks instead of two? Teachers can invite student **explanations [SEP-6]** (Why does the marble fall off the track there? What did you notice about the marble's speed?) or challenge students to try something else (Can you push the marble hard enough that it goes up to the top of the ramp? Can you make the marble turn a corner?). These exchanges help students develop mental **models [SEP-2]** of events that **cause [CCC-2]** motion to **change [CCC-7]**. Teachers also document the process through photographs and videos and use them during whole-class discussions to highlight specific learning opportunities. Because this activity resembles play, it does not need to be introduced as a separate learning activity and can be used throughout the school year (for rainy day recess, during unstructured play times, or during IS3 to develop language about how the wind pushes against things, etc.). There are strong connections to the CA CCSS in mathematics, including counting blocks (K.CC.4–5), describing the weight of marbles (K.MD.1), comparing them (K.MD.2), analyzing and constructing shapes (K.G.4–6), and describing relative position (K.G.1). The more time students spend, the richer their mental models of motion become.

How can we get an object to start moving? How do we stop it? What causes the motion to change? Students are now ready to describe the **cause and effect relationships [CCC-2]** more explicitly and to add words that label them. Objects don't move unless they interact with some other object that pushes or pulls them. Pushes or pulls can cause a change in motion, meaning an object speeds up, slows down, or changes direction. Students can actually feel these pushes during a class game of kickball (When you push the ball, what happens to it? Can you feel the ball pushing against your hands when you catch it?) and the pulls during a class tug-of-war (Can you feel how your body starts to move when the rope pulls it?). Every time an object changes motion, there must be a push or pull that is causing that change. Recognizing these pushes and pulls can be hard when students can't feel them directly. A push can occur during a collision, like a marble hitting the wall of the track and changing direction when moving from one ramp to the next at a 90-degree turn in the track. Sometimes an interaction is not visible, like the marble interacting with the Earth by the pull of gravity. Teachers can help make some of these pushes tangible by inviting students to gently touch the track and feel the vibrations of the collision when the marble makes its turn. A student can lie on the ground while a ball rolls towards the soles of their shoes—they feel a gentle push when the ball bounces off and changes directions just like the wall feels a push when the ball bounces off. Students continue to explore the motion of objects in the classroom, including toy cars and marbles, noting the pushes and pulls that change their motion (figure 3.3). These experiences help students refine their **mental models [SEP-2]** of motion, adding the concept that *every change in motion requires a push or pull to cause it*. They can apply that model and new language labels (*push* and *pull*) to **explain [SEP-6]** a novel situation (The bat pushes the baseball, so it changes direction). Students might also come up with **questions [SEP-1]** that teachers may or may not have considered before such as, Where is the push or pull that moves a car on the road? While it is understandable for teachers to feel a little intimidated by questions that they cannot answer, they can embrace these questions as markers of success and use them to highlight the nature of science and explicitly discuss how crosscutting concepts are tools for thinking about things. By focusing on **cause and effect [CCC-2]**, the student who asked about cars realizes that there must be a push or a pull somewhere but they cannot see it. Physicists use similar questions to discover new phenomena, and engineers use them to improve their designs.

Figure 3.3. Diagram Illustrating How Pushes Cause Changes in Motion

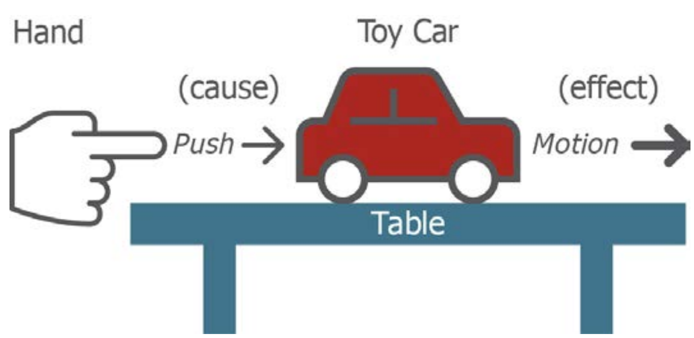


Diagram by M. d'Alessio

All the observable parts (hand, car, and table) are represented schematically and are labeled. The push is indicated with an arrow, and the movement of the block is indicated by a thicker arrow. Graphically distinguishing between the two arrows makes clear what is the cause (the push) and what is the effect (the movement). The diagram also shows that the direction of the movement is the same direction as the push.

Opportunities for Mathematics Connections

Students can keep track of the results of their motion experiments in a table format, serving as a prelude to picture graphs introduced in grade two. They can compare results using greater than/less than vocabulary, such as, "The ball went farther after it hit the cardboard tube than after it hit the bubble wrap." Students in kindergarten have not yet been introduced to standard measurement, such as using a ruler.

CA Math Standards: MP.2, K.CC.6, K.MD.1–2

Opportunities for ELA/ELD Connections

Teachers can supplement the discussion of motion and pushes and pulls using any book where motion is depicted. Looking at an illustration, students can describe the direction the object is moving, what push or pull caused it to start moving, and which direction that the push or pull was acting (CA CCSS for ELA/Literacy RL.K.10a–b). Informational texts can reinforce some of the DCIs encountered during instruction while the firsthand experiences provide context for mastering CA CCSS for ELA/Literacy on reading informational texts (RI.K.1–10). Example texts include *Move It!: Motion, Forces, and You (Primary Physical Science)* by Adrienne Mason; *Motion: Push and Pull, Fast and Slow (Amazing Science)* by Darlene Stille; and *Forces Make Things Move (Let's-Read-and-Find-Out Science 2)* by Kimberly Brubaker Bradley. Students can compare the explanations of similar topics from two of the texts (CA CCSS for ELA/Literacy RI.K.9).

CA CCSS for ELA/Literacy: RI.K.1, 2, 3, 9, 10a–b; SL.K.1, 2, 3; L.K.6
CA ELD Standards: ELD.PI.K.5

Kindergarten Snapshot 3.3: Classroom Talk about Pushes and Pulls

Since the beginning of the school year, Mr. H has worked each day to establish a safe and respectful environment for his students to discuss ideas throughout their learning and have productive conversations in which all students participate. Mr. H recognizes students need to feel safe to talk before their ideas are fully developed so that they can collaboratively work through problems with peers (ELD.PI.K.1) and so that he can redirect his teaching to meet their current thinking.

Mr. H introduced the norms for Classroom Talk at the beginning of the school year to promote respectful speaking (ELD.PI.K.3) and listening (ELD.PI.K.5), and he reinforces them every time he uses this technique. He established the following norms with the help of his students:

Classroom Talk Rules

- We can think and learn together by talking about our ideas.
- We talk to share ideas with others.
- We listen carefully to learn from others.
- We have to ask questions when we do not hear or understand somebody.
- We have to take turns so everybody gets a chance to talk.
- Each person's thinking is different and unique.

Mr. H designed a short unit using the 5E instructional model (See chapter 11 on instructional strategies) that introduces his students to the foundation of forces: the push and pull. Unlike many other snapshots in this framework that provide a glimpse at a single lesson, this snapshot provides a full sequence of lessons.

Everyday phenomenon: Students feel pushes and pulls.

He engaged them by drawing on their everyday life experiences with a Classroom Talk session. Mr. H started this Classroom Talk session by singing a Talk Song that invites children to the circle. Mr. H asked students, "Tell me about when you pushed or pulled something here at school." Mr. H wanted students to develop the language required for precisely describing actions of motion (CA CCSS for ELA/Literacy L.K.5b), and his question tied these language labels directly to student experiences (CA CCSS for ELA/Literacy L.K.5c). One student described pushing a friend on a swing. Others focused on activities in the school garden: pushing a cart full of compost, pulling a weed out of the ground, pushing a small shovel in the soil. Mr. H used some of the talk moves from chapter 11 of this framework ("Instructional Strategies"): "Cynthia, what about the push you described is similar to the pull Stephanie described? What's different?" "Tom, tell us more about how your body feels when you pull a really big weed." Mr. H also used the Classroom Talk to develop rich prepositional phrases such as "Maria pushes the cart slowly *around the garden*" (CA CCSS for ELA/Literacy K.L.1e). He discussed the meaning of this sentence and provided

Kindergarten Snapshot 3.3: Classroom Talk about Pushes and Pulls

opportunities for students to add prepositional sentences to the push-pull examples they shared already (CA CCSS for ELA/Literacy K.L.1f). Throughout the sequence, he highlighted these types of sentences in texts that the class read about pushes and pulls.

Investigative phenomenon: Objects can be both pushed and pulled, which causes them to change their motion.

Mr. H then provided several opportunities to *explore* pushing and pulling different objects through different hands-on **investigations [SEP-3]**. Using a sentence frame, students predicted a ball's pathway based on how they planned to push the ball: "I predict that when I push the ball ____, it will ____." They also pushed and pulled plastic crates filled with heavy blocks around the schoolyard.

During the *explain* stage of the 5E model, students had to be able to formulate their own **explanations [SEP-6]** of how pushes and pulls affected objects. Mr. H brought the class back together to another Classroom Talk circle. Mr. H asked students to agree or disagree with the statement, "The only way to get an object to move around a corner is to pull it." When students disagreed with the statement, he prompted them to provide evidence from their investigations. Maria stood up and used her body to show how she would push the object this way and then that. Mr. H introduced the necessary academic vocabulary of *direction* and *motion* and repeated her idea by saying, "When you change the direction you push, you can change the crate's motion." Kirk added, "And when you push harder, it goes faster." Mr. H then added the academic vocabulary of speed. After the Classroom Talk, students drew diagrams in their notebooks showing how they could move an object around a corner using a push and then a second diagram showing how they could use a pull (**pictorial models [SEP-2]**).

In the *elaborate* stage of the 5E model, students applied their ideas and academic vocabulary to new situations. Students labeled objects around the school according to how they applied pushes and pulls to them. The food tray in the school cafeteria could be pushed or pulled to move it to the end of the line, and the classroom door could be pulled or pushed to open or close it. Students made entries into their notebooks giving at least one example of an object and whether it would be pushed, pulled or both. Mr. H again provided a sentence frame for his students: "An example of an object that is (pushed, pulled, or pushed and pulled) is __________." Mr. H used these observations of constructed devices to motivate an engineering challenge in which students designed a replacement handle for a wagon with a handle that had broken off. (They built prototypes using string, toothpicks, and tape attached to toy cars.)

Mr. H then *evaluated* his students with a structured assessment in which students predicted the effects of different strengths and directions of pushes and pulls on different objects and explained the basis for their predictions.

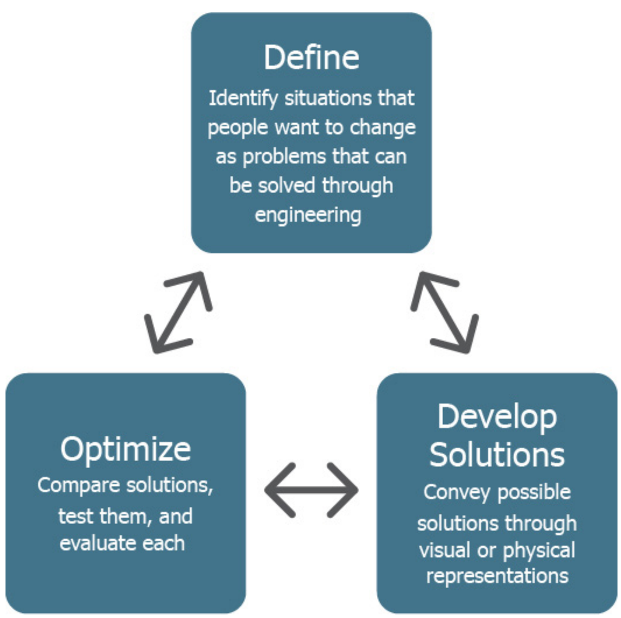
Students next refine their models to describe the strength and direction of pushes and pulls. To a physicist, pushes and pulls are the same thing—they both make objects change motion, and they differ only in their direction. Stronger pushes and pulls cause quicker changes in motion. The different effects of different pushes and pulls are well illustrated when students are given the challenge to move a heavy object with their own bodies (K-PS2-1, K-PS2-2). Students can move a heavy box of copy paper or a sturdy cardboard box with a child riding inside around an obstacle course on the schoolyard or around the classroom. To move the box around corners, they must push from a different side. To go faster, they must push harder. They can use a rope looped around the box to see that they can complete the course by either pushing or pulling. Students can decorate the cardboard boxes using a particular technique that ties to the art curriculum. They then perform similar investigations in other physical systems. For example, they can play air hockey (or make a homemade hockey table using cups to push a marble on a tabletop surrounded by hardcover books on all sides) or design a cardboard pinball machine (in which the speed and angle of the flappers makes the marble bounce off at different speeds and directions). Teachers can assess understanding by asking students to **explain [SEP-6]** why a certain motion caused a specific effect or **apply their models [SEP-2]** of motion to predict how a certain push or pull will affect an object.

Engineering Design Challenge: Save a Structure

Students design a way to change the direction or decrease the speed of a ball that is moving towards a structure made of blocks, thus saving the structure from being destroyed. Because students are natural engineers, they will approach the problem using their own implementation of the steps of the engineering design process. Rather than explicitly introducing the engineering design cycle, the teacher could let students complete the task first and then ask them guiding questions about how they solved the problem. Most students use an intuitive trial-and-error method and probably don't talk much about the first stage of the engineering process. The teacher can help students define the problem by asking, "Does it count if the marble causes the blocks to move but not fall over?" or, "What would you do differently if I took away some of the materials you used?" The teacher can then introduce a simplified graphic of the engineering design process and discuss some of the unknown vocabulary.

Figure 3.4 describes the engineering design process for K–2. In kindergarten, teachers guide students to look at situations or events that may be considered as problems. The focus of the engineering design process is not to transform activities into competitions to see which solution is best. Rather, the idea is to have students collaboratively generate multiple ideas, design solutions, and test those solutions to determine if they are appropriate for the goal. Throughout the process, the emphasis is on developing students' collaboration and communication skills.

Figure 3.4. Engineering Design Cycle for Kindergarten Through Grade Two

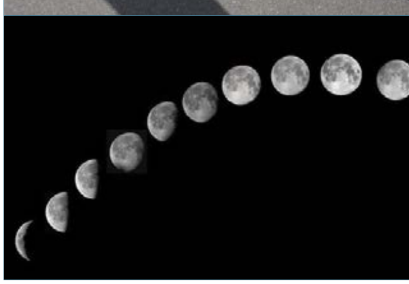


Source: NGSS Lead States 2013a
Long description of Figure 3.4.

Grade One

In grade one, students engage with plants, animals, light, and sound to recognize more **patterns [CCC-1]** in the world around them. All of the instructional segments in grade one set up future learning: What causes plants and animals to look different from one another but similar to their parents? How does light allow our eyes to see things? What causes the phases of the Moon and the seasons? None of these questions will be answered at this grade level, but the CA NGSS learning progression will revisit them repeatedly in later grades. The purpose of grade one is to give students a common background experience with these phenomena and have students observe them well enough to recognize **patterns [CCC-1]** that prompt them to start asking questions about **cause and effect [CCC-2]** relationships.

Table 3.3. Overview of Instructional Segments for Grade One

	**1 Plant Shapes** Students explore their natural surroundings with nature hunts and garden planting. They examine the shapes and parts of plants and begin to ask questions about what purpose these parts serve, how the shape of the parts helps them accomplish this purpose, and how the shapes of young plants are similar to the shapes of their parents.
	**2 Animal Sounds** Students observe the behavior of parents and babies, noticing patterns in how they communicate. They explore the nature of sound, notice the physical parts of animals that produce sounds, and construct physical models that mimic animal sounds.
	**3 Shadows and Light** Students plan and conduct investigations of how light travels and interacts with different objects. They use these observations as the foundation for constructing models of how people see.
	**4 Patterns of Motion of Objects in the Sky** Students track the motions of the Sun, Moon, and stars, noticing patterns in how sunlight varies throughout the seasons and Moon phases change over the month. They analyze their data to develop a model that predicts the position of objects.

Sources: Saber 2006; Wander 2007; Matthews 2009; Okada 2005

The sequence of instructional segments in this example (table 3.3) is driven by the need to collect data about slowly occurring natural processes: a garden that grows slowly (IS1) and changes in the sky (e.g., the time and location of sunset) over a large portion of the year (IS4).

IS1

Grade One Instructional Segment 1: Plant Shapes

In kindergarten, students recognized patterns in what plants need to survive (K LS1–1). In this instructional segment, they look more closely at the shapes and parts of plants and begin to ask questions about what purpose these parts serve, how the shape of the parts helps them accomplish this purpose, and how the shapes of young plants are similar to the shapes of their parents.

GRADE ONE INSTRUCTIONAL SEGMENT 1: PLANT SHAPES

Guiding Questions

- How can we tell different types of plants apart?
- How do these differences help the plants?

Performance Expectations

Students who demonstrate understanding can do the following:

1-LS1-1. Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.* [Clarification Statement: Examples of human problems that can be solved by mimicking plant or animal solutions could include designing clothing or equipment to protect bicyclists by mimicking turtle shells, acorn shells, and animal scales; stabilizing structures by mimicking animal tails and roots on plants; keeping out intruders by mimicking thorns on branches and animal quills; and, detecting intruders by mimicking eyes and ears.]orns on branches and animal quills; and, detecting intruders by mimicking eyes and ears.]

1-LS3-1. Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents. [Clarification Statement: Examples of patterns could include features plants or animals share. Examples of observations could include leaves from the same kind of plant are the same shape but can differ in size; and, a particular breed of dog looks like its parents but is not exactly the same.] [*Assessment Boundary: Assessment does not include inheritance or animals that undergo metamorphosis or hybrids.*]

K–2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

Performance expectation introduced, but not assessed until later segments:

1-ESS1-1. Use observations of the Sun, Moon, and stars to describe patterns that can be predicted. [Clarification Statement: Examples of patterns could include that the Sun and Moon appear to rise in one part of the sky, move across the sky, and set; and stars other than our Sun are visible at night but not during the day.] [*Assessment Boundary: Assessment of star patterns is limited to stars being seen at night and not during the day.*] (IS4)

GRADE ONE INSTRUCTIONAL SEGMENT 1: PLANT SHAPES

1-PS4-3. Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light. [Clarification Statement: Examples of materials could include those that are transparent (such as clear plastic), translucent (such as wax paper), opaque (such as cardboard), and reflective (such as a mirror).] [*Assessment Boundary: Assessment does not include the speed of light.*] (IS3)

The bundle of performance expectations above focuses on the following elements from the NRC document *A Framework for K–12 Science Education*:

Highlighted Science and Engineering Practices	Highlighted Disciplinary Core Ideas	Highlighted Crosscutting Concepts
[SEP-1] Asking Questions and Defining Problems [SEP-2] Developing and Using Models [SEP-3] Planning and Carrying Out Investigations [SEP-4] Analyzing and Interpreting Data [SEP-6] Constructing Explanations (for science) and Designing Solutions (for engineering)	LS1.A: Structure and Function LS3.A: Inheritance of Traits LS3.B: Variation of Traits ESS1.A: The Universe and its Stars PS4.B: Electromagnetic Radiation ETS1.B: Developing Possible Solutions	[CCC-1] Patterns [CCC-6] Structure and Function

Highlighted California Environmental Principles and Concepts:

Principle I The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services.

Principle III Natural systems proceed through cycles that humans depend upon, benefit from and can alter.

Principle IV The exchange of matter between natural systems and human societies affects the long-term functioning of both.

CA CCSS Math Connections: 1.MD.2

CA CCSS for ELA/Literacy Connections: W.1.1, 8; SL.1.4

CA ELD Standards Connections: ELD.PII.1.6

Before embarking on any of the scientific practices, students need to appreciate science as the study of the world around them. Children are natural scientists and are innately curious. This instructional segment focuses that desire for exploration on plants. Different students have different levels of experience observing plants in nature. Some schools are situated in urban settings where plants are rare while other families might have backyard vegetable gardens. To give all students a common library of observations, students embark on a schoolyard nature hunt with the instructions to collect as many natural objects as they can. They can pull weeds growing in sidewalk cracks, pluck blades of grass, collect fallen leaves, and gather a handful of sand from the sandbox. Back in the classroom, they look for **patterns [CCC-1]**. Can they sort the objects into different categories based on these patterns (such as plants, rocks, and animals)? Which objects might come from plants? How can they tell? Since different schoolyards have different natural elements, the hunt could be extended as a homework assignment to collect natural objects from around the neighborhood, or a teacher may need to accumulate a small collection to share with the students. Students might discover different seedpods or a range of leaves (figure 3.5). Students write an observation about what they see (given a sentence frame, if necessary) and **ask a question [SEP-1]** related to their observation (e.g., What causes those leaves to be red? What is inside an acorn? Why is some bark smooth and other bark rough? Why do different plants have different shape leaves?) At this stage, the focus is on stimulating curiosity and asking questions, so teachers do not need to know all the answers. Many of the questions will remain unanswered until much later in students' careers, which reflects the practice of professional scientists who often have questions that they do not have enough information to answer. Teachers can maintain a nature table with a rotating collection of found objects throughout the year. They can refer to objects on the table when related concepts come up later in the year, or they can photograph them for future reference. The goal of these activities is to focus student attention on natural phenomena around them.

Figure 3.5. Diverse Seeds and Leaves Collected by Students at a School with a Garden

Sources: Descouens 2012; M. d'Alessio; Mdf 2006; Ross 2007

Opportunities for Mathematics Connections

Students could be challenged to create a model of a seed that depends on wind to disperse it (for example a dandelion seed). On a breezy day, the seed models could be flown to determine which models go the farthest. Students measure how far the model flew in standard or nonstandard units. Questions that could be asked include the following: Which model flew the farthest? What about its design allowed it to fly farther? Students could also be asked to put the models in order of how far they flew.

CA CCSSM: 1.MD.2

Students next focus on observing specific structures within plants. The best way to do this is to grow plants in small pots or planter boxes outside the classroom, or, alternatively, mini or herb gardens in plastic containers grown inside. Growing food can introduce healthy eating habits (CA Health Education Standards K1.1.N) and ways that humans depend on things that grow for our own survival (EP&C I). A variety of vegetables, including leafy greens (lettuce), root vegetables (radishes), and climbing vines (snap peas) grow well in autumn gardens in California. These plants have very different shapes (both above and below ground) when they are fully grown. Students **conduct an investigation [SEP-3]** tracking how the plants change over time. Does a tiny baby lettuce look like lettuce they buy in the store? If they pick a radish when it is young, how is it similar to one picked later? Students should be able to **provide evidence to support the argument [SEP-7]** that young plants are similar to their parents (1-LS3-1). This argument forms the foundation for the concept of inheritance that students will investigate during grade three.

Engineering Connection: Using Bio-Mimicking to Solve a Problem

Nature gives humans ideas that can be used as design examples for objects that solve a problem (bio-mimicking). Students should be able to use plant structures to **design [SEP-6]** something that solves a problem they have at school. For example, students design a coat rack that has enough hooks to hold their jackets. How thick should the base be? How should it connect to the ground in order to be stable? Students can look at trees to help decide. Perhaps they want to send a message across the schoolyard. Students could design a message carrier based on the shape of seeds that disperse in the wind. Or perhaps they want to construct a new rope ladder for their playground structure. How will they attach it? They can look to the tendrils of a snap pea. Students should be able to describe how the **structure of their object helps achieve its function [CCC-6]**, possibly illustrating it with a simple sketch or diagram showing their invention and the plant structure that inspired it (K–2 ETS1–2).

Sample Integration of Science and ELD Standards in the Classroom

Students use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs (1-LS1-1). As they investigate mimicking solutions for clothing or equipment inspired by nature, the teacher guides them to combine clauses, through a process of examining a text for the ways an author combines ideas and then trying it out together using joint construction. The result is sentences such as the following: (1) a turtle hides under its shell *when* threatened by a predator; (2) *although* the turtle may be turned upside down, the shell provides protection; and (3) biking helmets protect us *because* we design them to resemble turtle shells. Prior to this lesson, during designated ELD time, students at the Emerging and early Expanding levels of English proficiency have practiced combining similar sentences in more simple ways: A shell protects a turtle. A helmet protects a person riding a bike. A shell protects a turtle, and a helmet protects a person riding a bike. The teacher supports students' understanding through using pictures, highlighting cognates (e.g., *protect/proteger*), and allowing students to use their home language in partner discussions.

CA ELD Standards: ELD.PII.1.6
Source: Lagunoff et al. 2015, 240–241

Students know from kindergarten that plants need light to survive (K-LS1-1), so what happens when taller plants begin to shade shorter plants? Teachers can introduce the concept that thin leaves are translucent and allow some light to pass through them so that plants below them can still survive while thicker leaves are more opaque and block more light. This observation is one form of an **investigation [SEP 3]** into the how light interacts with different materials (1-PS4-3; though students are not ready to be assessed on this performance expectation until they complete a more detailed investigation in IS3). Many people associate science practice with *experiments*, but CA NGSS uses the term *investigation* because students do not necessarily have to manipulate things in order to gather evidence. Students make observations at different times of day to determine when specific plants are in the shadow of another plant. Repeating the observation over several days allows students to recognize that the Sun moves following a predictable pattern and has natural cycles (EP&C III). In fact, by **analyzing [SEP-4]** a few days of observations about the exact time when a plant starts being shaded, students should be able to predict when it will be shaded on a subsequent day (1-ESS1-1). Students can also begin observing the amount of daylight during the autumn that they can later compare to winter and spring (1 ESS1 2).

IS2

Grade One Instructional Segment 2: Animal Sounds

Just like baby plants, baby animals often resemble their parents. They usually have the same external structures as their parents (baby fish have fins and gills, baby crayfish have claws, etc.), but both parent and child also have certain behaviors that help the children survive. For example, babies of many animal types cry when they are hungry. Students investigate the structural similarities, the behaviors, and some of the physics behind animal noises such as crying.

GRADE ONE INSTRUCTIONAL SEGMENT 2: ANIMAL SOUNDS

Guiding Questions

- How are parents and their children similar and different?
- How do animal parents and children interact to meet their needs?
- How do animals communicate and make sound?

Performance Expectations

Students who demonstrate understanding can do the following:

1-LS1-2. Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive. [Clarification Statement: Examples of patterns of behaviors could include the signals that offspring make (such as crying, cheeping, and other vocalizations) and the responses of the parents (such as feeding, comforting, and protecting the offspring).]

1-LS3-1. Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents. [Clarification Statement: Examples of patterns could include features plants or animals share. Examples of observations could include leaves from the same kind of plant are the same shape but can differ in size; and, a particular breed of dog looks like its parents but is not exactly the same.] [*Assessment Boundary: Assessment does not include inheritance or animals that undergo metamorphosis or hybrids.*] (Revisited from IS1)

1-PS4-1. Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate. [Clarification Statement: Examples of vibrating materials that make sound could include tuning forks and plucking a stretched string. Examples of how sound can make matter vibrate could include holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork.]

1-PS4-4. Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.* [Clarification Statement: Examples of devices could include a light source to send signals, paper cup and string "telephones," and a pattern of drum beats.] [*Assessment Boundary: Assessment does not include technological details for how communication devices work.*]

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a practice or disciplinary core idea.

GRADE ONE INSTRUCTIONAL SEGMENT 2: ANIMAL SOUNDS		
The bundle of performance expectations above focuses on the following elements from the NRC document *A Framework for K–12 Science Education*:		
Highlighted Science and Engineering Practices	**Highlighted Disciplinary Core Ideas**	**Highlighted Crosscutting Concepts**
[SEP-3] Planning and Carrying Out Investigations [SEP-6] Constructing Explanations (for science) and Designing Solutions (for engineering) [SEP-8] Obtaining, Evaluating, and Communicating Information	LS1.B: Growth and Development of Organisms LS3.A: Inheritance of Traits LS3.B: Variation of Traits PS4.A: Wave Properties PS4.C: Information Technologies and Instrumentation	[CCC-1] Patterns [CCC-2] Cause and Effect: Mechanism and Explanation
CA CCSS Math Connections: MP.5; 1.MD.1–2		
CA CCSS for ELA/Literacy Connections: RI.1.1, 3, 7, 9, 10; W.1.2, 8; SL.1.1, 2, 4, 5		
CA ELD Standards Connections: ELD.PII.1.1, 5, 6		

To lay the foundation for later grades, this instructional segment introduces students to the **mental model [SEP-2]** of a family or herd as a **system [CCC-4]** of organisms within which parents behave in ways that support the survival of their offspring. Teachers should probably not introduce this language explicitly to students in grade one; students should just recognize **patterns [CCC-1]** in physical appearance that are similar between offspring and their biological parents, and patterns in behavior of adults (feeding, protecting, teaching, or playing with their children) and children (crying, observing their parents).

Teachers begin by finding local opportunities for observing animals and their offspring such as a classroom aquarium or terrarium, a field trip to a farm, duck pond, or zoo, or a webcam or video clips if physical observations are not possible. Students **communicate [SEP-8]** their observations about animal appearance and behavior to their classmates through science notebook entries or oral presentations. Teachers reinforce the notion of families through picture books and activities related to students' own families.

Opportunities for ELA/ELD Connections

To introduce the concept that young animals look like their parents, divide the class into two groups—the children and the parents. Use sets of picture cards that show an animal in the beginning of its lifespan and a matching card of the same animal in adult stage. Students need to find their matching partner by asking questions (not by showing the picture on the card), such as, my animal has fur. Does your picture have fur? If no, they can find another student to ask the question. If yes, then another categorizing question can be asked. One way to organize the students is to have inside/outside circles, with the students with parent cards on the inside and students with the children cards on the outside. Before beginning, students can brainstorm and discuss possible questions to ask each partner. Once the two pictures are paired together, students can then discuss how the parent and the children are similar and how they are different, **explaining [SEP-6]** their conclusions using sentence frames or in graphic organizers (1-LS3-1).

CA CCSS for ELA/Literacy Standards: SL.1.1, 4, 5
CA ELD Standards: ELD.PI.1.1, 6

Sample Integration of Science and ELD Standards in the Classroom

Students have been exploring how structures of plants and animals are similar between parents and young (offspring), and the teacher invites the children to explore the patterns in the behavior of parents and offspring that help offspring survive (1 LS1-2) by reading texts and using media, modeling the use of adverbials: *When animals are young*, they signal their needs to their parents by calling *loudly* or *softly*, depending on how many babies there are, and the distance from their parent. *Some* animals cry, others chirp, and others make *all sorts* of sounds. *Usually* the parents feed and comfort their young. The teacher supports the students' use of adverbials in their own speaking and writing by prompting them to add information about *when*, *how*, *where*, *why*, *how much*, etc.

CA ELD Standards: ELD.PII.1.5
Source: Lagunoff et al. 2015, 238–239

As students notice the strong resemblance of parents and offspring, they can be prompted to ask questions about why certain types of animals have certain structures. The goal here is to further develop the crosscutting concept of **structure and function [CCC-6]**. For example, by studying crayfish in a classroom aquarium students can make claims supported by evidence demonstrating that different body parts of the crayfish serve different purposes for the survival of the animal. Students can also obtain evidence from texts, videos, and online resources. They can record what they learn in drawings in which body parts are labeled and their function is identified. With teacher support, they can also create tables of information (table 3.4).

Table 3.4. Crayfish: How is the Structure of a Body Part Related to its Function?

STRUCTURE OR BEHAVIOR	FUNCTION
Mouth that opens, claws to grab	Get food
Lots of legs, body	Move
Claws	Protect/defend, dig in ground, grab/hold food
Eyes, antenna	Sensing the environment
Gills, skin	Breathe

Source: Gomez-Zwiep and Polcyn 2015

The idea that many tasks require an animal to apply a force to move or break open an object is connected to ideas they developed in kindergarten about forces. Learning about the structure and function of body parts engages students in performing simple research using books and other content-rich materials to **obtain information, evaluate if it is relevant to answer classroom questions, and communicate to each other [SEP-8]**.

Opportunities for ELA/ELD Connections

Read literature books such as *What If You Had Animal Teeth?* and *What If You Had Animal Hair?* by Sandra Markle and Howard McWilliam and *What Do You Do With a Mouth Like This?* and *What Do You Do With a Tail Like This?* by Steve Jenkins and Robin Page. Discuss and record how the different external parts and features of the animals aid in their survival and growth. Students could select one or more different parts of an animal(s) and create (or draw) a new animal. Each student should be able to explain the importance of each feature, with extra support if necessary.

CA CCSS for ELA/Literacy Standards: RI.1.1, 3, 7, 9, 10; W.1.2, 8; SL.1.2, 4, 5

CA ELD Standards: ELD.PI.1.1, 6

One common behavior of young animals is that they cry out when they need food or are in danger. How exactly do animals cry or make other sounds? Students investigate the nature of sound and perform an engineering task to create a physical model of how animals communicate (see “Sounds Wild” snapshot 3.4). The key disciplinary core idea is that sound makes vibrations and vibrations make sound. Students can generate sounds using a rubber band stretched around the opening of a paper cup. Teachers can ask students to describe the motion of the rubber band (back and forth) and then introduce the term *vibrate* to describe what they see. They can feel the vibrations in their own throats as they talk or sing. They can further visualize the motion of an object that makes sound by gently dipping a vibrating tuning fork in a cup of water or by placing it adjacent to a lightweight ping pong ball and watching the ball move.

Grade One Snapshot 3.4: "Sounds Wild" Engineering Challenge

Mr. K, a grade one teacher, has created an interdisciplinary instructional segment called "Sounds Wild" to demonstrate to his students how animals use special parts of their bodies to make sounds. Mr. K helped his students connect what they learned about the **function [CCC-6]** of different animal body parts to how animals make sounds.

Anchoring phenomenon: Crickets make sounds with their bodies.

He engaged the students by reading two stories about crickets and the sounds they make: *I Wish I Were A Butterfly* by James Howe and *The Very Quiet Cricket* by Eric Carle. He brought in some live crickets for students to observe and students watched a video for a closer look at how crickets behave and how their body parts function. Students drew diagrams of a cricket and labeled its body parts, paying particular attention to the wings as the source of the cricket's sound (K–2-ETS1-2).

Investigative phenomenon: When objects rub together, they make sounds.

The students used construction paper to develop a large-scale **model [SEP-2]** of a cricket and added a strip of sandpaper to the edge of a wing to simulate the chirping effect (1-PS4-1). During a music lesson, students continued exploring how sound was generated by playing scrapers, simple musical instruments that mimic the way crickets make sounds.

Everyday phenomenon: Different animals make sounds.

Mr. K presented a combination of stories, informational texts, and videos as resources for students to use as they studied the rattle of rattlesnakes, the howling of coyotes, and screech of bats. The students learned about the specific external part of the body in the

Grade One Snapshot 3.4: “Sounds Wild” Engineering Challenge

animal that vibrated to produce sound and could locate the sound-producing body part on pictures of the animal.

Investigative phenomenon: How do we create a device that simulates a baby animal crying out loud enough to communicate with its parents?

Mr. K connected music to science with an engineering design challenge: students were to design and build their own sound device emulating a baby animal. Mr. K asked students to close their eyes and makes a very quiet chirp. Would that be loud enough? Students **define their challenge [SEP-1]** by agreeing about a few guidelines: (1) instruments must be loud enough so that an imaginary parent animal on the opposite side of the playground could hear the device cry out for help, and (2) students must be able to communicate the difference between a cry of hunger and a cry of being in danger. Would they use a different pitch for each need? Or a different number of drum beats? Students needed to **develop a solution [SEP-6]** to both create the sound and use it to communicate over a long distance (1-PS4-4). The shakers, scrapers, and string instruments they created demonstrate the students’ understanding of the processes animals use to create sound and that vibrations cause sound.

Opportunities for Mathematics Connections

When students design and test their animal sound devices (or even simple paper cup and string communicators), they can measure distances on the schoolyard. Students in grade one do not use standard units of measure, but they understand the concept of reiterated units to measure length. For example, students could choose among a paper clip, a craft stick, or a yardstick as a unit of measure.

CA CCSSM: MP.5; 1.MD.1–2

IS3 Grade One Instructional Segment 3: Shadows and Light

By conducting hands-on investigations, students will build the foundation of a **model [SEP-2]** of how people see. In grade one, this model only includes the fact that light is necessary for vision and that light interacts with different objects in different ways. Since shadows are one piece of evidence of that interaction, this segment flows into IS4 during which students will notice patterns in the shadows cast by the light of the Sun.

GRADE ONE INSTRUCTIONAL SEGMENT 3: SHADOWS AND LIGHT

Guiding Questions

- What causes shadows?
- What happens when there is no light?

Performance Expectations

Students who demonstrate understanding can do the following:

1-PS4-2. Make observations to construct an evidence-based account that objects can be seen only when illuminated. [Clarification Statement: Examples of observations could include those made in a completely dark room, a pinhole box, and a video of a cave explorer with a flashlight. Illumination could be from an external light source or by an object giving off its own light.]

1-PS4-3. Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light. [Clarification Statement: Examples of materials could include those that are transparent (such as clear plastic), translucent (such as wax paper), opaque (such as cardboard), and reflective (such as a mirror).] [*Assessment Boundary: Assessment does not include the speed of light.*]

The bundle of performance expectations above focuses on the following elements from the NRC document *A Framework for K–12 Science Education*:

Highlighted Science and Engineering Practices	Highlighted Disciplinary Core Ideas	Highlighted Crosscutting Concepts
[SEP-3] Planning and Carrying Out Investigations [SEP-6] Constructing Explanations (for science) and Designing Solutions (for engineering)	PS4.B: Electromagnetic Radiation	[CCC-2] Cause and Effect: Mechanism and Explanation [CCC-4] Systems and system models

Highlighted California Environmental Principles and Concepts:

Principle III Natural systems proceed through cycles that humans depend upon, benefit from and can alter.

CA CCSS Math Connections: MP.5; 1.MD.1–2

CA CCSS for ELA/Literacy Connections: 1.W.3

CA ELD Standards Connections: ELD.PI.1.9, 10, 12; ELD.PII.1.5

Opportunities for ELA/ELD Connections

To transition into this instructional segment and give students direct experience with shadows, students write a story about a sequence of events that happens to a baby animal from the previous instructional segment and then act it out as shadow puppets by placing their hands in front of the light on a projector screen and describing the sequence using words.

CA CCSS for ELA/Literacy Standards: 1.W.3

CA ELD Standards: ELD.PI.1.9, 10, 12; ELD.PII.1.5

Recognizing the value of play and motor development in solidifying learning for early elementary children, teachers can introduce concepts of light and shadows through a game of shadow tag on the schoolyard. Selecting a particularly sunny day shortly before beginning the instructional segment, students play tag, but with the twist that they never actually touch—one shadow needs to tag another person's shadow. No matter which direction the children run or turn, students notice the **pattern [CCC-1]** that their shadow always points the same direction on the schoolyard during the short game (such as toward the soccer goal). Teachers can highlight that it always points directly away from the Sun. By playing the game at a different time of day, students see that all their shadows point to a different landmark on the schoolyard (such as toward the library). Students can **construct an argument [SEP-7]** that their shadows are a marker that allows them to track the moving position of the Sun throughout the day or year; they will use this argument in IS4. But what causes a shadow?

The shadow tag game also helps students begin to **develop a model [SEP-2]** that light travels in a direction (such as from the Sun toward them in the shadow tag game). Students do not generally think about light as something that moves from place to place, but rather as something that fills a space and is either off or on. In this instructional segment, they will collect evidence that supports the idea that light travels from a source to an object and is either absorbed by or bounces off the object. Students learn that they see the object because light bounces off of it and reaches their eyes. This understanding requires conceptual development through step-by-step **investigation [SEP-3]** of different scenarios (1-PS4-3).

Many light sources emit light in all directions. This is an important idea for explaining how the whole room seems to be full of light. However, it is useful to start with light sources that emit a narrow a beam, such as a laser pointer or a flashlight with a narrow beam, to **refine the model [SEP-2]** that light travels in a direction. In a darkened classroom, students look around and observe things are dim and harder to see. They are able to see things clearly when they shine a narrow light on them, but not as clearly without that light. The teacher shows video clips of explorers in caves where it is much darker. Cave explorers are only able to see things where they shine their flashlight. Students use this **evidence to support the argument [SEP-7]** that objects can only be seen when they are illuminated (1-PS4-2), an example of **cause and effect relationship [CCC-2]**. Students can construct a class cave for students to explore, covering desks with heavy blankets so that students can gather more evidence that they can only see when light is present.

Students then **plan an investigation [SEP-3]** to compare the effect of placing different types of objects in the path of the light (1-PS4-3), much like they placed their bodies in the path of the Sun to make shadows. The collection of objects should include opaque (cardboard), transparent (glass or clear plastic), translucent (plain white paper, black construction paper, wax paper, young plant leaves, their own hands), and reflective materials (a mirror, foil, or Mylar—the shiny plastic of some birthday balloons), though the teacher should not introduce these distinctions prior to the investigation. It will be the job of students to identify these differences. Students will need to decide how they can describe the differences between the various materials. What will they have to notice and record about each material? By using a mirror and a sheet of glass as examples, teachers can guide students to a plan to observe the amount of light traveling through to the other side, the amount of light that goes back toward the light source, and the light that seems to cause the object itself to glow. These observations are data, which provide the opportunity for age-appropriate **analysis of the data [SEP-4]**, using comparisons such as the following: (1) the amount of light that goes through this object is more than the light that reflects back, or (2) more light shines through the white paper than the black paper. Students can group the materials into categories based on **patterns [CCC-1]** about the amount of light that travels through them. Only after students have constructed these categories based on their own experience should teachers introduce labels such as *opaque* and *transparent* to help develop children's academic vocabulary. Like many categories in science, these categories are not rigid and absolute; glass reflects some light, allows other light to travel through, and absorbs a small amount of light (which is why it heats up in the sun). So, is glass transparent, reflective, or translucent? During this investigation, students constructed a simple **model [SEP-2]** that tracks the path of light from one place to another. They will build on this model in grade four (4-PS4-2). Students revisit the focus question for this instructional segment and **construct an explanation [SEP-6]** about how different materials block light and therefore **cause [CCC-2]** shadows.

IS4

Grade One Instructional Segment 4: Patterns of Motion of Objects in the Sky

Students will make observations of the Sun, Moon, and stars and develop ways to record, describe, and organize their patterns of motion. At this stage of their learning, it is more important for students to use their own observations to recognize predictable **patterns [CCC-1]** of **change [CCC-7]** than to learn through lecture or texts. Note that the crosscutting concept of cause and effect is not highlighted in this segment because the cause of these patterns is not addressed until later grades.

GRADE ONE INSTRUCTIONAL SEGMENT 4: PATTERNS OF MOTION OF OBJECTS IN THE SKY

Guiding Questions

- What objects are in the sky and how do they seem to move?
- When will the Sun set tomorrow?
- How does the Moon's appearance change over each month?

Performance Expectations

Students who demonstrate understanding can do the following:

1-ESS1-1. Use observations of the Sun, Moon, and stars to describe patterns that can be predicted. [Clarification Statement: Examples of patterns could include that the Sun and Moon appear to rise in one part of the sky, move across the sky, and set; and stars other than our Sun are visible at night but not during the day.] [*Assessment Boundary: Assessment of star patterns is limited to stars being seen at night and not during the day.*]

1-ESS1-2. Make observations at different times of year to relate the amount of daylight to the time of year. [Clarification Statement: Emphasis is on relative comparisons of the amount of daylight in the winter to the amount in the spring or fall.] [*Assessment Boundary: Assessment is limited to relative amounts of daylight, not quantifying the hours or time of daylight.*]

The bundle of performance expectations above focuses on the following elements from the NRC document *A Framework for K–12 Science Education*:

Highlighted Science and Engineering Practices	Highlighted Disciplinary Core Ideas	Highlighted Crosscutting Concepts
[SEP-3] Planning and Carrying Out Investigations [SEP-4] Analyzing and Interpreting Data	ESS1.A: The Universe and its Stars ESS1.B: Earth and the Solar System	[CCC-1] Patterns

Highlighted California Environmental Principles and Concepts:

Principle III Natural systems proceed through cycles that humans depend upon, benefit from and can alter.

GRADE ONE INSTRUCTIONAL SEGMENT 4: PATTERNS OF MOTION OF OBJECTS IN THE SKY

CA CCSS Math Connections: 1.MD.3

CA CCSS for ELA/Literacy Connections: RI.1.2, 4, 7, 10.a; L.1.4, 6; W.1,2

CA ELD Standards Connections: ELD.PI.2.5, 6, 7

Students build on what they learned about how light travels in IS3 to **develop models [SEP-2]** they can use to predict motions of the Sun, Moon, or stars. Students will need to have recorded data about the amount of daylight throughout fall, winter, and spring so they can draw comparisons between observations at different times of the year. Data on sunrise and sunset times and the locations of planets and stars can be found in a number of sources, including local newspapers and online resources.

Students' observations of the time of sunrise or sunset over multiple days across the year are analyzed using the same point of reference to develop a model for the pattern of change students observe. Students use this pattern to predict whether the time of sunset or sunrise will be later or earlier than the previous day for the next few days. They can **communicate [SEP-8]** their prediction using a graph of times of sunset for several days or a clock face marked with sunset times for successive days, an example of a pictorial **model [SEP-2]**. Other students should be able to use their pictorial model to predict the time that the Sun rises, but first-grade students are not expected to develop a conceptual model that can explain or justify what causes these differences. Other visual representations could also be used, such as pictures of the same landscape or outdoor feature that have been taken at the same time of the day but during different times of the year. Class discussions and reading should include children's stories from their own experiences and literature that emphasize how the length of day is different at different times of the year.

GRADE ONE VIGNETTE 3.2: PATTERNS OF MOTION OF THE SUN

Performance Expectations

Students who demonstrate understanding can do the following:

1-ESS1-1. Use observations of the Sun, Moon, and stars to describe patterns that can be predicted.

Highlighted Science and Engineering Practices	Highlighted Disciplinary Core Ideas	Highlighted Crosscutting Concepts
[SEP-4] Analyzing and Interpreting Data	ESS1.A: The Universe and Its Stars PS4.B Electromagnetic Radiation	[CCC-1] Patterns [CCC-2] Cause and Effect [CCC-4] Systems and System Models

Highlighted California Environmental Principles and Concepts:
Principle III Natural systems proceed through cycles that humans depend upon, benefit from and can alter.

CA CCSS Math Connections: 1.MD.3

CA CCSS for ELA/Literacy Connections: W.1.2

CA ELD Standards Connections: ELD.PI.1.10

Introduction

Mrs. H is planning an instructional segment in which students observe the patterns of motion of objects in the sky, specifically the Sun. She wants her students to observe and then describe the movement of the Sun in the sky throughout a school day. The observation of these regular patterns of movement across multiple days will provide students a foundational understanding of disciplinary core idea ESS1.A: The Universe and Its Stars. This instructional segment also allows a strong connection between the CCC of **patterns [CCC-1]** and the SEP of **analyzing and interpreting data [SEP-4]**. She considers this instructional segment to be a natural link to what the students have learned in mathematics about time, and she plans to include concepts related to time measurement to integrate mathematical concepts.

Day 1: Shadows

Anchoring phenomenon: Shadows come in different shapes and sizes.

Mrs. H began her instructional segment on Groundhog Day (traditionally celebrated on February 2). As the school day began, she took students outside and asked them to find as many shadows as they could, and to explore them. How many could they find? What was making each shadow? What made the biggest and smallest shadows? What discoveries did they make as they explored? What questions did they have about shadows? They returned inside and she read a story about the groundhog and its shadow to engage the students. She told them that they would be observing their shadows over the next few days.

GRADE ONE VIGNETTE 3.2: PATTERNS OF MOTION OF THE SUN

Investigative phenomenon: Shadows change direction and length during the day.

Immediately after reading the story, Mrs. H took the students back outside to a paved section of the school grounds. The students would return to this location to observe and measure their shadows during the week. The students worked with partners to trace their shadows. One student drew two chalk Xs to mark the position of the feet where her partner was standing while the other traced the shadow on the pavement. Then they traded roles and traced the second student's shadow. They were amazed at the length of their shadows! Just before lunch they returned to their traced shadows, placed their feet on the Xs, and traced the new positions of their shadows in a different color. They're so short! Mrs. H asked the students to predict where and how long their shadows would be in a few hours. At the end of the school day, the students returned one more time to trace the new position of their shadows. Before they left school for the day, the students compared their predictions with the actual positions and lengths of their shadows.

Days 2–3: Observations and Patterns

Investigative phenomenon: Shadows follow a similar pattern each day over the course of a week.

The students observed the position of their shadows and measured the length of the shadows from the position of their feet to the head of the shadow at the same three times each day for three days during the week. With assistance from Mrs. H, the students recorded the lengths and positions on charts she had prepared for them. The chart had places for students to write the date, the time, and the length of their shadow and to draw a picture of the position of the shadow. By recording the time of their observations, students practiced telling and writing time by the hour and half hour, a connection to mathematics (CA CCSSM 1.MD.3).

Mrs. H could have also worked with the expanded learning program at the school so that some students measured shadows during the late afternoon to provide the whole class with more opportunities to identify **patterns [CCC-1]** based on additional observations and recorded information.

When the students **analyzed the data [SEP-4]** in their charts, they could see that there was a pattern between the length of the shadow and the time of day, and that the pattern repeated each day that week. Mrs. H had them create a table that summarized their findings:

	Morning	Lunch	Afternoon
Shadow direction	west	north	east
Shadow length	long	short	long
Shadow darkness	dark	dark	dark

GRADE ONE VIGNETTE 3.2: PATTERNS OF MOTION OF THE SUN

The students noticed the differences among the ways these three features changed. The darkness of the shadow did not change at all, the shadow direction moved in one direction (a trend) and the length went up but then came back down (a pattern).

Day 4–5: Creating and communicating models

Investigative phenomenon: The arrangement of objects and light sources in the classroom affects the length and direction of shadows.

Mrs. H wanted students to **create a model [SEP-2]** of a **system [CCC-4]** that made a similar pattern. She asked them what objects they would need to create a shadow (What components does the system need?). She gave the students a light source and an object to block the light and told them, "I want you to perform an 'exploriment' with these materials, moving them around so that you can see what causes the shadows to change. In five minutes, your goal is to be ready to describe the changes you can make to the shadow using the sentence *When I ______, it causes* ________." Mrs. H circulated around the classroom trying to harness the students' playful energy. She encouraged them to try to shine the light at the object from crazy places like right up above it (Where did its shadow go?) and from across the room (It doesn't work). At the end of the time, she asked students to **communicate [SEP-8]** one finding to the class. She asked the rest of the students to identify and separate the **cause and the effect [CCC-2]** in each student's contribution.

Mrs. H then gave students the challenge to move their light so that it reproduced the trend in shadow direction, the pattern in shadow length, and the lack of change in shadow darkness. Would they start with the flashlight close to the object in the morning and move steadily away? No! She circulated helping students reflect on whether or not their model accurately reproduced all three features they had recorded on the data table. Students then converted their physical model to a **pictorial model [SEP-2]** by drawing a diagram that they could share with others.

Vignette Debrief

This vignette is anchored in a phenomenon that students experience every day, the rising and setting of the Sun. Rather than observing the Sun directly, they observe shadows and then relate the shadows to the apparent motion of the Sun across the sky using a classroom model.

SEPs. Students **conduct an investigation [SEP-3]** but play only a minimal role in the planning at this stage. On days 4–5, students develop a physical model that reproduces the patterns they observe.

DCIs. This vignette builds on students' understanding of shadows and light (PS4.B) from IS3. At the grade one level, students observe and describe patterns in the apparent movement of the Sun, Moon, and stars (ESS1.A). They do not, however, explain how Earth's rotation is the **cause [CCC-2]** of the pattern. Although teachers can certainly respond to students who

GRADE ONE VIGNETTE 3.2: PATTERNS OF MOTION OF THE SUN

have background knowledge about Earth's rotation, it is not part of the grade one performance expectation because many early elementary students do not have the spatial reasoning to develop a complete physical model of the Earth-Sun system. As part of the developmental progression, they will extend their observations of these patterns in grade five (5-ESS1-2) and finally develop a model of the Earth-Sun system in the middle grades (MS-ESS1-1).

CCCs. This lesson focuses on observing and describing **patterns [CCC-1]**. Students begin to recognize patterns that recur over time (instead of simply patterns in what they can see in a given moment) and use them to make predictions. Students **investigate [SEP-3]** how changes in the position of a light in a simple **system [CCC-4]** that includes a flashlight and an object **cause [CCC-2]** the shadow to change length and position.

EP&Cs. The pattern of shadows is one of many important natural cycles that humans depend upon (EP&C III).

CA CCSS Connections to English Language Arts and Mathematics. Students use information they collected and recorded to write informational/explanatory text to accompany their models. This connects to CA CCSS for ELA/Literacy W.1.2. As they recorded their observations of their shadows, they wrote down the time of their observations (CA CCSSM 1.MD.3).

Resources:
Teacher-selected book on Groundhog Day

Like the Sun, the Moon also has several **patterns [CCC-1]** of change that students can discover by direct **investigation [SEP-3]**. Students can focus on describing a single pattern and using it to make predictions (1-ESS1-1). Students often ask, "How can we study the Moon at school because we aren't here during the night?" Storybooks usually use the Moon as a symbol of the night, but students will discover that it is actually visible just as often during the day as the night. Students can record which days it is visible during the school day, taking careful note of the time of their observations (CA CCSSM 1.MD.3). Students will record similar data in grade five and then represent it more precisely using graphs (5-ESS1-2). In grade one, students' **data analysis [SEP-4]** should answer questions about how many days the Moon was visible and whether it was more often visible or hidden during the day (CA CCSSM 1.MD.4). Since the Moon can be hard to spot during the day, teachers might need to direct student attention to the proper location in the sky (teachers can consult an online almanac or app to help them). Students might **ask questions [SEP-1]** about why the Moon looks so dim during the day. Teachers can return to the idea that we see objects only when they are lit (by having light shined on them or by glowing themselves, as they learned in IS3), but students are not ready to develop a full model of phases of the Moon until the middle grades (MS-ESS1-2).

Students can draw or photograph the shape of the Moon over several weeks; however, only some of the Moon phases are visible during school hours. As a home–school connection, children observe the Moon at night with their families (especially during winter months when darkness comes before first grade bedtime). Students can search through a selection of picture books and notice how the illustrator chose to draw the Moon. They can arrange pictures from different books so that they reveal the **pattern [CCC-1]** in the Moon's apparent shape. Students should be able to use this pattern to make simple predictions. How long does it take for the pattern to repeat? What will its shape look like next week?

Opportunities for ELA/ELD Connections

Student can become familiar with the different phases of the Moon through a series of read-aloud books such as *The Moon Book* by Gail Gibbons; *Faces of the Moon* by Bob Crelin; *Phases of the Moon* by Gillian M. Olson; and *The Moon Seems to Change* by Franklyn M. Bradley. The words *full, half*, *rising,* and *setting* are all high-utility words that are worth introducing. Many books also emphasize names for each phase of the Moon, and focusing on these terms can distract from the more important goal of recognizing a consistent pattern in the Moon's appearance.

CA CCSS for ELA/Literacy: RI.1.2, 4, 7, 10.a; L.1.4, 6

CA ELD Standards: ELD.PI.2.5, 6

Students can also collect data about how the Moon moves across the sky over the course of a single day by direct observation. How long does it take to get from one place to another in the sky? Is it the same pattern each day? Where will the Moon be at the same time tomorrow? How does the Moon's motion compare to the Sun's? Students can complement direct observations with other sources such as the sequence of illustrations of the rising Moon in *Goodnight Moon* by Margaret Wise Brown (and the clocks in the illustrations record the time).

Sample Integration of Science and ELD Standards in the Classroom

Students use observations and daily firsthand recordkeeping of the Sun (where it is in the sky at different times of the day, the changes in a shadow throughout the day) and Moon (where it is in the sky in relation to different parts of the schoolyard); and use media and observations about the stars to describe patterns that can be predicted (1-ESS1-1). They share the recorded information, via charts, pictures, and writings, to compare predictions and analyze the patterns of these phenomena. They use sentence frames to analyze the patterns, for example, "Today at ___, the Sun will be ____ in the sky." As students report patterns of motion of the Sun, Moon, and stars in the sky, they select specific language needed for clarity, and can analyze other writers' use of language. For example, students can describe the choice of verbs in a statement describing what happens when the Sun and the Moon move across the sky: they appear to rise in one part of the sky, and move across the sky, to set in another part of the sky. To support students at the Emerging level of English proficiency, the teacher selects key verbs and spends time teaching the meaning of these verbs in vocabulary lessons. The teacher also asks students specific questions, such as, What verbs does the author use? and, when necessary, verbally supports students when they respond.

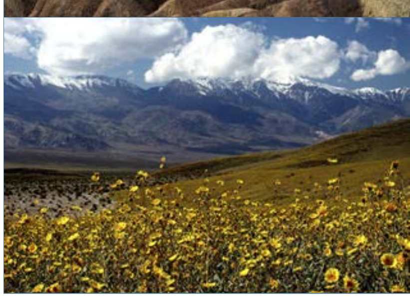
CA ELD Standards: ELD.PI.1.7

Source: Lagunoff et al. 2015, 218–219

Grade Two

The CA NGSS performance expectations for grade two organize themselves well around a unifying theme of California landscapes. The year introduces the shapes of the mountains, valleys, and coasts; plants and animals that live in them; the properties of the rocks and materials that make them up; and the forces that cause them to change. Table 3.5 shows an outline of four possible instructional segments to organize the year.

Table 3.5. Overview of Instructional Segments for Grade Two

	**1 Landscape Shapes** Students represent landscapes with 3-D physical models and 2-D maps. They recognize patterns in the shapes and locations of landforms and water bodies. They ask questions about how these features formed.
	**2 Landscape Materials** Students learn to describe differences in material properties. They explain how material properties can change, especially focusing on changes caused by changing temperature. Some of these changes can be reversed while others cannot. Students relate the properties of materials to how they can be used. Properties important to landscapes and landforms include the strength of materials and their ability to absorb water.
	**3 Landscape Changes** Some changes on Earth occur quickly while others occur slowly. Students investigate several processes that sculpt landforms and then create engineering solutions that slow down those changes.
	**4 Biodiversity in Landscapes** Different landscapes support different types and quantities of life. Students investigate the needs of plants and engineer models that mimic their pollination and seed dispersal structures. They then ask questions about how plant needs are met in the physical conditions of different habitats.

Source: M. d'Alessio; Giel 2007; Woelber 2012; Abbe 2005

IS1 Grade Two Instructional Segment 1: Landscape Shapes

California is known for its majestic mountains, sculpted glacial valleys, rolling coastal hills, and expansive central valley. This instructional segment is the first step on students' paths to understand how California came to look the way it does today. Many grade two students are not yet familiar with these broad features of the state, but can recognize the local landscape such as a slight tilt in sections of their schoolyard or mountains seen in the distance between buildings. In this instructional segment, students notice and describe different shapes in their local landscape. They use physical or pictorial models to represent these landscapes (as 3-D models and 2-D maps) and use published maps and models to learn about landscape features in California and around the world. They ask questions about what causes these features to form and how quickly or slowly the change takes place.

GRADE TWO INSTRUCTIONAL SEGMENT 1: LANDSCAPE SHAPES

Guiding Questions

- How can we describe the shape of land and water on Earth?

Performance Expectations

Students who demonstrate understanding can do the following:

2-ESS2-2. Develop a model to represent the shapes and kinds of land and bodies of water in an area. [*Assessment Boundary: Assessment does not include quantitative scaling in models.*]

2-ESS2-3. Obtain information to identify where water is found on Earth and that it can be solid or liquid.

The bundle of performance expectations above focuses on the following elements from the NRC document *A Framework for K–12 Science Education*:

Highlighted Science and Engineering Practices	Highlighted Disciplinary Core Ideas	Highlighted Crosscutting Concepts
[SEP-1] Asking Questions (for science) and Defining Problems (for engineering) [SEP-2] Developing and Using Models [SEP-4] Analyzing and Interpreting Data [SEP-8] Obtaining, Evaluating, and Communicating Information	ESS2.B: Plate Tectonics and Large-Scale System Interactions ESS2.C: The Roles of Water in Earth's Surface Processes	[CCC-1] Patterns [CCC-3] Scale, Proportion, and Quantity [CCC-4] Systems and System Models

CA CCSS Math Connections: 2.MD.10, 2.G.1–2

CA CCSS for ELA/Literacy Connections: W.2.2, W.2.7–8, W.2.10, SL.2.2, SL.2.e

CA ELD Standards Connections: ELD.PI.2.6, ELD.PI.2.10

CA History–Social Science Content Connections: K.4.4, 1.2.3, 2.2.1

There is no better way to experience Earth materials and the forces that shape them into a landscape than digging, pouring, and piling in a sandbox. Even with today's modern computers and tools, researchers at California's top universities still use physical **models [SEP-2]** called *fluvial geomorphology flumes* that are essentially giant sandboxes. While formal experiments in the schoolyard sandbox can be useful, this instructional segment begins with relatively unstructured time to play in the sandbox. Teachers provide materials to dig, perhaps some water, and then observe and photograph different aspects of the play to highlight later during the instructional segment. Schools that don't have a sandbox could consider building one as a class project, or teachers could use small plastic tubs filled with sand.

Teachers next connect the play in the sand to what students know about local landscapes. Are there mountains nearby? Hills? Places that are higher or lower than others? Walking around the schoolyard, students search for places where the landscape is not flat. They roll balls or pour water and identify evidence that there are slopes even in some of the flattest looking places by noticing the motion of the balls or water. How would they describe the locations of these mini hills to someone in another class? Earth scientists use maps for this challenge. Maps are **models [SEP-2]** of the world; they not only represent geographic features, but maps are tools used to answer questions. Road maps depict how long it will take to travel from place to place, weather maps predict where air will move, and geologic maps record the history of ancient plate motions. Students may have designed their own maps in earlier grades (CA History–Social Science Content Standards K.4.4, 1.2.3), and now they must be able to represent the shape of landscapes on maps (including hills and slopes). Teachers can return to the schoolyard sandbox (or classroom trays of sand or clay) and challenge each student to design a mini landscape where they would like to live. Then, students draw a map of their landscape and the teacher snaps a photo of the sandbox. Trading maps, another student must try to recreate the landscape from scratch. Which maps were most effective at communicating a landscape's features?

Students progress to **modeling [SEP-2]** larger spaces, such as the entire school or a park where they must indicate variations in topography (2-ESS2-2). Students are not expected to construct or even be familiar with traditional topographic maps; they need to develop their own ways of representing hills and valleys. Maps in grade two do not need to include a precise scale. Students can then use maps to **obtain information [SEP-8]** about geographic and environmental features of their town, a local park or region, or the entire state.

Students then focus on how these maps depict bodies of water. The intent is not for students to memorize where water is found, but to recognize **patterns [CCC-1]** in where water is found on Earth (2-ESS2-3). Water can move fast down a narrow path in a river or spread out in a lake or pond. It can be salty like the ocean or fresh like a lake. Maps help students recognize that most of these bodies are connected as part of a water **system [CCC-4]**. By tracing the paths of rivers on maps, students notice that most of California's rivers flow into and out of lakes and eventually make their way to the ocean. In fact, the vast majority of water on Earth exists in the oceans. Tossing around an inflatable globe, students can tally up the number of times their index finger lands on ocean versus land and make a bar graph (CA CCSSM 2.MD.10) that illustrates the **proportion [CCC-3]** of Earth's surface that is covered by land and water. In grade two, students notice patterns in Earth's features that they will analyze in more detail during grade four (4-ESS2-2).

Opportunities for ELA/ELD Connections

While scientists use maps to depict geographic features, they also use language to describe them. Students can make a list of all the different words they know to describe land and water features (mountain, hill, valley, river, lake, pond, etc.). Some of these words have very similar meaning (i.e., stream and creek) while others depict differences in **scale [CCC-3]** (i.e. stream versus river or hill versus mountain). Students **gather information [SEP-8]** from books and media to create a booklet about landforms and the words to describe them. They draw and label a different landform or body of water on each page, starting with the smallest bodies of water or the lowest landforms on the first page and adding progressively larger or taller features on subsequent pages.

CA CCSS for ELA/Literacy Standards: W.2.2, 7, 8, 10; SL.2.2
CA ELD Standards: ELD.PI.2.6, 10

Sample Integration of Science and ELD Standards in the Classroom

In small groups, students engage in developing models to represent the shapes and kinds of land and bodies of water in an area (2-ESS2-2). Each group examines graphics of a different type of landscape, labeling and writing brief text explanations on the location and characteristics of the area. Students collaborate and plan with their peers, using the image and text evidence to support their choices for the materials, size, and process that they use to develop their models. After creating their models, students briefly explain in writing why they chose the materials they did and why they built the model the way they did. Before the students write, the teacher leads them through examining a text with a similar structure so students can see the way an author introduces the choices and supports them with reasons and evidence (e.g., We chose to use crumpled paper to show mountains because we can make them tall and jagged. Mountains in real life are tall and jagged.) To support students at the Emerging level of English proficiency, the teacher pulls a small group and co-constructs an explanation with them, taking ideas from the students while recasting and asking probing questions to strengthen the writing.

CA ELD Standards: ELD.PI.2.11
Source: Lagunoff et al. 2015, 226–227

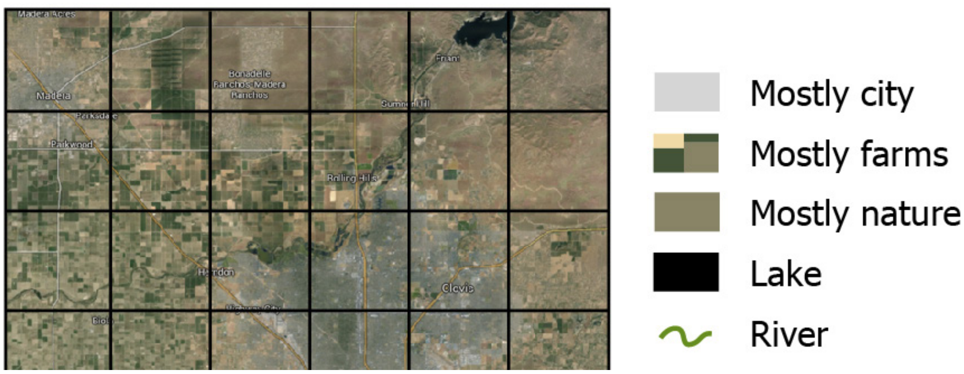
Maps and globes can also have symbols to depict ice and snow, another form of water. This is the first time that students formally discuss the relationships between solids and liquids. They discuss these materials more in the next instructional segment (IS2).

The class could then work together to create a giant model of California (or their own town) using the entire sandbox, piling up mountains and carving out major river channels in the places indicated on a map. They can add a grid system and practice locating features (CA History–Social Science Content Standards 2.2.1).

Opportunities for Mathematics Connections

Students draw a grid on a map or aerial photo of their community (figure 3.6) by dividing up a rectangle into rows and columns with same size squares. They count the total number of squares that have a particular feature (city versus nature versus farms, land versus water, mountains versus valley floors, etc . . .) (CA CCSSM 2.G.2). They create a bar chart communicating the comparison (CA CCSSM 2.MD.10).

Figure 3.6. Aerial Photo of a Community



Source: Illustration by M. d'Alessio using an image from Google Maps 2016.

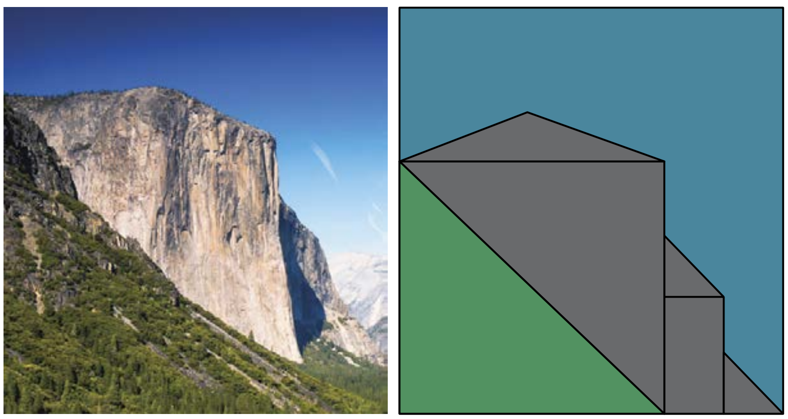
CA CCSSM: 2.MD.10, 2.G.2

Up to this point, students have used the sandbox, drawings, and maps as representations of their landscape, which is not quite the same as a model in the CA NGSS. A model is a thinking tool that can be used to predict or explain how different objects will interact. A representation can be used as a model when students ask questions like, "How long does it take for water to travel from the mountains to the ocean?" or, "What happens when the wind blows across this valley and then hits the mountains on the other side?" Students will put their representations to work as models in the grade two IS3.

Opportunities for Mathematics Connections

Paralleling the study of shapes in the CA CCSSM for K–2, the CA NGSS has students exploring the significantly more complex shapes of natural landscapes. While students have mastered the ability to identify simple shapes (CA CCSSM K.G.1) and create composite shapes (1.G.2), how can they represent the bends and curves of real-life objects in nature? Looking at a picture of a mountain, a valley, or a coastline, students can draw a simplified version of the landscape (figure 3.7) using only simple shapes such as triangles, quadrilaterals, and circles (CA CCSSM 2.G.1). Students observe that a great variety of objects can be built from a small set of pieces (PS1.A, 2-PS1-3). How well do these simple shapes represent the curves and bends in nature?

Figure 3.7. Using Shapes to Represent Natural Landscapes



Source: Cook 2013 (left); M. d'Alessio (right)

CA CCSSM: 2.G.1

Grade Two Instructional Segment 2: Landscape Materials

IS 2

In IS2, students explore four key ideas about materials: (1) different materials have different properties; (2) material properties can change; (3) some of these changes can be easily reversed and some cannot; and (4) the properties of a material affect how it can be used by people and its role in the natural environment.

GRADE TWO INSTRUCTIONAL SEGMENT 2: LANDSCAPE MATERIALS

Guiding Questions

- How can we describe different materials?
- How are materials similar and different from one another?
- What sort of changes can happen to materials?
- How do the properties of the materials relate to their use?

Performance Expectations

Students who demonstrate understanding can do the following:

2-PS1-1. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties. [Clarification Statement: Observations could include color, texture, hardness, and flexibility. Patterns could include the similar properties that different materials share.]

2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.* [Clarification Statement: Examples of properties could include, strength, flexibility, hardness, texture, and absorbency.] [*Assessment Boundary: Assessment of quantitative measurements is limited to length.*]

2-PS1-3. Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object. [Clarification Statement: Examples of pieces could include blocks, building bricks, or other assorted small objects.]

2-PS1-4. Construct an argument with evidence that some changes in matter, caused by mixing, heating, or cooling can be reversed and some cannot. [Clarification Statement: Examples of reversible changes could include materials such as water and butter at different temperatures. Examples of irreversible changes could include cooking an egg, freezing a plant leaf, and heating paper.]

K–2-ETS1-3. Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a practice or disciplinary core idea.

GRADE TWO INSTRUCTIONAL SEGMENT 2: LANDSCAPE MATERIALS

The bundle of performance expectations above focuses on the following elements from the NRC document *A Framework for K–12 Science Education*:

Highlighted Science and Engineering Practices	Highlighted Disciplinary Core Ideas	Highlighted Crosscutting Concepts
[SEP-3] Planning and Carrying Out Investigations [SEP-4] Analyzing and Interpreting Data [SEP-6] Constructing Explanations (for science) and Designing Solutions (for engineering) [SEP-7] Engaging in Argument from Evidence	PS1.A: Structure and Properties of Matter PS1.B: Chemical Reactions	[CCC-1] Patterns [CCC-2] Cause and Effect: Mechanism and Explanation [CCC-5] Energy and Matter: Flows, Cycles, and Conservation

Highlighted California Environmental Principles and Concepts:
Principle I The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services.

Principle II The long-term functioning and health of terrestrial, freshwater, coastal and marine ecosystems are influenced by their relationships with human societies.

Principle III Natural systems proceed through cycles that humans depend upon, benefit from and can alter.

Principle IV The exchange of matter between natural systems and human societies affects the long-term functioning of both.

Principle V Decisions affecting resources and natural systems are complex and involve many factors.

CA CCSS for ELA/Literacy Connections: RI.2.3, 8; W.2.1, 8; L.2.6

CA ELD Standards Connections: ELD.PI.2.6, 10, 11, ELD.PII.2.5

One of the goals of playing with sand in IS1 was to give students first-hand experience with material properties and how they could change. When sand is wet, it holds together differently than when it is dry. To make a sand castle, which properties work best? To build on this prior experience, students explore their schoolyard with a specific focus on the materials that make it up. They make observations and record them in a table, noting what materials they find, words to describe the material (ELD.PII.2.5), and what the material is used for (table 3.6).

Table 3.6. Example Schoolyard Exploration Notes

MATERIAL	WORDS TO DESCRIBE IT	WHAT IS IT USED FOR?
Metal	Shiny, Silver	Chair
Wood	Splintery, White	Fence
Playground Pavement	Hot, Broken	Playing

When students return, the class discusses the different words/adjectives they used to describe each material. Does the adjective always apply to this material? For example, the metal of the chairs in the classroom is always fairly shiny, but the concrete of the playground is not always hot (especially on cold mornings). Students recognize that the playground is broken and has cracks in it this year, but it probably didn't when the school was first built. From this wide range of descriptions of objects and materials in the schoolyard, teachers help students focus on which are properties of the material itself and which are simply how the materials are put together. If you break off a piece of concrete, is it still concrete? Even though the concrete of the schoolyard is cracked, the relevant property that describes concrete as a material is that it is breakable (though not easily!). Classes can then come up with a list of properties of materials such as texture, hardness, absorbency, flexibility, and whether the material is a solid or liquid. Then they can use these properties to describe everyday materials during in-class explorations (2-PS1-1). The two properties that are most important for landscapes are the hardness/strength of the material (discussed more in IS3) and the ability to absorb water (discussed in IS4). To build knowledge for these future segments, additional activities can explore each of these properties. For example, to explore material strength, students make synthetic rocks using different materials and drop them from different heights to see which are strongest. To explore absorption, students can time how long it takes for a cup of water to soak into different surfaces in the schoolyard (students may have to be taught how to use or read a stopwatch).

While materials have certain properties when they are alone, those properties sometimes change when different materials are mixed together. Students conduct investigations to determine if objects mixed or fastened together can be separated into their original components. For example, students can mimic the sorting strategies of recycling facilities by separating metal and paper objects mixed together by using their unique properties (paper floats while many metals are magnetic). While these materials remain separate when mixed together, other materials change properties when they are mixed, such as flour and water in pancake batter, which students can explore with cooking activities.

Properties of some materials change when the temperature changes. Liquid water turns into a hard solid when cooled in the freezer. Butter and chocolate both soften when warm. Students can explore making sculptures out of beeswax, which begins as a rigid material but becomes more flexible as students warm it in their hands. Other materials also flow more easily when they become warmer, including corn syrup. Students can pour corn syrup at different temperatures down a cardboard ramp and see how long it takes to travel a certain distance. With corn syrup, its past history does not really affect its ability to flow—a cup of syrup that was once in the freezer but now returned to room temperature should flow identically to a cup that remained at room temperature the entire time. In other words, the effects of temperature on corn syrup are entirely reversible. Students explore the melting and freezing of ice cubes and find that it, too, is entirely reversible. Other changes, however, are not. A toaster oven uses heat to turn soft, flexible bread into a browned, rigid, and crispy toast. Cooling it back down does not make it soft again. Clay heated and fired in a kiln never becomes soft and pliable again. Using evidence from a variety of experiences, students should be able to construct an argument that some changes from heating, cooling, or mixing can be reversed while some cannot (2-PS1-4).

Material properties become important in some forms of engineering because each part must serve a specific function. Engineers try to design solutions that meet certain criteria. If a material is not strong enough, too heavy, or simply unattractive, it may not be the best choice for a particular solution. Would a jacket made out of paper keep you dry in the rain? Would a jacket made out of aluminum foil be comfortable? Students can reverse engineer different products by looking at the parts that make them up and their material properties. To assess if students can choose the appropriate material for different engineering challenges, teachers can present students with a series of design challenges, which they begin by **defining the problem [SEP-1]** (figuring out what criteria are most important). Then they select the appropriate materials to solve the problems (2-PS1-2). They would need to **perform tests [SEP 3]** to determine the material properties and **analyze [SEP-4]** the results.

Engineering Connection: Create a Better Soil

Students play the role of agricultural engineers, trying to create a soil that retains as much moisture as possible for plants to grow. They test sand, woody material (bark), and clay (vermiculite) to see which will absorb the most water. They place each ingredient in a plastic cup with holes in the bottom and pour in a fixed amount of water. How much water leaks out? (Be sure to catch the water in containers below to compare the amount that flowed through). They weigh each cup before and after to figure out how much water was retained. Over the next few days, they record how quickly the soil dries out (by measuring the weight). They get to blend ingredients together to get the optimum mixture and test it (2-PS1-2; K–2-ETS1–3). *(This engineering connection could be completed during IS4 when students explore the needs of plants in more detail.)*

Engineering Connection: Create a New Toy with Old Parts

Teachers can ask parents to bring in old electronics and appliances that students can disassemble. With a briefing about proper safety precautions for sharp edges (and with a few parent volunteers), the students use screwdrivers and pliers to dismantle the devices. In their engineering notebooks, students make a list of the different parts they find and their material properties. They **ask questions [SEP-1]** about what each part does. Then, they try to reassemble the parts to **design [SEP-6]** a new toy with the existing materials. They make a sketch of their toy and document why they chose particular materials (2-PS1-3).

IS3

Grade Two Instructional Segment 3: Landscape Changes

Students apply their understanding of material properties to figure out which natural forces affect landscapes. Every rock records a story. Earth scientists look out on a landscape and **ask questions [SEP-1]** about both the processes that are actively shaping it today and the specific sequence of events in the past that led up to the present-day. What makes the mountains tall? Why are some mountains steeper than others? How are mountains and volcanoes related? Scientists **plan and conduct investigations [SEP-3]** to answer those questions using what geologists often refer to as their natural laboratory—Earth's present-day landscape.

GRADE TWO INSTRUCTIONAL SEGMENT 3: LANDSCAPE CHANGES

Guiding Questions

- What evidence do natural processes leave behind as they shape the Earth?
- How do the material properties of rocks affect what happens to them in landscapes?

Performance Expectations

Students who demonstrate understanding can do the following:

2-ESS1-1. Use information from several sources to provide evidence that Earth events can occur quickly or slowly. [Clarification Statement: Examples of events and timescales could include volcanic explosions and earthquakes, which happen quickly, and erosion of rocks, which occurs slowly.] [*Assessment Boundary: Assessment does not include quantitative measurements of timescales.*]

2-ESS2-1. Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.* [Clarification Statement: Examples of solutions could include different designs of dikes and windbreaks to hold back wind and water and different designs for using shrubs, grass, and trees to hold back the land.]

K–2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

The bundle of performance expectations above focuses on the following elements from the NRC document *A Framework for K–12 Science Education*:

Highlighted Science and Engineering Practices	Highlighted Disciplinary Core Ideas	Highlighted Crosscutting Concepts
[SEP-2] Developing and Using Models [SEP-6] Constructing Explanations (for science) and Designing Solutions (for engineering) [SEP-8] Obtaining, Evaluating, and Communicating	ESS1.C: The History of Planet Earth ESS2.A: Earth Materials and Systems ETS1.B: Developing Possible Solutions ETS1.C: Optimizing the Design Solution	[CCC-6] Structure and Function [CCC-7] Stability and Change

CA CCSS for ELA/Literacy Connections: RI.2.1, 3

CA ELD Standards Connections: ELD.PI.2.6, 11

How long is “a long time”? When it comes to the Earth, some changes take so long that they are difficult for adults to fathom, let alone students in grade two. But not all Earth processes are slow: an entire mountainside that took millions of years to be thrust up might collapse in a few minutes during a major landslide or volcanic explosion. The San Andreas Fault, which has been active for more than 20 million years, can move an entire city more than 30 feet in a single lurch lasting just a few seconds. Each of these processes leaves evidence behind by the way it **changes [CCC-7]** the shape of landscape. Students have some familiarity with different processes occurring on different time **scales [CCC-3]**: their hair may grow so slowly that they don't notice, but it can be cut in just a few seconds causing a major **change [CCC-7]** in their hair style.

Before students can understand the different timescales of Earth processes, they must have some familiarity with the processes that shape the landscape. In IS1, they documented the shapes of landforms and now they are ready to start **asking questions [SEP-1]** such as, "What **caused [CCC-2]** this landform to be shaped this way?"

Students begin by making observations of landforms that display different and interesting shapes (using local examples when possible). Much like sculpting a statue out of stone, certain natural forces had to break off pieces of rock and move them away to create each landform. On Earth, wind and water are the most common natural forces that accomplish these tasks. Students plan investigations of each. They pour water onto the top of a stream table (a container or tray filled with sand propped up on one end to represent a sloping mountain side), a **physical model [SEP-2]** that simulates a river. They **investigate [SEP-3]** the **effects [CCC-2]** of different amounts of water, steepness, or adding different materials to the riverbed. Within a given scenario, which changes happened rapidly and which changes happened slowly? Why? Which scenarios produce the most rapid changes overall? How would the results differ if the stream table were filled with a material that was stronger or less absorbent? The material properties of rocks have a strong effect on how quickly the rocks erode in real landscapes. In a different experiment, students blow into straws as a physical model of the wind. The landforms that are created by the wind often have very different shapes than landforms created by moving water. Students can learn to recognize these differences, and teachers ask students to use the shapes of the landforms as evidence to **argue [SEP-7]** that either wind or water was responsible for sculpting a given landform in a sandbox. Professional geologists use this same strategy of looking at landform shape to infer the history of the landform and the processes that shaped it.

Opportunities for ELA/ELD Connections

Using a cause and effect template [CCC-2] or note-taking guide, students investigate and record the natural processes that cause changes in landforms. Keep in mind that some students may benefit from working and discussing their thinking in pairs or in small groups. Students should address the questions *what*, *where*, *when*, *why*, and *how* when describing the processes that cause changes in landforms.

CA CCSS for ELA/Literacy Standards: RI.2.1, 3

CA ELD Standards: ELD.PI.2.6, 11

Engineering Connection: Design a Way to Slow or Stop Changes to the Landscape

Student can turn their investigations of natural processes that change landforms into an engineering design challenge to slow down or eliminate the changes to the landscape by wind or water. They sketch their design and add labels to depict how its shape reduces the effects of the wind or water (K–2-ETS1-2). They explain how the properties of the materials they use help the design accomplish its function. After building and testing their designs, they compare their solution to their classmates', identifying specific advantages and disadvantages of each design (2-ESS2-1).

Building on their firsthand experience with processes that shape landscapes, students **obtain information [SEP-8]** about specific landforms in California and beyond from textbooks or articles appropriate to their grade level. They focus on the processes and timescales in which water and wind shape each landscape. Some of the landforms can reveal the effects of different strength materials, like the hard dark rocks at Moss Beach that remain in curved layers while the waves have eroded the softer rocks around them (figure 3.8).

Figure 3.8. Examples Where Strong Rocks Erode More Slowly Than Weak Rocks

Curved layers of dark rock erode slowly at Moss Beach, California (left) and red layers are stronger and remain massive while white layers are eroded in dramatic vertical lines in Red Rock Canyon State Park, California (right). *Source*: Powell et al. 2007; David~O 2010

To assess their understanding of how different events change the landscape at different rates, each student selects two landforms to compare side-by-side: one that formed slowly and one that formed quickly. Which changes could they witness in a single day and which would take lifetimes? They describe how each one was shaped by different processes working on different timescales (2-ESS1-1).

Sample Integration of Science and ELD Standards in the Classroom

Students read a text comparing time periods (e.g., an instant versus their age versus centuries). They work as a class and in small groups to make observations (firsthand or from media) to construct an evidence-based account for Earth events that occur quickly (e.g., earthquakes) or slowly (e.g., rock erosion) (2-ESS1-1). The students participate in collaborative investigations such as tumbling various types of rocks in plastic tubs with water to see if any changes occur, and compare these investigations to a water-table model of erosion (using different soil types and/or different amounts of water) and/or video footage of mudslides, volcanoes, earthquakes, and beach erosion. Using key academic vocabulary that the teacher has posted on a word wall, students have conversations in which they provide detailed descriptions and analysis of their observations of text and images, as well as class collaborative and individually recorded ideas, to formulate clarification questions, provide summaries, and share results. The teacher provides various supports during these activities for the students at the Emerging level of English proficiency. For example, during the reading activity, the teacher shows pictures and other labeled graphic representations of the concepts to help students understand. After the reading activity during designated ELD time, the teacher works with the students to unpack the meaning of a key complex sentence within the text.

CA ELD Standards: ELD.PI.2.6

Source: Lagunoff et al. 2015, 216–217

IS4

Grade Two Instructional Segment 4: Biodiversity in Landscapes

Ecosystems include biological components (plants and animals) and physical components (e.g., water, light, soil, air). Living organisms within an ecosystem will survive and grow only if their needs are met. Different ecosystems provide different resources to plants and animals, and the variety of organisms in certain habitats depends on the availability and abundance of these resources.

GRADE TWO INSTRUCTIONAL SEGMENT 4: BIODIVERSITY IN LANDSCAPES

Guiding Questions

- How can we determine what plants need to grow?
- How do plants depend on animals?
- How many types of living things live in a place? How can we tell?

Performance Expectations

Students who demonstrate understanding can do the following:

2-LS2-1. Plan and conduct an investigation to determine if plants need sunlight and water to grow. [*Assessment Boundary: Assessment is limited to testing one variable at a time.*]

2-LS2-2. Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.*

2-LS4-1. Make observations of plants and animals to compare the diversity of life in different habitats. [Clarification Statement: Emphasis is on the diversity of living things in each of a variety of different habitats.] [*Assessment Boundary: Assessment does not include specific animal and plant names in specific habitats.*]

The bundle of performance expectations above focuses on the following elements from the NRC document *A Framework for K–12 Science Education*:

Highlighted Science and Engineering Practices	Highlighted Disciplinary Core Ideas	Highlighted Crosscutting Concepts
[SEP-2] Developing and Using Models [SEP-3] Planning and Carrying Out Investigations	LS2.A: Interdependent Relationships in Ecosystems LS4.D: Biodiversity and Humans ETS1.B: Developing Possible Solutions	[CCC-1] Patterns [CCC-2] Cause and Effect: Mechanism and Explanation [CCC-6] Structure and Function

Highlighted California Environmental Principles and Concepts:

Principle II The long-term functioning and health of terrestrial, freshwater, coastal and marine ecosystems are influenced by their relationships with human societies.

CA CCSS for ELA/Literacy Connections: W.2.3, 4, 7, 8, 10

CA ELD Standards Connections: ELD.PI.2.2, 6, ELD.PII.2.6

This instructional segment builds directly on activities and understandings from kindergarten and grade one. In kindergarten, students noticed patterns in the needs of living things. Here in grade two, they revisit the same DCI using a more sophisticated implementation of the SEPs. Rather than just noticing patterns in what they see and know, they now must **plan and conduct an investigation [SEP-3]** to gather and **analyze [SEP-4]** systematic evidence about the needs of plants (2-LS2-1). In grade one, they performed an engineering task to mimic the **structure/function [CCC-6]** relationships of plants or animals, and now they revisit the same CCC and SEP and use them to gain a deeper understanding of DCIs about how plants depend on animals to help them reproduce—both for pollination and seed dispersal (2-LS2-2).

Exploring the local schoolyard provides students valuable context to help them meet the performance expectations in this instructional segment. Students can begin by visiting their schoolyard and describing the physical conditions in different sections of the school. Which have the most sunlight and which receive the most water? These observations can motivate questions like, How much sunlight or water do plants need to survive? They can then **plan an investigation [SEP-3]** to answer that question (testing just one factor at a time; 2-LS2-1). In grade two, the emphasis of this investigation is on answering a question and students do not need to know any of the vocabulary related to investigational design. Students should start with living plants for this task rather than seeds since seeds can germinate and grow in the absence of light until they run out of the energy stored in the seed. Because every plant, like every person, is a unique individual that may have a different growth rate, teachers can explicitly emphasize the value of making many observations to answer this question. If one plant fails to grow, it may be due to a weakness in that specific plant. If almost all the plants that experience similar growing conditions fail to grow, students can be more confident in the strength of the evidence.

Students are now ready to put together their observations about the needs of plants, the fact that different locations have different physical conditions (including the amount of water and light), and the differences in material properties at each location. Can students expect different plants and animals to survive in different locations? The following vignette allows them to explore this question. In grade two, however, they will not explain the links between biodiversity and physical conditions. Instead, they will **ask questions [SEP-1]** and start to notice **patterns [CCC-1]** in where things live and what conditions are like there.

GRADE TWO VIGNETTE 3.3: BIODIVERSITY IN CHANGING ENVIRONMENTS

Performance Expectations

Students who demonstrate understanding can do the following:

2-LS4-1. Make observations of plants and animals to compare the diversity of life in different habitats. [Clarification Statement: Emphasis is on the diversity of living things in each of a variety of different habitats.] [*Assessment Boundary: Assessment does not include specific animal and plant names in specific habitats.*]

Highlighted Science and Engineering Practices	Highlighted Disciplinary Core Ideas	Highlighted Crosscutting Concepts
[SEP-3] Planning and Carrying Out Investigations	LS4.D Biodiversity and Humans	[CCC-2] Cause and Effect: Mechanism and Explanation

Highlighted California Environmental Principles and Concepts:

Principle II The long-term functioning and health of terrestrial, freshwater, coastal and marine ecosystems are influenced by their relationships with human societies.

CA CCSS Math Connections: 2.MD.10

CA CCSS for ELA/Literacy Connections: W.2.7, W.2.8

CA ELD Standards Connections: ELD.I.2.1, 9; 12

Introduction

In this series of lessons, Mr. B takes his students outside the classroom to observe animals (mostly insects) and plants in their habitats. He augments the students' observations with informational texts and class discussions on animals and plants and their habitats. His goal is for students to understand concepts such as diversity and abundance and the impacts of human activities on habitats.

Day 1–2: Plants and Animals Near Our School

Students conduct an investigation by collecting data about this diversity of plants and animals on their schoolyard or in the surrounding neighborhood.

Day 3: Different Needs of Various Plants in an Ecosystem

Students obtain information from texts about the factors that affect diversity in a particular place.

Day 4–5: Mapping Habitats

Students identify patterns in the diversity of different sections of their field area and make maps of different habitats. They then compare their map to a map of California's habitats.

Day 6: Documenting Human Changes to Habitats

Students return to the field to compare areas that are more natural with those that are affected by human activities. Students identify specific cause and effect relationships in their observations.

GRADE TWO VIGNETTE 3.3: BIODIVERSITY IN CHANGING ENVIRONMENTS

Day 7: Improving a Local Habitat

Students communicate ideas for reducing human impacts on their local habitat and put them into action.

Day 1–2: Plants and Animals Near Our School

Anchoring phenomenon: Different numbers of organisms and types of organisms live in different locations on the schoolyard.

Students in Mr. B's class were going to **investigate [SEP-3]** living things in a few different areas around the schoolyard, in a nearby park, in the local neighborhood, or at a nature center. Mr. B asked them, "Since the whole class is going, we will certainly find people everywhere we go. But do you think we will find anything else that is alive on the schoolyard?" A few students shook their heads no at first, but then someone mentioned the trees, the weeds, and even tiny ants. Mr. B agreed that most of the animals they would encounter are small such as insects, which meant that students would need to look very carefully. He also asked them if they thought some places would have more living things than others. They generally agreed that the playground would have fewer living things than the school garden, but they disagreed about how much life there would be in the plants by the front office. Mr. B told them that he wanted them to find out which places had the most life. A student asked, "Do we have to count all the creatures? There could be a thousand ants, but that's just one type of thing." Mr. B said that both the number of different types of things and the number of things could be interesting and that they should track both **quantities [CCC-3]**. Students complained that it will take them all day to count all the blades of grass on the entire soccer field, so Mr. B suggested that they focus on a small section of each location and shows them how they can take the ends off of a cardboard box so that it creates a little fence around an area (field biologists use a device called a *quadrat* box to accomplish the same task). If every group of students had the same size box, they could all look at the same size area and then compare their results.

The students took their science notebooks and pencils with them on a walk outside. With Mr. B leading the way and a parent volunteer following along, the students visited green areas on the campus, in a nearby park, in the local neighborhood, (or at a nature center). At each location, they placed their quadrat box down and counted the number of organisms and the number of different types of plants and animals. Since students could not identify many different species by name, Mr. B told them to just draw a picture and label it with a few descriptive words like "brown bug." At each location, Mr. B also had students describe the area in as much detail as possible in their science notebooks. What materials did they see? What did it feel like to sit at this location? They took a photograph of each location to supplement their descriptions.

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When students returned to their classroom, Mr. B had students compile all their data into a table on the board. For each location, each group wrote up the number of different types of living things and the total number of individual organisms they had recorded. Mr. B asked the students to **analyze their data [SEP-4]** by sorting the locations based on the two numbers they collected. The middle of the playground was the lowest on both counts (though everyone was surprised that they had found a number of different organisms there, too!). The school garden had the most types of living things, but a grassy section by the front yard of the school had more individual organisms. Mr. B asked students to look at their field notes and see if they could find evidence about why some sites had more life than others. Mr. B asked students to record some possible explanations in their science notebooks, labeling them with **"Possible Interpretations of Our Data" [SEP-4]**. Students wrote down several observations: "There is no place for plants to grow on the playground because the ground is too hard," "The garden has a lot because we water it all the time," and, "I think the school waters the plants by the front office and it is also shadier than the hot garden." For each interpretation, Mr. B instructed students to write out complete sentences below that clearly stated the evidence they were using to help them make this **claim [SEP-7]**. As Mr. B circulated around, he spotted one particularly interesting entry and wrote it on the board: "I think that there are more animals at the sidewalk because there are more plants there." Mr. B asked students if they could test this idea. He asked them to return to their notebooks and tally up the number of plants and animals. Did locations with more plants have more animals? If so, why might that be? Mr. B was laying the foundation for concepts of interdependent relationships in ecosystems. What affects how much life there is at a particular location? Mr. B instructed each student to write one **question [SEP-1]** of their own in their science notebook about the data the class had collected.

Day 3: Different Needs of Various Plants in an Ecosystem

Students had ended the previous day with a question about what affected the amount of life in a particular location. Students could come up with many ideas about important factors, so Mr. B decided to give the students a word to describe all of these factors together: *ecosystem*. He asked students if they had heard this word before and what they think it means. Building on the students' suggestions, Mr. B explained that an *ecosystem* is made of living and nonliving things that are found together and that affect each other.

Everyday phenomenon: Blackberry plants and Joshua trees grow in different places with different physical conditions.

Since students had experience in the school garden, Mr. B decided to focus on that ecosystem. He asked students to list some of the things that the plants in their garden need to survive. As students brought up different plant needs, Mr. B posted a word card (available at https://www.cde.ca.gov/ci/sc/cf/ch3.asp#link6) on the wall to reinforce each of these several domain-specific terms that students will use to describe what plants need from the habitats where they live: *moisture*, *nutrients*, *pollination*, *soil*, *suitable temperatures*, *water*. As he

GRADE TWO VIGNETTE 3.3: BIODIVERSITY IN CHANGING ENVIRONMENTS

introduced each new term, he asked a student to describe one of their observations from the previous day's notebook entries using the new word. He expanded on this discussion by having the class brainstorm a list of some of the things that plants living in a forest ecosystem need to grow and survive. Then, working in groups of three, the students read and discussed two sets of informational text, *Would Blackberries Grow…?* and *What a Joshua Tree Needs from the Desert* (available at https://www.cde.ca.gov/ci/sc/cf/ch3.asp#link7). Mr. B asked students to compare (**evaluating information [SEP-8]**) the specific needs of blackberries and Joshua trees using the new words they had learned. Could students identify plants from their schoolyard field trip that have different needs or can survive in different conditions?

Days 4–5: Mapping Habitats

Investigative phenomenon: Different numbers of organisms and types of organisms live in different locations on the schoolyard (returning to investigate the anchoring phenomenon).

The following day, Mr. B had students walk their field trip route a second time, this time to make a map of areas with similar conditions and similar living things. They needed to identify **patterns [CCC-1]** in the ecosystems. The grass of the school playing field was similar to the small patch of grass between the sidewalk and the road in front of the school, so students decided to mark both of those spaces green and added a new category to their map legend called "grassy." The sidewalk, the playground, and the road all had hard ground and only a few weeds growing in cracks, so they colored those spaces grey and added the legend item "pavement." Landscaped garden areas received a different category, while various "wild patches" of weeds were a different one—even though both have lots of plant life, the types of plants were clearly different.

Investigative phenomenon: Different regions of California have different plants and animals.

When they returned to the classroom, Mr. B showed them a wall map of California's *Habitats* (available at https://www.cde.ca.gov/ci/sc/cf/ch3.asp#link8). In grade two, students were just beginning to examine maps of California and beyond and could identify essential map elements on the wall map (CA History-Social Science Standards 2.2.2). Like on their own map, areas with similar conditions and similar plants and animal life are grouped together using the same symbols. Mr. B called on different students and asked them to describe the differences they see between two different habitats on the map. "What might make them have different plants and animals?" he asks. The answer always has the same general pattern—the two regions had different amounts and types of the things needed by plants and animals to survive. These differences in conditions led to a wide variety of living things, a concept called

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diversity. Students recorded the diversity of living things during day 1 when they counted the number of different types of organisms. Mr. B used the habitat map to emphasize diversity in California's ecosystems, plants, and animals.

Day 6: Documenting Human Changes to Habitats

Investigative phenomenon: Areas affected by humans have different organisms than areas not affected by humans.

Students returned to their field trip route one more time, this time looking for places where humans have influenced plant and animal life. He asked students, "In what ways can humans change the habitats where plants and animals live? How do these changes affect the survival of the plants and animals that live there? What might happen to the variety of living things around the school or in the nearby park if humans change the conditions again?"

During this field trip, the class investigated two types of areas: ones that had been disturbed by humans and others that were in a more natural condition. As they visited these sites, the students made notes and simple drawings in their science notebooks about the condition of the habitats, the evidence for human activity, and the abundance of plants and animals.

Upon their return to the classroom, the students worked in pairs using the notes from their field trip to summarize their observations. To help draw their attention to specific **cause and effect [CCC-2]** relationships, Mr. B created a two-column chart. He labeled one column "cause" and the other "effect." Students shared ideas based on their observations about the changes that had occurred in the different habitats they investigated as they tried to place their observations into the correct column of cause or effect. Mr. B circulated around the class, helping students distinguish between the causes and effects and making sure that students were able to articulate both a cause and a matched effect for every row.

Day 7: Improving a Local Habitat

Investigative phenomenon: How do we decrease the effects of humans on plants and animals?

Mr. B challenged the students to come up with ideas about what they as a class or as individual students might do to decrease the effects of human activities on plants and animals. He then acted as the recorder as the students shared their ideas about how to decrease the effects of human activities.

To assess their understanding of these concepts, Mr. B told the students that they were going to **communicate [SEP-8]** what they learned through their research by creating informational posters. He told them that they should include three different items on the posters: a drawing from their science notebook showing a natural habitat, a drawing from their science notebook showing the effects of human activities, and a description of how humans could decrease

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their impact. Excited by what they had learned, the students asked if they could display their posters in the hall outside the classroom to share with other students and their parents.

Student posters focused a lot on trash in the natural environment, with much of the litter being recyclable. Mr. B helped students collaborate with the school's expanded learning program on a recycling project. During expanded learning time, students created signs to glue to recycling boxes and placed the recycling boxes around the expanded learning space. They encouraged other students in the expanded learning program to recycle used paper. At the end of week, the students emptied the boxes in the school's recycling containers.

Vignette Debrief

This vignette is anchored in a phenomenon that students experience every day. As they walk to and from school, they may see different trees, shrubs, birds, squirrels, or other animals and plants. Students go on a field trip around the school and neighborhood to observe different types of organisms that live in various locations. Most importantly, students communicate their ideas for reducing human impacts on their local habitats and put them into action through a recycling project.

SEPs. Students were engaged in a number of science practices with a focus on the SEP of **planning and carrying out investigations [SEP-3]**. Each time they went out to collect data, they were motivated by a specific question. And each time they returned, they always had a specific activity designed to help them analyze and interpret their data. Sometimes the analysis used some mathematical thinking (days 1–2) during which students were making quantitative comparisons and sorting them. Students **communicated their understanding [SEP-8]** on the final day as an informational poster.

DCIs. This lesson highlights the concept of biodiversity, and how humans can influence that biodiversity (LS4.D).

CCCs. On days 4–5, the map itself was a form of analysis as students noticed patterns and created categories while they were still in the field. On day 6, students described the pattern and interpreted their observations in terms of **cause and effect [CCC-2]**.

EP&Cs. The vignette also demonstrates the utility of getting outside into the schoolyard and surrounding community to make observations. Urban habitats are the ones most familiar to many students, and it is the goal of the CA NGSS that all students understand the world around them. Part of the goal is so that they will be better stewards of that world and seek to make it better. Since habitats close to schoolyards are almost certainly affected by humans, this lesson also provides a forum to for students to develop an understanding of California Environmental Principle II Concept a: *Direct and indirect changes to natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems.* The lesson ends with students not only suggesting ways to minimize human impacts, but with them pursuing a specific solution. This lesson sequence does not go into great depth about the design process, but developing systems to solve problems is an example of engineering.

GRADE TWO VIGNETTE 3.3: BIODIVERSITY IN CHANGING ENVIRONMENTS

CA CCSS Connections to English Language Arts and Mathematics. Students used the text in *Would Blackberries Grow...?* and *What a Joshua Tree Needs from the Desert* as the sources for a shared research project, connecting to the CA CCSS for ELA/Literacy Standard W.2.7. In addition, they used their science notebooks to make notes and gather information about the diversity of plants and animals living nearby and human disturbances they observed. Students also used this information to answer questions during a round-robin discussion, corresponding to CA CCSS for ELA/Literacy Standard W.2.8, as well as creating an informational poster. After students conduct an investigation of the schoolyard, they compile their data in a table (CA CCSSM 2.MD.10). They identify patterns in the diversity of different sections of their field area and make maps of different habitats. They then compare their map to a map of California's habitats.

Resources:

California Education and the Environment Initiative. 2011. *Cycle of Life*. Sacramento: Office of Education and the Environment. https://www.cde.ca.gov/ci/sc/cf/ch3.asp#link9

California Education and the Environment Initiative. 2011. *Flowering Plants in Our Changing Environment*. Sacramento: Office of Education and the Environment. https://www.cde ca.gov/ci/sc/cf/ch3.asp#link10

California Education and the Environment Initiative. 2011. *Open Wide! Look Inside!* Sacramento: Office of Education and the Environment. https://www.cde.ca.gov/ci/sc/cf/ch3 asp#link11

Engineering Connection: Design a Seed

Animals can move around in a habitat, while plants cannot. Due to this lack of mobility, plants depend on animals to pollinate them or to move seeds around. Students can directly observe these relationships by watching bees visit flowers or by looking at seeds stuck to their clothing after they walk through a patch of weeds. Students can dissect seeds and flowers that they or their teacher collected from the schoolyard or around the community. They can closely inspect the specific structures of the flower that are involved in pollination or parts of the seed that allow it to stick to an animal's fur or a person's clothing. Using simple materials provided by their teacher, students can create physical **models [SEP-2]** that mimic the behavior of pollinators or seeds (2-LS2-2). Students can compare their solutions by testing their devices to see how well they pollinate or disperse seeds. Using the evidence from their tests, they can **engage in argument [SEP-7]** to compare and contrast the characteristics of different devices.

(A detailed snapshot of this engineering design challenge appears in chapter 11 of this framework on instructional strategies.)

Opportunities for ELA/ELD Connections

To help students develop their understanding of **causality [CCC-2]**, have them think of several effects for a cause or circumstance involving plants in different habitats using an "if/then" structure (either in narrative text or a poem). For example:

If a plant lives in the desert where there is not much water,

… *then* it needs long roots to get water.

… *then* it often has few leaves or a protective coating on the stem.

… *then* it won't grow much during times with little water.

CA CCSS for ELA/Literacy Standards: W.2.3, 4, 8, 10

CA ELD Standards: ELD.PI.2.2, 6, ELD.PII.2.6

Science Literacy and English Learners

Science classes are ideal environments for all students to learn and develop language skills. Science and engineering give students something to talk about because they address high-interest topics, manipulate real-world materials, and have collaboration inherent in science and engineering practice. To maximize the synergies between English language development (ELD) and science, the SBE commissioned a document—*Integrating ELD Standards into K–12 Mathematics and Science Teaching and Learning: A Supplementary Resource for Educators*—which provides examples of how the state ELD standards and the CA NGSS can complement one another (Lagunoff et al. 2015; https://www.cde.ca.gov/ci/sc/cf/ch3.asp#link12).

Excerpts from that document appear throughout this chapter as "Sample Integration of Science and ELD Standards in the Classroom."

The vignette below shows a glimpse into a classroom where a deliberate approach to integrate the CA NGSS, CA CCSS for ELA/Literacy, and the CA ELD Standards enhances all three of these areas. Like all the vignettes in this document, this is just one example approach to teaching these standards. In fact, the three performance expectations featured in this vignette also appear within snapshots in IS2 and IS3 in kindergarten to provide different perspectives on how to teach the same content.

This particular vignette highlights scaffolding approaches for English learners at both the level of lesson organization and individual student interactions. It is not a comprehensive view of all the factors that educators need to consider nor is it universal since pedagogical and scaffolding approaches will depend on individual student needs. Nonetheless, it attempts to illustrate a few research-based instructional practices.

KINDERGARTEN THROUGH GRADE TWO INTEGRATED SCIENCE, ELA, AND ELD VIGNETTE 3.4: CARING ABOUT AND PROTECTING THE ENVIRONMENT

Performance Expectations

Students who demonstrate understanding can do the following:

K-LS1-1. Use observations to describe patterns of what plants and animals (including humans) need to survive. [Clarification Statement: Examples of patterns could include that animals need to take in food but plants do not; the different kinds of food needed by different types of animals; the requirement of plants to have light; and, that all living things need water.]

K-ESS2-2. Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs. [Clarification Statement: Examples of plants and animals changing their environment could include a squirrel digs in the ground to hide its food and tree roots can break concrete.]

K-ESS3-3. Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.* [Clarification Statement: Examples of human impact on the land could include cutting trees to produce paper and using resources to produce bottles. Examples of solutions could include reusing paper and recycling cans and bottles.]

Highlighted Science and Engineering Practices	Highlighted Disciplinary Core Ideas	Highlighted Crosscutting Concepts
[SEP-4] Analyzing and Interpreting Data [SEP-7] Engaging in Argument from Evidence [SEP-8] Obtaining, Evaluating, and Communicating Information	LS1.C: Organization for Matter and Energy Flow in Organisms ESS2.E: Biogeology ESS3.C: Human Impacts on Earth Systems ETS1.B: Developing Possible Solutions	[CCC-1] Patterns [CCC-2] Cause and Effect: Mechanism and Explanation [CCC-4] Systems and System Models

Highlighted California Environmental Principles and Concepts:

Principle I The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services.

Principle II The long-term functioning and health of terrestrial, freshwater, coastal and marine ecosystems are influenced by their relationships with human societies.

Principle V Decisions affecting resources and natural systems are complex and involve many factors.

CA CCSS Math Connections: 1.MD.3

CA CCSS for ELA/Literacy Connections: W.K.1, W.K.7 , SL.K.1

CA ELD Standards Connections (Expanding): ELD.PI.K.2, ELD.PI.K.5, ELD.PII.4

KINDERGARTEN THROUGH GRADE TWO INTEGRATED SCIENCE, ELA, AND ELD VIGNETTE 3.4: CARING ABOUT AND PROTECTING THE ENVIRONMENT

Introduction

Mrs. J's Kindergarten classroom is a place where children can wonder about the world and actively engage in inquiry about it through observing, questioning, exploring, communicating, and working with others. At the beginning of this vignette, the children are learning about how people can choose to care about and protect the environment. Mrs. J's goal is to immerse her young students in interactive learning tasks during which they can explore new ideas about the environment and environmental issues, discuss their questions and thinking, and work collaboratively to problem solve. She does not merely want her students to learn about environmental protection and conservation; she wants them to be able to practice it by developing the knowledge and skills needed for lifelong environmental stewardship.

Mrs. J integrates environmental awareness every day, all year long. For example, the words and photographs on the alphabet cards the children use to learn their letter names represent the natural environment (*L* is for *Leaf*, *O* is for *Ocean*, *R* is for *Rainbow*, etc.). This allows her to (1) support the children in their foundational skills development and build their vocabulary knowledge, (2) use the rich context of the natural world and students' personal experiences, and (3) engage the children in conversations about the natural world and environmental issues related to the words.

Currently, the class is learning about water and water conservation: why animals, plants, and people need clean, fresh water to survive; the effects of a recent California drought; and how people can choose to protect and conserve fresh water (EP&Cs I and II). The three big ideas that guide lesson planning for the learning segment are

1. living things in the natural world have similar needs;
2. children can choose to care about nature and conserve natural resources;
3. children can engage other people to care about and protect the environment.

Mrs. J's students live in a culturally and linguistically rich urban neighborhood. Roughly half of the children in the class speak African-American English with their families at home, and several children are bilingual and proficient in both Spanish and English. The remaining students are English learners (EL), most of whom were born in the United States. Most of the EL children are at the Expanding level of English language proficiency, and they have a solid grasp of conversational, or everyday English. Three of the EL children are new to the United States and are at the early Emerging level of English language proficiency. Most of the children in the class have socioeconomically disadvantaged backgrounds and have limited access to academic English in their home environments. Mrs. J knows that each of her students is capable of thriving with an intellectually rich science curriculum and that she needs to both cultivate their curiosity about the world and support their deeper learning with appropriate types and levels of scaffolding.

KINDERGARTEN THROUGH GRADE TWO INTEGRATED SCIENCE, ELA, AND ELD VIGNETTE 3.4: CARING ABOUT AND PROTECTING THE ENVIRONMENT

Lesson Context

At this point in the learning segment, the children have been learning about water for about a week. They have been listening to and discussing the ideas in many informational texts that Mrs. J has been reading aloud to them, and they have been exploring water during science investigation lessons and at the science observation station. The previous week, the children started learning about different marine and freshwater aquatic ecosystems in California (estuaries, salt marshes, lakes, ponds, rivers, wetlands), and they viewed short media pieces about some of the ecosystems. As they were learning about these ecosystems, the class started a large butcher paper mural representing them, along with labels and questions they had written on sticky notes. As they progress through this learning segment, they will add details regarding how ecosystems provide resources that living things need.

The class has also started building a scientific vocabulary wall with these and other words, including *conserve*, *protect*, *natural resource*, *pollute*, *reduce*, and *recycle*. The words are accompanied by pictures and illustrations, along with student-friendly explanations (for example, *reduce—use less*; *protect—keep safe*). Mrs. J would like the children to feel comfortable using these words in their conversations and when they write daily about the topic, so she has used students' natural language during class experiences and discussion to define the technical vocabulary in the lesson. For example, when the class washes their hands before snack time, she asks, "Is it ok to just let the water run for a long time while I wash my hands? Do I care how much water I use?" Students respond with ideas such as "No, the water costs money" or "That would waste the water." Mrs. J then asked, "So, we should save the water? Another way to say that is *conserve*. Let's be sure to turn off the faucet while we soap up our hands so we don't use more than we need to. That way, we're *conserving* water." She then encouraged students to say, "I am conserving water," when they turn off the faucet to soap up their hands.

At other times, Mrs. J explicitly taught some of the words to the children and encouraged them to use the words frequently in meaningful ways (for example, when they sing songs or chant poems or when they are making observations).[1] Mrs. J also models how to use the words several times each day.

By focusing intentionally on both content knowledge and language, Mrs. J is supporting the children to build both their science conceptual understandings and their awareness of how language works in science. The children will draw upon all of this integrated knowledge to write a letter about water conservation to the editor of the local newspaper. The following learning target and CA NGSS performance expectations guide Mrs. J's lesson planning.

1. See the *ELA/ELD Framework*, chapter 3, Kindergarten designated ELD vignette for an idea how to teach vocabulary explicitly.

KINDERGARTEN THROUGH GRADE TWO INTEGRATED SCIENCE, ELA, AND ELD VIGNETTE 3.4: CARING ABOUT AND PROTECTING THE ENVIRONMENT

Lesson Excerpts

Everyday phenomenon: People use water in many different ways.

Mrs. J began the day's lesson by inviting the children to sit in a big circle. She showed them a large, clear bucket containing five gallons of water and asked them to think about all the different ways they and their families use water in their daily lives (EP&C I). She provided an example: drinking a glass of water when she's thirsty. Before she had the children share their ideas with a partner, she gave them about 10 seconds to think quietly about as many ideas as they could (at least three). This provided a valuable opportunity for the children to prepare a response. She checked in with each of the children who were ELs at the Emerging level of English language proficiency to make sure they understood the question and supported them to prepare a response. She then prompted all students to use a language frame to tell their ideas to their partner: "My family uses water to ____."

After the children had shared with their partners, Mrs. J asked them to share some of their ideas with the whole class. She then asked them to help her sort the activities, separating the ones for which water was needed to survive—or stay alive like drinking, watering the garden—from the ones for which it was nice to have water but not really necessary for survival (swimming, making popsicles). She wrote the children's ideas on a T-chart that was big enough for the whole class to see, and the class decided together by voting (thumbs up, thumbs down) in which category each activity belonged. The children discussed whether taking a shower or brushing their teeth were activities for which they need water in order to survive. In the end, the class decided that water was necessary for brushing teeth (because they need their teeth to eat food so they can stay alive) but not for swimming (because they don't have to swim in order to live).

Inquiry Activator: Where's the Water on Earth?

Investigative phenomenon: Water is found in many places on Earth, but freshwater is very rare.

Mrs. J then returned the children's attention to the bucket of water, next to which she placed a globe.

Mrs. J: Children, today we're going to be thinking and talking about how much water is on the planet and where it is stored. We're also going to talk about why it's important for everyone to conserve and protect fresh water, or the water we need in order to survive,

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or live. You all said we use water to do a lot of things in our daily lives. Where do you suppose the water we use for drinking, cooking, brushing our teeth, and many other uses, comes from? And why do you think that? You can use our water mural for ideas.

The children thought for a moment and then discussed their thinking with their partner as Mrs. J. listened in, making sure that each child had a chance to share. She also encouraged them to ask their partner clarification questions and to respond to their partner's ideas.

Chanel: I think … I think the water we use for brushing our teeth comes from … comes from … I don't know.

Ana: (Pointing to the water mural.) Do you think it comes from the lake? Or from the ocean, maybe?

Chanel: From the lake! I think it comes from the lake 'cuz the water in the ocean, it's too salty.

Ana: Yeah, I think if you drink the water from the ocean, you get sick. And maybe the water comes from that. (Pointing to the mural.)

Chanel: That's a pond. I don't want to drink water from there. It has fish and stuff. Yuck!

Ana: The lake has fish in it too, right? I wonder if that's where we get our water to drink. How do they get the fish out?

Mrs. J told the children that she heard some very interesting ideas with good reasons to justify them and also some great questions that they'll be investigating. She clarified that the water we drink is fresh water and not the salt water from oceans, which would make us sick. Then, she asked them to look at the large bucket of water and the globe.

Mrs. J: (Points to the bucket.) This represents all the water on our planet Earth, including the water that is in the atmosphere, glaciers, ice caps, lakes, rivers, oceans, groundwater and streams. So, if this is all the water there is on the planet, how much of it do you think is available for us to use for drinking, cooking, and other things we said we need water for in order to survive?

Jesse: (Placing his hand in the middle of the bucket.) Like, up to here?

Sadie: No, I think it's more, 'cuz we have to use a lot of water at my house.

Ricardo: (Pointing to the Pacific Ocean on the globe.) But… but, look the ocean. Is big!

Mrs. J: That's a great observation, Ricardo. Yes, a lot of the planet is covered in ocean, and we can see that on the globe. All of you are doing some great science thinking. Let's find out how much of the water on the planet is in the oceans and how much is available for us to use for our survival needs. Ricardo, can you help me?

Mrs. J invited Ricardo to help her demonstrate where the Earth's water is located. She asked Ricardo to take out 25 tablespoons of water from the bucket and place it in a large, clear jar labeled "Fresh Water" as everyone counted to 25. She took the jar over to the mural so that she can point to the bodies of water as she explained what the bucket and jar represented.

Mrs. J: The water in this jar represents all the fresh water on Earth. Fresh water is in the air, glaciers, rivers, ponds, lakes, and groundwater. Let's say those words together as I point to them. All the remaining water in the bucket, or the water that's left in there, represents all the salt water on Earth, which is mostly in the oceans.

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Jasmine: There's a lot in that bucket. That's a lot of salty water.

Lawrence: Can we drink it?

Jasmine: No! You can't drink salty water! I went to the ocean one time, and I got water in my mouth. It didn't taste good. I don't think you can drink salty water.

Lawrence: But, can you make it not salty? Can you get the salt out?

Mrs. J: Jasmine is right, it's not healthy to drink salt water, and Lawrence, your question is one we could investigate. Should we put that on our water inquiry chart?

After placing the question on the chart, Mrs. J invited another child to help her take out eight tablespoons from the freshwater supply and place it in the jar labeled "Groundwater." She told the children that this represented all the groundwater on Earth. She showed them and explained an illustration of groundwater in a book and told them that in the area where they live, a lot of the drinking water they use is groundwater, and more so when there is a drought.

Solange: But, how do we get it if it's in the ground? How do they get it to the kitchen?

Jesse: And the bathroom!

Mrs. J: Hmm… That's another good question I bet we can investigate.

Solange: Put it on the inquiry chart!

After posting the question to the chart, Mrs. J invited another child to use an eyedropper to transfer 25 drops from of the freshwater supply to a very small jar labeled "Rivers and Lakes." She told the children that this water represented all the water in rivers and lakes on Earth. All the water contained in groundwater, rivers, and lakes from the world's fresh water has been removed. The "Fresh Water" container now represented all the water contained in the atmosphere (clouds, rain, snow, etc.) and all the water on the planet that is frozen (polar ice caps and glaciers). She asked the children to observe the containers and how much water was in each container and to discuss their thinking in groups of three. After a few minutes of discussion, she asked each triad to write down at least one of their questions on a sticky note and to place the question on the Water Inquiry Chart before going to their tables and writing and drawing one thing they learned about water that day. As the children were writing, Mrs. J encouraged the children to talk about their ideas at their tables, ask and answer one another's questions, and include any questions they are wondering about.

Hands-on Investigation: How Do We Clean the Water?

The next day, Mrs. J showed the children a short and engaging video about why it's important to turn off the water while brushing one's teeth (Sesame Street 2010). In their table groups, the children briefly discussed what they learned from the video and how it related to the activity from the previous day.

Mrs. J reminded the children about how much they've already learned about bodies of water and aquatic ecosystems (referring to the mural), and how much of the water on Earth is fresh water (referring to the bucket and jars, which are now displayed on a counter). She told the children that they were going to go outside and investigate what happens when the fresh water gets dirty (Clean Water Challenge).

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She took the children to the grassy area of the school grounds. Parent volunteers had worked with the school staff to create an outdoor space that allowed for science exploration and learning, including a vegetable garden and a large grassy area surrounded by bushes and trees, which provided a place for observing nature and conducting messy science investigations. She reminded the children that when they go outside, they are to handle plants and animals gently and with respect. Because it was a wide-open space, she knew the children would want to run around and that if she allowed them to, they would be more engaged in the science investigation she has planned for them to do afterward. She asked the children to pretend they were a body of water. They could flow gently, like the water flowing down a gentle stream, they could flow quickly, like the water rushing down a river, or they could be like any body of water they preferred. She asked them to try as many different bodies of water as they could, but before they did, she provided an example, inviting the children to say, “I’m flowing like a rushing river!” and run briskly with her to the other side of the yard.

After several minutes, Mrs. J asked the children to gather around her in a circle. She showed them a cup of clean water and a cup of *dirty* water (water with safe organic debris, such as orange peels or blades of grass). She asked the children to compare the two cups of water and discuss their ideas with their partner. She then asked them to think about which cup of water is best for plants and animals. She asked, “Which cup of water holds something that is not good for plants, animals, or humans?” She introduced the term *pollution* or *polluted* and explained that this is what we call water that has become dirty due to human activity.

Investigative phenomenon: How do we clean up polluted water?

Mrs. J explained that they will now try to clean a sample of *polluted* water. She used an empty plastic cup, a plastic cup filled with dirty water, as well as tools they might use to clean the water, such as paper towels, cotton balls, coffee filters, sponges, pieces of nylon (or other fabric), sand, gravel, and rubber bands. She told them that she wanted them to share ideas and discuss with each other what might work to clean the water before they started using the materials. She also reminded them that scientists test many ideas before finding one that will work, so, since they’re kid scientists, they should try out many different ways of cleaning the water (there was plenty of dirty water in the bucket she had brought outside). She grouped the children strategically into teams of three, and the children collected their materials and began the challenge. As the children worked together, Mrs. J moved from team to team, listening to their discussions and prompting them to share their ideas before they started testing them. Solange, Hernán, and Rafael are working as a team.

Solange: I know, I know! Let’s use the cotton. I think we can scoop up the dirty stuff with it.

Hernán: Yeah, we can do it. We can use this (pointing to the coffee filter).

Solange: That’s a coffee filter. Okay, so we could use the coffee filter. But how?

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Hernán: You can…You can put the water in. Here (miming how he would pour the water through the coffee filter).

Rafael: Yeah, we could pour the dirty water through the coffee filter and into the clean cup. But will the water get clean?

Solange: Let's do it!

Mrs. J: Have you shared lots of different ideas first? Have you talked about all of the materials you have? You can test out many different ways of cleaning the water, and it's a good idea to talk about lots of ideas before you start testing them.

Rafael: I wonder if the water can go through the sponge. Maybe that would just keep it there.

Solange: I think, I think it would get stuck. So, we talked about the cotton balls, the coffee filter, and the sponge. What's the sand for?

As the teams shared ideas and then tested them out, Mrs. J encouraged them to explain their thinking to one another and to continue to ask questions about what was working best to clean the water. Through trial and error, most of the children figured out they needed to build a filter rather than adding items to the water to *clean* it. Once the teams had tried out many different ways of cleaning the water, Mrs. J asked a few students to help her pass out the children's science journals and pencils, and she asked them to discuss with one another which way or ways worked best, showing what they discussed through drawings with labels. The teams then worked together to write a brief explanation of their design solution, with evidence from their investigation. Once the children had recorded their notes on a large piece of chart paper she had brought outside, she would post it in the classroom afterward. At the end of the discussion, the children concluded that it is easier to keep water clean than to have to clean it up once it was *polluted*. She introduced the term *protect* in the context of keeping water clean and not polluted.

Using Science Informational Texts: How Dirty is the Water?

Mrs. J asked the children to join her so she could read them several pages from a complex science informational text about water protection and conservation. She asked the children to be thinking about all the things they had been learning about and wondering about as she read aloud. As she read, she stopped several times to explain new terms and concepts, refer to terms already discussed, such as *pollution* and *protect*, and have the children turn and talk about strategic questions she posed. On one page, she drew the children's attention to a circle graph representing all the water available on Earth. The graph showed that 97 percent of the Earth's water is ocean water and less than 1 percent of the Earth's water is usable by people (for drinking, sanitation, cooking, growing crops) and for wildlife that need fresh water. She asked students to reflect back to the activity they conducted with the bucket and eyedropper of water. She asked students to discuss how this graph compares. On another page, Mrs. J read that all the water that exists on Earth right now is all that is available and, even though this water is recycled over and over again, it is impossible to make more.

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Investigative phenomenon: Fish died in a river after harmful chemicals were poured in.

When Mrs. J got to a page with a photograph of a polluted river with dead fish floating at the top, she asked the children to discuss with a partner what they thought had happened (EP&C II). She asked students to reflect back on the *polluted* water they cleaned the day before. To make sure her three EL students at the Emerging level of English language proficiency were able to engage in the conversations, she had paired each of them with an English-proficient partner who spoke the same primary language. She also used the water distribution activity and clean water challenge to provide context to the information in the text. After the children had had a chance to discuss their ideas, she called on a few of them to share. She called on Hernán, one of the EL children at the Emerging level of English language proficiency. At first, he was hesitant to respond, but then his partner, Victor, prompted him to respond in Spanish.

Hernán: *Se mueren. Los peces se mueren porque el agua está bien sucia*.

Victor: He says, the fish die because the water is very dirty.

Hernán: (Nodding, then repeating) The fish die. Water is very dirty.

Mrs. J: (Expanding on Hernán's response.) Yes, the water does look very dirty. It has a lot of greasy stuff and garbage in it (looking closely at the photograph and then showing it to the children). Is this like our polluted water yesterday? Let's read the caption underneath the photograph. It says that some harmful chemicals were dumped into it. Hernán, tell me more about what you're thinking.

Hernán: *Podemos… Podemos limpiar el río. Podemos limpiar el agua, y así, los animales, los peces pueden vivir*. The fish can live. And the river, we can also swim there. We can … we can clean the water.

Alicia: Yeah! We can clean it! We learned how to yesterday. Let's clean up the water so the fishes can survive!

Mrs. J: Do you think we can do that? Can we clean up the water? Can we protect the animals that live in water?

All of the children: Yeah!

Mrs. J: Okay! Well, let's see if we can find a way to do that. Let's read on to see what else we can learn from this book.

Investigative phenomenon: Water held deep underground can be contaminated by human pollution.

Later in the book, the children learned that, in some places in the world, people do not have access to clean water. In some places, aquifers have been contaminated, and water is

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scarce. Mrs. J asked students to think about the clean water challenge activity and explained that some people have only dirty water or very little water in their cup.

Alicia: How come the people don't have clean water to drink?

Mrs. J read the text, pointing to the illustration of an aquifer:

Some of our drinking water comes from under the ground in pools of water, called aquifers. People drill down into the ground, through soil and rock, to get the water, which we call ground water. Unfortunately, the ground water can become dirty, or contaminated, with things that shouldn't be in it, such as the chemicals in products people use to clean their houses. Some farms use chemicals on their crops, and that can get into the water, too.

Mrs. J: Let's think about that for a minute. It says that people drill through the ground to get water for drinking and to use for other things. But sometimes, things that are not safe for animals, plants, or people, like poisons in some chemicals, get into the aquifer, and they *pollute* the ground water. That can make people and animals sick if we drink the water. But, the aquifer is so far down in the ground, under the rocks and soil. How do you think the water gets polluted?

Mrs. J gave the children a few moments to think about this question, and then she asked them to discuss it in triads. Using the document reader, she projected an illustration in the book, which showed a model of how an aquifer can become polluted, and she told them that they should refer to the illustration as they explained their thinking. She listened carefully as the children discussed their ideas. Many of the children struggled to explain how the toxins in some chemicals might get from someone's house or lawn all the way down into the groundwater, and Mrs. J encouraged them to refer to the illustration. After a couple of minutes, Mrs. J strategically calls on one student, Inés, to explain what she and her partner, Rafael, discussed.

Inés: My partner say that maybe the bad stuff, the chem-, the chem-

Rafael: Chemicals. That's pollution!

Inés: Oh, yeah! He say the chemicals get into the ground, the ground water because maybe people they put it in the street, they pour it there, and it can all go down into the ground.

After hearing other children's explanations, Mrs. J realized that the concept of groundwater and how it can become polluted is quite complex for young learners and that the book alone is insufficient to help them understand this process. She decided that later that week, the children would build a classroom model of an aquifer so that they could observe its structure and how it works, as well as what happens when it becomes polluted. (The children would also build their own aquifers and take home a kit so they could recreate it at home to teach their families about aquifers.)

Writing an Argument: Why Should We Protect and Conserve Water?

Later, and after many discussions, book readings, videos, and hands–on experiences—including building both the class model and individual models of aquifers—the children had much to say about why people should protect and conserve water. Mrs. J asked the children if

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they would like to write a letter to the newspaper so that they could share their ideas with a lot of people. The children decided that this would be a way for them to help others know how to make choices that would help both the natural environment and their communities.

Mrs. J guided the children to co-construct the argument, prompting them to provide evidence to justify their claims. She explained that they should provide evidence from what they had read and discussed but that in science it is important to provide evidence from their investigations. During the joint construction of the text, she asked the children to tell her what to write, first by having them brainstorm all of the different ideas they could use, and then grouping the ideas together. Mrs. J. wrote the ideas on a chart, and then showed the children how she grouped them together by circling each word or group of words with a different color marker. Next, she asked the children to tell her what to write, using the ideas from the brainstorm and all of the ideas they had in their heads. She did not write what they said verbatim, but rather, supported them to rephrase and extend their thinking, as needed.

Henry: We could say, please don't get the groundwater dirty 'cuz we want to drink clean water, not dirty water.

Mrs. J: That's a great idea, Henry! Hmm… I'm thinking that there's another way of saying "get the water dirty." Maybe we could use one of the words from our "kid scientist" word wall.

Henry: Pollute! We could say, please don't pollute the groundwater 'cuz we don't want to drink dirty water. We want to drink clean water.

Mrs. J: Can anyone say more about why we don't want to drink polluted ground water?

Rafael: We don't want to drink the polluted ground water because when it's dirty like that, it can make us sick. That's what the book said.

Celeste: And, don't get the chemicals in there.

Mrs. J: Can you say more about that?

Celeste: Please don't get the chemicals in the water because that can make the fishes sick, and they can't survive. The polluted water can make people sick, too. And it's really, really hard to clean the water when it's polluted!

Solange: And if the river is polluted, we should clean it up 'cuz that's not fair to the animals that live there. They could die, and then the river is sick, too.

All of the students had ideas to add to the letter and solutions to this environmental problem: turn off the water when you brush your teeth so you don't waste it; use the bath water to water the plants because it's good to reuse water; and do not put chemicals into the ocean or rivers because then the fish get sick, and sometimes we eat the fish, and we don't want to get sick (EP&C V).

After the class had completed their letter to the editor, which Mrs. J typed up and e-mailed to the local newspaper, the children worked on creating a class book focused on teaching younger students about protecting the environment. They decided to call the book *We Can Protect Water*. Each child made a small poster with illustrations, labels, and writing, which was then gathered into a book that the children could read together in the library corner and later share with their families at the monthly family science nights.

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Teacher Reflection and Next Steps

When Mrs. J met with the kindergarten teaching team for their weekly grade-level planning time, the teachers shared their reflections about the learning segment and examined student work together. They used their observation notes and the children's science journals and big book pages to make strategic decisions about the teaching and learning tasks they would modify or add to the learning segment, as well as how they would plan scaffolding approaches for individual students. They also discussed the types of activities they would plan for the next monthly family science night, during which the students would teach their families what they had been learning about in science that month.

Based on their observations of student language use and analysis of written work, the teachers also discussed how they would design or adjust their designated ELD lessons moving forward. They used the CA ELD Standards to plan focused language development lessons for designated ELD, differentiated by the children's English language proficiency levels. These lessons build into and from the science teaching and learning tasks. For the EL children at the Emerging level, the teachers had noticed that the children were gaining confidence using everyday English, but they were not yet using some of the new domain-specific vocabulary (e.g., *pollute*, *protect*) needed to discuss the science ideas. Although she had taught these words explicitly to the whole class, Mrs. J felt that these children would benefit from some additional practice using them orally, so she planned structured conversations during which the children could use the new words as they discussed the illustrations in the books the class had been reading, using strategies such as sentence starters or conversation prompts that explicitly asked students to use the target words. For the EL children at the Expanding level, Mrs. J and the other teachers planned to try out a technique they read about called *sentence unpacking*, during which they discussed all of the meanings in the long, information–dense sentences that were in the science informational texts they read aloud to the children. The teachers recorded their agreements in their Team Meeting Record Sheet so that they could reflect on how the activities they planned have worked out when they met again the following week.

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