Engineering Connection: Design a Simple Water Filtration Process

As water passes through layers of the Earth in nature, contaminants are filtered out or settle. Sometimes, however, humans pollute the water with contaminants that are not naturally filtered out (EP&Cs II, IV). To protect the environment, humans also use water filtration to clean water so that we can use it or it can be returned to the natural environment. In 2014, California's Proposition 1 allocated almost $1.5 billion to groundwater cleanup efforts and future investments are also likely. Engineers will need to develop new techniques and procedures, and existing ones need to be refined to make them more effective and cheaper (EP&C V). In this activity, students play the part of groundwater contaminant engineers and design a simple filter to clean dirty or contaminated water (see "Hands-on Activity: Water Filtration," at https://www.cde.ca.gov/ci/sc/cf/ch4.asp#link21). Students **define the problem [SEP-1]**, **gather information [SEP-8]**, **plan a solution [SEP-6]**, and design and carry out a prototype given a set of constraints or limits, such as available materials, money, and/or time. The students can then gather information, work in teams to brainstorm a number of solutions, and compare them against the criteria and constraints of the problem to see which is most likely to succeed. Students are given a sample of "dirty" water made of safe classroom materials like twigs, dirt, sand, brown liquids (tea) and are presented with the challenge of cleaning the water with available materials: cotton balls, coffee filter, etc. Students first design a working **model [SEP-2]**, build it, test it, and then compare their filtered water against a color standard. Students can refine their design by trying to keep it effective but use less material.

IS4 Grade Five Instructional Segment 4: Patterns in the Night Sky

Each night, the Sun appears to set and the stars become visible. At first glance, stars appear to be randomly strewn about the sky with some shining brighter than others. As the human eye is drawn to patterns, ancient people imagined the brightest stars marking the outlines of animals and people. Modern students can use detailed measurements of where stars are in the night sky, how bright they are, and when they become visible to discover patterns in the motion of celestial bodies. IS4 provides the data and analysis that set the stage for much more sophisticated models of planetary motion and the origin of the universe in the middle grades and high school. IS4 has three independent sections: (1) Gravitational Force; (2) Patterns of Motion; and (3) Brightness of Stars.

GRADE FIVE INSTRUCTIONAL SEGMENT 4: PATTERNS IN THE NIGHT SKY

Guiding Questions

- How far away are the stars? How can we tell?
- What trends and patterns are there in the movement of the Sun and stars?

Performance Expectations

Students who demonstrate understanding can do the following:

5-PS2-1. Support an argument that the gravitational force exerted by Earth on objects is directed down. [Clarification Statement: "Down" is a local description of the direction that points toward the center of the spherical Earth.] [*Assessment Boundary: Assessment does not include mathematical representation of gravitational force.*]

5-ESS1-2. Represent data in graphical displays to reveal patterns of daily changes in the length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. [Clarification Statement: Examples of patterns in the sky could include the position and motion of Earth with respect to the Sun and select stars that are visible only in particular months] [*Assessment Boundary: Assessment does not include causes of seasons.*]

5-ESS1-1. Support an argument that differences in the apparent brightness of the Sun compared to other stars is due to their relative distance from Earth. [Clarification Statement: Absolute brightness of stars is the result of a variety of factors. Relative distance from Earth is one factor that affects apparent brightness and is the one selected to be addressed by the performance expectation.] [*Assessment Boundary: Assessment is limited to relative distances, not sizes, of stars. Assessment does not include other factors that affect apparent brightness (such as stellar masses, age, and stage).*]

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	ESS1.A: The Universe and Its Stars ESS1.B: Earth and the Solar System	[CCC-1] Patterns [CCC-2] Cause and Effect: Mechanism and Explanation

CA CCSS Math Connections: 4.MD.6; 5.NF.6; 5.G.2

CA CCSS for ELA/Literacy Connections: RI.5.3; W.5.7, 10

CA ELD Standards Connections: ELD.PI.5.1, 5, 11

The night sky is full of wonder. Grade five students should begin by asking questions about the stars, the planets, and space exploration. During this segment, teachers should strive to relate the learning required in the CA NGSS to students' interests and emphasize questions about "how far?" and "how do we know?"

Gravitational Forces Pull Down

Grade five is the first time that students explicitly focus on gravity in the CA NGSS, though they may have used it as an example of a force in grade three. The gravitational force is an extension of other noncontact forces (a force that acts even when objects are not touching) that students investigated in grade three (magnetic and electrostatic electricity). Gravity has a profound impact on our everyday lives and is also foundational to Earth's place in the universe (ESS1), though the connection to planetary motion is beyond grade five. At this point, students just need to gather evidence that gravity always pulls objects downward. Since students cannot directly observe forces, they will need to plan and conduct investigations to help them understand that objects move in the direction in which forces are applied (3-PS2-1). Downward is a relative term—it refers to the center of the planet. For astronauts in orbit, the direction of down is constantly changing as they circle around the planet. They feel weightless because they are constantly falling around the planet.

Opportunities for Mathematics Connections

Students can tie a string to a meter stick and attach a weight to the string. Using a carpenter's level (or calibrated smartphone app), students can arrange the meter stick so that it is perfectly horizontal. Then, students measure the angle between the meter stick and the string. Since gravity always pulls downward, the angle should always be 90 degrees. Students will find it challenging to get precise measurements because the meter stick will not be exactly level and the string will swing back and forth. By sharing multiple measurements, students can see the power of averaging multiple results to minimize experimental error.

CA CCSSM: 4.MD.6

Earth Patterns: From a Day to a Year

Students observed the patterns of shadows, the Sun, and Moon in grade one (1-ESS1-2), but now they bring the more advanced quantitative skills to analyze the data. A fifth-grade class could partner with a first-grade class to collect observations. The fifth graders would prepare graphs and presentations and present them back to their first-grade buddies (planet partners). Students can make graphs of the length of shadows throughout a day, the length of shadows at the same time every day for a month or more, or the number of daylight hours throughout the year. Measurements should begin early in the school year so that students have data to analyze during this instructional segment. Students can use free planetarium software (e.g., Stellarium at https://www.cde.ca.gov/ci/sc/cf/ch4.asp#link22) to simulate measurements during the night. Measurements should begin early in the school

year so that each student can track a different star every two hours for a week's worth of nights; this can be done much more quickly in a simulator than in real life. After recording data, they can plot their star's position by its compass angle and observe how its position changes. What patterns do they recognize? How often do these patterns repeat? Can they predict the star's position 24 hours in the future? It will be in a similar position, but not identical. How about six months in the future? Some students will discover that their star is not visible six months later. This might prompt students to collect data at longer time intervals such as at the same time every month for a year or two. The goal is for students to recognize that there are multiple cycles of motion occurring simultaneously. The Sun and stars return to a similar location every 24 hours, but their position slowly migrates over the course of 365 days. Students will explain these patterns using a model in the middle grades, but students should recognize similarities between the behavior of the Sun and the stars. These similarities imply that whatever causes one to appear to move likely causes the others.

Opportunities for Mathematics Connections

Students obtain information about sunrise and sunset times from an online database. They calculate the length of daylight by representing hours and minutes as mixed numbers (5.NF.6). They plot the number of hours of daylight versus the number of days since January 1 (numbers from 1–365) in the first quadrant of the coordinate plane. What **trends or patterns [CCC-1]** appear? Students **ask questions [SEP-1]** about what **causes [CCC-2]** these patterns. How long does it take for the pattern to repeat? Having different students use data from different years allows students to recognize that the pattern repeats almost exactly every 365 days.

CA CCSSM: 5.NF.6; 5.G.2

Far, Far Away

Ask students to draw what the night sky looks like and most of them will include a few bright stars surrounded by immense blackness (and possibly the Moon, though it is a feature of the daylight hours as often as it is the night sky). If students observe the night sky through small telescopes or even binoculars, they see that the dark sections of the sky are not as dark as they thought. They are filled with thousands of stars and galaxies too far and too dim to see with the naked eye. Students can experience a similar phenomenon by making a **physical model [SEP-2]** of stars on the schoolyard using flashlights. Each student goes to a different place on the schoolyard and holds an identical flashlight. Students that are close together can see one another's flashlights shining, but it is hard to tell if distant flashlights are on or off. What would happen if one flashlight were

brighter than the others? Students can refine their model for what determines the apparent brightness of a star to include both the amount of light energy released by the star (called *absolute brightness* in astronomy) and how far away the star is from Earth.

The Sun is the closest star to Earth and for this reason it appears larger and brighter than any other stars in our galaxy. The factors affecting absolute brightness of stars are beyond the fifth-grade level and students will only be assessed on their understanding of the role of distance in determining apparent brightness (5-ESS1-1). The farthest stars away in the universe are hardly even visible with the best telescopes. When the Hubble space telescope pointed in the same spot in the darkest part of the sky for 10 days straight, it gathered enough to see the faintest stars ever observed. This Hubble Deep Field image (https://www.cde.ca.gov/ci/sc/cf/ch4.asp#link23) is a profound reminder that even something that appears to be nothingness holds more complexity in it than we can imagine.

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 ELD and science, the State Board of Education commissioned a document with examples of how the state ELD standards and the CA NGSS can complement one another (https://www.cde.ca.gov/ci/sc/cf/ch4.asp#link24). Excerpts from that document appear throughout this chapter as "Sample Integration of Science and ELD Standards in the Classroom."

The vignette below provides 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 performance expectations featured in this vignette also appear with snapshots in IS3 in grade three to provide different perspectives on how to teach the same content.

This particular vignette highlights scaffolding approaches for EL students 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.

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Performance Expectations

Students who demonstrate understanding can do the following:

3-LS4-3. Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. [Clarification Statement: Examples of evidence could include needs and characteristics of the organisms and habitats involved. The organisms and their habitat make up a system in which the parts depend on each other.]

3-LS4-4. Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.* [Clarification Statement: Examples of environmental changes could include changes in land characteristics, water distribution, temperature, food, and other organisms.] [*Assessment Boundary: Assessment is limited to a single environmental change. Assessment does not include the greenhouse effect or climate change.*]

**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-3] Planning and Carrying Out Investigations [SEP-6] Constructing Explanations (for science) and Designing Solutions (for engineering) [SEP-7] Engaging in Argument from Evidence	LS2.C: Ecosystem Dynamics, Functioning, and Resilience LS4.C: Adaptation LS4.D: Biodiversity and Humans	[CCC-2] Cause and Effect: Mechanism and Explanation [CCC-4] Systems and System Models

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.3.1, 2, 7; SL.3.1, RI.3.3

CA ELD Standards Connections: ELD.PI.3.1, 2, 4, 6, 10, 11, ELD.PII.3.1

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Introduction

Mr. B's third-grade class is learning how people's activities and behavior can change animal habitats (EP&C II). Mr. B's goal is to provide a variety of rich, hands-on interactive learning experiences in which his students observe the natural world, learn from texts, discuss their thinking, and work collaboratively, all with the goal of making a positive impact on animal habitats through mitigating human damage (EP&C V). Mr. B wants his students both to learn about the area in which they live and understand that they could positively affect the environment through their words and actions. The big ideas that guide Mr. B's planning for the instructional segment are as follows:

- *We can explain why some animals can survive well, some survive less well, and some cannot survive at all in different habitats.*
- *We can explain how humans impact animal habitats and make an argument for protecting them by making evidence-based claims.*

Mr. B's class of 34 students is comprised of 20 native English speakers or students who are bilingual and proficient in English and 14 students who are ELs. Of the 20 students proficient in English, the majority speak a nonstandard variety of English or a language other than English with their families. Twelve of the ELs are at the Expanding or early Bridging level of English proficiency and use everyday English comfortably. Two of Mr. B's students have recently arrived in the United States and are at the early Emerging level of English proficiency. The majority of Mr. B's ELs and many of his bilingual students speak Spanish as their home language, but he has two students who speak Hmong as a home language. Mr. B's goal is for each of his students to successfully engage in the academic and linguistic content of the class, and he works hard to provide the supports necessary for them to succeed.

Lesson Context

Investigative phenomenon: Different numbers and types of plants and animals grow in different parts of the schoolyard.

Earlier in the year in a previous instructional segment, students began to learn what plants need in order to grow and what they get from the ecosystems where they live. In this instructional segment, Mr. B's students have started to learn about the diversity of life in different habitats. He started the learning segment by taking his students on a field trip in which they spent the morning examining nearby habitats. To help his students become excellent observers and data collectors, he asked them to take their science notebooks with them to make notes, in whichever language they were most comfortable writing, and to draw pictures about the plant and animal life they observed. The students examined the school garden, the neighborhood near the school, and a nearby wooded park. Students recorded the number of different plants and animals in each area. When they returned to the classroom, the students discussed the differences in the living things they observed in each habitat, and Mr. B led the class through

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a discussion that culminated in the jointly constructed statement: "Different numbers and types of living things, including plants and animals, live in different habitats." Mr. B facilitated a class conversation about what data could be used to support this statement such as the number of different trees observed in each area. This is added to the statement.

Investigative phenomenon: Different plants and animals grow in different parts of California.

Mr. B and his students had also read and collaboratively discussed two informational texts, "Would Blackberries Grow…?" and "What a Joshua Tree Needs from the Desert" (available at https://www.cde.ca.gov/ci/sc/cf/ch4.asp#link25). Mr. B posted Word Wall Cards (available at https://www.cde.ca.gov/ci/sc/cf/ch4.asp#link26), and he helped the students add translations of the words in their home languages. Mr. B taught these words to students, and he modeled how to use them as often as he could. Additionally, Mr. B facilitated a discussion in which his students connected their observations of the diversity of life in the habitats they observed and read about to the California Habitats wall map (available at https://www.cde.ca.gov/ci/sc/cf/ch4.asp#link27). The students wrote sentences that described the similarities and differences between what they observed on their nature walk and the plants and animals highlighted on the map.

The children were building both their science conceptual understandings and language and literacy skills, all of which they used to create informational posters that included an evidence-based argument about how some animals survive well, less well, or not at all in a particular habitat; photographs or illustrations that show the animal habitats they have researched; data that show human impact on the habitat (graphs or tables); and suggestions for what students and their families can do to reduce the impact humans make on animal habitats. The students presented their posters to their families on the school's Family Science Exhibition Night. Each student also wrote a letter to the editor of the local newspaper to engage the community to care about and protect local animal habitats. The following learning target and CA NGSS performance expectations guide teaching and learning for the lesson.

Learning Target

We will create posters that explain how humans affect animal habitats and suggest ways we can protect them (EP&Cs II, V). We will write letters to the editor arguing why we should protect animal habitats.

CA NGSS Performance Expectations

3-LS4-3. Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.

3-LS4-4. Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.

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Lesson Excerpts

Since Mr. B's students had started to build up an understanding of animal and plant diversity in habitats, he was ready for them to begin examining the impact humans have on animal habitats. He posted two questions that the children would consider over the course of the next several days:

- How can human activities change the habitats where plants and animals live?
- How do these changes affect the survival of the plants and animals that live there?

Everyday phenomenon: Animals lose their homes when people cut down trees.

Mr. B began the lesson by asking the class to think about a human activity that might affect an animal's habitat. He first gave an example: When humans cut trees down to make things, like houses and paper, some animals might lose their homes. Then, he asked his students to think about as many ideas as they could and gave them a few moments to do so. As the students thought, Mr. B checked in with his two students at the Emerging level of English language proficiency to ensure they understand the question. After the students had had time to think, Mr. B asked them to share with their partners using an open sentence frame in order to challenge them to include human impact and its effects:

When humans _____ (cause), _____ (effect), **[CCC-2]**.

He listened in as students shared their ideas. He heard some students share an idea very similar to his, while other students said things such as, "When humans make a parking lot, and that's where there were trees before, I think it causes animals to lose their homes, like birds and squirrels and stuff," and "When humans put pollution in the air, because they're driving their cars a lot, I think the animals can get sick or die because they can't breathe clean air."

Meaningful Interaction with Science Informational Texts:

Mr. B's next step was to help his class to understand deeply the relationship between an animal, the animal's habitat, and human actions that affect an animal's habitat. To help build his students' understanding, he chose the relationship between the monarch butterfly, the milkweed plant, and the elimination of milkweed due to human use of weed killer (EP&C II).

Investigative phenomenon: Mallow plants grow taller when they have the right amount of water and sunlight.

To provide context to the monarch story, Mr. B had his students raise painted lady caterpillars and mallow plants in the classroom. Students planned and conducted investigations about how the amount of water and sunlight might affect the height of the mallow plants (3-LS3-2).

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Investigative phenomenon: Caterpillars follow a specific life cycle and grow into butterflies.

Students also observed the development of the caterpillars into a chrysalis and then an adult butterfly. Students conducted safe and respectful investigations to understand how the environment (food, water, space) could affect the butterfly. These investigations were necessary to provide context when students interacted with informational text. The data from the investigation would also be used when students needed evidence to support their claims later in the unit.

Investigative phenomenon: Monarch caterpillars eat milkweed plants.

Mr. B read aloud the informational text *Monarch and Milkweed* by Helen Frost and Leonid Gore. He read the text to the children as they sat on the carpet. Being cognizant of each student's level of English proficiency as well as science content knowledge, Mr. B pre-assigned students to heterogeneous partnerships so all student had thinking buddies. Mr. B reminded students that they had already learned a great deal about another type of butterfly, the painted lady, as well as one of the butterfly's food sources, the mallow plant. He explained that they were now going to learn about another butterfly, the monarch. As Mr. B read, he stopped periodically to define words and to prompt his students to repeat words and definitions and to make an accompanying hand gesture that will help them remember the words. For example, when Mr. B came to the word *migrate*, he said, "Migrate means to travel in a group from one place to another." He said the word clearly and then asked his students to chorally repeat the word and the definition while also making the motion of moving their hands from the center of their chest straight out away from themselves, making wriggle fingers to show both movement and that it is a group of many.

Throughout the book, Mr. B stopped periodically to ask students questions and make connections to their previous butterfly investigations. He also allowed them time to think then share with their partners after each question, to ensure they understood the reading. He emphasized how illustrations can help the students understand the scientific concepts, as when an illustration shows the caterpillar inside the chrysalis. He asked students to compare the illustrations in the text with their own drawings of the painted lady butterflies from their previous investigations.

When Mr. B got to the end of the book, he asked his students to discuss with their partners the questions: What would happen if most of the milkweed were gone? What did we learn about the painted lady butterfly and the mallow plant? He listened closely as partners discussed. Once the students had had about a minute to discuss with their partners, he brought the class back together and asked a few partners to share out. Mr. B had an instructional routine in which

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when one partner shares, and the other partner also has to share by adding on to their partner's response.

Mr. B called on a pair of students, Veronica, who is at the early Emerging level of English language proficiency and has a grasp of some academic Spanish because of her schooling in Mexico, and her thinking buddy, Alicia, who is bilingual. Both girls speak Spanish as their home language.

Mr. B: Veronica and Alicia, I would like you to respond. Which of you will go first? (Veronica and Alicia confer briefly.)

Alicia: I'll go first and Veronica will add on. We think the butterflies will die.

Mr. B: Yes, that does seem likely. I'd like to hear more. Why do you think the butterflies will die? Veronica, can you say more?

Veronica: I…I think…

Alicia: (whispering to Veronica to prompt her) I would like to add…

Veronica: I would like to add…that…butterflies need milkweed to…*¿Cómo se dice sobrevivir?*

Alicia: *¿Sobrevivir?* Uh … Survive!

Veronica: Butterflies need milkweed to survive, so…*cuando*…when the milkweed… (turning to Alicia) *¿Puedes decirlo tu?*

Alicia: If all the milkweed is gone, the butterflies would die.

Mr. B: Thank you, Veronica and Alicia. (He writes under the document camera, "Butterflies need milkweed to survive, so when the milkweed is gone the butterflies die.") (To Veronica and Alicia) Is that right? (Both girls nod their heads). Let's see if we can expand on that idea a little bit. (Mr. B chooses another pair to share, Bryan and Santiago. Bryan is a native English speaker and Santiago is an English Learner at the early Bridging level of English proficiency). Bryan and Santiago, can you elaborate on Veronica and Alicia's ideas?

Bryan: The butterflies are a special kind called monarch butterflies.

Mr. B: (Adds the word monarch before butterflies in Alicia and Veronica's sentence.) Thank you for being specific about the type of butterfly.

Santiago: I don't know what else to say.

Mr. B: Let's see if we can figure it out together. Can you say anything more about this idea of the butterfly surviving? Can we unpack that a little bit? (Picking up on the students' hesitation, Mr. B makes an adjustment to address vocabulary.) In fact, this might be a new word for some of us. Let's all say the word survive. (The class chorally says the word.) Survive means to continue to live. Let's all say that. Survive means to continue to live. (The class chorally repeats the definition.)

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Mr. B quickly provided the sentence frame: "_____ helps _____ survive by ..." He said, "We're going to practice using the word survive." He modeled, touching the appropriate part of the posted frame as he spoke, "Sunlight helps plants survive by providing energy for plants to turn into food." He had students take turns completing the sentence frame with their elbow partners for one minute. During this time, Mr. B paid particular attention to the sentences the ELs produce; he used these observations when determining what kind of support to provide during subsequent tasks. Mr. B then gave students another 30 seconds to practice completing the sentence frame, this time focusing their sentences only on monarch butterflies.

Mr. B: Santiago, what is one way milkweed helps the monarch butterfly survive? I'd like you to use the stem "Milkweed helps the monarch butterfly survive by..." (Mr. B writes this stem below the document camera, under the sentence the class has started.)

Santiago: Umm. Okay. Milkweed helps the monarch survive by giving it... Can you go back to the page about the caterpillar?

Mr. B: (Opens the book to the page about the caterpillar.) This one?

Santiago: Yeah. Milkweed helps the monarch butterfly survive because... it hangs on the leaf.

Mr. B: The caterpillar is hanging there, yes. Let's brainstorm a list of all the ways the milkweed plant helps the monarch butterfly.

He writes, The milkweed plant helps the monarch butterfly by providing a place for the caterpillar to hang while it grows. He prompts the class to echo read the statement; this practice gives all students an opportunity to develop their expressive reading skills. Mr. B continues to elicit responses from different students, supporting them as they develop their ideas and clarify their understandings about the importance of the milkweed plant to the life cycle of the monarch.

Investigative phenomenon: Monarch butterfly populations are shrinking.

The next day, Mr. B had the class engage in an "Expert Group Jigsaw" reading using texts about threats to the monarch butterfly (including a Newsela article called "Scientists worry over disappearing monarch butterfly"). The children had engaged in this type of collaborative reading activity before and enjoy its game-like flavor. They took their science notebooks, which they used to take notes, as they convened in their expert groups. The process they used was as follows:

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Expert Group Jigsaw Procedure

Step 1: Students read a text independently in their Expert Groups. The expert groups convened. Sometimes, groups would be put together randomly (by counting off, for example). At other times, teachers wanted to group students strategically to balance/leverage strengths, learning needs, and interests. Each person in the same expert group read the same text, but each of the different expert groups read a different text. This could be different sections from the same text, or it could be different texts that provide various lenses on the same topic. Each student read their text independently, along with focus questions and a note-taking guide (graphic organizer) to take notes.

Step 2: Students become experts in their Expert Groups. In this step, each person was responsible for adding information from their independent reading, noting (in their note-taking guide) what others shared, and building on what has been shared. After the initial sharing, the students moved on to discussion questions about the text where they could delve deeper into the text together and further develop their expertise of the topic. At the end of this phase, the group members agreed on key points they would each share in their jigsaw groups.

Step 3: Students share their expertise and learn from others in Jigsaw Groups. Students convened in their jigsaw groups, comprised of one (or two) people from each expert group. Each person shared their expertise while the others took notes and asked clarification or elaboration questions. Once each person had shared, the group sometimes had an additional task, such as synthesizing the information that had been shared or discussing one or more of the big ideas from the different readings.

Step 4: Students share what they learned in their Expert Groups.

After the class had researched the threats facing the monarch butterfly, Mr. B asked students the two overarching questions for the instructional segment:

- How can human activities change the habitats where plants and animals live?
- How do these changes affect the survival of the plants and animals that live there?

The children discussed these questions in small groups of four students, who then have an opportunity to share out their responses.

Preparing to Create Posters

After his students had connected closely with the idea that humans can impact the habitats of animals (EP&C II), Mr. B wanted to bring their understanding back to the animal habitats around the school.

Mr. B took the class on a second nature walk. The students explored an unused parking lot near the school, and they made a return visit to the nearby wooded park. As they visited these sites, the students made notes and/or simple drawings in their science notebooks about the condition of the habitats and abundance of plants and animals in each. They also made observations about the number of different plants and animals in each area. Mr. B told his students to note if an area had lots of different plants and animals, if it had mostly one type covering the area, or if there were few plants and animals over all. He encouraged his students to record specific data such as numbers of plant types or descriptive words from their word bank.

Once the class returned to the classroom, Mr. B led a Talking Points activity to help his

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students bolster their learning and understanding. In this activity, Mr. B wrote a series of statements related to the lesson's learning goals, and students had to agree or disagree with the statement, using evidence to support their stance.

Mr. B wrote the statements on a piece of paper and using the document camera, revealed one at a time. Both to prompt all students to include their rationale and/or evidence in their responses and to support ELs who may need help structuring their responses, Mr. B included sentence frames:

- Some habitats have more plants and animals than others. (I agree/disagree that some habitats have more plants and animals than others because _____.)
- An animal's habitat helps it to survive, or live. (I agree/disagree that an animal's habitat helps it to survive because _____.)
- Humans have no impact on animal habitats. (I agree/disagree that humans have no impact on animal habitats because _____.)
- Humans can help make animal habitats healthier. (I agree/disagree that humans can help make animal habitats healthier because _____.)

After he uncovered each statement, Mr. B asked the students to turn and talk with their thinking buddies. He encouraged students to use data from their nature walk to support their statements. Mr. B made a point to listen to all of his students' conversations, but he took special care to ensure his EL students had understood the task and were actively participating.

As students shared out, Mr. B charted their ideas because he wanted students to be able to use these ideas when they made their posters. He didn't write the exact words the students said. Instead, he worked with students to jointly construct statements, making sure to capture students' intended meaning in error-free, grammatically sound sentences. He created an anchor chart for each statement that included different pieces of evidence students gave to support their ideas. Two sample anchor charts for the statements are shown below.

Statement: Some habitats have more plants and animals than others.

We agree!

- We observed many different types of plants and animals in the park. There were at least five different types of trees and we counted six squirrels and four kinds of different birds.
- We observed almost no plants or animals in the parking lot. Some weeds grew through cracks. Only one bird was standing on the edge of the parking lot.

Statement: Humans have no impact on habitats.

We disagree!

- People paved the parking lot so no trees are left there. Without trees, many animals have no home.
- People killed milkweed with weed killer. Monarchs need milkweed to survive. Milkweed is important to the monarch habitat.
- People build whole cities and the animals have to find somewhere else to live.

After Mr. B had worked with his students to create each of the three anchor charts, he challenged them to come up with ideas about what they as individuals or as a class might do

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to decrease the effects of human activities on the habitats of plants and animals (EP&C V). Mr. B's class came up with many great ideas, such as the following: plant milkweed in the school garden; use less paper so we have to cut down fewer trees; and pick up trash from the park. Mr. B charted these ideas as well, leaving them up as support for students when they create their own lists of suggestions for their posters. Mr. B encouraged his students to justify the merit of their solution with evidence from their investigations.

Mr. B concluded that students were prepared to move into writing. He wanted to support his students in successfully writing an informational report, so he brought out a model text that he had created. Mr. B wanted to help his students learn about the features of the type of text they would write, but he wanted students to use their own ideas for the text they would write independently. So the model text was written in the style of an informational report, but on a subject the class studied earlier in the year— what plants and animals need to survive. The class examined the purpose of the text (to provide information), as well as the parts of the text, including the claim (general topic statement), followed by several pieces of data from investigations and details that support the claim, and then a concluding statement.

Before releasing students to write on their own, Mr. B led his students through jointly constructing a text on a closely related topic: How does its habitat help an animal survive? The students were sitting on the carpet next to their thinking buddy while Mr. B wrote the text on chart paper. The class decided to focus its informational report on one animal with which the students were all familiar—the monarch butterfly. Mr. B helped his students refine their thinking and phrasing, as necessary, as they worked to jointly construct an informational report.

Mr. B: We first have to tell our reader what we're going to be writing about. What could we say? (He gives students about 10 seconds to think.)

Npaim: We could say we're going to tell you all about monarch butterflies!

Mr. B: That's certainly accurate! I wonder if there's a way that we can tell our readers a little bit more.

Npaim: Oh! Their habitats. We're going to tell you all about the habitat of the monarch butterfly.

José Luis: Yes, they have to have...what's it called? That milk plant?

Adriana: Umm...milkweed!

Mr. B: Thank you for sharing your ideas! Let's see if we can turn that into a sentence that makes us sound like scientists. What if we write, "The monarch butterfly depends on—that's another way to say *has to have*—milkweed to survive?"

Npaim: But, we didn't use habitats.

Mr. B: Thank you for that observation. Let's make sure we use the word habitat. Does anyone have any ideas on how to use the word habitat here?

Mr. B continued to facilitate the discussion as he and the class jointly construct the text, paying careful attention to the structure, thus "apprenticing" his students into using the language of science.

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Mr. B continued to facilitate the discussion as he and the class jointly construct the text, paying careful attention to the structure, thus "apprenticing" his students into using the language of science. Once they had jointly constructed the text, Mr. B released most of the class to independently write the informational report that would go on their posters. He directed the students to the anchor charts on the walls as well as the Word Wall. His students also knew that they could rely on one another as resources when they were writing. While most of the class was writing independently, Mr. B pulled a small group—his students at the early Emerging level of English language proficiency and two other students whom he has determined need additional, individualized support with their writing. With these students, he provided greater scaffolding throughout the writing process, first by helping them brainstorm and outline their ideas and then with more one-on-one support as they constructed their informational reports.

Once students had finished their informational reports, Mr. B led the class through a peer review, in which each student compared their informational report with that of another student. Mr. B told the students that they should compare how evidence from the investigations was used in the text. Was it convincing? Was there enough evidence? Did the evidence fit with the claim (appropriate)? He also asked students to compare the logic used to connect the evidence to the claim. Was it convincing? Mr. B provided a checklist of the features each report should include to assist students as they worked together, and he rotated around the room as students shared and discussed their writing, providing assistance as needed. He then delivered a mini-lesson on expanding their writing by including additional evidence, after which each student expanded at least one sentence in their informational reports.

Once students had finished revising their informational reports, they finished their posters by writing a list of ways humans can help restore or protect animal habitats (EP&C V). They also found pictures and drew illustrations that showed the animals and habitats they wrote about. The students presented their posters to their parents at the school's Family Science Exhibition Night. They led their families on a gallery walk of the classroom, serving as docents, as they explained the posters and helped them conduct some science investigations at the many stations around the room.

Collaborative Research Projects and Engaging the Local Community

Investigative phenomenon: How can humans reduce their impact on local wildlife?

After researching and creating posters about the monarch butterfly and its habitat, the class delved into collaborative research projects in small groups (three to five children in each group). Mr. B invited several speakers to share their knowledge with the class, including a wildlife biologist from the local university and a docent from a local wildlife conservation center. After hearing and reading about different animal habitats that are under threat from human impact, in their small research groups, the children selected a California animal habitat under threat, researched it together, and individually wrote letters to the editor of the local newspaper to inform the public and engage them in thinking about environmental protection.

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To learn how to write effective letters to the editor (arguments), Mr. B supported the students as they analyzed published letters written by other students in grades three through five, such as the following:

Balance wildlife and energy needs

Wind power is both a valuable source of renewable energy and a terrible threat to birds and bats. Wind turbines—located in the Altamont Pass, Tehachapi Mountains and the Montezuma Hills—kill birds in flight and they take up valuable habitat.

Wind turbines kill roughly 108,000 birds and thousands of bats each year in California. A recent study published in Biological Conservation says that while 10 percent of the United States' wind energy is produced in California, 46 percent of all yearly wildlife kills are caused by California's wind turbines.

Although there are other causes of bird deaths— like collisions with telephone wires and buildings and attacks by house cats and feral cats —turbines are an important problem, especially for raptors, which glide with the wind and are often found in windy places where the turbines are located.

California Department of Fish and Wildlife biologist Elliot Chasin says one solution is to locate wind farms in altered lands far from nesting habitats. Using shrouded turbines also helps birds avoid the blades. You can help by telling your elected officials that it is important to balance the needs of wildlife with the needs for renewable energy.

Braeden Ingram
Fifth grader
Korematsu Elementary School

Pesticides can do great harm

My name is Emily Jiang and I am part of my school Nature Bowl team. I am currently working on an environmercial. That is an environmental report on a local issue. My issue is biomagnification and bioaccumulation of legacy pesticides.

Just to be clear, biomagnification is the increasing concentration toxins as they moves up a food chain. Bioaccumulation is the increasing concentration of a toxin from the environment to the first organism in a food chain. Legacy pesticides are a group of banned pesticides that include dichlorodiphenyltrichloroethane (DDT), the chlordanes and dieldrin. So if you put them together, it equals an amazing but deadly link.

Here's an example: If a sufficient amount of DDT was sprayed on a marsh to control mosquitos, then plankton will eat that, and then a clam will eat that plankton, and then a gull will eat that clam.

But then the amount of DDT in that gull will be lethal, killing that bird.

You see how big of a problem this is. But many people don't. They think that when they spray a pesticide onto some grass, or on a marsh, at most it will harm a small insect. That can cause a huge blowout, which will end up harming a much larger and threatened organism.

There are plenty of ways I am going to help. The best way will be to raise awareness. But what you can do is to tell your friends how big of a problem this is, and have them tell their friends. Hopefully, this will make people think twice about using dangerous pesticides like the legacy pesticides.

Thank you very much for taking part in helping our society.

Emily Jiang
Davis

(Ingram 2014, Jiang 2014)

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Some of the letters to the editor called for people to spread the word or call their local representatives. Others provided suggestions for taking action in daily life. Mr. B and the parent volunteers took care to avoid influencing the position that students were taking, limiting their guidance to supporting the development of students' writing skills. Students, working in small groups, completed appropriate editing and revision; then they had writing conferences with Mr. B and parent volunteers (over the course of the next several months), each of the children's letters was published in the local newspaper and/or an online venue. In addition, the children were inspired by some of the letters they read to produce their own short *environmercials*, which the principal of their school posted to the school Web site.

Teacher Reflection and Next Steps

During all of the conversations and tasks, Mr. B had been observing his students carefully so that he could plan appropriately for their learning for the rest of the instructional segment. He saw that some of his students were having trouble using sufficient details in their writing, while others were veering from the topic. This prompted him to incorporate more tasks into future lessons to help his students use more details and stick more closely to the topic they were writing about. He knows from analyzing student writing and monitoring their conversations that most students understood the big ideas of the lesson, so he planned to design and implement more well-rounded lessons in which students have multiple opportunities to interact with one another as they work with science concepts in a real-world context.

During designated ELD time, Mr. B also used his observations, notes, and the CA ELD Standards to plan focused language development lessons that built into or extended from his integrated lessons. He had noticed that the EL students at the Emerging level of ELD were using more everyday and social language but needed more support with academic vocabulary. He planned several vocabulary lessons for designated ELD time so that students had a range of opportunities to use the target general academic (Tier 2) and domain-specific (Tier 3) words, as well as lessons that look specifically at language features used within informational reports (e.g., subheadings to organize information, present tense, etc.).

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