Engaging in Phenomena from Project-Based Learning in a Place-Based Context in Science

Integration of language and content, including science, has been called for all students, and this is a challenge for ELLs in particular, who are tasked to learn the content in the language they are still developing. This call has become a policy initiative with direct impact on classroom teaching through the Common Core State Standards (CCSS) for English Language Arts (ELA) & Literacy in History/Social Studies, Science, and Technical Subjects (National Governors Association Center for Best Practices [NGA] & Council of Chief State School Officers [CCSSO], 2010a), on the one hand, and the Next Generation Science Standards (NGSS; NGSS Lead States, 2013a), on the other hand. The NGSS became public in 2013, while implementation of the CCSS has been underway since adoption starting in 2010.

The CCSS emphasize literacy in history/social studies, science, and technical subjects for Grades 6–12 as follows:

The grades 6–12 standards are divided into two sections, one for ELA and the other for history/social studies, science, and technical subjects. This division reflects the unique, time-honored place of ELA teachers in developing students’ literacy skills while at the same time recognizing that teachers in other areas must have a role in this development as well.

Part of the motivation behind the interdisciplinary approach to literacy promulgated by the Standards is extensive research establishing the need for college and career ready students to be proficient in reading complex informational text.
independently in a variety of content areas. Most of the required reading in college and workforce training programs is informational in structure and challenging in content; postsecondary education programs typically provide students with both a higher volume of such reading than is generally required in K–12 schools and comparatively little scaffolding. (NGA & CCSSO, 2010a, p. 4)

In the NGSS, “every effort has been made to ensure consistency between the CCSS and the NGSS” (NGSS Lead States, 2013b, p. 1). While connections to the CCSS for ELA are included across all grade levels/bands in the NGSS, connections for Grades 6–12 are highlighted in the NGSS Appendix M (2013b):

Literacy skills are critical to building knowledge in science. To ensure the CCSS literacy standards work in tandem with the specific content demands outlined in the NGSS, the NGSS development team worked with the CCSS writing team to identify key literacy connections to the specific content demands outlined in the NGSS. (p. 1)

In this chapter, we address the CCSS for literacy in science for ELLs in Grades 6–12. We highlight three key ideas. First, we describe how the CCSS, interwoven with the NGSS, present ELLs with learning opportunities and demands in both language and science. Second, we focus on specific demands as well as opportunities that ELLs may experience as they engage in argumentation. Third, for pedagogical practice, we combine components of project-based learning (engaging in phenomena) with place-based learning. The classroom vignette illustrates learning opportunities and demands in language and science for middle school ELLs.

The Common Core State Standards and Specific Demands for ELLs

The CCSS for ELA and literacy offer “a portrait of students who meet the standards set out in this document” (NGA & CCSSO, 2010a, p. 7). The CCSS further state, “As students
advance through the grades and master the standards in reading, writing, speaking, listening, and language, they are able to exhibit with increasing fullness and regularity these capacities of the literate individual” (p. 7). The seven capacities or practices for ELA and literacy include:

1. Demonstrate independence
2. Build strong content knowledge
3. Respond to the varying demands of audience, task, purpose, and discipline
4. Comprehend as well as critique
5. Value evidence
6. Use technology and digital media strategically and capably
7. Come to understand other perspectives and cultures (p. 7)

In a similar manner, “A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas” (National Research Council, 2012), from which the NGSS were developed, highlight science and engineering practices. The framework emphasizes “developing students’ proficiency in science in a coherent way across grades K-12 following the logic of learning progressions” (p. 33). The eight science and engineering practices include:

1. Ask questions (for science) and define problems (for engineering)
2. Develop and use models
3. Plan and carry out investigations
4. Analyze and interpret data
5. Use mathematics and computational thinking
6. Construct explanations (for science) and design solutions (for engineering)
7. Engage in argument from evidence
8. Obtain, evaluate, and communicate information (p. 3)
Science and engineering practices are language intensive, and engagement in these practices requires science classroom discourse (CCSSO, 2012; Lee, Quinn, & Valdés, 2013). Students speak and listen as they present their ideas or engage in reasoned argumentation with others to refine their ideas and reach shared conclusions. They read, write, view, and visually represent as they develop their models and explanations. These practices offer rich opportunities and demands for language learning at the same time as they promote science learning.

This chapter highlights three key ideas. First, across the CCSS and NGSS, these new standards share a common emphasis on disciplinary practices and classroom discourse. These practices raise the bar for content (academically rigorous), raise the bar for language (language intensive), and call for a high level of classroom discourse. Because the CCSS and NGSS are academically rigorous, teachers should make instructional shifts to enable all students to be college and career ready. At the same time, because disciplinary practices in the CCSS and NGSS are language intensive, teachers should address increased language demands while capitalizing on language learning opportunities across these subject areas for all students. Furthermore, teachers should engage all students, including ELLs, in rich classroom discourse in oral and written forms.

Second, we focus on the CCSS capacities 4 and 5: comprehend as well as critique, and value evidence. The CCSS Anchor Standards focus heavily on argument, involving claim, evidence, and reasoning across grade levels. Not only are these CCSS capacities and Anchor Standards critical for ELA and literacy, but they overlap with the NGSS science and engineering practice 7: engage in argument from evidence. (Note: The CCSS for ELA and literacy and the NGSS also overlap with the CCSS for mathematical practice 3: construct viable arguments and
critique the reasoning of others [NGA & CCSSO, 2010c, p. 6], but this chapter does not address
the CCSS for mathematics).

Third, in connecting the CCSS to science instruction with all students and ELLs in
particular, we propose pedagogical practice that combines components of project-based learning
(engaging in phenomena) with place-based learning. Through project-based learning, students
are immersed in investigating a driving question to explain a phenomenon or design solutions to
a problem through collaborative activities (Krajcik & Czerniak, 2013). Through place-based
learning, students are immersed in local contexts of homes and communities (Smith, 2002;
Sobel, 2005). In the science classroom, students make sense of phenomena or problems
(components of project-based learning) in local contexts of homes and communities (place-based
learning). The focus on making sense of a phenomenon or problem in a place-based context
presents opportunities and demands for both science learning and language learning with all
students, including ELLs. Specifically, we highlight how ELLs engage in argument from
evidence as they explain a phenomenon or design a solution to a problem in their home and
community context.

**Rationale**

Pedagogical practice of engaging in phenomena in a place-based context combines
components of project-based learning and place-based learning. In this section, after a brief
description of project-based learning and place-based learning, we explain how and why this
pedagogical practice helps teachers address both the CCSS and NGSS with ELLs, specifically
the language and science demands as ELLs engage in argumentation from evidence. We
highlight that although the pedagogical practice is effective for all students, it is particularly
effective for ELLs.
Project-Based Learning and Place-Based Learning

Project-based learning is an approach that immerses students in driving questions, investigations, and collaboration to explain phenomena in the natural world and develop solutions to problems in the designed world. Project-based learning is based on six design features (Krajcik & Czerniak, 2013):

1. Learning goals driven
2. Focus on making sense of meaningful phenomena and solving real-world problems
3. Collaborative activities to explore driving questions
4. Creation of products that address driving questions
5. Use of learning technologies as tools
6. Scaffolds or more knowledgeable others supporting learners with complex tasks

Although each of the above design features is essential in project-based learning, we highlight focus on making sense of meaningful phenomena and solving real world problems, which allows access for ELLs in learning science. The phenomenon or the problem connects students to academically rigorous ideas in science and engineering, as they figure out explanations for the phenomenon or solutions to the problem over an extended period of time. In addition, collaborative sense making is language intensive, as students communicate their ideas, argue about the credibility of ideas, and revise their explanations and solutions based on new evidence.

Place-based learning structures learning around culture, language, environment, local history, and economy (see Avery, 2013, for details):
Place-based education uses the local environment as a starting point to teach subjects including language arts, mathematics, social studies, and science. Emphasizing hands-on, real-world learning experiences, this approach increases academic achievement, strengthens students’ ties to their community, enhances students’ appreciation for the natural world, and creates a heightened commitment to serving as contributing citizens. (Sobel, 2005, p. 7)

Smith (2002) emphasizes that place-based education emerges from a specific place that includes cultural and nature studies from that place, connects students with the community and involves them in decision-making and real-world problem solving, and bridges the gap between their local knowledge and school science. Thus, the literature indicates that a place-based context allows students to learn science across local contexts of school, home, and community that capitalize on their everyday language and experience, including ELLs’ home language and culture. A place-based context shows students that science is rooted in their daily lives.

**Learning Opportunities and Demands for Science and Language with ELLs**

Pedagogical practice of engaging in a phenomenon from project-based learning in a place-based context presents learning opportunities and demands for both science and language with ELLs (Lee, Quinn, & Valdés, 2013; Miller & Krajcik, 2015). An engaging phenomenon from project-based learning offers various entry points for science and language learning with ELLs. In addition, relating the phenomenon to a place-based context of ELLs’ home and community allows them to build on their prior knowledge, including home language and culture. Furthermore, engaging in a phenomenon in a place-based context provides opportunities for authentic and meaningful discourse through engagement in science and engineering practices with appropriate language supports.
Although the CCSS for literacy in science and technical subjects as well as history/social studies include standards only for reading and writing (NGA & CCSSO, 2010a, pp. 59–66), we emphasize that oral discourse through listening and speaking is critical for collaborative sense-making for both science and language learning. Oral discourse is particularly important with ELLs:

This focus on oral language is of greatest importance for the children most at risk—children for whom English is a second language and children who have not been exposed at home to the kind of language found in written texts (Dickinson & Smith, 1994). Ensuring that all children in the United States have access to an excellent education requires that issues of oral language come to the fore in elementary classrooms. (NGA & CCSSO, 2010b, p. 27)

Argument from Evidence

As ELLs try to figure out the phenomenon, they engage in argument with evidence based on observations and data (NGSS science and engineering practice 7); comprehend as well as critique, and value evidence based on science texts and discourse (CCSS capacities 4 and 5); and meet the CCSS Anchor Standards focusing on argumentation that involves claim, reasoning, and evidence. In ELA, evidence is drawn from texts, both literary and informational. While reading, a student critically weighs a range of evidence drawn from texts and an author’s reasoning. While writing, a student considers what evidence best fits the particular task at hand with audience and purpose in mind. In science, evidence is based on data, including both laboratory and field observations, about a phenomenon or system. As students advance through the grades, they gain facility with various uses of evidence across subject areas.
While students use various modalities of language through speaking and listening (oral), reading and writing (written), and viewing representing (visual), we emphasize oral discourse for collaborative sense-making. As students engage in argument, they rely heavily on oral discourse in small or large group settings. Students discuss their observations and engage in argument using evidence with others in small groups until they reach a shared “best” explanation or model. After small groups of students make oral presentations of their results and conclusions, they engage in discourse with other students who ask questions and discuss issues raised in the presentations. Because the oral discourse of such presentations and discussions is different from their everyday discourse, scientific arguments in oral forms precede in written forms. More typically, the development of both oral and written forms of scientific arguments proceeds in parallel.

In this section, we have offered the rationale for how and why the pedagogical practice of engaging in phenomena in a place-based context helps teachers address both the language and science demands as ELLs engage in argumentation from evidence. In the next section, we present a classroom vignette of ELLs engaging in phenomena from project-based learning in a place-based context across life and physical science disciplines in middle school.

**Pedagogical Practice: Engaging in Phenomena from Project-Based Learning in a Place-Based Context**

This vignette describes a science unit in middle school (MS) that aligns to performance expectations (or standards) in life science (LS2-2) and physical science (PS1-4). The instruction took place in a medium sized shipbuilding and port city in the Midwest.

- Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. (MS-LS2-2)
- Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. (MS-PS1-4)

In addition, the vignette addresses the CCSS for literacy in science, with a focus on the Anchor Standard Integration of Knowledge and Ideas under Reading Standards for Literacy in Science and Technical Subjects 6–12 (NGA & CCSSO, 2010a, p. 62):

- Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (RST.6–8.7)

- Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. (RST.6–8.8)

- Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (RST.6–8.9)

The vignette highlights three key ideas emphasized in this chapter. While the vignette is organized into two sections on the first two key ideas, the third idea is embedded throughout the vignette.

1) The use of an engaging phenomenon in a place-based context is key to supporting ELLs’ engagement and discourse. The phenomenon itself—an invasion of a local lake by a harmful zooplankton—is the scaffold that the teacher relies on to foster meaning making. The numerous avenues he employs to build more complex and increasingly nuanced meaning from the phenomenon are illustrated.

2) The CCSS and the NGSS emphasize the practice of argumentation in terms of supporting and substantiating claims based on reasoning and evidence, but science takes this practice of argumentation further. Scientists seek to create scenarios where the claim is tested
and either refuted or supported using observations or data in evaluation of the claim. In the vignette, the teacher pushes the students to analyze each other’s claims critically in light of the evidence and reasoning, but also in terms of accuracy of science knowledge.

3) As students try to make sense of a phenomenon in a place-based context, they experience learning opportunities and demands in science and language. With support from the teacher and peers, ELLs at varying levels of proficiency successfully engage in argumentation about the phenomenon in the context of home, community, and school.

Vignette

Students Engage in a Phenomenon in a Place-Based Context

Mr. Edelstein’s 7th-grade science class discovered that their science field trip was a walk to nearby Lake Michigan. The lake was beginning to look more like a soupy pond in places where the waves met the shore. There were a dozen dead fish in various stages of decomposition and a thick carpet of algae. Mr. Edelstein led the students straight to the dead fish amid loud protests from students. “What’s this?”

Mr. Edelstein asked everyone the first driving question of the unit: “Why do we have all these dead fish at our lake?”

“Alright!” Edrissa said with excitement, “Now that’s what I’m talking about!” He leaned over, identified the fish as smelt, and dramatically took a step back. The smelt was really weird looking. It looked as though the middle-sized fish had been feeding on darning needles and safety pins. Small spikes jutted out of the fish’s stomach and made weird-shaped bulges. The teacher asked students to talk with their assigned small group partners. What had happened to the smelt?
Rosalie said confidently, “It had something wrong with it. Probably a disease.” She paused, “And the fish, it is definitely long dead.”

Vanessa nodded, “Probably. She looks alien. The fish has this big tumor.”

Adrian had a different opinion, “The stomach tumor, no.” He pointed to his own stomach, “The fish, she… nunca he visto. She ate a, how you say, ate… very bad krilling, or… particulars.” Rosalie and Vanessa saw that Adrian was right, the pokey things were in the stomach area and by the mouth.

The group of the above four students were at different levels of English proficiency. Adrian and Vanessa spoke Spanish as their home language. Vanessa, originally from Mexico, was an ELL at English language proficiency (ELP) level 3. Adrian, also from Mexico and a year in the United States, was an ELL at ELP level 2. Edrissa, a native English speaker, is African American. Rosalie, also a native English speaker, is Caucasian. (Note: All the names are pseudonyms.)

About half of the students in Mr. Edelstein’s 7th-grade 55-minute science block love to fish. Edrissa fishes so often that he is considered the fishing expert of the class. Vanessa has a lot of experience fishing with her family in the small lakes around the city. Adrian has fished a few times. Students who do not fish, like Rosalie, have heard of the spiny water flea because of the community’s shipbuilding and sport fishing economy.

Edrissa joined Adrian, Rosalie, and Vanessa and shared his thoughts about the strange looking smelt with his group and the class, “I think all of this disgusting disgustingness is because of the spiny water flea. It makes the lake green and kills fish. I still fish here sometimes, TBH, but mostly go to Aniwa Lake.” Some of the students had already encountered the spiny water flea. They had seen marshmallow-like blobs midway on their fishing lines, and juvenile
fish with the 1-cm long crustaceans’ jagged spines lodged in the mouths. Adrian said to his group, “I caught a big fish and see the fish eating that… on the mouth.”

“Did you let it go?” asked Vanessa.

Adrian said, “I let it go, the fish.”

Mr. Edelstein told the students that their job was the same as scientists. The students were going to predict which of two very different lakes, Lake Vilas or Lake Aniwa, could become invaded by the spiny water flea. They would be creating a class video to inform the community members how to keep the “invader” from spreading to that lake. He said that only six of the state’s 16,000 lakes had been invaded so far, but the spiny water flea was found in Lake Michigan and scientists were worried it would spread throughout the state. “First, we need to know more about the spiny water flea,” he announced, “and also a lot more about these two lakes.”

Mr. Edelstein’s instructions for the small student groups were to discuss and ask questions about what was happening in Lake Michigan. They needed to (a) locate specified items (dead fish, algae, lake water, macrophytes, and, if possible, spiny water flea, and Daphnia); (b) photograph or sketch the items using iPads; (c) agree upon and record descriptions of the items; and (d) discuss and record the features of the lake. The group consisting of Adrian, Edrissa, Rosalie, and Vanessa decided that the best way to describe the spiny water flea was “white mosquito.” They needed to discern the shape and deepness of the lake, the lake’s productivity (level of organic activity in the lake), and water input and output. They also recorded the water temperature. Last, they used their iPad to create a short video of the shore, the status of the invasion of the spiny water flea, and their initial thoughts.
The activity—looking for items, taking pictures and videos, and describing and discussing the invasive species event—immersed Adrian and Vanessa, both ELLs with emerging proficiency in English, in the focus of study. Because the phenomenon was a shared experience in the classroom and in the community, they became acquainted with the science topic and began initial meaning making around the topic in English.

The day after visiting the lake, back in the classroom, the students shared fishing stories (netting smelt, avoiding sheephead) and discussed what their families had answered to the homework question, “What makes lakes get algae?” At home, some students had talked about these questions with family in languages other than English. These discussions in home languages about place-based topics offered leverage for the ELLs to build on linguistic and cultural resources. They connected school science with home and community, which fueled their understanding.

Mr. Edelstein solicited student-initiated questions to give rise to the driving question for investigation. The student groups reviewed their data in videos, photos, and texts, and wrote down questions. Each group selected questions to share with the class, and Mr. Edelstein wrote them down on the white board. Some questions were about Lake Michigan: “Does the spiny water flea make the algae?” and, “What else does the spiny water flea do to Lake Michigan?” Some questions were about other lakes: “Will the spiny water flea get into Lake Aniwa or Lake Vilas, or both?” and “Will it like one lake more than the other?” And some questions were about the spiny water flea: “How can such a tiny, almost invisible thing, cause so much stress?” Mr. Edelstein said that the students would be figuring out the second driving question of the unit: “Will the spiny water flea more likely thrive in Lake Aniwa or Lake Vilas?”
Although the class couldn’t take a field trip to Lake Aniwa or Lake Vilas, they collected and examined photos and maps of the lakes. Mr. Edelstein videotaped himself measuring the temperature and collecting data about the lakes’ features. He shared the videos with the class, who recorded the new information on their shared small group iPad data collection page. Lake Vilas had no algae and no dead fish. Lake Aniwa was much warmer than Lake Vilas.

The class needed to figure out how the two lakes were different from Lake Michigan, and how those differences determine which environments were suitable for the spiny water flea. They studied topographical maps of all three lakes and created 3D models. The class made use of and built on the language they had developed on the first day when describing the features of Lake Michigan. Aided by the photos and the videos they had taken, they constructed ideas using more accurate and precise language to compare the two lakes with Lake Michigan. For example, Lake Vilas was narrower and had steeper slopes than Lake Michigan, whereas Lake Aniwa was shallower and wider. Lake Vilas was fed by cold groundwater flow, whereas Lake Aniwa had surface water flow.

To understand the effects of these differences, Mr. Edelstein made a model of convection using a beaker, food coloring, and a hot plate. He then asked students, in small groups, to investigate how changes in temperature affect the particle movement of water. The students used food coloring to model the water particle movement in Lakes Aniwa and Lake Vilas. In a shallow beaker blown by a hair dryer to represent warm air temperatures mixing with water in Lake Aniwa, the water mixed constantly. But in the tall beaker with ice under the bottom to represent the cold groundwater input of Lake Vilas, only the top layer mixed. The students in small groups drew models to explain the differences in layers of temperatures, and the mixing of these layers, between the two lakes. They used the topographical maps, the models, and the
videos and photos of the features of Lake Michigan and the other two lakes as sources of evidence to support their discussion.

Mr. Edelstein had collected two types of zooplankton in the lakes: the invasive spiny water flea and the native Daphnia. In the days that followed, the students observed the zooplankton under microscopes and modeled the life cycles of the crustaceans, and how these life cycles correspond to the changing feeding habits of growing fish. The spiny water flea clones itself when resources are plentiful, and only sexually reproduces under stressful conditions. The groups used their iPad photos and sketches from the first day to create food webs. Many of the students shared that the walleye, bass, and northern pike eat minnows, which in turn eat Daphnia. The Daphnia eat algae. So when there are many Daphnia, the algae is kept in check.

Mr. Edelstein placed on the overhead a graph from a research paper about Lake Michigan and the clarity of water before and after invasion. He used the students’ collected samples of water, with their short written descriptions of the items from the first day, to construct shared meaning around the discussion of the graph. The graph showed that after invasion of the spiny water flea, the population of Daphnia was depleted and algae flourished. Edrissa said, “I think the graph showing contamination in the water pre- and postinfestation, it means that Lake Aniwa would get more spiny water flea because it has all the algae.”

Vanessa disagreed. She argued, “It’s obviously that I can see more water- no- more deep of this lake preinfestation. After infestation I cannot see more deep water.”

Edrissa said, “I don’t get it. Why is that evidence that the spiny water flea would be successful—that there is less algae?”
Vanessa picked up a vial of Daphnia and used the word “crash,” the academic term introduced by the graph for population reduction: “Because the Daphnia is eating the algae. Too much algae, and the algae-grazer is crashing too much.”

Rosalie added, “Vanessa means that lots of algae shows that Daphnia are missing in the lake!”

Adrian pointed to the group’s hand-drawn trophic pyramid, which added another major consequence in the microecosystem. He said, “The big, big fish, it’s gonna die because his food it’s die, because his food die.”

Edrissa nodded glumly, “It’s a disaster. They would be most successful where everything is already balanced.”

Vanessa and Edrissa both used the same graph that compared water clarity in the fall before and after invasion as evidence for their conflicting claims. Vanessa reasoned differently from Edrissa that an invasion of the spiny water flea was more likely in the deep lake with less algae than in the shallow lake with more algae. She reasoned a cause and effect relationship between the two correlated variables. Despite the challenging task of sense making, the group was engaged and persevered in understanding Vanessa’s idea. Rosalie and Adrian clarified and extended Vanessa’s idea for the group.

**Students Engage in Argumentation through Claim, Evidence, and Reasoning**

After 3 weeks of study, Edrissa’s group placed their scientific explanation next to another group’s explanation. The two groups were to critically respond to each other’s explanation. As instructed by Mr. Edelstein, the students wrote their claims using a Claims, Evidence and Reasoning template. Edrissa’s group came to the following explanation:
The spiny water flea can survive in Lake Vilas and not in Lake Aniwa. (claim) Lake Vilas has almost no algae and Lake Aniwa has a lot. This is important because in lakes where there is less algae, there is likely more Daphnia. We saw in the microscope that Daphnia eat algae, and spiny water flea eat Daphnia, and spiny water fleas do not eat algae [evidence]. In order for animals to survive they must have energy, which Daphnia can get from food algae and spiny water flea get from Daphnia. If animals do not get their energy they will die (reasoning). Lakes where there is more algae, there is less Daphnia living there to eat it. The spiny water flea survive only where there is Daphnia because they eat Daphnia (reasoning).

The neighboring group discussed this explanation and whether the evidence and reasoning was sufficient. One student said, “It’s true, when you see no algae then Daphnia has grazed there. And Lake Vilas is the most similar to Lake Michigan, and we know they like Lake Michigan already.”

Another student brought up an interesting point, “But we investigated Daphnia and watched them eat the piece of algae. They have to have algae to live, and no algae might just mean there never was algae in the lake, and so there would be no food for the Daphnia. At all. The spiny water flea would not survive without food.”

Mr. Edelstein asked a question of Edrissa’s group, “Could you test your claim? How?”

Adrian answered hesitantly, “We can put a little algae. If we see the Daphnia eating that…”

Vanessa answered at the same time, “We could just check for Daphnia in Vilas Lake!”

It is noted that the evidence and reasoning that Edrissa’s group used to support their claim seemed sound. They used substantial evidence from the labs and a graph handout,
seemingly sufficient evidence paired with logical reasoning. However, the explanation was scientifically inaccurate. The group suggested that the absence of algae indicated the presence of Daphnia, organisms that consume algae. They supported this claim because, in the graph, the presence of algae in Lake Michigan corresponded with a crash in the Daphnia population, and the absence of algae occurred when Daphnia were present consumers. Yet, they had not considered another possibility that the absence of algae in Lake Vilas could also indicate that neither algae nor the Daphnia were present. Mr. Edelstein asked the students how they would test their claim, making their problematic logic clear.

Next, Edrissa’s group was expected to react to their neighboring group’s explanation with critical analysis. The neighboring group came to the same conclusion that Lake Vilas was more at risk, but they used different evidence and reasoning:

Lake Vilas is more likely to have spiny water fleas than Lake Aniwa because it is deep and narrow and Lake Aniwa is shallow, wide and deep and narrow lakes are best for spiny water fleas (claim). We know this because in the model and the maps, Lake Vilas is a very deep, clear lake with cold thermal layers and Lake Aniwa is shallow and warm, with no cold layers. We saw the life cycle that all of the spiny water flea survive and have eggs in cold clear water and they don’t all live in warm water (evidence). Because of low temperature for their eggs and seeing their prey, and because the shape doesn’t make much sediments and heat mixing, deeper lake is the best for the spiny water flea. Two things make a lake have cold layers, one is hydrologic inputs for water flow and the other is lake types. The lake type has to do with shape, and the shape of the Lake Vilas makes it mix only two times a year, and the shape of Lake Aniwa makes it always mixing (reasoning).
After the group read the text together, Edrissa faced the group and spoke up first. He was curious about the group’s evidence about the spiny water flea’s eggs in cold water. He said that when the spiny water flea had enough to eat and the water was an ideal temperature, it cloned itself; but when it didn’t have enough food or the right temperature, it sexually reproduced. He asked, “What is best for survival? Is cloning better because it takes less energy?”

Vanessa and Rosalie listened to Edrissa and whispered together. Then they argued that Lake Aniwa could actually get more spiny water flea because it was less hospitable. Vanessa started emphatically, holding up her group’s life cycle model of the spiny water flea, “I totally changed my mind. Here, the spiny water flea is so comfortable. She puts out 10 clones, two weeks, 10 clones, two weeks, 10 clones…The lake is desbordado…It’s when the water lake it’s up, she reproduces sexually. She is more…different… more successful.”

Mr. Edelstein supplied, “more genetically different?”

Rosalie agreed with Vanessa and added, “Remember, yes, our life cycles, they are evidence to the opposite claim! Happy spiny water fleas clone. Just like that article about cloned bananas, clones can be weak. It is better for the spiny water flea to sexually reproduce, like…it does when it is not happy, because then it does not get too weak and die out, and more variety!”

Vanessa offered her argumentation that was scientifically accurate. Cloning, although efficient, causes the population to be weak. In contrast, the spiny water flea sexually reproduce when there is not enough food. They become genetically diverse, making them more resilient. Despite her emerging proficiency in English, Vanessa demonstrated complex reasoning with scientific accuracy that helped other students to explain the phenomenon that guided the entire unit.
Mr. Edelstein was pleased with Vanessa and Rosalie’s argument and brought up the topic to discuss first in partners and then as a whole group. Students argued both sides, using the evidence collected and shown around the room. Mr. Edelstein reminded students that scientists were investigating a lot of these questions right now, as well. He asked the class to think about how a scientist could test the claim that a more genetically diverse population would be a greater threat to the ecosystem.

Adrian, Edrissa, Rosalie, and Vanessa agreed to make their educational video about precautions for the spiny water flea in the state’s lakes. Together, the group used their video to warn other students in the school and families about the importance of drying boats and equipment when travelling from lake to lake. They decided to make one video in English and one in Spanish, because the people in the community spoke both languages.

Throughout the instruction, the evidence the students utilized for their argumentation came from funds of knowledge, the community setting, and in-class investigations. While engaging in argumentation, they used language in various oral and written forms. They created oral and written texts and used evidence and reasoning to engage critically in those texts. Adrian and Vanessa, both ELLs, were pivotal in making sense of the phenomenon with their group, shaping the group’s knowledge, and producing the final group project of the educational video in both English and Spanish.

Conclusion

The CCSS and the NGSS emphasize integration of language and content. The CCSS stress literacy in science and other subjects, while the NGSS make connections to the CCSS. Both the CCSS and the NGSS point out the importance of language and content integration for
Grades 6–12 specifically. The CCSS and the NGSS, respectively and collectively, require instructional shifts with all students and ELLs in particular.

We have highlighted three key ideas in this chapter. First, the pedagogical practice of engaging in phenomena from project-based learning (Krajcik & Czerniak, 2013) in a place-based context (Smith, 2002; Sobel, 2005) scaffolds both language learning and science learning with ELLs. In the vignette, during a science field trip to nearby Lake Michigan, students observed dead fish in various stages of decomposition and a thick carpet of algae. To make sense of this phenomenon, the teacher introduced the driving question: “Why do we have all these dead fish at our lake?” As the unit progressed, students’ investigations of the phenomenon generated the subsequent driving question: “Will the spiny water flea survive in Lake Aniwa or Lake Vilas?”

As the phenomenon occurred in a shared space of home and community settings, the teacher used the notion of place and students’ expertise with their prior science knowledge as a scaffold for meaning making. Furthermore, the shared space of home and community settings supported ELLs to use a shared language via home language and English.

Second, the CCSS and the NGSS emphasize disciplinary practices, which are language intensive and require a high level of classroom discourse (CCSSO, 2012; Lee, Quinn, & Valdés, 2013). In particular, both the CCSS and the NGSS highlight the practice of argumentation from evidence. In the vignette, ELLs were immersed and invested in the phenomenon at hand and lent their expertise and community-based knowledge to make sense of the phenomenon and construct increasingly complex ideas through making claims, providing evidence, and communicating their reasoning. The final group project to produce an educational video was responsive to a real-world problem in the community.
Third, the CCSS and the NGSS present both learning opportunities and demands in language and science. As a case in point, the practice of argumentation from evidence is academically rigorous and language intensive. In the vignette, the teacher supported ELLs to meet increased language demands while capitalizing on language learning opportunities. Students were immersed in multimodal, multisensory, and interactive modes of discourse in various oral and written forms across small group and whole class settings. As they tried to make sense of the phenomenon, they used multiple languages, including home language and English. Language is used for function and action (Van Lier & Walqui, 2012), which presents a contrast to a more traditional approach to second language acquisition that focuses on discrete elements of vocabulary and grammar.

Reflection Questions and Action Plans

Reflection Questions

The reflection questions address how the pedagogical practice of engaging in phenomena from project-based learning in a place-based context is highlighted in the vignette. Specifically, the questions focus on argumentation from evidence as highlighted in the CCSS and the NGSS:

- What were some ways that the teacher used the phenomenon as a scaffold for learning language and science?
- How did the teacher utilize the place of students’ home and community to engage them in learning language and science?
- What example(s) in the vignette indicate when students’ explanations were scientifically inaccurate, although the evidence and reasoning seemed logical? How was this discrepancy resolved?
• How did the teacher’s purposeful attention to collaborative group work promote learning language and science?

• How were the two small groups supported in analyzing and critiquing each other’s explanations?

• How did the final group project of producing educational videos for the community lend authenticity to doing science and using language?

**Action Plans**

The action plans include recommended tasks and activities for teachers to apply the ideas presented both within and outside their classrooms. These recommendations are illustrated in the vignette.

1) The phenomenon to guide science instruction should be engaging to students.

   Furthermore, a phenomenon should be engaging enough to sustain students’ interest throughout the unit.

   a) A phenomenon is powerful when it is a local event that is shared among students and relevant to their lives at home and community. The importance of a shared experience that scaffolds meaning making cannot be underscored. Carefully plan what this phenomenon will be and how it will be leveraged.

   b) For ELLs, a shared experience in home and community settings invites use of home languages as a scaffold for meaning making. For ELLs, consider a phenomenon that the students have experience in, so they can be leaders in shaping the discussion. This also sets the stage for other students to seek out ELLs’ expertise.
2) Teachers need to hone their place-based science knowledge. They must be invested in culling the current science understandings, on the one hand, and the questions and concerns in the community, on the other hand. To communicate this critical relationship between the science and the community, teachers must present that investment as another member of the community.

3) In supporting students to engage in argumentation from evidence in the science classroom, teachers need to attend to accuracy of science knowledge in the reasoning process. Science has a canon of accepted knowledge that explains how the natural world works, which is often inconsistent with students’ preconceptions. An idea that seems sound logically may not be accurate scientifically. Teachers use this situation as an important opportunity to construct new understandings.

4) In the science classroom, language is being used for function and action (Van Lier & Walqui, 2012), that is, making meaning of science. When supported appropriately, most ELLs are capable of learning science “through their emerging language and of comprehending and carrying out sophisticated language functions (e.g., arguing from evidence, providing explanations) using less-than-perfect English” (Lee, Quinn, & Valdés, 2013, p. 227). Teachers engage ELLs in disciplinary practices of ELA and science to promote the students with both science knowledge and language proficiency.

5) Students’ ideas can be translated to videos and to texts, which can be leveraged for learning. Student-created videos and texts can be used to help the students gradually attend to precision and accuracy of language. Students must learn to clarify each other’s words, and to critique and challenge these texts.
References


