

## Making Everyday Phenomena Phenomenal

### Using phenomena to promote equity in science instruction

By Okhee Lee

**A** *Framework for K–12 Science Education* and the *Next Generation Science Standards* (NGSS) are intended for all students, hence “all standards, all students” (NGSS Lead States 2013). To make this vision a reality, the NGSS highlight three key instructional shifts: (a) explain phenomena or design solutions to problems, (b) engage in three-dimensional learning, and (c) build learning progressions over time. Combining these three shifts, students in the NGSS-aligned classroom explain phenomena or design solutions to problems by engaging in three-dimensional learning and, over time, develop deeper understanding in their learning progressions.

Whereas three-dimensional learning and learning progressions are explicitly addressed in the *Framework* and the NGSS, the role of phenomena is not clearly articulated. Yet, making sense of phenomena could be the most important instructional shift for students who have not experienced science as real or relevant to their lives or future careers. The phenomena that teachers select can either help students access science by relating science to their lives or exacerbate marginalization by alienating them further from science. Thus, phenomena must be compelling to students based on their experiences in their homes and communities.

The purpose of the article is twofold: (a) to offer guidance on how teachers can select and use local phenomena to develop NGSS-aligned instructional materials with diverse student groups and (b) to illustrate the implementation of a local phenomenon with diverse stu-

dent groups in fifth-grade science classrooms in an urban school district. The article highlights how local phenomena compel students from diverse backgrounds to engage in three-dimensional learning and build their science understanding coherently over a sustained period of instruction. As a result, teachers who select and use local phenomena that are real and relevant to their diverse student groups advance the goal of “all standards, all students.”

In this article, the term “diverse student groups” refers to students from both dominant and nondominant groups in terms of race, ethnicity, culture, language, and social class. While the article uses “diverse student groups” to be inclusive of all students, it focuses specifically on nondominant groups who have traditionally been underserved by the education system.

### THE ROLE OF PHENOMENA

The new science standards place equity at the center (NGSS Lead States 2013), and this is achieved through contemporary approaches to science instruction. In traditional approaches, scientists and science teachers defined the knowledge of science disciplines. This canonical science knowledge was typically presented in science textbooks as a static body of knowledge. Some students learned science, but science did not make sense to many students. In contemporary approaches, as envisioned in the *Framework* and the NGSS, all students are making sense of phenomena or designing solutions to problems as scientists and engineers do

in their professional work. As science instruction “starts with phenomena,” the phenomena should be compelling to students. This helps students see the relevance of science to their everyday lives and gives a purpose to their science learning. As students “do something” with science, they become agents of their own learning.

In the past, when science instruction was guided by hands-on approaches, there was a danger of hands-on activities lacking purpose beyond being fun and engaging (referred to as “activitymania” by Moscovici and Nelson 1998). In a similar manner, the focus on phenomena raises a new danger of selecting “phenomenal phenomena” because they pique students’ interest (e.g., a visually striking yet rare natural phenomenon that students have not personally experienced). While phenomenal phenomena inspire wonder and awe (e.g., students ask, “How could that happen!?”), they may have little relevance to students’ experiences in their everyday lives. Furthermore, phenomenal phenomena may not be robust enough to sustain a science unit around a targeted set of performance expectations (PEs) over the course of instruction.

### INTEGRATING PLACE-BASED AND PROJECT-BASED LEARNING

In our work developing and implementing yearlong NGSS-aligned instructional materials in fifth grade for diverse student groups, we aim to *make everyday phenomena phenomenal*. Spe-

cifically, we use local phenomena that meet two criteria (see Figure 1).

The first criterion is that local phenomena should be real and relevant to students and thus compelling to figure out. From an equity perspective, through place-based learning, students apply science and engineering to their everyday lives in their homes and communities (Endreny 2010). By capitalizing on the cultural and linguistic resources that students from diverse backgrounds bring to the science classroom, local phenomena engage students in science and engineering.

The second criterion is that local phenomena should be comprehensive enough to sustain a science unit that addresses multiple PEs within and across science disciplines over the course of instruction. From a science perspective, through project-based learning, students engage in collaborative investigations as they explain phenomena or design solutions to problems (Krajcik and Czerniak 2013). As students recognize the relevance of science and engineering to their lives or future careers, they are compelled to use their knowledge to solve problems in their communities and participate in citizen science.

### SELECTING AND USING LOCAL PHENOMENA

For this unit, fifth-grade students enter the classroom and see in the center of the room a mound of garbage collected from their school cafeteria, including their own lunch garbage. From the beginning of the unit, as students express a wide range of reactions from excitement to disgust, the everyday phenomenon of garbage becomes phenomenal. The anchoring phenomenon for the unit is that the school, home, and neighborhood make large amounts of garbage every day, which all goes to a landfill in the local community. Then, the driving question for the unit is framed broadly, “What happens to our garbage?” To answer this driving question, students

develop physical models of a landfill by creating “landfill bottles” as open systems and closed systems (see Figure 2). The garbage materials in each landfill bottle are from students’ lunch garbage, including food (banana, orange) and nonfood (spoon, aluminum foil) materials, so that students can observe changes in the properties of materials in the landfill bottles over time.

Over the course of nine weeks of instruction, students’ understanding of science builds coherently as they in-

vestigate what happens to the garbage in the landfill bottle systems. Students begin by investigating what happens to garbage materials (5-PS1-3 on properties of materials). When the landfill bottles start to smell in the open system, students ask, “What is that smell?” (5-PS1-1 on particle nature of matter/gas). They also ask, “What causes changes in the properties of materials in the garbage?” and “What causes smell from the garbage?” (5-PS1-4 on chemical reactions). They obtain information

FIGURE 1

Components in selecting and using local phenomena with diverse student groups.

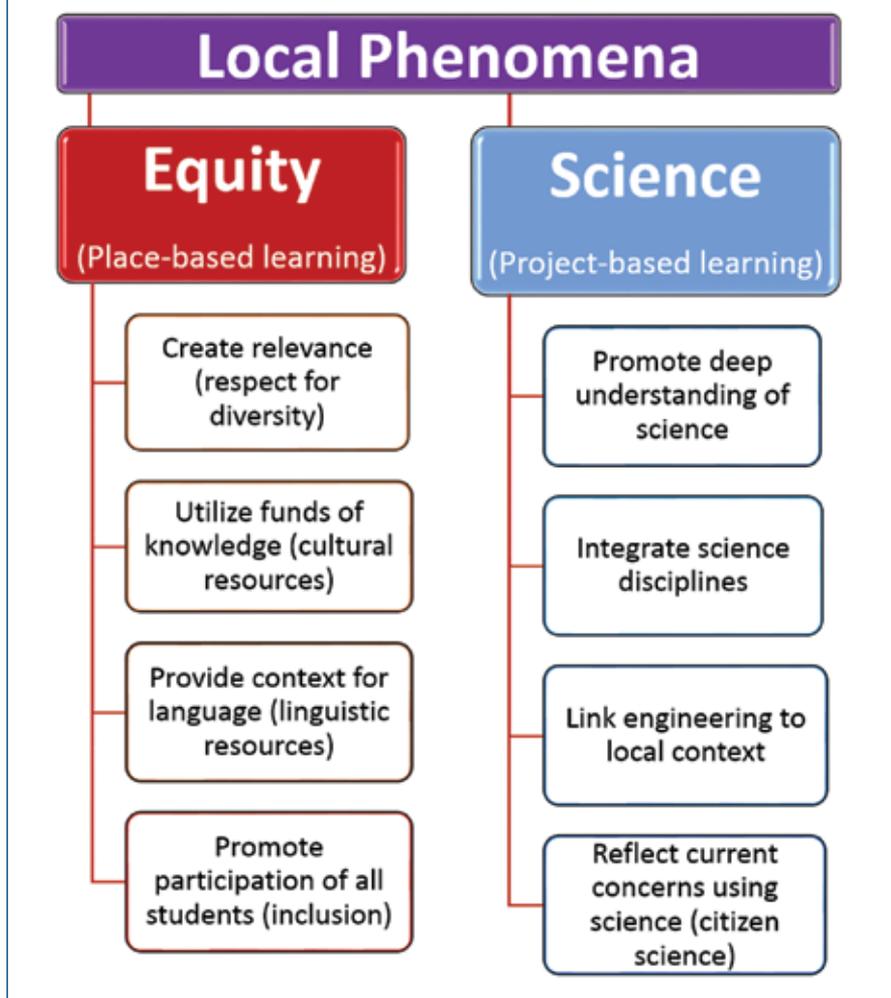


FIGURE 2

**Landfill bottles.**

about microbes causing food materials to decompose and produce smells (5-LS2-1 on decomposers in the environment). In addition, they make observations of the weight of the garbage materials after some garbage materials (e.g., banana and orange) in the closed landfill bottle systems seem to have vanished (5-PS1-2 on conservation of weight/matter).

As with many science units, it is important to follow safety guidelines when students sort the garbage materials into categories and make observations of the landfill bottles (see Figure 3). Teachers should also consult school and/or district policies regarding safety in the science classroom.

Below, we describe how the phenomenon of garbage addresses each of the equity components (left column in Figure 1) and science components (right column in Figure 1) that teachers should consider when selecting local phenomena to use in their classrooms.

**AN EQUITY PERSPECTIVE**

We select the local phenomenon of garbage, which is rooted in students' everyday experiences in their homes and communities, because it capitalizes on the following equity components (see the left column in Figure 1):

- Equity component 1: The phenomenon of garbage creates relevance for all students since they experience garbage every day.
- Equity component 2: The phenomenon of garbage in the school, home, and neighborhood that goes to a community landfill capitalizes on students' funds of knowledge.
- Equity component 3: The phenomenon of garbage provides a context for all students to communicate their ideas using all of the meaning-making resources at their disposal, including everyday language, home

language, and multimodality (Lee, Llosa, Grapin, Haas, and Goggins 2019; NASEM 2018). Students also progress from everyday registers to specialized registers over time.

- Equity component 4: The phenomenon of garbage promotes participation of all students by offering access to science and inclusion in the science classroom. As a result, abstract ideas of matter (e.g., particle nature of matter, properties of matter, chemical reaction, conservation of weight/matter) are made accessible and relevant to all students.

**A SCIENCE PERSPECTIVE**

- We select the local phenomenon of garbage, which is comprehensive enough to address multiple PEs over a sustained period of instruction, because it capitalizes on the following science components (see the right column in Figure 1):
- Science component 1: The phenomenon of garbage allows students to build their understanding of structure and properties of matter coherently over the course of a unit.
- Science component 2: The phenomenon of garbage allows students to understand science more broadly across science disciplines by integrating physical science and life science.
- Science component 3: The phenomenon of garbage sets the foundation for engineering in the subsequent Earth's systems unit as students find out that plastic, which does not decompose, pollutes Earth's systems. They design solutions to this problem by reducing the amount of

plastic from water bottles in their classroom and school.

- Science component 4: The phenomenon of garbage raises students' awareness of societal concerns about garbage and plastic pollution. As a result, students use science ideas to protect the Earth's resources and environment and to participate in citizen science.

## A SNAPSHOT OF TWO LESSONS

This section offers a snapshot of two lessons from the garbage unit to illustrate how local phenomena are implemented with diverse student groups in fifth grade. The first lesson highlights place-based learning from an equity perspective, and the second lesson highlights project-based learning from a science perspective. The two lessons also highlight how teachers use grouping strategies to promote student engagement and how they use formative and summative assessments.

### *Snapshot 1: Garbage in the School, Home, and Neighborhood*

The local phenomenon of garbage is compelling to students because it draws on their everyday experiences in their school, home, and neighborhood. In the first lesson of the unit, each group of four or five students with varying levels of English proficiency is assigned to a pile of school lunch garbage. Students wear plastic gloves and protective goggles and use tongs to sort the garbage materials. They make observations of the garbage materials and categorize those materials based on properties (e.g., color, texture, hardness, reflectivity). In a whole-class discussion, students identify patterns of similarity and difference in their observations of the school lunch garbage. Then, students make observations of materials in their home garbage and categorize those materials based on

properties. In small-group and whole-class discussions, students identify patterns of similarity and difference in their observations of the home garbage. This lesson addresses three-dimensional learning by blending the science and engineering practice (SEP) of planning and carrying out an investigation, the disciplinary core idea (DCI) of properties of materials, and the crosscutting concept (CCC) of patterns.

The phenomenon of garbage provides a context for all students, including English learners, to communicate their ideas using all of their meaning-making resources, such as everyday language, home language, and multimodality (Lee et al. 2019; NASEM 2018). The opportunity to use all of their meaning-making resources from the outset of in-

struction promotes participation of all students in the science classroom. For example, at the beginning of the garbage unit, students make observations of the mound of garbage using everyday language (e.g., students say, "It smells like when the garbage truck drives by my house!") and home language (e.g., students say, "¡Qué asco!"). Importantly, their observations are valued for their contribution to the discourse, not their linguistic accuracy. Students also use multiple modalities, including gestures, drawings, symbols, and text.

In the second lesson of the unit, students investigate garbage disposal systems in their school, home, and neighborhood. As shown in Figure 4, they use sticky notes to represent components of each system (e.g., garbage trucks) and

FIGURE 3

### Safety guidelines for garbage sort and landfill bottles.

#### Garbage sort safety guidelines

- ✓ Assemble the piles of garbage for the activity, making sure not to include broken glass or sharp objects.
- ✓ Ensure the garbage has as little liquid as possible.
- ✓ Direct students to wear protective goggles and use plastic gloves and tongs for handling the garbage.
- ✓ Direct students to wash their hands after handling the garbage.
- ✓ If students have allergies (nuts, mold, etc.), consult the school nurse before proceeding with the garbage sort. Students may view videos of decomposition.

#### Landfill bottle safety guidelines

- ✓ When students make observations of the landfill bottles, instruct them to look through the side of the bottles and waft smell out of the bottles. Students should not place their faces directly over the open landfill bottles.
- ✓ If a student has a known mold allergy or severe asthma, store the open landfill bottle outside the classroom. Consult with the school nurse.
- ✓ Open the closed landfill bottles outside to allow the smell to diffuse.
- ✓ Direct students to wash their hands after handling the landfill bottles.

arrows to represent interactions of the components (e.g., garbage trucks transport garbage from the dumpster to the landfill). This lesson addresses three-dimensional learning by blending SEP of developing and using models, DCI of properties of materials, and CCC of systems and system models.

Garbage from the school, home, and neighborhood that goes to a community landfill capitalizes on students' funds of knowledge from home and neighborhood. For example, students make observations of garbage in their homes and communities, comparing the garbage materials and their properties. They connect observations of their home garbage to the community garbage disposal system. They use their experiences with the components of the garbage disposal system (e.g., taking out the trash, seeing garbage trucks in the neighborhood) to connect the components in terms of the larger system of garbage in their community.

At the end of the second lesson, students complete an exit slip in response to the following question: "What would happen to the garbage disposal system if a component were missing? Give an example to support your an-

swer." The purpose of the exit slip is to use the familiar context of garbage in the school, home, and neighborhood for formative assessment of students' emerging understanding of systems, which the teacher uses to guide subsequent instruction. Throughout the unit, each lesson concludes with a formative assessment, such as an exit slip, revised model, or science and engineering notebook entry.

### Snapshot 2: Group Modeling of Landfill Bottle Systems

The local phenomenon of garbage is comprehensive enough to address multiple PEs within and across science disciplines. In one of the final lessons of the unit, students work in small groups to develop diagrammatic models of what happens to the garbage in the open and closed landfill bottle systems. At this point in the unit, students have developed understanding of the DCIs of the unit to explain the phenomenon of garbage. Teachers form small groups strategically by placing English learners with at least one peer who shares the same home language.

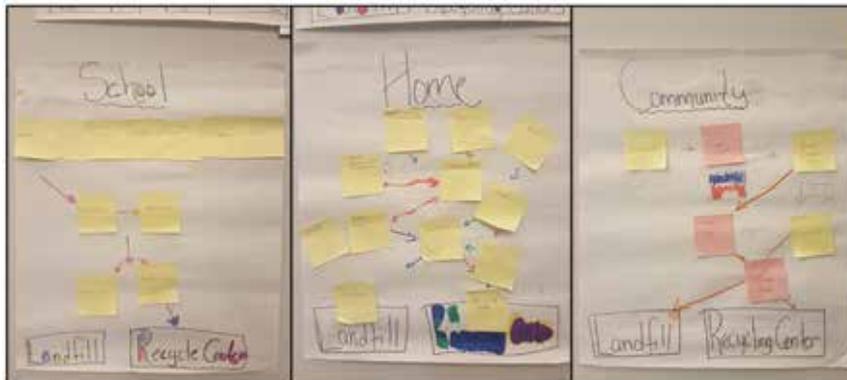
Next, students participate in a "gallery walk" in which individual students use sticky notes to write respectful questions and comments on each group's model. Figure 5 shows one group's model demonstrating their understanding of how microbes (called "bacteria" [sic] in the model) decompose the banana and orange, producing smell/gas particles that flow out of the open system (bottom left panel of Figure 5) but are conserved inside the closed system (bottom right panel of Figure 5). A student from another group comments on the model by using the crosscutting concept of systems: "Explain inputs and outputs" (see blue sticky note in the middle of Figure 5).

As students develop deeper understanding of science to make sense of the phenomenon of garbage, they use modalities more strategically (e.g., students use arrows to represent gas particles moving freely in space) and adopt a more specialized register (e.g., students say, "Smell is a gas made of particles too small to see.") to communicate the sophistication of their ideas (Lee et al. 2019; NASEM 2018). Abstract ideas of matter that address physical science PEs at fifth grade (i.e., properties of matter, particle nature of matter, chemical reactions, and conservation of weight of matter) are made accessible and relevant to all students, including English learners. Students' contributions are valued based on the merit of their ideas, not their social status or linguistic accuracy.

At the end of the garbage unit, group models serve as artifacts for summative assessment of student understanding in relation to the targeted set of PEs. Throughout the school year, each unit concludes with summative assessment of final models to explain the anchoring phenomenon of the unit. In earlier units, students develop final models in groups, whereas in later units, students develop final models individually. As such, the totality of the units in our fifth-grade curriculum promotes pro-

FIGURE 4

### Garbage disposal systems in the school, home, and community.



gression of three-dimensional learning over the course of the year.

## CONCLUSION

The *Framework* and the NGSS present key instructional shifts, including a shift toward explaining phenomena. Enacting these shifts, in general, and using local phenomena, in particular, are especially critical when working with students who have not experienced science and engineering as real or relevant to their lives or future careers. In this article, we offer guidance on how teachers can select and use local phenomena that compel students from diverse backgrounds to

engage in three-dimensional learning and build their science understanding coherently over a sustained period of instruction. Since diverse student groups come from a wide range of backgrounds, teachers could work with their students to select local phenomena that draw on everyday experiences in students' schools, homes, and communities. By *making everyday phenomena phenomenal*, we move a step closer to realizing the vision of "all standards, all students" (NGSS Lead States 2013).

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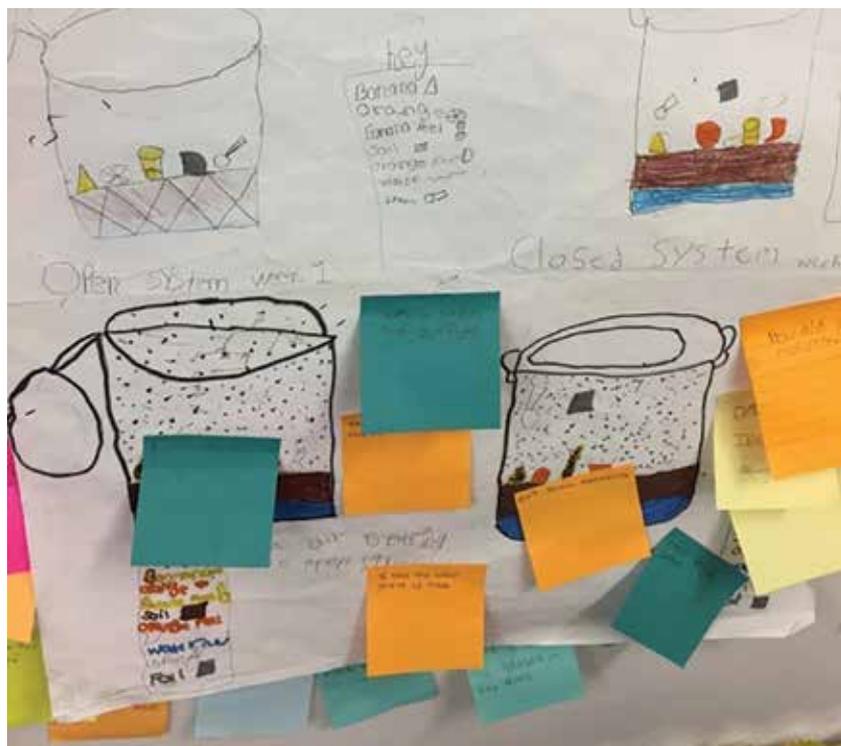
1503330). Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the position, policy, or endorsement of the funding agency.

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FIGURE 5

### Group model of open and closed landfill bottle systems for 2-3 weeks.



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## NSTA Connection

Download the NGSS connections associated with this lesson at [www.nsta.org/science-and-children](http://www.nsta.org/science-and-children).