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Making Everyday Phenomena Phenomenal:

NGSS-Aligned Instructional Materials Using Local Phenomena With Diverse Student Groups

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Abstract

In collaboration with a Teacher Advisory Board, our research team is currently developing yearlong NGSS-aligned instructional materials for fifth grade that address physical science, life science, Earth science with engineering embedded, and space science. For each of the four units, we select and use a local phenomenon that integrates place-based learning from an equity perspective and project-based learning from a science perspective. For the first unit, we use the phenomenon of garbage, which is collected from the school, home, and neighborhood and taken to a landfill in the local community. Over the course of the unit, students build their understanding of matter in physical science to explain what happens to their garbage. We illustrate how a local phenomenon like garbage promotes access to science and inclusion in the science classroom for diverse student groups. In this chapter, we offer guidance on how to select and use local phenomena in developing NGSS-aligned instructional materials. We also describe challenges and how we address those challenges.

Making Everyday Phenomena Phenomenal: NGSS-Aligned Instructional Materials Using Local Phenomena With Diverse Student Groups

With the release of *A Framework for K-12 Science Education* (National Research Council [NRC], 2012; shortened to the *Framework* hereafter) and the Next Generation Science Standards (NGSS; NGSS Lead States, 2013), there is a general consensus in the science education community around three key instructional shifts. The first shift involves explaining phenomena in science or designing solutions to problems in engineering. As students use science knowledge to make sense of phenomena or design solutions to problems, they experience the work of scientists and engineers. The second shift involves three-dimensional learning by blending science and engineering practices (SEPs), crosscutting concepts (CCCs), and disciplinary core ideas (DCIs). The third shift involves learning progressions of student understanding over time. Combining these three shifts, students in the NGSS-aligned classroom explain phenomena or design solutions to problems (shift 1) by engaging in three-dimensional learning (shift 2). As students refine their explanations of phenomena or solutions to problems, they develop deeper understandings over time (shift 3). The NGSS are written as performance expectations (PEs) that describe what students should be able to do by the end of a grade level or grade band in order to demonstrate their understanding.

Although three-dimensional learning and learning progressions are clearly delineated in the *Framework* and NGSS, the role of phenomena is not explicitly defined and requires further attention. In the past, when science instruction was guided by inquiry approaches (NRC, 2000), there was the danger of hands-on activities lacking purpose beyond being fun and engaging (referred to as “activitymania” by Moscovici & Nelson, 1998). With a shift toward explaining phenomena and designing solutions to problems, students in the NGSS-aligned classroom have a purpose for learning science and engineering. At the same time, a focus on explaining phenomena raises a new danger of "phenomenal phenomena" that are selected primarily because they pique students' interests (e.g., a visually striking yet rare natural disaster 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 with explanatory power to sustain a science unit around a targeted set of PEs.

While selection of phenomena is important for all students, it is especially important for students who have not experienced science or engineering as real or relevant to their lives or future careers. For these students, selection of phenomena could either provide access to science by relating science to their lives or exacerbate marginalization by alienating them further from science. Despite growing recognition of the importance of students explaining phenomena in NGSS-aligned instructional materials (Achieve, Inc., 2016, 2017; BSCS, 2017; Carnegie Corporation of New York, 2017; National Science Teachers Association, n.d.), this topic has not received comprehensive treatment, especially as it relates to student diversity.

The purpose of this chapter is two-fold. First, we offer guidance on how to select and use local phenomena in developing NGSS-aligned instructional materials with diverse student groups. Second, we describe challenges in selecting phenomena for instructional materials and how we address those challenges. As part of our Science And Integrated Language (SAIL) project in which we are developing yearlong NGSS-aligned instructional materials for fifth grade, we use local phenomena with diverse student groups and English learners (ELs) in particular. We aim to "make everyday phenomena phenomenal" because even the most quotidian things are phenomenal when looked at closely. In collaboration with a Teacher Advisory Board, we are in the process of developing, field-testing, and revising four science instructional units that address physical science, life science, Earth science with engineering embedded, and space science.

Local Phenomena With Diverse Student Groups: Integrating Place-Based Learning and Project-Based Learning

To make sense of phenomena or design solutions to problems, students engage in three-dimensional learning and develop more sophisticated understanding over time. Krajcik (2015) emphasizes that "three-dimensional learning involves establishing a culture of figuring out phenomena or designs to problems" (p. 51). He advises science teachers to "look for engaging phenomena or problems that build toward performance expectations" (p. 51). In this section, we describe how we develop our NGSS-aligned instructional materials with diverse student groups.

Phenomenon-Based Science Instruction

Some approaches to developing NGSS-aligned instructional materials consider student diversity as part of their criteria for selecting phenomena (Achieve, Inc., 2016, 2017; BSCS, 2017; Carnegie Corporation of New York, 2017; National Science Teachers Association, n.d.; Penuel & Bell, 2016). For example, the recently published *Primary Evaluation of Essential Criteria (PEEC) for Next Generation Science Standards Instructional Materials Design* (Achieve, Inc., 2017) highlights selecting phenomena in local contexts of homes and communities:

- Inclusion of phenomena and problems that are relevant and authentic to a range of student backgrounds and interests, with supports for modifying the context to meet local needs and opportunities for students to make meaningful connections to the context based on their current understanding and personal experiences.

- Teacher materials including suggestions for how to connect instruction to the students' home, neighborhood, community and/or culture as appropriate and providing opportunities for students to connect their explanation of a phenomenon and/or their design solution to a problem to questions from their own experience. (p. 25)

In our work developing NGSS-aligned instructional materials in fifth grade for diverse student groups and ELs in particular, we use local phenomena that meet two criteria. First, they are compelling to figure out as students experience these phenomena in their homes and communities (i.e., place-based learning). Second, they are comprehensive enough to sustain a science unit that addresses multiple NGSS PEs within and across science disciplines over an extended period of instruction (i.e., project-based learning). In addition to these two criteria, our research team is also concerned with selecting and using local phenomena that are universal phenomena across school districts and states so that our instructional materials could be implemented at large scale (This criterion is not addressed specifically in this chapter).

Local phenomena integrate place-based learning from an equity perspective and project-based learning from a science perspective in mutually supportive ways (see Figure 1). 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. 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.

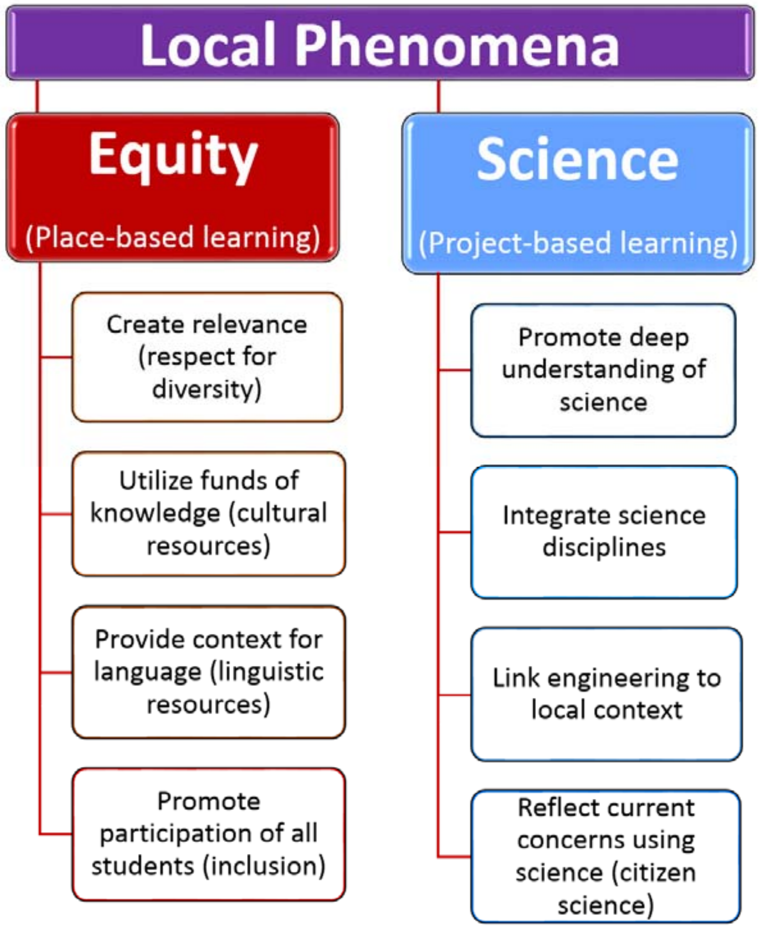

Figure 1. Local phenomena with diverse student groups.

Place-Based Learning From an Equity Perspective

From an equity perspective, through place-based learning, students apply science and engineering to their everyday lives in local contexts (Avery, 2013; Brehm, Eisenhauer, & Stedman, 2012; Endreny, 2010; Haywood, 2014; Semkin & Freeman, 2008; Smith, 2002; Tolbert & Knox, 2016). The goal of place-based learning is to "ground learning in local phenomena and students' lived experience" (Smith, 2002, p. 586). Place-based science has been advocated for its relevance and potential to attract underrepresented groups to science, particularly members of indigenous or historically inhabited communities, through place attachment (i.e., an emotional bond between a person and a place) and place meaning (i.e., the meanings that a person associates with a place; Brehm et al., 2012). Our instructional materials connect student diversity to science and engineering by capitalizing on equity components that local phenomena or problems present to diverse student groups (see Table 1; also see Figure 1):

Table 1

Equity Components of Local Phenomena With Diverse Student Groups

Equity component 1 – Create relevance	Using local phenomena or problems makes science real by grounding experiences in students' everyday lives. As students figure out local phenomena, they realize how science is relevant to their lives, their communities, and their future careers.
Equity component 2 – Utilize funds of knowledge	Using local phenomena or problems allows students to use their funds of knowledge from their homes and communities. Students capitalize on their cultural resources by engaging in authentic tasks that build on their everyday experiences.
Equity component 3 – Provide context for language use	Using local phenomena or problems generates language and facilitates communication. Students capitalize on their linguistic resources by engaging in meaningful discourse through all of the modes of communication at their disposal, including everyday language, home language, and multimodality.
Equity component 4 – Promote participation of all students	Using local phenomena or problems creates an inclusive learning environment by acknowledging the diversity of students, their families, and their communities. Students bring their cultural and linguistic resources into the science classroom, which are recruited as valued resources for learning science.

Project-Based Learning From a Science Perspective

From a science perspective, through project-based learning, students integrate science disciplines as they explain phenomena or design solutions to problems through collaborative investigations (Harris et al., 2015; Krajcik & Czerniak, 2013; Krajcik, McNeill, & Reiser, 2008).

Project-based learning is an approach to designing learning environments that promotes active construction of understanding through participation in authentic and meaningful experiences. According to the *Framework* and NGSS, phenomena or problems are central to science and science learning, as “the goal of science is to develop a set of coherent and mutually consistent theoretical descriptions of the world that can provide explanations over a wide range of phenomena” (NRC, 2012, p. 48). In the NGSS-aligned classroom, students make sense of phenomena as scientists do and design solutions to problems as engineers do. Our instructional materials make connections across science and engineering disciplines by capitalizing on science components that local phenomena or problems present to diverse student groups (see Table 2; also see Figure 1):

Table 2

Science Components of Local Phenomena with Diverse Student Groups

Science component 1 – Promote deep understanding of science	Using local phenomena allows students to develop deep understandings of science as they try to make sense of the phenomena in personally meaningful ways. This is in contrast to the traditional approach of learning abstract science content without personal connection.
Science component 2 – Integrate science disciplines	Using local phenomena or problems allows students to make connections across science disciplines in order to explain phenomena or design solutions to problems. This is in contrast to the traditional approach of learning a particular science idea, topic, or concept without crossing disciplinary boundaries.
Science component 3 – Link engineering to local contexts	Using local phenomena or problems connects science with engineering as students design solutions to problems in their communities. This is in contrast to the traditional approach of learning science and engineering in isolation from each other.

Science component 4 – Address current concerns using science	Using local phenomena or problems allows students to participate in citizen science by contributing to knowledge-building and effecting change in their communities (Bonney et al., 2009). This is in contrast to the traditional approach of learning science without reference to societal issues or concerns.

Selecting and Using Local Phenomena in the SAIL Instructional Materials in Collaboration With a Teacher Advisory Board

We are currently developing yearlong NGSS-aligned instructional materials for diverse student groups in fifth grade and ELs in particular. The NGSS for fifth grade identify 16 PEs, including six physical science; two life science; five Earth and space science; and three engineering, technology, and applications of science. Our instructional materials bundle the NGSS PEs into four units addressing physical science, life science, Earth science with engineering embedded, and space science. Each unit is intended for approximately one marking period of 9 weeks, assuming 45-60 minutes of science instruction three times per week.

Unit 1: What happens to our garbage? (physical science)

Unit 2: Why did the tiger salamanders disappear? (life science)

Unit 3: Why does it matter if I drink tap water or bottled water? (Earth science with engineering embedded)

Unit 4: Why do falling stars fall? (space science)

Collaboration With Teacher Advisory Board

The initial versions of our instructional materials were field-tested in five fifth-grade classrooms from five elementary schools in an urban school district in a northeast state during the 2016-2017 school year. The district administrators in science education and ESL/bilingual education selected the teachers based on having large numbers of ELs in their classrooms and being willing to participate in the project. The teachers served as the Teacher Advisory Board for the project and worked closely with the project personnel to implement and provide feedback on the draft instructional materials.

We held four Teacher Advisory Board meetings over the course of the school year. Following each meeting, the teachers field-tested the science units in their classrooms. Multiple sources of data provided insights about the opportunities and challenges of implementing our phenomenon-based instructional materials with diverse student groups in the classrooms. First, the project personnel visited each teacher weekly, taking detailed notes about each lesson. For the majority of lessons, we made multiple observations. Second, teachers filled out a brief feedback form at the end of each class period and a more comprehensive online feedback form using both ratings and written responses at the end of each lesson. Teachers provided additional feedback about the unit that they had just implemented during the subsequent Teacher Advisory Board meeting. Third, the project personnel held weekly debriefing meetings throughout the year to discuss strengths, areas for improvement, and suggestions for revision. We kept extensive notes for each of these debriefing meetings to guide subsequent revisions and field-testing. Through triangulation across multiple data sources, we were able to identify opportunities and challenges in selecting and using local phenomena with diverse student groups.

Selection and Use of Local Phenomena in SAIL Instructional Materials

We use the first unit on physical science and parts of life science to illustrate how we select and use local phenomena in SAIL instructional materials. Specifically, we attend to place-based learning from an equity perspective and project-based learning from a science perspective.

The phenomenon of garbage. For this first unit, we selected the phenomenon of garbage in the school, home, and neighborhood, which all goes to a landfill in the local community. The anchoring phenomenon for the unit is that the school, home, and neighborhood make large amounts of garbage every day. Then, we frame the driving question for the unit broadly, "What happens to our garbage?" In answering this driving question over the course of the unit, students investigate a series of questions about garbage (e.g., What is that smell? What causes changes in the properties of materials in garbage?) that addresses the targeted set of PEs across science disciplines. Over the course of the unit, students develop a coherent understanding of the structure and properties of matter to make sense of the anchoring phenomenon and to answer the driving question.

The garbage unit is comprehensive enough to fully address four fifth-grade physical science (PS) PEs and to introduce one life science (LS) PE (see Figure 2).

5-PS1-1. Develop a model to describe that (SEP) matter is made of particles (DCI) too small to see (CCC).

5-PS1-2. Measure and graph quantities to provide evidence that (SEP), regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter (CCC) is conserved (DCI).

5-PS1-3. Make observations and measurements (SEP) to identify materials (DCI) based on their properties (CCC).

5-PS1-4. Conduct an investigation to determine (SEP) whether the mixing of two or more substances results in (CCC) new substances (DCI).

5-LS2-1. Develop a model to describe (SEP) the movement of matter among (DCI) plants, animals, decomposers, and the environment (CCC). (This PE is partially addressed in the unit.)

Note:

SEPs: science and engineering practices
CCCs: crosscutting concepts
DCIs: disciplinary core ideas

Figure 2. Performance expectations for the garbage unit.

To answer the driving question of "What happens to our garbage?," students develop physical models of a landfill by creating "landfill bottles" as open systems and closed systems (see Figure 3).

Figure 3. Open and closed landfill bottle systems for the garbage unit.

As the unit progresses, students' understanding of science builds coherently as they investigate 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 in Figure 2). 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 about microbes causing food materials to decompose and produce smell (5-LS2-1 on decomposers in the environment). In addition, they make observations of the weight of the garbage materials when some materials (e.g., banana and orange) seem to have vanished (5-PS1-2 on conservation of weight of matter).

Moreover, our instructional materials promote learning progressions over the course of the year. Students learn that microbes cause food materials to decompose, which is also addressed in the subsequent ecosystems unit (5-LS2-1). Likewise, materials that do not decompose (e.g., plastic) are addressed in the Earth's systems unit, as students learn that plastic from water bottles pollutes Earth's systems (5-ESS-2-1) and that individual communities can use science ideas to protect the Earth's resources and environment (5-ESS3-1).

Place-based learning from an equity perspective. We start the development of each unit by selecting a compelling phenomenon rooted in everyday experiences. First, the phenomenon of garbage creates relevance for all students in local contexts (equity component 1). As 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, they express a wide range of reactions from excitement to disgust. The everyday phenomenon of garbage becomes phenomenal.

Second, garbage from the school, home, and neighborhood that goes to a community landfill also capitalizes on students' funds of knowledge (equity component 2). For example, students make observations of garbage in their homes and communities, comparing the garbage materials and their properties (e.g., texture, color). 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.

Third, the phenomenon of garbage provides a context for all students, and ELs in particular, to communicate their ideas using all of the meaning-making resources at their disposal, including everyday language, home language, and multimodality (equity component 3). The opportunity to use all of their meaning-making resources from the outset of instruction 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 drawings, symbols, and text, to develop initial models of smell. Over the course of the unit, as students develop deeper understanding of science to make sense of the phenomenon of garbage, they adopt a more specialized register (e.g., students say, “Smell is a gas made of particles too small to see.”) and use modalities more strategically (e.g., students use arrows to represent gas particles moving freely in space) to communicate the sophistication of their ideas.

Finally, the phenomenon of garbage promotes access and participation of all students in the science classroom (equity component 4). As a result, abstract ideas of matter (e.g., particle nature of matter, properties of matter, chemical reaction, and conservation of weight of matter) are made accessible and relevant to all students. Students’ contributions are valued based on the merit of their ideas, not their social status or linguistic accuracy.

Project-based learning from a science perspective. We select a phenomenon that is comprehensive enough to address multiple PEs over an extended period of instruction (in our case, approximately a 9-week marking period) and allows students to develop their understanding coherently over the course of a unit (science component 1). In each unit, students develop a driving question board, which serves as a physical location in the classroom to organize their questions about the phenomenon. Students create the driving question board based on their initial experience with the phenomenon and then add to and reorganize the board as they progress through the unit. The phenomenon connects the student questions together and provides a context to investigate a series of subquestions. Every lesson starts with a subquestion that students decide based on previous investigations to help them explain the phenomenon. Over the course of the unit, each investigation contributes to progressively figuring out the phenomenon.

Designing a unit around the phenomenon of garbage allows students to understand science more broadly across science disciplines (science component 2). As students use science to make sense of the phenomenon, they experience the work of scientists who investigate questions that transcend disciplinary boundaries. For example, fifth-grade students explain the smell of garbage in terms of the particle nature of gas (i.e., a physical science idea) and the cause of the smell as microbes decomposing the banana and orange (i.e., a life science idea). In figuring out what happens to garbage, students meet PEs across physical and life science disciplines.

Moreover, the phenomenon of garbage leads to engineering in the subsequent Earth's systems unit, as students find out that plastic, which does not decompose, pollutes Earth's systems. Then, they design solutions to solve this problem by reducing the amount of plastic from water bottles in their classroom and school (science component 3). The Earth's systems unit addresses engineering PEs (3-5-ETS1-1, 3-5-ETS1-2). Students' experiences with societal concerns about garbage and plastic pollution could lead them to use science ideas to protect the Earth's resources and environment and to participate in citizen science (science component 4).

Challenges in Selecting and Using Local Phenomena With Diverse Student Groups

Through the development of initial instructional materials and field-testing, we gained insights into challenges in selecting and using local phenomena with diverse student groups. Below, we organize our insights in terms of challenges in promoting place-based learning from an equity perspective and project-based learning from a science perspective. Again, we use examples from the garbage unit to illustrate challenges and how we address these challenges.

Place-based learning from an equity perspective. As the concept of "local" is relative and interpreted variably, it is challenging to select a phenomenon that is perceived as relevant by all students. Phenomena are generally perceived as local if students have had experience in their school, home, or neighborhood. For our instructional materials, we do not begin the garbage unit with the phenomenon of a community landfill because not all students know a landfill or experience it daily. Instead, we use school lunch garbage as an entry point to talk about the larger garbage handling system, including a landfill in the community. As students figure out what happens in their landfill bottles in the classroom, this everyday phenomenon becomes phenomenal.

Furthermore, it is challenging to identify a local phenomenon that is engaging and relevant for students while also comprehensive enough to address multiple PEs. One candidate phenomenon may be engaging and relevant for students but may not address a targeted set of PEs or sustain a unit over several weeks. Another candidate phenomenon may be well matched with the PEs but have little relevance to students' everyday experiences in their homes and communities. Thus, it is necessary to consider each candidate phenomenon in terms of trade-offs (i.e., what is gained and what is lost) while keeping equity at the forefront. As described earlier, the phenomenon of garbage meets both criteria as it is compelling and relevant to students while addressing multiple PEs over a 9-week period. Garbage as a locally relevant phenomenon offers an entry point for all students to develop deep understanding of complex and abstract ideas in physical science over a sustained period of instruction.

Project-based learning from a science perspective. Selecting an anchoring phenomenon and a driving question that build toward a targeted set of PEs over a sustained period of time requires teachers to possess deep and extensive knowledge of the phenomenon, PEs, and their relationship. Implementing phenomenon-based instructional materials presents a challenge to teachers who need to have sufficient knowledge about the DCIs and the phenomenon of a unit. For example, to implement the garbage unit, teachers must be familiar with the particle nature of matter, the process of rotting garbage materials producing a smell, and the causal relationship between microbes on garbage materials and the particles of smell in the air. These demands on content knowledge are especially acute for teachers who do not have a strong background in science. To address this challenge in our instructional materials, we embed just-in-time science background knowledge for teachers so that they can make connections (and, ultimately, help their students make connections) between the PEs and the phenomenon under study.

It is also unclear to what extent student learning transfers beyond the phenomenon to other contexts. An affordance of phenomena is that they create rich contexts for learning science ideas through engagement in science and engineering practices. However, students should also be able to apply what they have learned beyond the context of the phenomenon to new contexts.

For example, as part of the garbage unit, students learn that materials in the landfill do not disappear or vanish since weight is conserved. In field-testing, however, students struggled to transfer their understanding of conservation of weight to other contexts. To address this challenge in our instructional materials, we embed assessments that probe students' understanding of key science ideas in less familiar contexts that are outside of the unit phenomenon. For example, after students come to understand conservation of matter in the context of garbage, they are asked to predict the weight of an ice cube in a plastic bag after the ice cube melts. Teachers use these assessments formatively to tailor subsequent instruction.

Bringing phenomena to the classroom presents logistical challenges. Students may understand how a phenomenon is real and relevant to their lives, but continued student interest and engagement in learning science requires multiple and varied experiences with the phenomenon over the course of a unit. Although a trip to the local landfill would be ideal in the garbage unit, schools cannot always afford these types of experiences. Instead, we substitute this experience with a video that simulates a virtual trip to the landfill. While students continue their study of the landfill bottles over the course of the unit, they also conduct related investigations to reinforce their understanding of core ideas (e.g., crushing and tearing everyday objects to learn about conservation of matter/weight; compressing air in a syringe to learn about the particle nature of gas). While necessary to address the targeted PEs, these related investigations could take the focus away from the phenomenon and the storyline of the unit. To address this challenge in our instructional materials, we select related investigations based on everyday occurrences and make explicit their purpose and connection to making sense of the phenomenon under study.

Conclusion

The NGSS present key instructional shifts that pose both opportunities and challenges to teachers and students. Providing these opportunities and meeting these challenges are particularly critical when working with students who have not experienced science and engineering as real and relevant to their lives or future careers. We argue for local phenomena or problems that compel students from diverse backgrounds to engage in three-dimensional learning and to build their science understanding over a sustained period of instruction. Local phenomena promote access and inclusion in the science classroom by grounding experiences in students' everyday lives.

In this chapter, we describe how we select and use local phenomena in developing NGSS-aligned instructional materials with diverse student groups. Specifically, we describe how our instructional materials integrate place-based learning from an equity perspective and project-based learning from a science perspective. We also describe both opportunities and challenges in selecting and using local phenomena with diverse student groups. In light of these opportunities and challenges, we propose inquiry questions for science education researchers and action research suggestions for practitioners in Appendices A and B, respectively.

As our work continues through an iterative process of field-testing in classrooms and subsequent revisions, we aim to capitalize on opportunities and address challenges. The insights we gain through our collaboration with the Teacher Advisory Board will further improve our instructional materials specifically and the NGSS community broadly. By "making everyday phenomena phenomenal," we move a step closer to realizing the vision of the *Framework* and NGSS and to ensuring all students, especially those underserved in science education, have access to rigorous science learning that prepares them for college and careers.

Inquiry Questions for Science Education Researchers

This chapter describes both opportunities and challenges in selecting and using local phenomena with diverse student groups. For science education researchers concerned with issues of equity, it is important to address challenges while capitalizing on opportunities. We propose the following inquiry questions to examine the challenges discussed in the chapter.

Inquiry Question 1

Challenge: Phenomena are generally perceived as local if students have had experience in their school, home, or neighborhood. As the concept of "local" is relative and interpreted variably, it is challenging to select a phenomenon that is perceived as relevant by all students.

Question: How is a "local" phenomenon defined? What are key features of a local phenomenon?

Inquiry Question 2

Challenge: It is challenging to identify a local phenomenon that is engaging and relevant for students while also comprehensive enough to address multiple performance expectations (PEs). It is necessary to consider each candidate phenomenon in terms of trade-offs (i.e., what is gained and what is lost) while keeping equity at the forefront.

Question: What are design principles for instructional materials to address a phenomenon, a targeted set of PEs, and student diversity simultaneously in a science unit?

Inquiry Question 3

Challenge: Selecting an anchoring phenomenon and a driving question that builds toward a targeted set of PEs over a sustained period of time requires teachers to possess deep and extensive knowledge of the phenomenon, PEs, and their relationship.

Question: What are features of instructional materials so that teachers have sufficient knowledge to integrate a phenomenon, a targeted set of PEs, and student diversity in their teaching?

Inquiry Question 4

Challenge: It is unclear to what extent student learning transfers beyond the phenomenon to other contexts.

Question: How can science instructional materials be developed to promote transfer of science knowledge beyond the phenomenon under study to other contexts?

Inquiry Question 5

Question: For developers of instructional materials aimed at large-scale implementation, how can materials utilize local phenomena that are also universal phenomena across settings so that the materials could be implemented at large scale?

Action Research Suggestions for Practitioners

For practitioners who are interested in designing NGSS-aligned instructional materials based on local phenomena with diverse student groups, we offer the following action research. We emphasize that the process of designing such materials is iterative and nonlinear.

1. Identify the intended grade level for a science unit.
2. List NGSS performance expectations for the unit.
3. Identify a local phenomenon (for science) or a problem (for engineering) to serve as the anchoring phenomenon or problem for the unit.
4. Establish a driving question for the unit.
5. Give your reasoning of how the phenomenon or problem meets the following two criteria (see Figure 1, Table 1, and Table 2):

   Criterion 1: Place-based learning from an equity perspective

   Criterion 2: Project-based learning from a science perspective
6. Design an outline of the unit or revise an existing unit that enables your students to meet the targeted set of performance expectations by explaining the phenomenon or designing solutions to the problem.

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