SPONSORED BY CAROLINA® | Building Blocks OF SCIENCE™ 3D

WINTER 2021

The Power of Analogous Phenomena

How the transfer of knowledge to everyday phenomena deepens sensemaking in three-dimensional science learning

In a kindergarten classroom, students are eagerly observing pumpkin seed germination and plant growth. As a student mists a plant, she watches rain falling on a tree outside the classroom. And then it clicks—she makes the connection that trees are also plants that require light and water to grow, just like the plants in the classroom and by her home.

Analogous phenomena—also called everyday, relevant, or related phenomena—are multiple observable events that are the same or similar and are explainable using the same core ideas.

"There is a power in analogous phenomena, in making time for students to share those ideas of a phenomenon that is related to them," Bridget Hughes-Binstock, a science curriculum developer for Carolina Biological Supply Company, says. "We want to make sure that what students experience in everyday life is a true representation of the understanding of the core idea they're studying in science class. This practice addresses equity and relevance and coherence, things the Next Generation Science Standards strive to achieve."

Explaining phenomena and solving problems are central to the Next Generation Science Standards* (NGSS) and other standards based on the National Research Council's *A Framework for K–12 Science Education.* Students ask questions and identify problems to figure out why or how something happens to build general ideas that can be applied in the real world, leading to deeper and more transferable knowledge (Achieve 2016). Hughes-Binstock, along with Carolina curriculum developers Heather Haley and Heidi Duty, recognize that providing multiple opportunities for students to apply concepts they have experienced in class to phenomena in their lives enables them to achieve a higher and more demonstrable level of understanding.

Making connections between plants in the classroom to plants outside supports the core idea that plants need water and light to live and grow.

> "We want to make sure that what students experience in everyday life is a true representation of the understanding of the core idea they're studying in science class. This practice addresses equity and relevance and coherence..."
>
> *—Bridget Hughes-Binstock*

"Analogous phenomena are critical for sensemaking," Haley says. She explains that, following a classroom activity, "if you can tap into this other phenomenon that students have experience with, you strengthen the neurological connections that lead to lasting learning and also a more robust understanding of all the ways they might see that science idea happening in their lives."

"The idea is to build that core idea," Duty adds. "With analogous phenomena, it's really bringing in those personal experiences, those real-world connections that they have, to make better sense of the core science idea."

Analogous Phenomena and the 5E Model

The NGSS and similar standards based on the National Research Council's *A Framework for K–12 Science Education* are organized into three dimensions—science and engineering practices (SEPs), crosscutting concepts (CCCs), and disciplinary core ideas (DCIs)—that, together, lead students to demonstrate knowledge while they figure out phenomena or solve problems (Achieve n.d.). While the NGSS provide a logical progression designed to engage students in sensemaking and lead them to become critical, innovative thinkers, the standards don't specify how teachers should teach these skills.

One model of instruction that supports NGSS, is familiar to many teachers, and offers a coherent approach that leads students to apply CCCs and the DCI to make sense of analogous phenomena is the BSCS 5E Instructional Model, or simply the 5Es.

- "The 5E model can include scientific practices for students at almost any level, and are already designed to facilitate sensemaking through explanation." (Institute for Science + Math Education 2014)
- "The 5E instructional model is grounded in theory and creates a focus with each phase that carries forward students' use of core ideas and crosscutting concepts to make sense of phenomena that have the same causes." (Moulding and Bybee 2017, 18)

5E Model	Science and Engineering Practices	Analogous Phenomena
Engage	Asking questions and defining problems	
Explore	Asking questions and defining problems, developing and using models, planning and carrying out investigations	
Explain	Developing and using models, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions	Explain, observe, and collaborate to make sense of related phenomena.
Elaborate	Analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions	Present evidence that supports explanations for related phenomena.
Evaluate	Engaging in argument from evidence; obtaining, evaluating, and communicating information	Demonstrate understanding of related phenomena.

> "Our task as teachers is helping students develop a logical and useful structure for making sense of phenomena beyond the classroom."
>
> *(Moulding and Bybee 2017, 23)*

Additionally, teachers' familiarity with the 5Es and the model's natural fit with a highly structured storyline make the 5Es a compelling choice for NGSS-aligned instruction. In this model, students and teachers:

- Engage: Students ask questions and show interest in a phenomenon. The teacher elicits responses that uncover what students know or think, along with misconceptions students may have, to assess prior knowledge.
- Explore: Supported with hands-on activities, simulations, and student readers, students collaborate to investigate phenomena and develop explanations. The teacher observes and guides learning.
- Explain: Students explain possible solutions. They make observations as they begin to apply their investigation to analogous phenomena. The teacher formatively assesses students' explanations.
- Elaborate: Students use crosscutting concepts to relate the phenomenon to other phenomena in their lives. The teacher encourages the student to deepen thinking by extending the concepts to related phenomena.
- Evaluate: Students self-reflect on learning and demonstrate an understanding of the phenomenon as well as offer evidence supporting analogous phenomena. The teacher evaluates students' reasoning and assesses their knowledge.

The disciplinary core idea—a fundamental idea necessary for understanding a science discipline—often equips students with accurate scientific vocabulary as they are guided by the 5Es in their investigations. Science and engineering practices, leading students to behave as scientists and engineers, are embedded in the 5E lessons (see the table, page 2). For example, Haley notes, in an "explore" lesson, students may demonstrate several SEPs as they explore the core idea and relate it to everyday phenomena. Crosscutting concepts provide a lens to think about the world as students recognize similarities between phenomena through CCCs such as system models and patterns. As they explain, elaborate, and evaluate, transferring knowledge to analogous phenomena leads to a more enhanced understanding of the core idea.

Promoting Equity

The NGSS and other standards based on the *Framework* highlight the importance of providing equitable, high-quality learning opportunities for all students to become scientifically literate citizens. Whether students are learning in a classroom or at home, relating phenomena from their everyday lives supports a diverse population, allows the teacher to effectively differentiate, and encourages students to apply their conceptual understanding of a core idea to something they're familiar with.

"The 5Es are built on a constructivist approach," Hughes-Binstock explains. "It promotes equity because you're giving students an opportunity to relate an abstract concept to something in their lives. You engage them and then see if there's something in their lives that reminds them of that by applying the abstract in more concrete ways based on personal experiences."

Haley agrees. "Analogous phenomena—especially phenomena that's from a student's home, community, or culture and that is specific to the student—is one of the ways to promote equity in the classroom," she says. "It gives them something to relate to and allows everyone to participate in some way."

NGSS strategies to assist diverse student groups in learning include capitalizing on students' cultural and linguistic resources from their backgrounds and connecting students' background knowledge with science

disciplinary knowledge (Januszyk, Miller, and Lee 2016, 48). As an example, Hughes-Binstock cites engaging grade 2 students by showing a video of glass blowing as they consider the concept of the properties of matter as it relates to temperature: students see the substances getting hot and molten. As they explore, they may relate the observable properties of the glass to lava coming from a volcano or a marshmallow being roasted over a campfire.

"If they can't understand what's happening to the glass pieces, they might understand different things that are related to them," Hughes-Binstock says. "From an analogous perspective, you're trying to bring things they can relate to that then support their learning, which transfers to how you hope they can explain what's happening in the glass-blowing event. When you get to the "elaborate" stage, the idea is they're going to take all their conceptual understanding and be able to apply it to a different area of their lives, providing a formative assessment opportunity to the teacher."

After observing glass blowing, students may compare the analogous phenomenon of a roasting marshmallow to better understand how heating or cooling a substance may cause changes that can be observed.

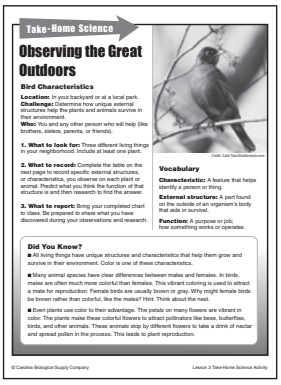
Applying Analogous Phenomena

All three dimensions of the NGSS and similar standards fall under the umbrella of phenomena, so it's key that every unit connects to an anchoring phenomenon representing the DCI, with lessons within the unit supporting that core idea through investigative phenomena. During the investigations, the teacher can encourage students to make connections with analogous phenomena through open-ended questions:

- What does this remind you of?
- Can you tell me more about ____?
- Tell me about a time in your life when you experienced _____.
- What does this make you wonder?
- How is this similar to or different from _____?

If students struggle to make comparisons, the teacher can guide them by asking more explicit questions and engage them in additional learning strategies:

- Lessons that encourage students to go outside, whether outside of their classroom or home, help learners notice phenomena that may relate to their investigations.


Take-Home Science

Observing the Great Outdoors

Bird Characteristics

Location: In your backyard or at a local park.
Challenge: Determine how unique external structures help the plants and animals survive in their environment.
Who: You and any other person who will help (like brothers, sisters, parents, or friends).

1. What to look for: Three different living things in your neighborhood. Include at least one plant.

2. What to record: Complete the table on the next page to record specific external structures, or characteristics, you observe on each plant or animal. Predict what you think the function of that structure is and then research to find the answer.

3. What to report: Bring your completed chart to class. Be prepared to share what you have discovered during your observations and research.

Vocabulary

Characteristic: A feature that helps identify a person or thing.

External structure: A part found on the outside of an organism's body that aids in survival.

Function: A purpose or job; how something works or operates.

Did You Know?

■ All living things have unique structures and characteristics that help them grow and survive in their environment. Color is one of these characteristics.

■ Many animal species have clear differences between males and females. In birds, males are often much more colorful than females. This vibrant coloring is used to attract a mate for reproduction. Female birds are usually brown or gray. Why might female birds be brown rather than colorful, like the males? Hint: Think about the nest.

■ Even plants use color to their advantage. The petals on many flowers are vibrant in color. The plants make these colorful flowers to attract pollinators like bees, butterflies, birds, and other animals. These animals stop by different flowers to take a drink of nectar and spread pollen in the process. This leads to plant reproduction.

© Carolina Biological Supply Company

Lesson 3 Take-Home Science Activity

- Take-home science activities encourage students to specifically look in their home communities for phenomena that support the science idea they investigated in class that day.
- Simulations can spark student thinking, leading to that aha moment that helps them relate phenomena.

The analogous phenomena students relate to can make their thinking more visible, illustrating the difference between what students know and what they think they know but may be a misconception.

"Kids may not have the information yet or the observation skills to make an accurate analogy," Duty says. "It's okay for students to have misconceptions initially, but then they reexamine those misconceptions and display what they've learned. It gives the teacher a formative assessment to then figure out ways to get students to come to an accurate understanding of the common idea. So even if it's just the basic formation of the idea, then they can expand on it as they go through the investigations."

"The teacher shouldn't just tell students they're wrong but should look for ways to help guide them back to discovering they have misconceptions," Hughes-Binstock adds. "They have to tease apart what are the similarities and differences between the phenomena. Have students see how far they can go before the relationships between the two phenomena break down. If the first one or two similarities go together but three or four steps down they start falling apart, it's not a strong analogy."

By making real-world connections that inspire curiosity about multiple phenomena, students are actively engaged in learning, leading to a deeper, more meaningful, and transferrable understanding of the core ideas in their science education.

Phenomena in the Classroom

Grade	Disciplinary Core Idea	Investigative Phenomenon	Analogous Phenomenon	Crosscutting Concepts that Support Explanations
K	**LS1.C:** Organization for Matter and Energy Flow in Organisms **ESS3.A:** Natural Resources	Students observe preferences that bessbugs have for different things in their habitat.	**Identify Phenomena:** Challenge students to think about the preferences of other animals, such as why birds build nests in trees or why dogs like to dig.	• Cause and Effect
1	**PS4.A:** Wave Properties	Students use a cup of water and an unsharpened pencil to observe that vibrations cause waves and sound.	**Ask students:** Where have you seen water move like the water in your cup moved? **Identify Phenomena:** Make connections to phenomena by providing other examples of waves, such as those produced by Slinkys, boats, and fans in sport stadiums.	• Cause and Effect
2	**PS1.A:** Structure and Properties of Matter	Students are provided with samples of liquid materials and identify words to describe and distinguish between them.	**Identify Phenomena:** Ask students to think about a time when they tried to get ketchup or honey out of a container. Encourage students to relate this experience to viscosity and fluidity. **Tell Me More!** Is a pool of maple syrup more viscous or more fluid than a pool of water? Explain how you know.	• Patterns
3	**LS3.B:** Variation of Traits **LS4.B:** Natural Selection	Students use model beaks to investigate how beak shape affects the ability to access various types of food.	**Take-Home Science Activity:** *Observing Birds and Their Feeding Patterns*—Students make birdfeeders with their families to observe patterns in the types of birds they see and the foods the birds eat.	• Patterns • Cause and Effect • Structure and Function
4	**ESS2.B:** Plate Tectonics and Large-Scale System Interactions	Students assemble a map of Earth's tectonic plates and make predictions about the effects of the plates' movements.	**Identify Phenomena:** Make connections between convection in the mantle and the convection of air, which rises as it heats (due to the Sun) and falls as it cools. **Tell Me More!** What do you think causes an earthquake? Think about Earth's plates.	• Patterns
5	**PS1.A:** Structure and Properties of Matter	Students explore condensation and evaporation by observing phenomena.	**Identify Phenomena:** Students draw connections between what they notice during this investigation and times in their lives when they have observed similar phase changes of water, such as steam rising over a pot of simmering soup. **Tell Me More!** When you sweat, the liquid on your body evaporates. Explain why this helps you cool.	• Cause and Effect

Examples of phenomena are from Building Blocks of Science™ 3D.

REFERENCES

Achieve. 2016. "Using Phenomena in NGSS-Designed Lessons and Units." Accessed November 2020: https://www.nextgenscience.org/sites/default/files/Using%20Phenomena%20in%20NGSS.pdf.

Achieve. n.d. "Next Generation Science Standards" Fact Sheet. Accessed November 2020: https://www.nextgenscience.org/resources/ngss-fact-sheet.

Institute for Science + Math Education. 2014. "Leading Instructional Models that Fit with NGSS." Accessed November 2020: http://stemteachingtools.org/sp/limfn.

Januszyk, Rita, Emily C. Miller, and Okhee Lee. April/May 2016. *The Science Teacher.* "Addressing Student Diversity and Equity." Accessed November 2020: https://static.nsta.org/pdfs/samples/tst1604_47.pdf.

Moulding, Brett D., and Rodger W. Bybee. 2017. *Teaching Science Is Phenomenal: Using Phenomena to Engage Students in Three-Dimensional Science Performance Consistent with the NRC Framework and NGSS.* Washington, Utah: Elm Tree Publishing.

National Research Council. 2012. *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* Washington DC: The National Academies Press. https://doi.org/10.17226/13165.

ABOUT

CAROLINA

Carolina Biological Supply Company is a leading supplier of science teaching materials. Headquartered in Burlington, North Carolina, it serves customers worldwide, including teachers, professors, homeschool educators, and professionals in health- and science-related fields. Carolina is the exclusive developer and distributor of the Building Blocks of Science™ 3D curriculum.

BUILDING BLOCKS OF SCIENCE™ 3D

Building Blocks of Science™ 3D is an all-inclusive, hands-on, phenomena-based curriculum developed to establish a solid foundation in elementary science while precisely connecting daily instruction to the NGSS. Every investigation is anchored in phenomena, empowering students to ask questions, investigate possibilities, and build solutions through multiple opportunities to engage and make connections to phenomena in the real world.

The new BBS3D@Home digital component maintains the continuity of the unit storyline used in the classroom for students who are learning remotely, enabling teachers to spend less time and energy on organizing and planning so they can provide the best learning experience for their students no matter where they learn.

Learn how the easy-to-use Building Blocks of Science™ 3D curriculum drives sensemaking for your students.

www.carolina.com/bbs

curriculum@carolina.com

800.334.5551

CB884242012

Building Blocks of Science™ 3D

CAROLINA®
www.carolina.com