Use of Phenomena

A phenomenon is simply an observable event that we can use our science knowledge to explain or predict. Engineers design solutions to problems that arise from phenomena. Phenomena provide context for the work of both scientists and engineers. Student inquiry can be driven by using a carefully chosen phenomena. Phenomena add relevance to the science classroom showing students science in their own world. A good phenomenon is observable, interesting, complex, and aligned to the appropriate standard. Use of phenomena helps students identify answers for "why they need to learn this," and shifts from learning about a topic to figuring out why something happens. The focus should not be on the phenomenon itself, but on the student generated questions that guide learning and teaching. The same phenomenon might be used in very different ways, depending on the student audience and grade level, to drive teaching and learning. Use of phenomena provides critical access for English learners or for students from historically underrepresented groups. There is a difference between anchoring phenomena, which serve as the focus for a unit, and investigative phenomena that might serve individual lessons.

Thinking about the use of phenomena has evolved since the public release of NGSS in 2013, as seen by the following table[2]:

EARLY THINKING ABOUT PHENOMENA	RECENT THINKING ABOUT USING PHENOMENA TO REALIZE THE POWER OF NGSS
Anything students are interested in would make a good phenomenon.	Students need deep engagement with the material to generate an explanation of the phenomenon using the three elements of the PE (DCI, SEP, CCC).
Explanations are examples of phenomena.	Phenomena (e.g., sunburn, vision loss) are a specific example of a general process; they are what can be experienced or documented.
Phenomena need to be flashy, fun, or using hands on to be engaging.	Authentic engagement can occur without fun or flash; instead engagement is determined by how students create real opportunities for learning.
Phenomena are just for the initial hook.	Phenomena can drive a lesson; use of a phenomena in this way drives deeper learning.
Phenomena need to be questions.	Phenomena are observable occurrences that are used to generate science questions or problems that drive learning.
Student engagement is nice but not required.	Engagement is an important access and equity issue. A good phenomenon builds on everyday experiences available to all students.
Phenomena are good to bring in after students develop the science ideas so they can apply what they learned.	Many students have trouble applying decontextualized content or ideas; anchoring the development of ideas in phenomena helps students build more usable knowledge.

In *A Natural Approach to Chemistry*, each chapter begins with a Getting Started section that includes an overview and a short representation of a hands-on activity that can be used to engage students in the anchoring phenomena and main themes. For example, in Chapter 2, students investigate a reaction between sodium borate and a glue solution[3] as a focus phenomena which leads to students brainstorming questions they have about the diversity of matter and how new substances are formed – the main themes for the chapter. Students learn chemistry by doing chemistry, exploring the science and engineering practices (SEP) as they work through more than 60 lab investigations - many of which feature the LabHub™, an advanced system that incorporates an RGB spectrophotometer, measures temperature and voltage, and a safe, control point heating system that eliminates the need for a bunsen burner. The LabHub can be controlled via Bluetooth connection to most smartphones, tablets, and laptops. The 5E model is used throughout, and each chapter shows a detailed treatment of every phase of the model. This is described earlier in this Introduction.

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2 https://www.nextgenscience.org/sites/default/files/Using%20Phenomena%20in%20NGSS.pdf

3 they can read about it, watch a video or do the mini-lab themselves

Examples of Phenomena in the Student Book

This is not an exhaustive list. It is prepared to give teachers some support for using phenomena in teaching chemistry. It is also encouraged to make connections to related local phenomena in your community when possible. Each chapter of the student book begins with 3-4 driving questions which also focus on phenomena developed in the chapter. The Lab Investigation Manual (LIM) is another source of support for this practice.

CHAPTER	PHENOMENA (STATED AS QUESTIONS)
1	When a tree grows, where does the mass of the tree come from? (1.1)
	What is fire? Is it chemical, matter, and/or energy? (1.1)
	Why does a bottle collapse if you remove the air from it? (1.2)
	What happens to the energy in hot coffee as it cools? (1.2)
2	Is the "stuff" that makes up your body the same "stuff that makes up everything else on Earth? (Getting Started; see also 6.1)
	How can the glue/borax mixture change its properties after mixing, going from liquid to solid? (Getting Started)
	How do we get millions of substances from mixing 90+ elements? (2.2)
	How can the same elements combine to form different compounds with the same chemical formula? (2.2)
	How can chemicals that are toxic combine to form compounds that are not? (Chemical Connections)
3	What is different about a substance when it is hot compared to when it is cold? (Getting Started)
	Why do hot things feel hot and cold things feel cold? (3.1)
	Why don't cold things get colder and hot things get hotter? (3.2)
	Why does water have a much higher specific heat than otherwise "strong" materials like steel? (3.2)
	How can water exist as ice and in liquid form at 0 °C? (3.3)
	Why does the boiling temperature of water decrease with altitude? (3.3)
4	Why are there only three kinds of electrical charge, neutral, positive, and negative ? (4.1)
	Why do chemical reactions occur? (4.2)
	Why do some chemical reactions liberate heat and others absorb heat? (4.2)
5	Why do elements have a characteristic emission spectra? (5.1)
	Where do all the elements come from? (5.1)
	How can the electron behave like both a wave and a particle? (5.2)
6	Why do compounds form? Why do elements bond with only certain other elements? (6.2)
	Why do elements in the same column –but not row –of the periodic table have similar properties? (6.2)
7	Why do different kinds of bonds form? (7.1)
	How can we use the periodic table to predict what will bond? (7.2)
8	If sugar and salt look alike, why do they have such different properties? (8.1)
	Why are diamonds so hard? (8.2)
	How do water bugs "walk" on water? (8.3)
	Why is solid water less dense than liquid water? (8.3)

CHAPTER	PHENOMENA (STATED AS QUESTIONS)
9	Why does water dissolve so many different substances? (9.1)
	Why do some solutions support an electric current, while others do not? (9.1)
	Why does ice melt when you sprinkle salt on it? (9.3)
10	Why does rusting generate heat? (Getting Started)
	Why are some compounds soluble in water while others aren't? (10.2)
11	If trees remove carbon dioxide from the atmosphere, why can't we just plant more trees to get out of the global warming crisis? (Chemical Connections)
12	Can chemical reactions really go "backward?" (Getting Started)
	Why are some chemical reactions fast while others are slow? (12.1)
	Why do chemical systems shift to offset stress? (12.2)
	How can substances speed up a chemical reaction without being used up? (12.4)
13	How can your stomach contain a chemical strong enough to burn skin and dissolve metals? (Getting Started)
	How can water act as both an acid and a base? (13.1)
	How can soil pH affect the color of flowers? (Chemical Connections)
14	Why do my tires get flat on a very cold day? Why won't my vacuum cleaner work on the moon? (Getting Started)
	Why do different gases have the same pressure at the same temperature? (14.1)
	Why is there really no such thing as suction? (14.2)
	How can training at altitude help increase endurance for athletes who compete at sea level? (Chemical Connections)
15	How do batteries work? (Getting Started)
	Why do some metals rust while others do not? (Getting Started)
	How can you get electricity from a lemon? (15.1)
	Why won't the same two metals work as electrodes for a simple battery? (15.1)
	How do catalytic converters work in auto exhaust systems? (Chemical Connections)
16	Can you really melt metal with just the heat of your hand? (Getting Started)
	Why are the properties of some solids different from others? (16.1, 16.2)
	How can adding such a small amount of carbon make iron so much stronger? (16.3)
	How do insects "walk" on water? (16.4)
17	Why do isomers of the same carbon molecule have such different properties? (17.1)
	How do hydrogels like sodium polyacrylate absorb so much water? (Chemical Connections)
18	Why are some fats and carbohydrates better for you than others? (18.1)
	How does eating too much sugar or starch result in your body producing fats? (18.1)
	How do plants make their own food? Why can't animals do this? (18.2)
	How can DNA possibly carry all the information your body needs to grow, live, repair itself, create offspring, and more? (18.4)

CHAPTER	PHENOMENA (STATED AS QUESTIONS)
19	How do chemical reactions in the atmosphere affect life? (19.1)
	How can carbon dioxide affect the global climate on Earth? (19.1)
	How are elements and molecules recycled on Earth? (19.1, 19.2)
	If Earth is made of mainly the same elements, why are the layers different? (19.3)
	Where do rocks come from? (19.3)
20	How are nuclear reactions different from chemical reactions? (20.1)
	Why are only some elements radioactive? (20.2)
	How can radioactive dating be used to give the approximate age of objects? (20.3)
	Why is nuclear fusion preferred to nuclear fission as an energy source? (20.4)
	How does radiation damage the human body? (20.5)
21	Where did the Sun and Solar System (and the rest of the universe) come from? (21.1)
	Where does the Sun and stars get their energy from? (21.1)
	Is it possible for life to exist elsewhere in the universe? If so, what conditions are required? (21.3)