IOWA Science PHENOMENA

Teacher Guide

Thank you!

First, we want to say thanks for participating in this project! Without science educators and professionals like you, Iowa Science Phenomena couldn't exist. The phenomena you contribute will help students across Iowa explore a wide variety of science topics in authentic and personally relevant ways.

This guide is designed to help you identify and capture science phenomena. You'll find information on contextualizing phenomena, technical tips for capturing phenomena and more.

Have questions or suggestions? Please email phenomena@iowapbs.org.

Funding provided by the Corporation for Public Broadcasting (CPB).

Table of Contents

Funding provided by the Corporation for Public Broadcasting (CPB).

Funding provided by the Corporation for Public Broadcasting (CPB).

What is Iowa Science Phenomena?

In 2015, Iowa schools and teachers began a dramatic shift in science content expectations and pedagogy with the adoption of the new NGSS-aligned Iowa Science Standards. A key part of this instructional shift is the emphasis on locally relevant, real-world issues and phenomena. In 2018, in response to this statewide need Iowa PBS created Iowa Science Phenomena, a new online resource and sustained service to create, curate, collect and share a growing collection of user-generated, media-based, standards aligned, science phenomena resources for use in Iowa classrooms, as well as support Iowa teachers as they continue to implement phenomena-based and place-based teaching practices.

As a result of this multi-year ramp-up, over 200 user-generated media-based phenomena resources are published and freely available to all Iowa educators via the Iowa Science Phenomena website (iowaphenomena.org).

This guide is intended to help educators grow in their knowledge, understanding, and practice of phenomena-based instructional practices as well as encourage interest in identifying, capturing, and submitting Iowa phenomena to the Iowa Science Phenomena website. As this collection continues to grow, we look forward to showcasing more phenomena and ideas from educators and partners across Iowa.

Acknowledgements

Content created by Iowa PBS in contract with the following developers:

- Jonnie Becker, Science/Virtual Learning Coordinator, Des Moines Public Schools
- Laney Berry, STEM Instructional Specialist, Muscatine Community Schools
- Kean Roberts, 8th Grade Science Teacher, Ames Community School District

Iowa Science Phenomena Guide Goals

Goals for Teachers

After using this guide, teachers will be able to:

1. Identify locally relevant science phenomena.
2. Connect students to their community through the science content.
3. Capture the phenomena using available digital technologies
4. Align phenomena to specific standards.
5. Apply place-based and phenomena-based instructional and assessment practices with classroom students.
6. Demonstrate a deep and robust understanding of science content and apply that knowledge accurately and appropriately.
7. Apply an understanding of the nature of science.
8. Develop a richer appreciation for phenomena in the local community and Iowa.

Goals for Students

After participating in activities and teacher-lead strategies from this guide, students will be able to:

1. Identify locally relevant science phenomena.
2. Capture the phenomena using available digital technologies.
3. Connect their phenomena to science concepts.
4. Describe their phenomena using appropriate scientific and engineering vocabulary.
5. Develop robust and open-ended investigatory questions related to local phenomena.
6. Communicate learning and investigation results.
7. Publish and share their phenomena through online sources.
8. Develop a richer appreciation for phenomena in the local community and Iowa.

Funding provided by the Corporation for Public Broadcasting (CPB).

Why Use Phenomena-Based Education?

What Is Phenomena-Based Education?

Natural phenomena are **observable events that occur in the universe** that cause one to wonder and ask questions and that we can use our science knowledge to explain or predict. In the science classroom, a carefully chosen phenomenon can drive student inquiry. Phenomena add relevance to the science classroom, showing students science in their **own** world. A good phenomenon is observable, interesting, complex and aligned with an appropriate standard.

Why Use Phenomena-Based Education?

By centering science education on phenomena that students are motivated to explain**, the focus of learning shifts from learning about a topic to figuring out why or how something happens**.

Explaining phenomena and designing solutions to problems allow students to build general science ideas in the context of their application to understanding phenomena in the real world**, leading to deeper and more transferable knowledge**.

Students who come to see how science ideas can help explain and model phenomena related to compelling real-world situations learn to appreciate the relevance of science. They get interested in and identify with science as a way of understanding and improving real-world contexts. Focusing investigations on compelling phenomena can help sustain students' science learning.

Anchoring learning in explaining phenomena supports student agency for wanting to build science and engineering knowledge. Students are able to identify an answer to "why do I need to learn this?" before they even know what the "this" is.

How Do We Use Phenomenon-Based Education to Drive Teaching and Learning?

The point of using phenomena to drive instruction is to help students engage in practices to develop the knowledge necessary to explain or predict the phenomena. Therefore, the focus is not just on the phenomenon itself. It is the phenomenon plus the student-generated questions about the phenomenon that guides the learning and teaching. The practice of asking questions or identifying problems becomes a critical part of trying to figure something out.

There could potentially be many different lines of inquiry about the same phenomenon. Using the phenomenon of tree growth, a middle school teacher might want their students to develop and apply DCIs about photosynthesis and mitosis; alternately, a 3rd grade teacher might want their students to

Funding provided by the Corporation for Public Broadcasting (CPB).

learn and apply DCIs about life cycles. In each case, teachers should help students identify different aspects of the same phenomenon as the focus of their questions.

Not all phenomena need to be used for the same amount of instructional time. Teachers could use an anchoring phenomenon or two as the overall focus for a unit, along with other investigative phenomena along the way as the focus of an instructional sequence or lesson. They may also highlight everyday phenomena that relate investigative or anchoring phenomena to personally experienced situations. A single phenomenon doesn't have to cover an entire unit, and different phenomena will take different amounts of time to figure out.

What Makes Local Phenomena Effective for Use in Instruction?

The most powerful phenomena from an educational perspective are culturally or personally relevant or consequential to students. These phenomena highlight how science ideas help us explain aspects of real-world contexts or design solutions to science-related problems that matter to students, their communities and society.

Focusing on local phenomena allows students to make personal connections to science in positive and constructive ways.

The focus on locally relevant phenomena also helps teachers connect science learning experiences to students' sense of place, cultural perspectives and community issues.

Using locally based phenomena allows students to connect with their own environment as a foundation for moving into larger systems, issues, causes and consequences**; instruction that is guided by student's interests and community helps to ensure instruction is equitable and inclusive; and a local connection helps students develop a sense of personal stake and responsibility towards the environment.**

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

Local phenomena promote access and inclusion in the science classroom by grounding experiences in students' everyday lives.

"Place-Based Education is the process of using the local community and environment as a starting point to teach scientific and interdisciplinary content. Emphasizing hands-on, real-world learning experiences, this approach to education increases academic achievement, helps students develop stronger ties to their community, enhances students' appreciation for the natural world, and creates a heightened commitment to serving as active, contributing citizens" (Sobel, 2004).

Explore more information about Place-Based Education.

Funding provided by the Corporation for Public Broadcasting (CPB).

Project-Based Learning is a teaching method in which students gain knowledge and skills by working for an extended period of time to investigate and respond to an authentic, engaging and complex question, problem or challenge.

Explore more information about [Project-Based Learning](#).

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.

Funding provided by the Corporation for Public Broadcasting (CPB).

Why Use Place-Based Education?

What Is Place-Based Education?

"Place-Based Education is the process of using the local community and environment as a starting point to teach scientific and interdisciplinary content. Emphasizing hands-on, real-world learning experiences, this approach to education increases academic achievement, helps students develop stronger ties to their community, enhances students' appreciation for the natural world, and creates a heightened commitment to serving as active, contributing citizens" (Sobel, 2004).

Why Use Place-Based Education?

Place-Based Education has many mental, physical and educational benefits to students, such as:

- Increased engagement
- Deeper understanding of scientific content
- Emotional regulation
- Improvements in motor fitness and physical activity
- Aided development of personal and environmental identities
- Skills necessary for environmentally-responsible actions (Gill, 2014).

How Do We Use Place-Based Education to Drive Teaching and Learning?

Place-Based Education can seem daunting at first but the instructional strategies are not as different as they seem. The following overview provides insight towards how a classroom functions with this type of educational framework.

- Science Pedagogy
  - Regardless of whether you're inside or outside, best practice instruction is still the optimum way to engage students with local phenomenon and science content.
- Environmental Stewardship
  - To develop environmental stewardship in students, teachers must engage them in concrete experiences paired with explicit discussions about environmental care to increase equity and inclusion through cultural relevance (Gruenewald, 2003; NGSS Lead States, 2013, Appendix D)
- Classroom Expectations and Management
  - Having clear and consistent expectations for students when they go outside are necessary for learning to occur. As students become more familiar with this protocol they will be more engaged in the content.
- Optional Connection to Project-Based Education
  - Project-Based Education can be added to Place-Based units and can be used to address community-specific issues. Pairing these two educational frameworks together can help students develop a sense of ownership, power and responsibility within their community.

Funding provided by the Corporation for Public Broadcasting (CPB).

Why Use Project-Based Learning?

What is Project-Based Learning?

Project-Based Learning is a teaching method in which students gain knowledge and skills by working for an extended period of time to investigate and respond to an authentic, engaging and complex question, problem or challenge. Project-Based Learning mirrors what scientists do when they attempt to explain phenomena.

Why use Project-Based Learning?

- Project-Based Learning provides real-world relevance and a genuine purpose for learning.
- Students experience higher levels of learning as they actively construct their own knowledge.
- Project-Based Learning provides an opportunity for students to make connections between disciplines.
- Students can solve problems that are important to them and their communities.
- Project-Based Learning leads to deeper understanding and greater retention of content knowledge. Students are better able to apply what they know to new situations.
- Students gain skills valuable in today's workplace and in life, such as how to take initiative, work responsibly, solve problems, collaborate in teams and communicate ideas.
- Technology tools are integrated from research and collaboration through product creation and presentation.
- Students engaged in Project-Based Learning opportunities demonstrate higher levels of achievement.

How Do We Use Project-Based Learning to Drive Teaching and Learning?

1. Start with a driving question, problem or local phenomena to be explained.
2. Using the inquiry process, students explore the question, problem or phenomena while learning and applying key science concepts and skills.
3. Students collaborate to find solutions or make sense of the question, problem or phenomena.
4. Teachers scaffold learning experiences for students to advance their knowledge and skills.
5. Students create a tangible product to address the question or to explain the phenomena.

Explore more information about Place-Based Education.

Explore more information about Phenomena-Based Education.

Funding provided by the Corporation for Public Broadcasting (CPB).

Definitions in Phenomena-Based Teaching

Phenomenon — singular happening with an uncertain cause or explanation for the observer(s). something uncertain in which our natural curiosity compels the need to figure out using all three dimensions.

Phenomena — a collection of happenings or events each or collectively with uncertain cause(s) or explanation(s) for the observer(s).

Place-Based — the process of using the local community and environment as a starting point to teach scientific and interdisciplinary content.

Project-Based — students gain knowledge and skills by working for an extended period of time to investigate and respond to an authentic, engaging and complex question, problem or challenge.

Sense-making — the active cognitive process used when figuring out a natural happening through focused wonder, idea refinement against observations and creating models, explanations or design solutions for specific goals.

Performance Expectation (PE) — a set of Iowa Core-adopted Next Generation Science Standard (NGSS) projections for what students should be able to do by the end of instruction (years or grade-bands). They set the learning goals for students, but do not describe how students get there.

Three-dimensional — simultaneous coordination of a limited set of disciplinary core ideas (DCI) and crosscutting concepts (CCC) knowledge and through the Science and Engineering Practices needed to engage in scientific inquiry.

Disciplinary Core Ideas (DCI) — fundamental understandings in four disciplinary areas: physical sciences; life sciences; earth and space sciences; and engineering, technology and applications of science content knowledge.

Crosscutting Concepts (CCC) — unifying understandings through their common application across fields across and beyond the science disciplines.

Science and Engineering Practices (SEP) — coordination both of knowledge and skill simultaneously for **how** scientific knowledge is produced and **how** engineering solutions are developed.

Problemitizing — the facilitation processes or routines to elicit dissatisfaction in learners for their initial explanations of a phenomenon. Moves to help them discover that they really can't explain or model the phenomenon fully or beyond a simple statement.

Funding provided by the Corporation for Public Broadcasting (CPB).

What Is a "Good" Phenomenon?

Phenomena and/or problems must have features in high quality scientific and engineering curriculum. Quality phenomena are not just an initial "hook" to activate engagement.

Instructionally productive and effective phenomena must:

- Activate curiosity for intrinsic agency sustaining the motivation to engage in three-dimensional sense-making.
- Require to shift the focus of learning from about a topic to a sustained figuring out why or how something happens.
- Be specific; not a topic or generally observed occurrence.
- Be a non-negotiable aspect of the journey which can't be completed without engaging with the scenario and figuring out some aspect of the phenomenon or problem. The learners would not be able to experience the learning context without the phenomenon. It is the essential sustained theme driving the questioning, investigations, analysis and modeling.
- Be related to compelling, intriguing, puzzling, consequential or real-world situations which can connect to the social relevance of science.
- Be presented in a way that intentionally shows why what is being figured out is important.
- Be strongly connected to the culture, lives and thoughts from the learner perspective.
- Be problemized by presenting with uncertainty which is not easily resolved from existing resources of knowledge.
- Be presented at grade level, explainable using the grade-appropriate DCIs, SEPs and CCCs. The experience, video, data, images, contextual language, etc. used must explicitly consider which science ideas and practices of focus, and at what level of sophistication, students need to demonstrate. For example, high school learners need complex systems, messy data and multiple sources with divergent observations.
- Be comprehensible using multiple modalities to engage without including aspects resulting in distracting or confusing problematizing.
- Fit the time span of the inquiry. An anchoring phenomenon or two should be used as the overall focus for a unit, along with other investigative phenomena along the way as the focus of a brief sub-aspect of the anchoring phenomenon for a shorter sequence or lesson.

Funding provided by the Corporation for Public Broadcasting (CPB).

Determining the Quality of a Phenomenon

How do you know if you've got a phenomenon you should consider building your unit upon or a lesson upon? Use this rubric to tune your instincts for phenomenon selection and phenomena-based planning.

Criteria 1: Centered on Student Perspectives

Red Flags
Phenomenon connects for the teacher's perspective, but may not interest your current students, or it connects to the teacher and a few students' interests, passions or identity but not most of the students.

Showing Potential
Some possible connections to your current students' perspectives, interests, passions or identities. More than two ways to approach the phenomenon

High Fives
Easy to imagine through the eyes of your current students' perspectives, interests, passions or identities. Many possible angles or lenses could be the focus of the phenomenon.

Criteria 2: Intrinsic Motivation

Red Flags
The phenomenon is fully explainable by the teacher and perhaps some advanced students without much research. The phenomenon can be quickly explained from an internet search.

Showing Potential
Some aspects feel explainable, while other aspects are unsure or problematic to explain. This includes the teacher. Has some level of newness or novelty for anyone.

High Fives
Perplexing to the students and in some aspects the teacher as well. Is new to the students and in some way new to the teacher. Phenomenon idea comes from the student(s) wanting to know why or how come. Directly related to the student's real normal lives for their context and culture. The students would feel relieved to better understand the phenomena. Has a want or urgency to know from the student.

Criteria 3: Invokes Disciplinary Core Ideas

Red Flags
Relates to science broad topics. Connects to a disciplinary core idea in the realm of the performance expectation, but it's a stretch. Connections for the DCI may be at a grade level above or below the grade level band of the students.

Funding provided by the Corporation for Public Broadcasting (CPB).

Showing Potential
Strongly and directly connects to the disciplinary core idea state for at least one of the performance expectation(s) of the unit. Partially or tangentially could be stretched to address the others. Connects to the disciplinary core idea for the grade level band.

High Fives
Strongly and directly connects to the disciplinary core idea state for ALL the performance expectation(s) of the unit (anchoring phenomenon). Fully connects to the DCI for the PE of the unit moment (instructional/lesson level phenomenon). Partially or tangentially could be stretched to address the others. Connects to the disciplinary core idea for the grade level band.

Criteria 4: Resources to Address the Science and Engineering Practice

Red Flags
Investigating the phenomenon would require science practices, however, you may not have the time, resources, talent or skills to approach figuring out through the SEP in the performance expectation. It would be hard to explicitly use the SEPs from the PE in your unit to do most of the figuring out for the phenomenon.

Showing Potential
Investigating the phenomenon would strongly require at least one of the SEPs in the performance expectation(s) (anchoring phenomenon) or would partially require the SEP from your PE which is the focus of the unit moment (lesson-level phenomenon). Not exactly confident on how lessons could use the required SEPs to do the figuring out of the phenomenon. Could only envision some "one and done uses" of the SEPs.

High Fives
Investigating the phenomenon would strongly require all of the SEPs in the performance expectation(s) (anchoring phenomenon) or would fully require the SEP from your PE which is the focus of the unit moment (lesson-level phenomenon). High confidence on how lessons could use the required SEPs to do the figuring out of the phenomenon. Envision recurring use of the required SEPs in a visible way for students.

Criteria 5: Leverage the Cross-Cutting Concepts

Red Flags
Phenomenon would have to be stretched maybe unnaturally to fit the CCCs from the PEs (anchoring phenomenon) or the PE of that unit moment (lesson level phenomenon). CCC could be implied, but not explicitly needed to figure out the phenomenon.

Showing Potential

Funding provided by the Corporation for Public Broadcasting (CPB).

Phenomenon may have a way to use and develop the required CCC from the PEs (anchoring phenomenon) or the PE of that unit moment (lesson level phenomenon). You can envision how addressing the CCC may be explicit to enhance figuring out the phenomenon in at least a "one and done" way.

High Fives

Phenomenon gives a natural way to use and develop the required CCC from the PEs (anchoring phenomenon) or the PE of that unit moment (lesson level phenomenon). You can envision how addressing the CCC enhances or makes figuring out the phenomenon easier and be used as a recurring theme.

Funding provided by the Corporation for Public Broadcasting (CPB).

Phenomena and High-Leverage Instructional Strategies

Phenomena-Based Education can be used in learning experiences that include instructional strategies that encourage learners to develop deep understanding of content areas and their connections, and to build skills to apply knowledge in meaningful ways. Here are some examples of high-leverage instructional strategies that apply to Phenomena-Based Education.

Eliciting and Interpreting Students' Thinking

To elicit individual students' thinking about science, teachers pose questions or tasks that provoke or allow students to share their thinking about science content in order to evaluate student understanding, guide instructional decisions and surface ideas that will benefit other students. To do this effectively, a teacher draws out a student's thinking through carefully-chosen questions and tasks, then considers and checks alternative interpretations of the student's ideas and methods. In science teaching, it is also important to consider students will have ideas about both the science content and the science practices.

Additional Resources:

- Eliciting and Interpreting (TeachingWorks Resource Library)

Examples:

- Eliciting and Interpreting PowerPoint
- Iowa Science Phenomena 8th Grade Exemplar

Scaffolding Strategies

Elementary School:	**Middle School:**	**High School:**
Provide question stems; provide students multiple ways to share their thinking; rephrase or restate student thinking to clarify and embed academic vocabulary; use probing questions to uncover student thinking; allow students to talk with an elbow partner before sharing with teacher or class**.**	Similar to the elementary school strategies, sentence stems can support student thinking, especially when they are discussing abstract ideas. Throughout the year, removing these structures can help facilitate growth in students and resembles the Gradual Release of Responsibility (GRR) model. Allowing students to use their own vocabulary when describing abstract terms and then replacing it with a more scientific	Allowing students to use their own vocabulary when describing abstract terms and then replacing it with a more scientific definition can provide an epistemic scaffold as well as increased understanding of abstract terms. This can be done as the vocabulary is learned throughout the unit.

Funding provided by the Corporation for Public Broadcasting (CPB).

	definition can provide an epistemic scaffold as well as increased understanding of abstract terms. Asking students to elaborate on their answers can often drive their thinking further into the concept and help other students gain a better understanding of the content. Lastly, wait time is an effective method to facilitate metacognition among middle school students. Increased wait time can help students structure their own thinking and then pairing that with a small group discussion can further support their thinking and personal understanding.	
Grade(s): PK-12 Prep Time: 10 minutes Sequence: Any Resource Intensive: 1 Student Centered: 3		

Explaining and Modeling Content

In science, constructing explanations is a key part of scientific practice. Consequently, for the high-leverage practice of *explaining and modeling content*, we focus on how teachers can support students to construct explanations rather than on teachers' ability to explain content to students. Constructing explanations and supporting them with arguments are two closely related scientific practices which students should engage in. One goal of science is to create explanations for why or how natural phenomena occur. These explanations are developed and supported through a process of argumentation negotiating different interpretations of evidence. Science teachers must be able to support students to construct their own explanations and arguments by using the data they collect during investigations.

In the classroom, this entails teachers providing support for students to make sense of scientific

Funding provided by the Corporation for Public Broadcasting (CPB).

phenomena by developing claims that answer investigation questions, transforming data that have been collected to serve as evidence for the claim, and identifying science principles or big ideas that can be used as reasoning to connect the claim and the evidence. Throughout this process, the teacher should provide support for students to engage in scientific argumentation as they work to develop the best explanation. The teacher provides tools and strategies for students to critique one another's claims, support their own claims with evidence, evaluate the relevance of data, and revise their claims or arguments based on other students' input.

Additional Resource:
- Explaining and modeling content (TeachingWorks Resource Library)

Example:
- Supporting Explanation Constructing PowerPoint

Scaffolding Strategies

Elementary School:	**Middle School:**	**High School:**
Model metacognition; provide access to anchor charts; use concrete objects; embed academic vocabulary.	Start by providing competing ideas for students to evaluate and support with evidence. Gradually release them to developing their own explanatory ideas, supported by evidence.	Start by providing competing ideas for students to evaluate and support with evidence. Gradually release them to developing their own explanatory ideas, supported by evidence.

Grade(s): PK-12
Prep Time: 20 minutes
Sequence: Explain
Resource Intensive: 2
Student Centered: 2

Leading a Group Discussion

In a group discussion, the teacher and all of the students work on specific content together, using one another's ideas as resources. The purposes of a discussion are to build collective knowledge and capability in relation to specific instructional goals and to allow students to practice listening, speaking, interpreting, agreeing and disagreeing. The teacher and a wide range of students contribute orally, listen actively and respond to and learn from others' contributions. Teachers work to ensure students are positioned as competent among their peers, that patterns of interaction are respectful, and that the

Funding provided by the Corporation for Public Broadcasting (CPB).

collective work of the group uses the strengths of and benefits each student.
Additional Resource: ● Leading a discussion (TeachingWorks Resource Library)
Example: ● Building Ideas Over Time: What NGSS Looks Like in the Classroom (NGST)

Scaffolding Strategies		
Elementary School: Provide question stems; provide students multiple ways to share their thinking; rephrase or restate student thinking to clarify and embed academic vocabulary; ensure routines and procedures for student talk are in place; model dialogue; use probing questions to uncover student thinking; anticipate student misconceptions; have effective flexible grouping routines and procedures in place.	**Middle School:**	**High School:**

Grade(s): 2-6
Prep Time: 20 minutes
Sequence: Explore, Explain, Elaborate, Evaluate
Resource Intensive: 1
Student Centered: 3

Notice and Wonder

The Notice and Wonder routine supports your students to enter the content and activate knowledge in a low-stakes way. Students observe or read about a new concept and discuss or write about what they notice about that image or text and what they wonder about that image or text. By engaging in this activity, your students may become engaged with the content before delving deeper.

Additional Resource:
- Notice and Wonder (Iowa PBS)

Funding provided by the Corporation for Public Broadcasting (CPB).

Example: ● Iowa Science Phenomena Notice and Wonder Chart Printable

Scaffolding Strategies		
Elementary School: Use sentence stems; allow students to respond verbally and/or in written form; model and practice strategy; allow students to share with a partner.	**Middle School:** Provide regular "notice and wonder" time for students in order to build habits of inquiry in students.	**High School:** Provide regular "notice and wonder" time for students in order to build habits of inquiry in students. Prompt students to consider how something they notice from the unit may be happening in the world around them.

Grade(s): PK-12
Prep Time: 20 minutes
Sequence: Engage
Resource Intensive: 1
Student Centered: 2-3

Creating Shared Work Time Norms and Expectations

By creating expectations and norms of what students are expected to be doing during group work, teachers can elevate student voice and manage student behavior during small group work time or during a station rotation. Students can own the expectations and feel confident and productive when they are engaging in learning tasks because they thoroughly understand the expectations. By creating shared expectations, the students can have a say in the consequences when expectations are not met. This empowers students to have a voice in both the setting of expectations and the consequences for not meeting those expectations.

Additional Resource:
- Creating Shared Work Time Norms and Expectations (Better Lesson)

Example:
- Establishing Clear Expectations (Better Lesson)

Scaffolding Strategies

Funding provided by the Corporation for Public Broadcasting (CPB).

Elementary School:	**Middle School:**	**High School:**
Provide picture boards and visual cues; model desired behavior(s); review strategy often; reference when desired behavior(s) are observed; determine how to "call each other out" prior to collaborating.	Develop classroom norms at the beginning of the course. Refer back to these throughout the course as students break the norms. Have students use the language from the norms to express unmet expectations in collaboration. Highlight a different norm each day or week and emphasize when students are doing this well.	Develop classroom norms at the beginning of the course. Refer back to these throughout the course as students break the norms. Have students use the language from the norms to express unmet expectations in collaboration.

Grade(s): PK-12
Prep Time: 10 minutes
Sequence: Prior to Engage or specific activity
Resource Intensive: 2
Student Centered: 2

Anchoring Phenomenon Protocol

The anchoring phenomenon protocol gives structure to help students focus on intense observation, elevate their thinking to bring out what aspects they cannot actually explain or assumptions they are using which do not yet have evidence.

- Stage 1: Observe, wonder and observe deeper.
- Stage 2: Have students individually try to model, draw out or explain the anchoring phenomenon. Form a class consensus model for a starting place.
- Stage 3: Share and connect to help students suggest how the phenomenon is like or related to other experiences they have had.
- Stage 4: Have students compose questions or wonderings and ideas they have that may help the classroom community improve their first models from Stage 2.

Additional Resources:
Anchoring Phenomenon Protocol works well with Driving Question Boards as a product to conclude this protocol.

- Anchoring Events that can Organize Science Instruction (Article)

Funding provided by the Corporation for Public Broadcasting (CPB).

• [Coherence from the Students' Perspective: Why the Vision of the Framework for K-12 Science Requires More than Simply "Comb"Combining" Three Dimensions of Science Learning (Article)] • [Artifact 1 - Planning Anchoring Phenomena Table (OpenSciEd)]
Example: • [Remote Learning Resource Leading an Anchoring Phenomenon Routine (OpenSci Ed)]

Scaffolding Strategies

Elementary School:	Middle School:	High School:
Provide a visual anchor chart of procedure for reference. Model and practice procedure prior to implementation and review as needed. Use a timer for the stages so discussions stay focused. List observations to later connect to explanations for the consensus model. If the consensus model includes something they cannot connect to an observation, make that aspect a question not part of the consensus model. Ask, "how do you know that?"	Use a timer for the stages so the discussions stay focused. List observations to later connect to explanations for the consensus model. If the consensus model includes something they cannot connect to an observation, make that aspect a question not part of the consensus model. Ask, "how do you know that?"	Provide additional observation tools and let students explore using them without formalized procedures when it is safe. Connect them to community resources to model how to wonder and ask like a scientist.

All Grade Levels:
Provide icons or sample pictures of many components which may or may not be part of the initial model so students can focus on the connections to the components.

Practice making observations with something very simple like a piece of paper to help them warm up their deep observation skills.

Grade(s): K-12
Prep Time: 20 minutes
Sequence: 1
Resource Intensive: 2
Student Centered: 3

Funding provided by the Corporation for Public Broadcasting (CPB).

Driving Question Board

A Driving Question Board (DQB) a way to brainstorm, sort, synthesize and continually revisit student questions that drive the investigations to figure out anchoring phenomena and instructional phenomena. A DQB is a physical presence in the space to bring focus and motivation. It makes it visible for visitors to easily know the focus of the class. The class usually forms an agreed-upon first attempt to explain and asks questions for the places they could not explain with their first model.

Additional Resources:

- Driving Question Board (OpenSciEd)

Example:

- Driving Question Board (Iowa PBS)
- Sample Driving Question Board (OpenSciEd)

Scaffolding Strategies

Elementary School:	Middle School:	High School:
Model strategy; rephrase or restate student thinking to clarify and embed academic vocabulary; use probing questions to uncover student thinking; provide question stems; provide graphic organizers and examples; provide anchor charts and research at varying levels of difficulty. Use images with text. Create a question board as a class.	Create large posters for the main questions to hang in the room and on a tracking sheet for keeping the clues to the answers of those questions. For enrichment opportunities, students can explore questions that are not explored by the whole class.	Create large posters for the main questions to hang in the room and on a tracking sheet for keeping the clues to the answers of those questions. Continue to refer back to these throughout the unit. For enrichment opportunities, students can explore questions that are not explored by the whole class.

All Grade Levels:
Provide open-ended question stems like "what if" and "how come."

Having a teacher write the questions on notes as students call them out can help when writing is a challenge.

Funding provided by the Corporation for Public Broadcasting (CPB).

Have an anonymous way to share questions for learners who are yet comfortable sharing.
Grade(s): K-12 Prep Time: 15 minutes Sequence: 1 Resource Intensive: 1 Student Centered: 3

Leveraging Graphic Organizers

Students who are still developing their sophistication as sense-makers can often find a graphic organizer helpful for channeling their ideas into models, flows and order. It can be helpful to use some premade options.

Additional Resource:

- [Graphics and Printables (The Wonder of Science)]

Example:

- [Systems and Models (The Wonder of Science)]

Scaffolding Strategies

Elementary School:	**Middle School:**	**High School:**
Provide examples of completed graphic organizers. Develop one as a class prior to asking students to complete them independently. Allow students to use text and/or images to capture their thinking.	Give students a way to fill it out the first few times then gradually ask them to draw their own.	Model how to move a graphic organizer into a tool for composing a writing piece.

All Grade Levels:
Starting with small organizers and then layering them together later can help to gradually build complex systems over time.

Funding provided by the Corporation for Public Broadcasting (CPB).

Provide a sample organizer filled out for a common student experience so they can see what type of information goes in each area. Consider filling in some parts and leaving others blank to come back to it later as they discover more.
Grade(s): 3-12 Prep Time: 10 minutes Sequence: 2 Resource Intensive: 2 Student Centered: 2

Talk Moves

As social learners, being able to talk about our ideas is a major aspect of sense-making. Student talking while teachers listen can be a valuable formative or summative assessment moment. It is challenging to facilitate productive conversations, especially with students who are not accustomed to talking in their science classes. Teachers can use tools to scaffold student science talk.

Additional Resource:

- Talk Activities Flowchart (STEM TeachingTools)

Example:

- How can teachers guide classroom conversations to support students' science learning? (StemTeachingTools)

Scaffolding Strategies

Elementary School:	Middle School:	High School:
Provide routines and procedures and model and practice before implementing. Provide sentence stems and ask people to use them so learners with limited English can hear and mimic. Pair students with an elbow partner.	Provide phrase stems and ask people to use them so learners with limited English can hear and mimic. Encourage and model hand motion to go with the talk for visual connections.	Be ready to provide additional visuals while the students talk to anchor their ideas to shared resources.

Funding provided by the Corporation for Public Broadcasting (CPB).

Encourage and model hand motion to go with the talk for visual connections.		
All Grade Levels: Try out the protocols with a low risk topic first. Choose one you will likely use more than once so students get used to the pattern. Try smaller groups first.		
Grade(s): 3-12 Prep Time: 15 minutes Sequence: 2, 3 Resource Intensive: 1 Student Centered: 3		

Funding provided by the Corporation for Public Broadcasting (CPB).

Identifying and Capturing Your Phenomena

Contextualizing Phenomena

Remember that the goal is not to explain the phenomenon. The expectation is that students will ask questions and/or conduct an investigation themselves while the teacher provides support with guiding or anchoring questions.

Example Phenomena

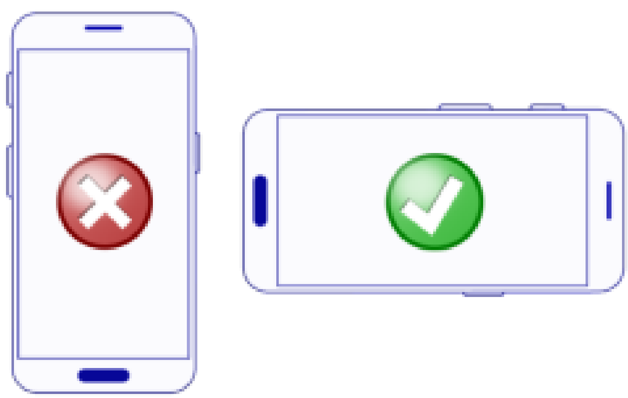
The following are examples of Iowa teacher captured and submitted phenomena, already available on the Iowa Science Phenomena website:

- The Mystery of the Saylorville Stones by Ryan Lensing
- Snow and Sound by Magdaly Santos-Villalobos

Once your phenomenon has been captured and submitted, facilitators and Iowa PBS staff will evaluate it. As you identify your phenomenon, it may be helpful to understand what exactly we are looking for. A rubric has been developed to evaluate each phenomenon.

Capturing Phenomena on Video

Need some help working with your science phenomena video? Here are some tips and tools to help you create and edit great videos.



If recording on a smartphone, make sure you are capturing in landscape orientation, not portrait orientation. This also applies to other devices such as DSLR cameras. The landscape orientation is better suited for viewing on a computer.

Funding provided by the Corporation for Public Broadcasting (CPB).

Editing Video-Based Phenomena

Phenomena need not be highly edited or produced to be effective. Often you may only need to trim a few seconds off the front or end of a video, or combine two video clips into one. Here are a few free tools to get you started with minor video editing:

- WeVideo
- YouTube

Capturing Phenomena in Other Ways

Not all phenomena need to be represented using video and images. You may also capture your own phenomena from articles, data sets or graphs. When using materials you did not create, it is very important you provide attribution and ensure that the material has the correct license to be reused. Questions about this can be directed to phenomena@iowapbs.org.

Sharing Your Phenomena

Once you are ready to complete the Basic Submission Template or the Enhanced Submission Template, you will need to make your phenomena publicly available. Here are ways to share your phenomenon, based on media type:

- **Video**: Post your video to YouTube and make sure it is publicly available.
- **Photo**: Post your photo to a publicly available service such as Flickr or Google Photo**.**
- **Mixed Media**: You can create a publicly available Google Slide presentation to embed photos with text. Please ensure the Google Slide presentation permissions are set to "Viewable by Anyone with the Link."

Funding provided by the Corporation for Public Broadcasting (CPB).

Appendix: Supporting Materials

Submission Templates

Once you are ready to complete the Basic Submission Template or the Enhanced Submission Template, you will need to make your phenomena publicly available. Email this completed document to phenomena@iowapbs.org

Funding provided by the Corporation for Public Broadcasting (CPB).

Submission Rubric

This rubric will be used to assess all phenomena submitted to Iowa Science Phenomena.

Criteria	Needs Work	Good	Excellent
Phenomena Description	Description does not connect with or relate to the science or standards. The focus of the phenomena cannot be determined.	Description does not connect with or relate to the science or standards. The focus of the phenomena cannot be determined.	Description is a literal explanation of the phenomena as it relates to the selected standard and science. The focus of the phenomena is clearly communicated.
Media Quality and Originality	Quality of video, audio, and/or images is low and makes it difficult to understand what phenomenon is being shared.	Quality of video, audio, and/or images is average but does not affect whether the phenomenon can be understood. Video is captured in appropriate orientation.	Quality of video, audio, and/or images is high. Video is captured in landscape orientation.
Extent to Which Phenomenon Inspires Questioning	Phenomenon does not inspire questioning. Anticipating what students would notice or wonder is difficult.	Phenomenon would generate some questions among students. Adjusting how the phenomenon is presented could inspire more questioning.	Phenomenon easily lends itself to questioning. Anticipating what students will notice and wonder about the phenomenon can easily be determined.
Connection to Standards	Phenomenon does not connect to the identified standard(s), either directly or indirectly.	There is an indirect connection between the phenomenon and the identified standard(s).	Phenomenon is clearly and directly connected to the identified standard(s).
Appropriateness of Driving Question	Provided question unrelated to phenomenon and provide an unclear path towards achieving the identified standard. Question is too simplistic or requires little investigation.	Provided question related to the phenomenon, but could be improved. The question could be more tightly aligned to the standard(s).	Provided question directly relate to the phenomenon, and will help meet the identified standard(s).
Appropriateness of Probing Questions	Provided questions unrelated to phenomenon, are too simplistic/closed	IProvided questions are related to the phenomenon, but could be improved.	Provided questions are thought provoking and will elicit rich discussion or investigation.

Funding provided by the Corporation for Public Broadcasting (CPB).

	and/or require little investigation.		
Classroom Suggestions	Provided classroom activities are vague and do not provide the necessary support for students to complete their investigations and answer the driving/probing questions.	Provided classroom activities could be improved so they provide better support for student investigations and answering the driving/probing questions.	Provided classroom activities provide clear, specific, and strong support for students to complete their investigation of the phenomenon and answer the driving/probing questions
Relevant Related Resources	Fewer than two resources included. Both related resources are not classroom appropriate and/or the description is unclear. Connection related to support for the phenomenon is unclear.	One but not both related resources are classroom appropriate and provides a description that supports ease of teacher use and understanding. Connection related to support for the phenomenon could be improved with additional clarity or description.	Both related resources are classroom appropriate and provides a description that supports ease of teacher use and understanding. Clear connection related to support for the phenomenon.
Relation to Iowa	Phenomenon has no apparent connection to Iowa.	Indirect connection to Iowa, or phenomenon may be more general and experienced by anyone anywhere.	Direct connection to Iowa. Phenomenon could be personally experienced by local Iowa students.

Funding provided by the Corporation for Public Broadcasting (CPB).

Generalized Framework for Unit Creation

This framework for unit creation can help as you plan a Phenomena-Based Learning unit for your classroom.

Macro — Standard ● What is the standard? ● What is the assessment criteria? ● What connections does this standard have to your local environment? ● What phenomena (found on Iowa Science Phenomena) could be your driving focus for the unit?
Meso — Concrete to Abstract ● What packages of content do you need to teach in your class for the students to be successful? ● What packages are the most concrete or prerequisite for deeper learning to occur? ● How are these packages represented in your local community? ● How can you provide hands-on learning for these packages of content?
Micro — Place-based ● Phenomena-based: Explicit phenomena that is local to students ● What other opportunities are close to your school grounds that students can interact with? ● What stakeholders or experts are in your area that are knowledgeable about the topic? ● Project-based: How will the students be assessed?

Building a Lesson (5E Framework)

Engage
Explore
Explain
Elaborate
Evaluate

*Note: As you build the unit, think about what content would be most concrete for students to engage with. What can be hands on for students and how can you get them to act like scientists? Sometimes allowing students to struggle and act more like scientists is better for their learning than if they were given a written out procedure. While struggling is good for students, frustration is not. Attempt to understand when your students are struggling and when they need a scaffold.

Funding provided by the Corporation for Public Broadcasting (CPB).

Example Unit

High Nitrate Levels in Iowa Waterways

8th Grade Exemplar Unit Plan

NGSS Connections

MS-ESS3-3:	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
MS-LS2-5: **(Assessment)**	Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

Connection to Phenomena

The unit plan below uses the water quality resource on Iowa Science Phenomena as the driving phenomena. While using place-based lessons and a project-based summative assessment, students are able to understand the connections between water quality throughout the state of Iowa and ways in which actors are attempting to reduce the harmful pollutants in Iowa waterways.

Unit Plan

Engage: Introductory definition of pollution.

We begin today's lesson with a bellringer to have students write their own definitions for "pollution" in their notebooks. After the bell rings and students have finished their definitions, instruct them to share their ideas in their small group. After all group members have shared, tell each group to create a new definition for pollution as a group. Share with the class and ask each group to explain why they included what they did. Write these ideas on the board and then as a large class come up with a further refined definition of the term "pollution." This definition will hold the misconception that only physical pollutants (i.e., bottles, straws, trash, etc.) are pollution.

After the class has created their definition for pollution, we instruct students that the class will be going outside today and that they will be looking for pollution on the school's grounds. We ask students for some areas in which they might anticipate pollution and why those areas would be of interest. We also posit what types of data we might collect from our time spent outside today. As students answer, we create a map of the school's grounds and potential points of interests based on student answers. We instruct students to copy this into their notebooks prior to us exiting the classroom. As students work outside, we remind them to identify where they are on the school grounds and to mark their data in that area. We also promote deeper thinking by asking questions like "What do you think caused this pollution to be here?" and "In what sense is pollution right or wrong?"

After students have collected thorough data (as observed by the teacher), return inside and draw the map on the board. Identify pollution "hot spots'' on the map and then ask "where might this pollution have

Funding provided by the Corporation for Public Broadcasting (CPB).

come from?" As students identify potential human sources of pollution, they will tend to ignore the sources such as agriculture, runoff, lawns, etc. We make a note to the class how all of the pollution the students noticed was physical things (i.e., bottles, straws, trash, etc.) and we posit "to what extent can pollution be 'invisible?'"

To expand students' ideas about pollution, we pull out one jar of water and ask "to what extent is this water polluted?" Students will respond with "It is not because it's clear and looks like you could drink it. We pull out a second jar of water (this time salt water unbeknownst to the students). Again asking the question "to what extent is this water polluted?" Yet again, students will say it is not and some students suggest that they want to drink it.

We ask students who are interested to come up and stand at the front of the class. We provide two Dixie cups to the students and fill up each Dixie cup halfway with each jar respectively. We are sure to tell the students not to taste the water yet as we will do it together on the count of 3. We start with the tap water cup and let the students who tasted it indicate whether they think that water was polluted or not. After we resolve the class discussion, we drink the salt water. We notice visible winces from the students and some even spit the water back into the Dixie cup. We again ask, "to what extent was that water polluted?" This time, students quickly state the water was polluted. We instruct the students to return to their seats and we turn our attention to our definition of Pollution. We say to the class "In our original definition we only included things that were physically there, like trash, bottles, ect., but after drinking the two water samples it appears that not all pollution can be seen with the naked eye. How should we modify our definition of pollution? Right before we clean up for the day, we provide a scientist's definition for pollution and compare and contrast similarities and differences between the two.

Explore: Identify sources on the school grounds and in the community.

Beginning with the school grounds, explore for potential sources of pollutants (as identified yesterday). This activity expands on the first day because the students will now have a more robust definition for pollution and where it comes from. Once the school grounds have been identified for potential pollutants, the next step would be to zoom out into the neighborhood, town/city, state and national levels. Make sure to explicitly connect the student's environmental choices and how they impact people at each of these levels. It may be helpful to hear from people within the community, state and national levels to determine the impact these pollutants have at varying micro and macro scales but if this is not a feasible option, a River Runner resource can provide a visual for how a single drop of water will move between watersheds.

Explain: How do you test water? Identify point and nonpoint pollution sources.

Today's activity uses the resources available on the Iowa Science Phenomena website for Water Quality. Today's activity can be substituted for your local water quality scientist. Bring them into your class (physically or virtually) and have them talk about all the ways in which they test the local water quality! If you are not able or do not wish to bring them into your class, today's activity will involve students determining how to test for water quality, what makes water quality poor and potential pollutant sources.

At this point, students would be able to address standard MS-ESS3-3 and MS-LS2-5 and should complete a formative assessment regarding the sources and impacts the pollution has in their local community.

Elaborate: Problem-solve and come up with solution ideas. Hear from community stakeholders.

Continuing from yesterday's activity, the goal for today is to determine the best possible solution for your community or school. To help students synthesize and evaluate information, it would be beneficial to hear from multiple stakeholders to see how each solution would impact their work in the community. As a class, you can then facilitate a discussion to process what solutions are best for your community. The next step is to put all of the pieces together through the following project.

Evaluate: Design solutions with models and share solutions with teachers and stakeholders.

After students have processed the potential solutions and have determined which would be best in their community, the next task would be to design a potential solution plan to present to the administrator or community stakeholders for the school grounds or community. To evaluate students, you could bring in community members that participated in the unit prior and can provide useful feedback to the students.

On the last day of the unit, students are evaluated by the teacher and community stakeholders (optional). This will help students feel like they are members of the community and have the ability to make an impact. If you would like to further develop their environmentally-responsible skills, then you can select one of the projects to complete and work through the work with them while monitoring the biodiversity of local flora and fauna.

Assessments

Unit Rubric

Standard	**0** **No Data**	**1** **Beginning**	**2** **Developing**	**3** **Proficient**	**4** **Above Proficient**
MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing human impact on the environment.	Student has provided no data for the current standard.	Student is able to identify and assess feasible solutions for decreasing human impact on the environment. Student needs support designing and	Student is able to identify, assess and design feasible solutions for decreasing human impact on the environment. Student needs support	Student is able to identify, assess, design and evaluate feasible solutions to best decrease human impact on the environment.	Student is able to identify, assess, design and evaluate feasible solutions to decrease human impact on the environment.

		evaluating solutions to best decrease human impact on the environment.	evaluating solutions to best decrease human impact on the environment.		Student includes multiple (>3) stakeholder perspectives in their evaluation of feasible solutions.
MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.	The student has provided no data for the current standard.	Student needs support evaluating competing design solutions for maintaining biodiversity and ecosystem services.	Student evaluates competing design solutions for maintaining biodiversity and ecosystem services. Student does not include any of the following considerations: scientific, economic and social.	Student evaluates competing design solutions for maintaining biodiversity and ecosystem services. Student includes some of the following considerations: scientific, economic and social.	Student evaluates competing design solutions for maintaining biodiversity and ecosystem services. Student includes all of the following considerations: scientific, economic and social.

Formative Assessment (MS-ESS3-3 and MS-LS2-5)

1. Nitrates play a large role in the pollution of Iowa's waterways. List 3 sources of nitrate pollution.
2. According to the [water quality expert], list 3 solutions that would decrease the amount of nitrates in Iowa's waterways. [Identify]
3. Of these three solutions, which one do you think would be most helpful to our community? Please include the scientific, economic and social effects of this solution? [Assess and MS-LS2-5]
4. Sketch what you think this solution would look like in our community. [Design]
5. Thinking of the people who live in the community, who do you think would be affected by this change? [Evaluate]

Summative Assessment

Directions: For this project your group will be given a location within our community that has a specific water quality issue. Your group will need to design, evaluate and draft a potential solution that decreases the amount of point and nonpoint source pollutants entering our waterway. These solutions must include the scientific, economic and social effects on our community and ways in which you will increase the acceptance from our board of executives [community stakeholders].

Some scientific effects include the following:

- How will this solution affect the local flora and fauna?

Funding provided by the Corporation for Public Broadcasting (CPB).

- How will this solution affect the waterway?
- Why do you think it will decrease the point and nonpoint source pollutants?

Some economic effects include the following:

- How much do you estimate the project will cost?
- How will you get the money for the project?
- Does this solution require maintenance? If yes, how will you get the money to maintain it?

Some social effects include the following:

- Who will be affected in our community?
- What future problems could you anticipate for the community?
- Does this solution require maintenance? Who will maintain it?

Funding provided by the Corporation for Public Broadcasting (CPB).

Iowa Science Phenomena Teacher and Student Guide: Citations and References (By Section)

Why Use Phenomena-Based Education?
Making Everyday Phenomena Phenomenal: NGSS-Aligned Instructional Materials Using Local Phenomena With Diverse Student Groups Lee, O., Goggins, M., Haas, A., Januszyk, R., Llosa, L., & Grapin, S.

NGSS Lead States. (2016). Using Phenomena in NGSS-Designed Lessons and Units. Using Phenomenon in NGSS. Retrieved August 12, 2021, from https://www.nextgenscience.org/sites/default/files/Using%20Phenomena%20in%20NGSS.pdf

Using Phenomena in NGSS-Designed Lessons and Units, Science Teaching Tools, Practice Brief 57: How place-based science education strategies can support equity for students, teachers, and communities). Published September 2016 View Creative Commons Attribution 3.0 Unported License at http://creativecommons.org/licenses/by/3.0/. Educators may use or adapt. If modified, please attribute and re-title. Retrieved August 20, 2021 from https://www.nextgenscience.org/sites/default/files/Using%20Phenomena%20in%20NGSS.pdf.

The Wonder of Science. Phenomena. Retrieved August 20,2021 from https://thewonderofscience.com/phenomenal.

Why Use Place-Based Education?
Gill, T. 2014. The benefits of children's engagement with nature: A systematic literature review. Children Youth and Environments 24 (2), pp. 10–34.

Gruenewald, D.A. 2003. The best of both worlds: A critical pedagogy of place. Educational researcher 32 (4), pp. 3–12.

Sobel, D. 2004. Place-Based Education: Connecting Classrooms and Communities. Orion Society.

Why Use Project-Based Learning?
What is PBL? Retrieved August 12, 2021 from https://www.pblworks.org/why-project-based-learning.

Krajcik, J., & Blumenfeld, P. (2005). Project-Based Learning. In R. Sawyer (Ed.), The Cambridge Handbook of the Learning Sciences (Cambridge Handbooks in Psychology, pp. 317-334). Cambridge: Cambridge University Press. doi:10.1017/CBO9780511816833.020.

Definitions in Phenomena-Based Teaching
Achieve Inc. (2019, February 26). Task Annotation Project: Phenomenon. Retrieved August 15, 2021, from https://www.nextgenscience.org/sites/default/files/TAPS%20Sense-making.pdf

Hogan, M. (2019, March Illuminate Education). Sense-Making is the Core of NGSS. Sense-Making is the Core of NGSS- Illuminate Education. Retrieved August 15, 2021, from https://www.illuminateed.com/blog/2019/03/sense-making-is-the-core-of-ngss/

National Research Council (NRC). (2012). A FRAMEWORK FOR K-12 SCIENCE EDUCATION: Practices, Crosscutting Concepts, and Core Ideas. NRC. https://www.nap.edu/read/13165/chapter/1

Funding provided by the Corporation for Public Broadcasting (CPB).

NGSS Lead States. (2016). Using Phenomena in NGSS-Designed Lessons and Units. Using Phenomenon in NGSS. Retrieved August 15, 2021, from https://www.nextgenscience.org/sites/default/files/Using%20Phenomena%20in%20NGSS.pdf

What is a "Good" Phenomenon?

Achieve Inc. (2019, February 26). Task Annotation Project: Sense-Making. Sense-Making. Retrieved August 15, 2021, from https://www.nextgenscience.org/sites/default/files/TAPS%20Phenomena.pdf

NGSS Lead States. (2016). Using Phenomena in NGSS-Designed Lessons and Units. Using Phenomenon in NGSS. Retrieved August 15, 2021, from https://www.nextgenscience.org/sites/default/files/Using%20Phenomena%20in%20NGSS.pdf

Determining the Quality of a Phenomenon

Project SING: Lesson Reflection Activity Flow Chart. Retrieved August 15, 2021, from https://drive.google.com/file/d/1e_YZL_NuWQTAJJXq0M3d_YKqP1AlLXBO/view

McKenna, T. J. (2016, June 20th). Using NGSS Phenomena to Engage Students. Spark with TJ McKenna: Using NGSS Phenomena to Engage Students. Retrieved September 6th, 2021, from https://www.onatlas.com/blog/ngss-using-phenomena-engage-students-2

McKenna, T.J. & UConn Mentoring Collaborative (2016). NGSS Phenomena: A Heuristic for Coming up with Academically Productive Phenomena. Retrieved August 15, 2021, from https://static1.squarespace.com/static/56e316c61bbee06d13210ed6/t/583090212e69cfe8eabe413f/1479577633966/AHeuristicforPhenomena.pdf

Phenomena and High-Leverage Instructional Strategies

Designing Phenomenon-Based Instruction. NGSS Hub @ NSTA. Retrieved August 15, 2021, from https://static.nsta.org/ngss/docs/Flowchart%20for%20Designing%20Phenomenon-Based%20Instruction.pdf

Suggested Resources

Teaching Works Resource Library. High-Leverage Practices. Retrieved August 15, 2021, from https://library.teachingworks.org/curriculum-resources/high-leverage-practices/

Better Lesson. Retrieved August 15, 2021, from https://betterlesson.com/

Cerwin, K., et.al. Next Generation Science Standards in Practice: Tools and Processes Used by the California NGSS Early Implementers. NGSS Early Implementers. WestEd. Accessed August 8, 2021 from https://k12alliance.org/docs/Next-generation-science-standards-in-practice.pdf

Funding provided by the Corporation for Public Broadcasting (CPB).