**Incorporating Phenomena in Developing Learning Activities**

**WHAT ARE PHENOMENA IN SCIENCE AND ENGINEERING?**

* Natural phenomena are observable events that occur anywhere and that can be explained or predicted using science knowledge. The goal of building understanding in science is to be able to develop general ideas, based on observable evidence, in order to make sense of the phenomena we can experience.
* Engineering involves designing solutions to problems that arise from phenomena, and using explanations of phenomena to design those solutions. *An Alaskan example is maintaining a road in a slide-prone area.*
* In this way, phenomena are the context for the work of both the scientist and the engineer.

**WHY ARE PHENOMENA SUCH A BIG DEAL?**

* Despite being an essential element that drives the study and application of science and engineering, phenomena have often been a missing or underutilized piece in science education. Too often students spend their time acquiring general knowledge without understanding its place in their experiences in the real world.
* Basing learning around explaining phenomena supports student interest in building 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. In contrast, students may be much less engaged when learning science ideas that educators have decided are important but students cannot connect to personal experience or awareness.
* Centering science education on phenomena that students are motivated to explain *shifts the whole experience from* ***learning about*** *a topic to* ***figuring out*** *why or how something happens*. For example, instead of simply learning about the topics of photosynthesis and seasonal changes, students are engaged in building evidence-based explanatory ideas that help them figure out what is really going on when leaves change color.
* Explaining phenomena and designing solutions to problems allow students to build on general science ideas in the context of their application to understanding phenomena in the real world, leading to deeper and more transferable knowledge. Making connections is the primary job of the brain in learning.
* Students who see how science ideas help explain and model phenomena related to compelling real world situations learn to appreciate the social relevance of science. They get interested in and identify with science as a way of understanding, improving, and responding to real world situations. Focusing investigations on compelling phenomena helps sustain students’ science learning, a benefit in daily life as well as career options.

**HOW ARE PHENOMENA RELATED TO THREE-DIMENSIONAL LEARNING?**

* Using a three-dimensional approach advocated in the Framework for Science Education helps students use science to make sense of phenomena in the natural and designed world, and engineering to solve problems.
* Learning to explain phenomena and solve problems is the central reason students engage in the three dimensions of the NGSS. Students explain phenomena by developing and applying the Disciplinary Core Ideas (DCIs) and Crosscutting Concepts (CCCs) through use of the Science and Engineering Practices (SEPs).
* Phenomena-centered classrooms also give students and teachers a context in which to monitor ongoing progress toward understanding all three dimensions. As students are working toward being able to explain phenomena, three-dimensional formative assessment becomes more easily embedded and coherent throughout instruction.

**HOW DO WE USE PHENOMENA 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 meaningful questions or identifying problems that emerge 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 seasonal change, a middle school teacher might want the students to develop and apply DCIs about photosynthesis; alternately, a 3rd grade teacher might want students to learn and apply DCIs about the tilt of the earth in its orbit as the cause of seasonal change. In each case, teachers should help students identify different aspects of the same phenomenon as the focus of their questions.
* Students also may ask questions about a phenomenon that motivate a line of investigation that isn’t grade appropriate, or might not be effective at using or building targeted disciplinary ideas. Teacher guidance can help students reformulate questions to lead to grade-appropriate investigations of important science ideas. At the same time, stretching into wondering prepares science minds for new understanding.
* *It is important that all students*—*including English language learners and students from cultural groups underrepresented in STEM*—*are supported in working with phenomena that are engaging and meaningful to them*. Not all students will have the same background or relate to a particular phenomenon in the same way. Educators should consider student perspectives when choosing phenomena, and also should prepare to support student engagement in different ways. While starting with one phenomenon in the classroom, it is always a good idea to help students identify related phenomena from their lives and their communities to expand the phenomena under consideration. For example, when teaching toward Kindergarten DCI PS3.B about how sunlight warms the surface of the Earth, a teacher could notice that students don’t have experience with hot concrete and instead engage the group in observations of hot sand or rock. When necessary, teachers can engage the class in a shared experience with a relevant phenomenon (e.g., by watching a video or hearing an elder tell a story).
* Not all phenomena must be used for the same amount of instructional time. Teachers could use an **anchoring phenomenon** as the overall focus for a unit, along with other **investigative phenomena** along the way that focus an instructional sequence or lesson. They may also highlight **everyday phenomena** that relate investigative or anchoring phenomena to situations experienced first-hand. A single phenomenon doesn’t have to span an entire unit, and different phenomena will take different amounts of time to figure out.

**WHAT MAKES PHENOMENA EFFECTIVE FOR USE IN INSTRUCTION?**

* The most powerful phenomena to drive learning are culturally or personally relevant or consequential to students. Such phenomena highlight how science ideas help us explain aspects of real world contexts or design solutions to science-related problems that excite them or matter to students, their communities, and society.
* An appropriate phenomenon for instruction should help engage all students in working toward the learning goals of instruction. The phenomenon needs to be useful for teachers to help students build the target pieces of the DCIs, SEPs, and CCCs. For example, engaging in discussions about red shifts of light from galaxies is unlikely to be helpful in moving 5th grade students to a grade-appropriate understanding of DCI ESS1.A, which, at the 5th grade level, focuses on the relationship between star brightness and distance from Earth.
* The process of developing an explanation for a phenomenon should advance students’ understandings. If students already need to know the target knowledge before they can inquire about the phenomenon, then the phenomenon is not appropriate for initial instruction (although it might be useful for assessment).
* Students should be able to make sense of anchoring or investigative phenomenon, but not immediately, and not without investigating it using sequences of the science and engineering practices. With instruction and guidance, students should be able to figure out, step by step, how and why the phenomenon works.
* *An effective phenomenon does not always have to be flashy or unexpected*. Students might not be intrigued by an everyday phenomenon right away because they believe they already know how or why it happens. It takes careful teacher facilitation to help students become dissatisfied with what they can explain, helping them discover that they really can’t explain it beyond a simple statement such as “smells travel through the air” or a vocabulary word, such as “water appears on cold cans of soda because it condenses.”

| **Prior Thinking About Phenomena** | **Thinking About Phenomena For the Science Standards for Alaska** |
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| If it is something fun, flashy, or involves hands on activities, it must be engaging. | Authentic engagement doesn’t have to be fun or flashy, instead, engagement is determined more by how the students generate compelling lines of inquiry that create real opportunities for learning. |
| Anything the students are interested in would make a good “engaging phenomenon.” | Students need to engage deeply with the material in order to generate an explanation for the phenomenon, using target DCIs, CCCs, and SEPs. |
| Explanations (e.g. electromagnetic radiation can damage cells) are examples of phenomena. | Phenomena (e.g. sunburn, vision loss) are specific examples of something in the world that is happening – an event or a specific example of a general process. Phenomena are not the explanations or scientific terminology behind what is happening. They are what can be experienced or documented. |
| Phenomena are just for the initial hook.  | Phenomena can drive the lesson, the learning, and reflection/monitoring throughout. Using phenomena in this way leads to deeper learning. |
| Phenomena are good to bring in after they develop the science ideas so they can apply what they learned. | Teaching science ideas in general (e.g., teaching about the process of photosynthesis) may work for some students, but often leads to decontextualized knowledge that students are unable to apply when relevant. Anchoring the development of general science ideas in investigations of phenomena helps students build more usable and generative knowledge.  |
| Engaging phenomena need to be questions  | Phenomena are observable occurrences. Students need to *use the occurrence to help generate the science questions or design problems* that drive learning.  |
| Student engagement is a nice optional feature of instruction, but not required. | Engagement is a crucial access and equity issue. Students who do not have access to the material in a way that makes sense and is relevant to them are disadvantaged. Selecting phenomena that students find interesting, relevant, and consequential helps support their engagement. A good phenomenon builds on everyday or family experiences: who students are, what they do, where they came from.  |