



Phenomena Driven Instruction: Don't Assume One Approach Fits All

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Correcting the record on phenomenon-based teaching

Science curriculum developers and educators agree that scientific precepts are best taught when illustrated by real-world "phenomena." However, modern misconceptions have clouded the facts on how best to employ them. When properly used, phenomena help teach not just the facts of science, the "what." Rather, they engage students more fully and deepen understanding by epitomizing the "why": how to think like scientists by doing science, actively investigating those principles in action. The problems arise when curriculum developers misread standards and misinform educators on how and when phenomena should be used.

For the past quarter century, K-8 science curricula built around active investigation of phenomena have harnessed their power in the classroom, raising test scores and sending on more students

to AP Science high school classes and STEM careers than competing curricula. Most recently, these principles can be found in the Next Generation Science Standards now recognized in 26 states.

In keeping with our history of bringing professional learning to science educators, Delta Education® and School Specialty® are proud to provide the following white paper by NGSS writing team member Craig T. Gabler, Ph.D. It deals with a critical deficiency of some popular post-NGSS science curricula: the growing misconception common to many NGSS newcomers that there is only one way to incorporate phenomena in a science lesson. It then highlights the broader range of pedagogical options that can engage each science student in a true three-dimensional process of discovery.

Foreword

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Separating fact from fiction about phenomena

With the arrival of Next Generation Science Standards (NGSS), science teaching has shifted from rote instruction of science topics to exploring how or why something happens. That “something” is the phenomenon. The NGSS explicitly state that science teaching should engage students with phenomena. However, they leave room for discretion not only in what phenomena should be used, but also when the phenomena should be introduced in the instructional sequence. A model now somewhat in fashion dictates that every lesson must immediately begin with

presentation of the phenomenon. However, this cookie cutter view of curriculum-building glosses over the reality that designing student learning experiences is very complex and is highly dependent on students’ prior experiences. Insisting on “phenomenon first” as a one-approach-fits-all template is not required by the NGSS, or by the empirical evidence, any more than any other sequence of instruction. In fact, it is a poor fit for many students and a highly imprudent choice.



A powerful tool that must be used properly

The decision of when to introduce phenomena in science teaching is a crucial one for student success. When properly used, phenomena are a vital tool to engage students with scientific principles at work in their world, sparking their comprehension and empowering them to engineer solutions to problems. However, popular misconceptions about how to use phenomena can neutralize their value and damage students' opportunity for learning. This white paper offers a brief background on how we came to this place, and discusses the many ways – not just one – that phenomena can be used to guide learning.

The question about phenomena: Does the path to understanding always start in the same place?

For more than 4 years, since the release of the Framework for K-12 Science Education (The Framework) and the Next Generation Science Standards (NGSS), science teachers have been working very hard to embrace the NGSS vision. That vision for students' learning experiences demands a shift from learning about a topic to figuring out how or why something happens. The NGSS requires that students should do so by engaging with a natural phenomenon or problem and then, with guidance, making sense of that phenomenon.

There is general agreement on what "phenomena" means: "observable events that occur in the universe."¹ However, choosing the stage when the phenomenon is introduced into the instructional unit seems to have fallen into a very singular, myopic formula that is not necessarily proven superior by the evidence. The imprudence of following such a "one-approach-fits-all" perspective is the focus of this paper.

Introduction

Recognizing the role of phenomena

Even before The Framework and the NGSS, educational theorists and practitioners championed the need for students' learning to be based on experiences. Going back to the early part of the 20th century and the work of John Dewey, we see that Dewey's approach was often viewed "as the pedagogical antidote to rote learning; for example, students should learn through experience rather than just sit there and memorize."³



How phenomenon-based teaching has evolved

Moving forward in time to the 1960s, J. Richard Suchman originated an inquiry teaching program that cast the student as an information seeker and problem solver. Widespread acceptance for a new definition of science proficiency followed, with advances in cognitive sciences research and the publication of *How Students Learn Science*⁶ and *Taking Science to School*.⁵ Notably, *Taking Science to School* emphasized that students should be able to participate in scientific practices and discourse, including being able to generate and evaluate scientific evidence and explanations.

This trajectory has brought us to the current vision of The Framework and the supporting competencies laid out in the NGSS. That framework is designed to help students actively engage in scientific and engineering practices and apply crosscutting concepts to deepen their understanding of core ideas. It should offer learning experiences that engage them with fundamental questions about the world, and show them how scientists have investigated and found answers.

Throughout grades K-12, students should have the opportunity to carry out scientific investigations and engineering design projects that relate to the disciplinary core ideas.⁴

Understanding how we came to this point in time is important. But it is also vital for educators to recognize that in the here and now, “NGSS are standards, or goals, that reflect what a student should know and be able to do—they do not dictate the manner or methods by which the standards are taught [emphasis added].”⁸ The standards communicate the importance of phenomena through the interweaving of Disciplinary Core Ideas, the Science & Engineering Practices and the Crosscutting Concepts. But there is no directive about the sequencing of instructional strategies – and for very good reason. In the next sections, we will review the “manner or methods” available for achieving these standards, and experts’ thinking on how to proceed.

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A modern definition of phenomena takes shape

While the Next Generation Science Standards “do not dictate nor limit curriculum and instructional choices,”⁸ the need for students to engage with phenomena is quite clear. Evidence can quickly be found in three rubrics widely used to review curriculum materials – the EQuIP Rubric, the PEEC Tool and the NextGen Time Tool. Table 1 compares language about phenomena from the three tools.



What the rubrics say

Table 1

EQuIP

The lesson/unit is designed so students make sense of phenomena and/or design solutions to problems by engaging in student performances that integrate the three dimensions of the NGSS.

A. Explaining Phenomena/ Designing Solutions:

- Making sense of phenomena and/ or designing solutions to a problem drive student learning.
- Student questions and prior experiences related to the phenomenon or problem motivate sense-making and/or problem solving.
- The focus of the lesson is to support students in making sense of phenomena and/or designing solutions to problems.
- When engineering is a learning focus, it is integrated with developing disciplinary core ideas from physical, life, and/or earth and space sciences.

PEEC

The instructional materials program focuses on supporting students to make sense of a phenomenon or design solutions to a problem.

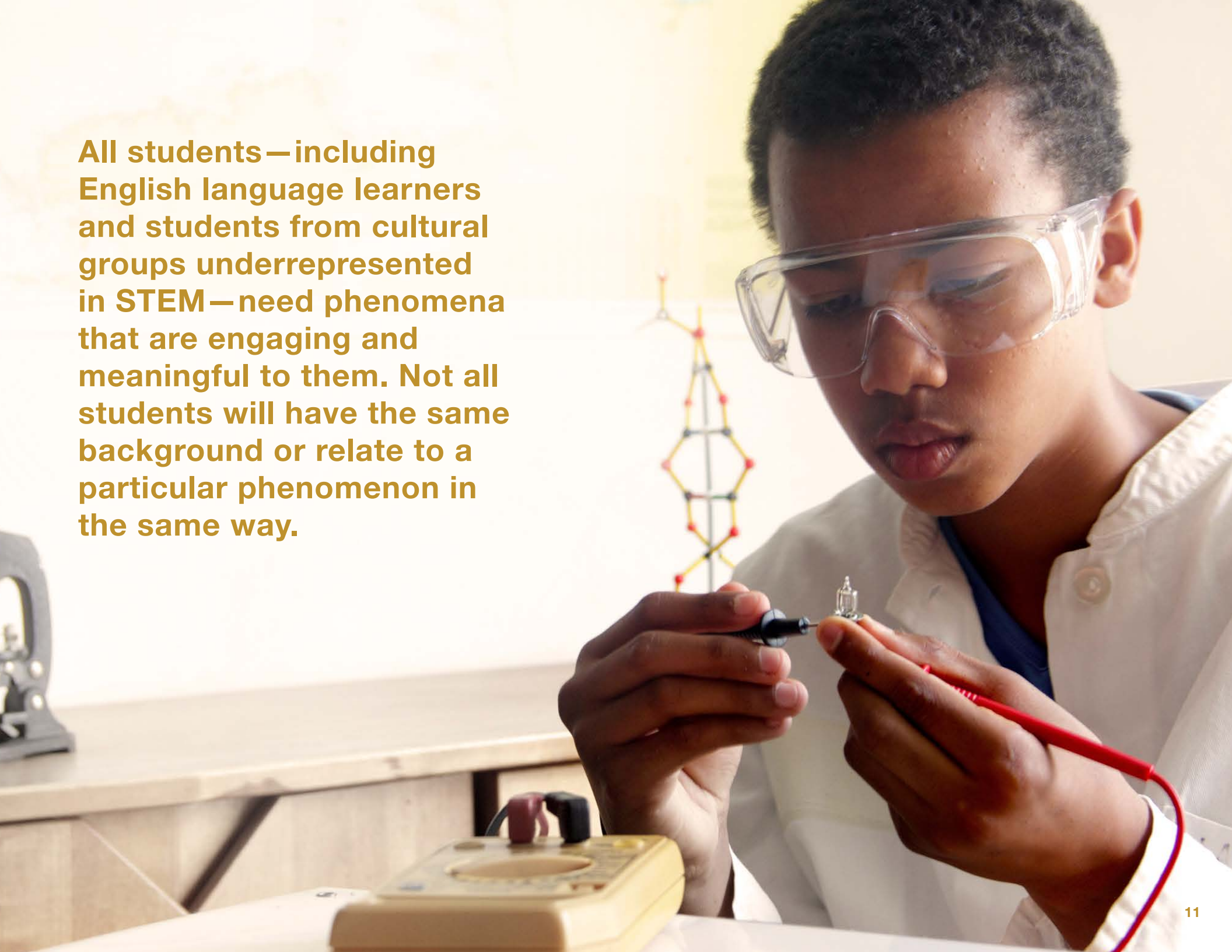
NextGen Time (Paper Screen)

F1. Presence of Phenomena/ Problem.

The materials include phenomena/problems that have the potential to drive student learning toward the targeted learning goals in the following ways:

- Phenomena/problems in the materials are to be relevant to students;
- Explanations for phenomena connect to the three dimensions; and,
- Solutions to problems connect to the three dimensions

All students—including English language learners and students from cultural groups underrepresented in STEM—need 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.



The standards call for phenomena, but not "phenomenon first"

The central role of phenomena is obvious. But it is interesting to note that neither The Framework, NGSS, nor the three rubrics compared here, identifies different types of phenomena. It has only been since NGSS implementation began that such terms as “anchor”, “everyday” and “investigative” have come into use. That said, the nature of a phenomenon is critical to its success in driving instruction. Highlighted here are a few key characteristics of phenomena, as they pertain to the nature of phenomena.

A good anchor [phenomenon] is observable to students. “Observable” can be with the aid of scientific procedures (e.g., in the lab) or technological devices to see things at very large and very small scales (telescopes, microscopes), video presentations, demonstrations, or surface patterns in data.⁷

It is important that all students—including English language learners and students from cultural groups underrepresented in STEM—can work 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.¹

In this connection, it is telling that the rubrics never presume to dictate when or how the phenomena should be introduced in the instructional sequence. This is where the curriculum developer, and the curriculum reviewer, must be careful not to make damaging assumptions that could stand in the way of learning for some students. Although phenomena should drive the curriculum, this does not mean the phenomenon must be presented in the opening moments of a unit. Nor does it mean the phenomenon has to be presented as a graphic image, a videoclip or a hypothetical scenario.

Indeed, a good anchor or phenomenon can be a wide variety of things: a case (pine beetle infestation, building a solution to a problem), something that is puzzling (why isn’t rainwater salty?), or a wonderment (how did the solar system form?). It has relevant data, images, and text to engage students in the range of ideas students need to understand. It should allow them to use a broad sequence of science and engineering practices to learn science through first-hand or second-hand investigations.⁷ But to ensure the anchor makes sense to all students, it will sometimes be advisable to provide a logical context before presenting it, not always to reflexively mention it first.

Standards



Although the phenomenon should drive the curriculum, it may not belong in the opening moments of the unit. Sometimes the best way to ensure the anchor makes sense to all students is to provide a logical context before presenting it, not always to reflexively mention it first.

When is the right time for the phenomenon?

First and foremost, the right answer to this question is: There is no one right answer. It depends on what approach works best for the material and the students, case by case. Noted science educators agree. As far back as 1938, Dewey asserted that “the work of educators is to select the kind of present experiences that live fruitfully and creatively in subsequent experiences.”³ In 2014 Rodger Bybee described four principles of instructional design that support students attaining the NGSS learning goals. One of those principles states that “Learning experiences are thoughtfully sequenced into the flow of classroom science instruction [emphasis added]”². And finally, the Achieve published document *Using Phenomena in NGSS-Designed Lessons and Units* offered this insight:

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 [emphases added], 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.”¹

Implications

So how might a phenomenon be used to drive a unit of instruction? It is essential that the teacher or curricular material developer consider an appropriate phenomenon from the very beginning of planning. However, when and where students are introduced to the phenomenon should not follow a one-approach-fits-all design model. Here are three examples of how to place a phenomenon effectively:

1 Students often need some shared experiences with materials in order to help them recognize a particular phenomenon. In these cases, the unit can start by ensuring that all students have a common background before proceeding with a particular phenomenon, then introducing the anchor phenomenon after this shared equity is established. Referencing Table 1, note that this approach still satisfies the NGSS requirements as described in the first bullet of the NextGen Time column, because the anchor phenomenon now has relevance to all students. The shared experiences can then serve as an everyday phenomenon for the students to connect back to, helping them make sense of the anchor phenomenon. As an example, elementary students may not have experienced rolling objects down an incline. If the lesson plan first lets them observe the behavior and then brings the focus onto how to change the movement, students are more ready to engage with the anchor phenomenon of the impact of forces on motion.

2 If the phenomenon is relevant and engaging to the students and helps them grasp the core idea to be developed, then it might be used as the launch or engage phase of the unit/lesson. But what is relevant in one region of the country may not be as applicable in another – for example, earthquakes. Along the West Coast of the U.S. this phenomenon is both relevant and engaging, and can help high school students see how and why the Earth is constantly changing. As a counter-example, opening a discussion of magnetism with an illustration of maglev "floating trains" without building a context first might immediately lose the interest of students in rural areas, who have never observed the technology in their world and may not find it either intuitively understandable or terribly relevant.

3 Begin a unit/lesson with an everyday phenomenon and solicit questions from students that can be used to connect to the larger, anchor phenomenon. Their questions can then be used to drive the smaller, investigative phenomenon. For example, at the middle school level students are aware of cell phones, but probably have many questions about how the information is actually transferred. These questions can be used as the focus of investigations, ultimately leading to the larger phenomenon of how waves transfer energy and information.

Examples

Conclusion: Students, not phenomena, always come first

The NGSS are based on the latest research in cognitive science, and they reflect what ALL students need in order to be proficient in science. To achieve the vision of The Framework and NGSS, teachers of science must use phenomena in the teaching/learning cycle. Yet, experience and scholarship both tell us that not all students learn in the same way and at the exact same pace, which is why the NGSS clearly states that the standards do not dictate curriculum. There are many high-quality approaches to driving instruction with phenomena. Teaching that is both engaging and NGSS-optimized can use phenomena that vary both in nature and in their placement within the course. The message is clear: For curriculum developers and local educators alike, rigid adherence to a one-approach-fits-all model should always take a back seat to well-reasoned presentation and proven effectiveness.



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Delta Education

Delta Education is the largest publisher of curriculum-based elementary school science kits in the United States. Working in partnership with premier academicians, Delta Education distributes the K-8 science curriculum that pioneered learning through exploration of phenomena, turning students from passive spectators at a computer screen to active investigators performing science – expressing the philosophy of hands-on learning that has distinguished Delta Education for over a quarter century. Delta Education is part of the School Specialty family of brands.

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School Specialty is the only science curriculum provider that creates not just curricula, but comprehensive learning ecosystems to harmonize with them and optimize student outcomes. For generations, School Specialty and its affiliates have proudly supported phenomenon-based science education and the professional development of those who teach it.

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