Smithsonian
Science Education Center

FALL 2020

Telling a STEM Story

How Smithsonian curriculum developers help K–5 students make sense of phenomena and problems

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Think about one of your favorite books that you read as a child. What made it your favorite book? Almost certainly, one of your answers will be something along the lines of "it was a great story." The way the book was put together made you want to find out more. Each chapter built on the previous chapter.

The Smithsonian Institution has been telling stories through the objects in its museums for years (Kurin 2014). Science curriculum is not that different. Each lesson plays a part in building a picture in a child's mind, like pieces of a jigsaw puzzle or a mosaic. To shed light on the process, several Smithsonian Science Education Center (SSEC) curriculum developers offered insights into how they develop storylines for a grades K–5 curriculum that's aligned to the Next Generation Science Standards* (NGSS). I spoke to several of my fellow curriculum developers to find out how they develop storylines for an NGSS-aligned K–5 curriculum. While no two developers work in exactly the same way, all developers agree that the process is not linear. Building a coherent storyline is like a complex engineering design problem: the steps are iterative, and the storyline is revised until the final picture becomes clear to all.

Credit: Christina Zdawczyk

Each lesson in a STEM curriculum is like a piece of a mosaic.

> "Sometimes when you get into writing the lessons, you realize the storyline needs some revision. You realize the concepts and practices might not connect as well as you thought from a student's perspective."
>
> —Beth Short
> SSEC Curriculum Developer

Taking Apart and Putting Back Together

Credit: MJB Rogers

Mapping a possible flow for student problem solving based on the bundled PE elements

There is no textbook for developing a storyline for a STEM curriculum. However, a good starting point for an NGSS-aligned curriculum is the performance expectation bundle (Krajcik et al. 2014). Combining performance expectations (PEs) together in a learning sequence allows students to make connections between different concepts (Achieve 2016).

After putting together PEs in a way that makes sense, it might seem strange that the first thing most curriculum developers do when they develop a storyline is to take the bundle apart. Deconstructing the PEs into their component dimensions—disciplinary core ideas (DCIs), science and engineering practices (SEPs), and crosscutting concepts (CCCs)—allows developers to see which elements might work well together. Although a PE may recommend combining a DCI with a particular SEP or CCC, a developer may feel that a different combination would create a more coherent storyline. Developers look for DCIs that will connect and identify those that will need more time to develop. They anticipate what students will need to know before moving to the next lesson. If they get it wrong, there will be a conceptual gap in student thinking. They then identify appropriate SEPs and CCCs that would help students make sense of these concepts.

The Glue That Holds the Pieces Together

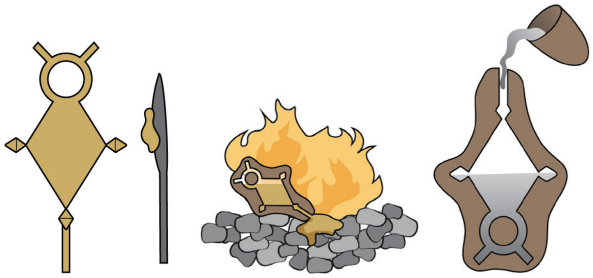
As developers piece together the elements of the PEs, they are almost certainly starting to think of engaging phenomena and problems that could be used to link several lessons together. A good phenomenon or problem sparks curiosity. For it to involve sensemaking, it needs to be something that students can't immediately explain or solve (Odden and Russ 2019). It should take extended classroom time for students to figure out (Penuel and Reiser 2018).

> "As I start to pick apart the PEs into their component parts, I begin to think about the phenomena that made me wonder or illustrated the concepts for me when I was a student. They are like puzzle pieces floating in my head. The puzzle pieces from my own experiences, as well as items and research I've found at the Smithsonian, filter down until they form a block of phenomena that will comprehensively illustrate the DCIs."
>
> —Logan Schmidt
> SSEC Curriculum Developer

How much of the surface of this playground is shaded from the Sun? Credit: clubfoto/iStock/Getty Images Plus

Students may need to develop understanding about science concepts before they can start solving a problem. For example, to design a solution to the problem of a playground surface being too warm to sit on, students first need to collect evidence that shows that sunlight warms surfaces. Then they need to design a shading device that will help stop the sunlight from reaching and heating up the playground surface.

A phenomenon or problem doesn't always need to be familiar to students. Students could look at an image of a piece of silver jewelry from the Smithsonian African Art Museum and be asked to think about how it might be made from wax. Students are unlikely to have personal experience of lost wax casting, which is the process of making a metal object starting with wax wrapped in clay. However, the idea of a silver necklace being made from wax will spark their curiosity and make them want to learn more.



Credit: Smithsonian Science Education Center

Students collect evidence from a text to help them explain how a silver necklace is made starting with wax.

Most modules will need multiple phenomena and problems to cover the various elements in the storyline. Multiple problems will also ensure the engagement of a diverse group of students (Penuel et al. 2017). Selection of great phenomena and problems that work together to tell a story is a critical part of curriculum development.

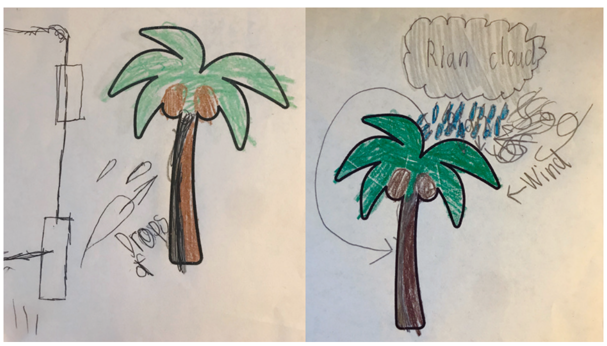
> "Identifying phenomena that can drive learning is the hardest and most time-consuming part of developing a storyline. What will seem unexplainable in the beginning but be explainable in the end?"
>
> —Sarah Glassman
> SSEC Curriculum Developer

Making Sense of Phenomena and Problems

It's not sufficient to just have great phenomena and problems in a curriculum. A phenomenon and problem can't just be for engagement. Students need to be actively engaged in figuring out a phenomenon or problem using the three dimensions of NGSS (EQuIP 2016). However, students do not come into school as blank slates. They will have ideas from their own experiences and background that they can build on.

Good phenomena and problems allow students to make connections to their everyday experiences (Penuel and Reiser 2018). Students may not be familiar with lost wax casting, but they may have experienced ice melting and objects made of wax, clay, and silver. It is up to the teacher to tease out these initial ideas (often called naïve ideas or naïve conceptions).

As students collect evidence, they build on their initial ideas through an iterative process of critiquing and revision (Odden and Russ 2019). Students use SEPs and CCCs together with DCIs as they make sense of phenomena and problems. For example, they may need to use a model or identify cause-and-effect relationships to explain how a tree becomes wet only on one side. As they build their content knowledge, they also build their proficiency in using SEPs and CCCs to help answer questions and solve problems.



Credit: Beth Short

Kindergarten students revise their explanation of a tree that is wet only on one side. On the left, a student draws the initial idea that a car splashed the tree. On the right, the same student draws a new model using their new understanding of wind and rain.

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How Smithsonian Science for the Classroom Curriculum Supports Student Sensemaking of Phenomena and Problems

NGSS requires that students make sense of phenomena and problems using three dimensions. Smithsonian Science for the Classroom includes authentic phenomena and problems that draw on the rich resources of the Smithsonian as well as research and data from other scientific organizations. In each module, students actively engage in figuring out multiple phenomena and problems that will enable them to complete an end-of-module performance assessment. In figuring out these phenomena and problems, students gain in proficiency in using a small number of SEPs and CCCs that they will use in the end of module assessment.

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