Information Crossfile*

REVIEW

A new science literacy standard

I THINK A LOT ABOUT THE FUNDAMENTALS OF SCIENCE literacy here at the Old-Growth Bottomland Forest Research and Education Center at Congaree National Park. As a Ph.D. scientist and educator, I am constantly struck by how science literacy includes so much more than just factual findings. At a cognitive level, it also addresses methods of knowing as well as conceptual paradigms—and these do not even address emotional dimensions of science, which are just as important. All of these factors come to mind as I approach science communication with park staff and partners, use the interpretive equation[1] in park programs, and converse with K–12 students and teacher partners.

Over the last several years I have found one reference that increasingly affects my understanding of science literacy: the *Framework for K–12 Science Education* (NRC 2012). The framework was originally conceived by the National Academy of Sciences as a prerequisite for updated K–12 academic standards that could be implemented broadly across the country. The document was developed in coordination with a wide array of private, public, and nonprofit partners as well as public comments. It was based on a consensus-driven approach to synthesize STEM (science, technology, engineering, and math) expertise with recent research in the learning sciences (an interdisciplinary field that includes dimensions of psychology, sociology, neuroscience, policy, and more—including studies of how students learn in informal settings such as parks). The framework vision is "a broad description of the content and sequence of learning expected by all students" to help science educators map out relevant, age-appropriate K–12 curricula and lesson plans. I find it a magnificent resource for science education aimed at adult staff, visitors, and partners as well.

The full document is lengthy at 401 pages, but the National Science Teachers Association has also published a condensed summary to help "unpack" the full-length framework (Pratt 2013). The simplest distillation of the framework is that any science lesson should center on three essential, equally important components. These are metaphorically represented in the document as a three-strand rope:

1. **Disciplinary core ideas (DCIs):** DCIs include factual topics, such as photosynthesis, magnetism, or tectonics, that are all organized in an outline perhaps akin to a Dewey Decimal System. From a park perspective, the DCIs *are* the "KR" (Knowledge of the Resource) in the interpretive equation.

2. **Science and engineering practices (SEPs):** The SEPs are an integrated, iterative set of practices that place any lesson firmly in the context of science as a *verb*. There are eight SEPs and my own evolving analogy of them is an octagonal web (fig. 1, next page). The SEPs vibrantly redefine the older, static model of the scientific method as a linear, proscriptive, nonnegotiable "fact recipe" that starts with a hypothesis. In this way the SEPs help define the "AT" (Appropriate Technique) in the interpretive equation.

3. **Crosscutting concepts:** These are broad paradigms for thinking that can be similarly applied in many areas of science. In no particular order they are (1) patterns; (2) cause and effect; (3) scale, proportion, and quantity; (4) systems and system models; (5) energy and matter; (6) structure and function; and (7) stability and change. They are, of course, defined very specifically in the context of the framework, but they open up *worlds* of possible connections with related disciplines, humanities, interpretive TIU models (i.e., tangibles, intangibles, and universals), and others. Defining crosscutting concepts on equal footing with the DCIs and SEPs is, for me, a huge development. They have always been components of good instruction, but have not always been clearly woven and fairly weighted in the considerations of curriculum development.

In addition to the three dimensions, the framework makes two more important contributions to science literacy. First, it effectively differentiates the language of science and engineering in context; *science* is defined as fundamental understanding of phenomena in the natural world, while *engineering* is defined as the application of understanding toward solving human problems. The second major contribution of the framework is its very presentation of logical, appropriate progressions in the DCIs, SEPs, and crosscutting concepts. There are countless ways to organize such an outline, but at the end of the day educators working across diverse settings—especially rangers and educators working for an organization as large and diverse as the National Park Service—need some consistent, common denominator. As a standing consensus of the country's leading scientists and educators, this document provides just that. While many different

[1]The interpretive equation is an analogy for understanding the relationship among foundational elements of effective interpretation. The equation is KR + KA x AT = IO and it stands for *Knowledge of the Resource* (KR) plus *Knowledge of the Audience* (KA) times *Appropriate Technique* (AT) equals an *Interpretive Opportunity* (IO) to make intellectual and emotional connections between visitors (students) and a resource (e.g., park, site, tree, building, bird, artifact).

*Information Crossfile synopsizes selected publications relevant to natural resource management. Unless noted, articles are not reviewed by reference source author(s).

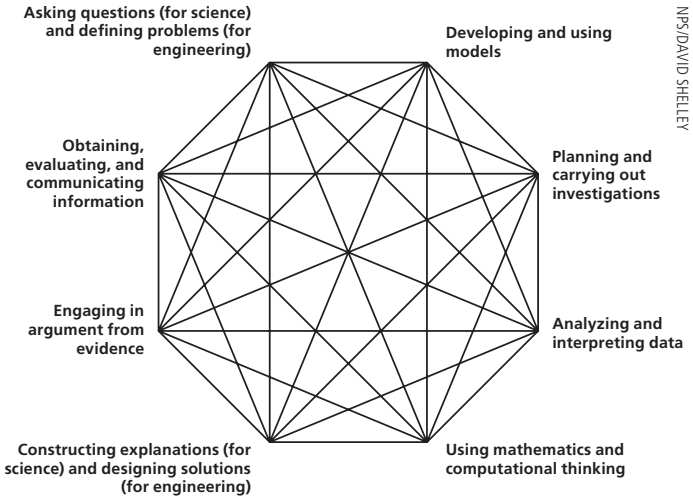

Figure 1. The author's own octagonal model for the eight science and engineering practices (SEPs). This vision is not linear like the traditional, proscriptive scientific method, but iterative. Any practice may lead a researcher, park ranger, manager, or student to any other practice.

states still develop their own K–12 academic standards for science, evolving iterations cannot ignore (and are not ignoring) this document. This means that the document and its language are here to stay and driving significant changes in how teachers think and talk about science.

The framework authors note that the document is not static but subject to change as it is implemented and evaluated. For my own part, I might expect (or even hope for) two changes. One hope is that the SEP "obtain, evaluate, and communicate information" may eventually be split into two. Skills in obtaining and evaluating information as a media consumer are certainly related to designing such communications, but at the end of the day they are indeed two different skill sets. Scientific communication (with nonscientists) also needs to be distinguished from other forms of communication in its reliance on models, data, analysis, and peer review per the SEPs. My second thought is that the crosscutting concept of "patterns" may be subdivided more explicitly to separate out classification in a relational sense (i.e., biological taxonomy, mineral identification, or the international stratigraphic code) from spatial (i.e., maps and GIS) and temporal patterns (i.e., time series) found in data.

Understanding this document and incorporating it into NPS communication—both external and external—are extremely relevant to a second century of NPS success in many ways: First, as a consensus document that increasingly underpins the public education system, working with the framework is critical to effectively reaching today's K–12 students as well as an increasingly broad spectrum of tomorrow's visitors (and even future staff). Second, it can efficiently streamline staff work to match specific audiences, content (especially age-appropriate vocabulary and prior knowledge), and techniques without constantly reinventing the wheel. Third, the common language can help facilitate education program/information transfer between parks in different states as well as staff relocations between diverse park units. Fourth, the authors acknowledge that the framework does not simply stand alone in a vacuum, but requires collaborations to explore "considerations of the historical, social, cultural, and ethical aspects of science and its applications, as well as of engineering and the technologies it develops." Parks can shine second to none in this regard, and perhaps help define the gold standard. Fifth, the mutual success of the NPS and the document are synergistic; by working with the framework, NPS staff and partners can play an important role in supporting its ultimate success.

In the context of all of these benefits, I find the framework an earth-shattering foundation—if that isn't an oxymoron—for rethinking staff, visitor, and K–12 education in the greater service of the NPS mission. As many NPS programs can attest, cultivating science literacy that is more than just facts is fundamental to helping park managers, partners, and visitors make stewardship decisions about the precious natural and cultural resources in our care. As the framework emphasizes, "personal and civic decision making is critical to good decisions about the nation's future." The vision laid out here is an ambitious but worthy one, I think, with great promise for the National Park Service as we move into our centennial and beyond.

References

NRC (National Research Council). 2012. A framework for K–12 science education: Practices, crosscutting concepts, and core ideas. Board on Science Education, Division of Behavioral and Social Sciences and Education; Committee on a Conceptual Framework for New K–12 Science Education Standards. National Academies Press, Washington, D.C., USA. Accessed 12 August 2015 at http://www.nap.edu/catalog/13165/a-framework-for-k-12-science-education-practices-crosscutting-concepts.

Pratt, H. 2013. The NSTA reader's guide to "A framework for K–12 science education, Second Edition: Practices, crosscutting concepts, and core ideas." NSTA (National Science Teachers Association Press, Arlington, Virginia, USA. Accessed 12 August 2015 at http://www.nsta.org/store/product_detail.aspx?id=10.2505/9781938946196.

—David C. Shelley