Science concepts connect us to the wonders of the natural universe. Why is the sky blue? [Air molecules behave much like tiny little tuning forks.] Is there gravity in space? [Yes, it extends to infinity.] What do fish “breathe” underwater? [It’s not the water.] A scientifically literate individual can answer questions such as these or at least be curious enough and sufficiently equipped to find accurate explanations.

Science concepts are the centerpiece when it comes to science literacy. What then are best practices for teaching these concepts? The following should be considered.

We all know that science concepts build upon one another. In physics, for example, Newton’s laws lay a foundation for momentum. Understanding momentum, in turn, sets the stage for understanding energy, and so on. Foundational concepts come first followed by more complex concepts, which is well represented by a forward moving line (Figure 1).

Teaching this step-by-step concept development is enhanced when students find the science concepts themselves inherently interesting. A delight in teaching these concepts is to be championed.

At the same time, remarkable and relevant applications can be woven into this concept development backbone.

The energy and teaching skill of the science teacher is also key. Can the teacher explain the concepts well, to the point that students can then effectively explain them back? Can the teacher also impart excitement, to the point that the students are equally if not more passionate? Perhaps the strongest scaffold a teacher can offer is one built of a genuine passion for the subject matter, matched only by their concern for each student’s well-being. We know passion and concern are infectious. Once the school year is over, these qualities will remain the tallest structures standing. We know the flavor of a class experience tends to far outlive any content details. Toward that end, we provide the full support science instructors need to do their jobs well.

**Scientific ways of doing**

The National Academies’ seminal 2012 *A Framework for K–12 Science Education* recognizes that the concepts of science and the practice of doing science are not the same thing. Why the sky is blue—that’s a concept. How do we measure atmospheric particulates? That’s a practice. Students should come to trust in the practices of science. After all, such practices originally led to our understanding of the concepts.

Traditionally, introducing students to the practices of science means embedding lab activities. Ideally, such labs are genuine to the ways of science being more investigative than a cookbook. Often overlooked is the following: As any working scientist knows, a scientific practice, such as a lab activity, isn’t scientific in the absence of documentation. This is why the Framework also encourages students to keep a “field journal,” “lab notebook,” or “portfolio.” This further supports the development of a student’s communication skills, which is yet another key element to doing science.

So, let’s pull these rich practices of science—the ways of doing science—out front and center as a helix wrapping around the core concepts heading in the same direction (Figure 2).

**Scientific ways of viewing**

As further pointed out by the Framework, doing science tends to strengthen one’s critical thinking skills. A scientist would ask, “If this idea is correct, then
how would I know?" They answer this question less by internal rumination, and more by looking outward for plausible evidence. This Sherlock Holmes approach and attitude leads to valuable ways of viewing one's surroundings.

For example, identifying patterns becomes most important, as does discerning causation from correlation. A scientist might look to the world and see it from the perspective of the flow of matter and energy. They may look to the structure of an object and see its function, or vice versa. They may witness stability and change through the lens of feedback loops. They stand ready to perceive phenomena on vastly different scales, from atoms to galactic clusters. For the unseeable, such as the behavior of a system, the practicing scientist develops and works with models.

Consider this: None of these ways of viewing, listed above, involve any specific concepts of physics, chemistry, or biology. Nevertheless, they cut across all science disciplines and certainly hold value for other fields, such as business, politics, and even the arts. All students benefit when these “scientific ways of viewing” are spelled out front and center.

Therefore, let’s highlight these rich cross-cutting ways of viewing as an important second helix, again, heading in the same direction (Figure 3).

The result is a double helical model pointing the way to authentic science literacy for all. This is a kinetic sketch of the three dimensions spelled out by the Framework and embraced by many state standards including those of Texas (TEKS) and the Next Generation Science Standards (NGSS). Disciplinary core ideas (DCI) are the black arrow. Science and engineering practices (SEP) are the blue helix, and the crosscutting concepts (CCC) are the red helix.

An actual curriculum
How might we translate this model into an actual curriculum that optimizes science literacy? Where the helices appear to overlap the core concepts, we can place a core concept lesson. Where the helices appear to open up, we can insert a menu of context-providing activities from which the instructor can choose (Figure 4).

This model points us to a rhythm of learning. An active day can be followed by a conceptual day, which gives one time to get ready for another active day, and so on. Like the DNA molecule, this model also calls for variety, as represented by the menu of activities. Each activity, by its own means, promotes the ways of doing science and the scientific ways of viewing. With these three dimensions in place, we are on our way to meeting or exceeding any state standard.

Implementation
Like a balanced meal, we should seek a healthy balance of activities to lessons (Figure 5). The nutritional needs of each group of students, however, will vary. Consider each block to be a class period. Even though one instructor might follow a particular sequence—activity, lesson, activity, lesson, activity (Figure 6).
Another instructor working primarily with younger and more action-oriented students might find it prudent to follow a different pattern, such as activity, activity, lesson, activity, activity (Figure 7). Yet another instructor working with more advanced students might choose to minimize the activities in favor of deeper concept exploration. Thus, we see many potential pathways from this one model, which makes sense because there can be no one-size-fits-all curriculum, even within a single age group. The instructor, right there in class, should have the flexibility to call the shots based upon the needs of the class. Further, each instructor will have their tried-and-true lessons and activities. These should be embraced. The suggestion here is simply in how they might be structured and/or complemented with more options for added spice.

To be clear, this double-helical model points to providing the instructor with a menu of different activities as well as types of activities for a single concept. As an example, the instructor might choose from a writing activity, a literature search activity, a hands-on activity, a phenomenon-based activity, an online simulation, a project-based activity, a worksheet activity, or a hearts-on community building activity—each covering the same concept, such as momentum. Coming to class, students won’t always know what to expect. The same can hold true for the instructor who, as per their judgment, might switch to a different activity at the last minute—made possible by a viable menu of related activities. With a weekly rhythm, everyone understands there is a thoughtful intention. There is a broader arc being followed toward an ultimate goal.

This model supports a teacher’s professional development. Internet sources already hold a wealth of activities for each science concept, but there remains the task of adapting these activities to the reality of one’s own classroom. All the better if the teacher is working with a community of teachers within their school and beyond. Using this common framework, each instructor develops and shares their favorite activities and lessons for each concept. The science program remains on a pathway to improvement, which makes one’s teaching career all the more rewarding—teacher burnout is quenched by nurturing the fire within.

**Commentary**

There is immense pressure in needing to translate detailed state science standards into real live classroom experiences. Ideally, the goal of science literacy is not subordinate to a well-intentioned checklist lacking passion as one of its key metrics. Such a checklist can be perceived less as a helpful guide and more as a lack of trust—as if to say, “You are not performing properly, so here is a list for you to follow.”
Guidance is surely called for, but there also needs to be a simplicity and adaptability, especially if we are to nurture trust. The double-helical model introduced here provides an easy-to-grasp handle for exactly that. Are we meeting those state standards? More importantly, are we building science literacy that includes a curiosity and respect for the wonders of our natural universe? If we embrace a growth mindset—as represented by this model—then we are heading in the right direction.

John Suchocki (John@ConceptualAcademy.com) is a chemistry instructor, author, and cofounder, with Paul Hewitt, of Conceptual Academy, a public benefit company dedicated to the mission of improved science literacy.

ONLINE CONNECTIONS


Conceptual Academy at PocketLab: https://www.thepocketlab.com/conceptual-academy

FIGURE 6

Experiential activities (green) can be placed where the helices appear to open up, while conceptual orientated learning (purple) can occur where the helices appear to overlap.

FIGURE 7

Like the DNA molecule, a curriculum should be able to adapt by offering a variety of possibilities.