SCIENCE

Florida

GRADE	SCORES		TOTAL SCORE
C	Content and Rigor	3/7	5/10
	Clarity and Specificity*	2/3	

REPORT CARD

Content & Rigor	**2.8**
Scientific Inquiry & Methodology	4
Physical Science	3
Physics	0
Chemistry	0
Earth & Space Science	5
Life Science	5
Clarity & Specificity*	**2.0**

Average numerical evaluations

Document(s) Reviewed

- *Next Generation Sunshine State Standards: Science*. 2008. Accessed from: http://www.floridastandards.org/Standards/FLStandardSearch.aspx

* After publication of this review, we realized that we double-faulted Florida for its failure to delineate specific standards for high school physics and chemistry (docking the state in both "content and rigor" and "clarity and specificity.") Upon further reflection, comparison of the standards against our rubric, and comparison to our review of other states' standards, we concluded that the Florida standards deserve a two out of three (rather than their initial one out of three) for clarity and specificity. This review reflects this change.

Overview

Florida's standards evoke a split personality. The document starts out well at the primary level, but in the higher grades it weakens into poor organization, ambiguous statements, and basic errors. One has the impression that the writers were pushing the limits of their scientific expertise at the higher grades. Taken as a whole, the document does not provide a solid foundation for a rigorous K-12 science curriculum.

Organization of the Standards

The Sunshine State standards for grades K-8 are divided first by grade level. They are then presented through a series of eighteen "Big Ideas" (like "changes in matter" and "earth and space in time"), which are further explained by a set of two to three descriptors each. All Big Ideas do not appear at every grade, but for those that do appear, grade-specific benchmarks are provided. Finally, a "depth of knowledge" indicator is attached to each benchmark to explain its "cognitive complexity."

The high school standards are broken down first into a series of "bodies of knowledge": life science, physical science, earth and space science, and nature of science. Within each body of knowledge is a set of "standards" (much like the Big Ideas in the K-8 standards), with benchmarks and "depth of knowledge" ratings linked to these standards.

Content and Rigor

Florida's science content presents a landscape of peaks and valleys, with uneven treatment both between and within disciplines. Life science and earth and space science are the best of the bunch, and manage to touch on most—but by no means all—of the critical content. Their presentation of the material also is fairly consistent throughout the grade levels. The same cannot be said for the other disciplines, which tend to offer more rigorous content in the K-8 years but stumble badly in high school.

Scientific Inquiry and Methodology

The nature of science is addressed competently but uninspiringly under four of the state's fifteen Big Ideas. To their credit, the writers make it clear that there is no single scientific method and that the terms used by scientists (notably, *theory*) often differ in meaning from their everyday usage.

But the benchmarks are somewhat vague and offer little guidance about how the ideas might be articulated in the classroom. For example, sixth graders are expected to "distinguish science from other activities involving thought." By eighth grade, students will "distinguish between scientific and pseudoscientific ideas [and] discuss what characterizes science and its methods," and in high school, they will examine the difference between science and "other ways of knowing." There could be something of value here in the hands of a competent teacher, but as is too often the case, discussion of demarcation (i.e., the philosophical problem of distinguishing between science and other activities) can lead to oversimplification and confusion. If this activity is to be carried out in the classroom, many teachers will need more help than the standards provide.

Physical Science/High School Physics/High School Chemistry

In many areas, the physical science standards get off on the wrong foot due to confusing or even erroneous Big Ideas. For instance, a descriptor under Big Idea 13 tells students that "it takes energy to change the motion of objects," which is not quite true. Consider a perfectly elastic collision of a Superball (or, for that matter, a gas molecule) with a wall. The ball changes direction but there is no change in energy.

Similarly, another descriptor of Big Idea 13 states that "energy change is understood in terms of forces—pushes or pulls." This statement is bound to confuse because, while there is certainly a connection between energy and force, this is not the most precise way to explain it.

Also, in fourth grade, two benchmarks that address heat flow are listed under a Big Idea that addresses waves. In fifth grade, two benchmarks that concern electric current flow are listed under that same Big Idea. Sadly, none of these is a wave phenomenon, and the standards that follow them are therefore a confused mess.

Further, students are asked to "describe heat as the energy transferred by convection, conduction, and radiation, and explain the connection of heat to change in temperature or states of matter" (high school physical science). But that doesn't define heat at all; it is no more illuminating than if one were to write "define money as the stuff transferred by sales, loans, and gifts." And the standard asking students to "relate temperature to the average molecular kinetic energy" (high school physical science) marks the sole appearance of kinetic theory—but the statement is in fact a consequence of the theory, which is never adumbrated.

Not surprisingly, there is a gratuitous reference to entropy that no one will understand and whose sole purpose is to place the readers in awe of the writers. As the reader will see in too many other state reviews, the very powerful and useful—but highly abstract—concept of entropy is often degraded to nothing more than a buzzword thrown around when those who do not understand it wish to impress the *polloi*. In this it is similar to the use of the term *quantum* by medical quacks.

The standards also suffer from internal inconsistencies. For instance, a descriptor of Big Idea 8 explains that, because the concepts of weight and mass "are complicated and potentially confusing to elementary students...the more familiar term 'weight' is recommended for use to stand for both mass and weight in grades K-5. By grades 6-8, students are expected to understand the distinction...and use [the terms] appropriately." But, in fourth grade, the state includes two standards that contradict this directive:

> **Measure and compare objects and materials based on their physical properties including: mass, shape, volume, color, hardness, texture, odor, taste, attraction to magnets. (grade 4)**
>
> **Explore the Law of Conservation of Mass by demonstrating that the mass of a whole object is always the same as the sum of the masses of its parts. (grade 4)**

To compound the confusion, the first explicit treatment of mass doesn't come until eighth grade.

Still, there are also some instances of appropriately rigorous content. In second grade we have:

> **Measure and compare the volume of liquids using containers of various shapes and sizes. (grade 2)**

This is an important point; younger children do not automatically make the abstraction that allows them to understand that the volume of a sample of liquid, for instance, is independent of the size and shape of the vessel that contains it. But Karplus showed, many years ago, that Kindergartners are ready for this concept, so perhaps it should be introduced earlier.

Finally, while sixth graders receive an estimable qualitative overview of the laws of gravitation and dynamics, this auspicious beginning is squandered in the higher grades. At the high school level, all we find is a fuzzy command to "interpret and apply Newton's three laws of motion," and then "develop logical connections through physical principles, including Kepler's and Newton's laws about the relationships and the effects of Earth, Moon, and Sun on each other." That comprises about four chapters in a typical textbook.

With no outline of a college prepatory chemistry course outside of the physical science material, the treatment of chemistry is weak throughout. Atomic models are not mentioned by name, though they are hinted at in the following high school physical science benchmark: "Explore the scientific theory of atoms (also known as atomic theory) by describing changes in the atomic model over time and why those changes were necessitated by experimental evidence." There is no mention of atomic spectra, spectroscopy, or electron transitions. Indeed, there is no mention of electrons at all prior to high school.

Chemical bonding is barely included, as a small part of the encyclopedic Standard 8B: "Atoms bond with each other to form compounds." Missing is the requirement for students to know ionic, covalent, and metallic bonding. Hydrogen bonds do appear (along with van der Waals forces), where they are explicitly distinguished from "bonding forces holding compounds together." The problem is that the standards do not clearly explain the nature of the interactions that hold atoms together in molecules and those that keep molecules themselves together—for example, the distinction between the forces at work in crystals or metals and the weaker attractions of, say, the hydrogen bonds that allow water molecules to become a liquid and a solid.

Earth and Space Science

Florida's treatment of earth and space science is fairly broad, but the coverage can be uneven and somewhat lacking in the detail necessary to insure proper depth of treatment. The early grades fare better than high school.

The topics that receive heavy emphasis are treated crisply, even elegantly. The eighth-grade astronomy standards, for example, are ambitious in introducing topics typically relegated to the high school level (when not all students take the earth and space science courses):

> **Distinguish the hierarchical relationships between planets and other astronomical bodies relative to solar system, galaxy, and universe, including distance, size, and composition. (grade 8)**

> **Create models of solar properties including: rotation, structure of the Sun, convection, sunspots, solar flares, and prominences. (grade 8)**

Other topics are glossed over or omitted entirely. The entire treatment of earthquakes and volcanoes, for example, is summed up with: "Recognize that heat flow and movement of material within Earth causes earthquakes and volcanic eruptions, and creates mountains and ocean basins" and "Explore the scientific theory of plate tectonics by describing how the movement of Earth's crustal plates causes both slow and rapid changes in Earth's surface, including volcanic eruptions, earthquakes, and mountain building" (grade 7). That's it.

Further, the treatment of plate tectonics is weak; the evidence leading to the development of this important twentieth-century theory is absent, as are the major details of the process itself.

The study of rocks begins in second grade with: "Recognize that Earth is made up of rocks. Rocks come in many sizes and shapes." But size and shape are the least useful observations that might be used to identify rocks, and certainly their least interesting properties. Fortunately, this coverage improves in later grades:

> **Identify the physical properties of common earth-forming minerals, including hardness, color, luster, cleavage, and streak color, and recognize the role of minerals in the formation of rocks. (grade 4)**

> **Identify the patterns within the rock cycle and relate them to surface events (weathering and erosion) and sub-surface events (plate tectonics and mountain building). (grade 7)**

In high school, the content offered is somewhat less helpful, providing more generalities than clear content expectations. For example, the study of stars starts out nicely in eighth grade:

> **Describe and classify specific physical properties of stars: apparent magnitude (brightness), temperature (color), size, and luminosity (absolute brightness). (grade 8)**

But the continuation of the topic in high school leaves some of the details to the reader:

> **Describe and predict how the initial mass of a star determines its evolution. (high school earth and space science)**

And the important topic of the greenhouse effect and its possible contribution to global climate change is reduced to a phrase in a standard so broad it could form the basis for an entire course:

> **Discuss the large-scale environmental impacts resulting from human activity, including waste spills, oil spills,**

runoff, greenhouse gases, ozone depletion, and surface and groundwater pollution. (high school earth and space science)

The Florida earth and space science standards aren't bad, but some extra work could make them excellent.

Life Science

The Kindergarten through eighth-grade sequence provides good coverage of basic materials in the life sciences. Evolution is treated straightforwardly and in good detail. The topic is introduced as a principle in sixth grade, though the only specifics at that level address taxonomic classification. Still, even this initial treatment constitutes a decent beginning for this grade level.

At times, the treatment of life sciences is more thorough, if a bit lopsided. For example, Big Idea 14 is called "organization and development of living organisms," but it says nothing about embryos or development. Instead, it heavily stresses physiology, including bones, ureters, and the nervous system.

Evolution, on the other hand, is very well covered. Take, for example, the following:

> **Explain how the scientific theory of evolution is supported by the fossil record, comparative anatomy, comparative embryology, biogeography, molecular biology, and observed evolutionary change. (high school life science)**
>
> **Describe the conditions required for natural selection, including: overproduction of offspring, inherited variation, and the struggle to survive, which result in differential reproductive success. (high school life science)**
>
> **Discuss mechanisms of evolutionary change other than natural selection such as genetic drift and gene flow. (high school life science)**

Even human evolution is treated—a rarity in state science standards:

> **Identify basic trends in hominid evolution from early ancestors six million years ago to modern humans, including brain size, jaw size, language, and manufacture of tools. Discuss specific fossil hominids and what they show about human evolution. (high school life science)**

Barely a handful of states tackle human evolution in their standards, bolstering the life science score of the Sunshine State's standards. Still, omissions in other key areas keep these standards from receiving top marks in this discipline.

Taken together, the bright spots are overshadowed by the numerous gaps, omissions, and errors, thus earning the Sunshine State a three out of seven for content and rigor. (See Appendix A: Methods, Criteria, and Grading Metric.)

Clarity and Specificity

The Florida standards are reasonably specific and present much clear, appropriately rigorous content. Take, for example, the following high school standard, which also exemplifies the strength of Florida's evolution coverage:

> **Describe the conditions required for natural selection, including: overproduction of offspring, inherited variation, and the struggle to survive, which result in differential reproductive success. (high school life science)**

Unfortunately, as noted at the outset, the high school standards are marred by a lack of organization, where content is often poorly sequenced and introduced out of context. This failing leads—perhaps inevitably—to detailed statements that are isolated and confused.

The standards also occasionally veer into the incomprehensible. An egregious example appears in one of the descriptors of Big Idea 2: "Scientific knowledge is based on empirical evidence, and is appropriate for understanding the natural world, but it provides only a limited understanding of the supernatural, aesthetic, or other ways of knowing, such as art, philosophy, or religion." What could this mean? Can we acquire even a limited understanding of the supernatural by means of scientific inquiry? Intelligent design, maybe?

Fortunately, these drawbacks are isolated, earning Florida an average score of two out of three for clarity and specificity. (See Appendix A: Methods, Criteria, and Grading Metric.)