SCIENCE

Arizona

GRADE	SCORES		TOTAL SCORE
D	Content and Rigor	3/7	4/10
	Clarity and Specificity	1/3	

REPORT CARD

Content & Rigor	**2.8**
Scientific Inquiry & Methodology	5
Physical Science	4
Physics	0
Chemistry	0
Earth & Space Science	5
Life Science	3
Clarity & Specificity	**1.0**

Average numerical evaluations

Overview

Arizona's science standards are generally weak on content and are plagued by disorganization and a frustrating lack of cohesion. These weaknesses undermine the ability of the material to serve as the foundation for a comprehensive K-12 science curriculum.

Organization of the Standards

Arizona's K-8 science standards are divided first into six strands: inquiry process; history and nature of science; science in personal and social perspectives; life science; physical science; and earth and space science. Each strand is then divided into a series of "concepts," and finally, grade-specific standards are provided.

The high school standards are presented similarly, except that only one set of standards is presented for all grades, 9-12. High school physics, chemistry, and biology are not covered as separate subjects.

Content and Rigor

While it is not always treated with adequate depth or rigor, much of the essential K-8 content students should learn is covered by the Arizona standards. Unfortunately, coverage of critical high school science material is spotty and unsystematic. In fact, the standards at this level read more like a general outline—or perhaps a set of scrambled chapter titles from a textbook—than a comprehensive set of standards.

Scientific Inquiry and Methodology

Arizona's standards addressing scientific inquiry and methodology are reasonably strong. Both process and history of science receive explicit mention. Attempts to set evolutionary theory into a category separate from and inferior to other scientific theories are anticipated and successfully negated by asking students to consider "how scientists continue to investigate and critically analyze aspects of [all scientific] theories" (grades 9-12).

Unfortunately, there are drawbacks, too. A few of the examples of historical figures who "have made important contributions to scientific innovations" seem relatively trivial,

Document(s) Reviewed[1]

▶ *Arizona Science Standards, Articulated by Grade Level*. March 2005. Accessed from: http://www.azed.gov/standards-practices/science-standard/

[1] Fordham's 2005 evaluation also reviewed Arizona's 2005 content-standards document. Since 2005, we have updated and improved the evaluation criteria used to judge the standards. (See Appendix A for a complete explanation of criteria used in this review.) Through this new lens, Arizona's science grade dropped from a B to a D. The complete 2005 review can be found here: http://www.edexcellence.net/publications-issues/publications/sosscience05.html.

as if favoring inclusiveness over universal significance. Take the following examples: Sally Ride (grade 1); Daniel Hale Williams, Charles Drew, and Elizabeth Blackwell (grade 2); Percy Lavon Julian (grade 5); and Walter and Luis Alvarez (grade 7). In addition, Arizona places far too much emphasis on inquiry, history and nature of science, and science in personal and social perspectives.

Physical Science/High School Physics/High School Chemistry

The physical science standards for Kindergarten through eighth grade have occasional flashes of competence, though never brilliance. The coverage of dynamics, for example, is very good.

Unfortunately, there are also many shortcomings. The "concepts" under which the standards are grouped are often poorly conceived. For example, one is called "energy and magnetism." Why would these two subjects be conjoined when work belongs with energy and electricity with magnetism?

Making matters worse, the standards grouped beneath each concept often defy explanation. For instance, a Kindergarten standard that asks students to "investigate how applied forces (push and pull) can make things move" is oddly grouped under "energy and magnetism" rather than under "motion and forces."

Adding to these organizational problems, the content of the standards is problematic. For instance, while students are introduced to forces and motion in Kindergarten, they must wait until fifth grade to finally discern the connection between the two concepts, and it isn't until eighth grade that they make a full-fledged, if likely only partially quantitative, study of Newton's laws.

Furthermore, the earliest mention of energy in the physical sciences is in sixth grade, where four standards address electrical generation, energy storage, methods of transforming energy, convection, conduction, and radiation. Up to that point, however, there has not been (and never is) a definition of energy or a discussion of the relation between work and energy, of kinetic and potential energy, or of anything other than the practical applications just noted. The only follow-up, in eighth grade, asks students to "investigate how the transfer of energy can affect the physical and chemical properties of matter." A tall order, indeed.

The chemistry standards for Kindergarten through eighth grade are equally problematic. For starters, chemistry content is again mostly relegated to fifth and eighth grades. There is woefully little background chemistry material for Kindergarten through fourth grade, and nothing in sixth and seventh grades. Indeed, the "chemical reactions" concept, which embraces all of chemistry, appears only at the high school level.

The high school standards covering both chemistry and physics are also distressingly inadequate. All of high school chemistry is covered in eleven vague sentences. And, while the standards do include a glossary that defines essential scientific terms, equilibrium—a fundamental concept of chemical reactions—is missing. In short, the content needed to inform traditional high school chemistry and physics courses is largely absent from the Arizona standards.

Earth and Space Science

The Arizona standards document addresses (or at least skims over) a great deal of earth and space content. Laudably, the concept of gas is introduced with care in second grade, both in general and in the context of the states of water. The treatment of basic astronomy is solid in fifth and seventh grades. Astronomy, however, is mostly limited to the solar system until high school. The discussion of rocks and fossils in third grade is strong, and some mention of earth structure and plate tectonics appears in seventh grade. By fleshing out the individual standards with more specific content and detail, Arizona's earth and space science standards could be excellent.

Life Science

What material is presented in Arizona's life science standards is clear and progresses adequately through the grades. Unfortunately, there are holes in the content, leaving Arizona teachers with a weak skeleton upon which to build a rigorous life science curriculum. In areas important to grasping modern biology, for example, the standards are skimpy, particularly prior to high school. For example, there is only one unit on the topic of heredity in eighth grade, which gives no indication of how the principles are to be taught:

> **Explain the basic principles of heredity using the human examples of:**
>
> - **eye color**
> - **widow's peak**
> - **blood type. (grade 8)**

This sparseness of content extends to high school, where molecular biology and genetics get little attention. Similarly, in the high school unit on evolution, there are bullet

points that include most important key words, but little development of any of the concepts.

There are a few exceptions to the rule: Ecosystems are well covered from Kindergarten through eighth grade, and the early coverage of physiology is quite robust. Beginning in second grade, we have such examples:

> **Describe the basic functions of the following systems:**
>
> - **digestive – breakdown and absorption of food, disposal of waste**
> - **respiratory – exchange of oxygen and carbon dioxide**
> - **circulatory – transportation of nutrients and oxygen. (grade 2)**

One may wonder whether the typical second grader can manage material of this sophistication, but a strong teacher could properly pitch the essential information at the appropriate level of rigor. But there is no coverage of physiology at all at the high school level, which is disappointing, given this solid introduction in the early grades.

While the Arizona standards occasionally cover key scientific topics with the appropriate level of depth and rigor, their drawbacks are significant, and the amount of content missing—particularly at the high school level—leaves the Grand Canyon State with an average score of three out of seven for content and rigor. (See Appendix A: Methods, Criteria, and Grading Metric.)

Clarity and Specificity

The Arizona standards suffer from two significant drawbacks. First, they frequently lack the specificity needed to drive rigorous curriculum development and instruction. Consider, for example, the following earth and space science standard:

> **Analyze the evidence that lithospheric plate movements occur. (grade 7)**

In this case, there are many lines of evidence. Which should the students analyze—and what should that analysis consist of?

Similarly, this life science standard describes all of biochemistry in fewer than twenty words:

> **Describe the role of organic and inorganic chemicals (e.g., carbohydrates, proteins, lipids, nucleic acids, water, ATP) important to living things. (grades 9-12)**

Sadly, these are not isolated cases.

Second, the organization and presentation of the document is a mess. With a few exceptions, notably the "diversity, adaptation, and behavior" concept, the standards consist of little more than broad lists of topics without proper sequencing or development.

Taken together, these drawbacks leave Arizona with an average score of one out of three for clarity and specificity. (See Appendix A: Methods, Criteria, and Grading Metric.)