SCIENCE

Oklahoma

GRADE	SCORES		TOTAL SCORE
F	Content and Rigor	1/7	2/10
	Clarity and Specificity	1/3	

REPORT CARD

Content & Rigor	**1.2**
Scientific Inquiry & Methodology	2
Physical Science	2
Physics	2
Chemistry	1
Earth & Space Science	0
Life Science	0
Clarity & Specificity	**0.6**

Average numerical evaluation

Overview

The Oklahoma science standards are simply not OK. Woefully little science content appears, and what is present is often flat out wrong, oddly worded, or not up to grade level. It is difficult to see how any curriculum that emerged from these standards (assuming that one could accomplish that task on such a basis) would not be fatally flawed. Oklahoma's motto is *Labor omnia vincit*—labor conquers all things—but this document would sorely test that maxim.

Organization of the Standards

Oklahoma's newly minted *Priority Academic Student Skills* (PASS) are offered for grades 1-8 and for these high school courses: Physical Science, Biology I, Chemistry, Physics, and Environmental Science. Within each grade or course, Oklahoma's learning expectations are divided into process/inquiry standards and content standards. The K-8 content standards are further subdivided into physical science, life science, and earth/space science standards. Finally, for all grades and courses, each standard is further specified by two or more learning objectives.

Content and Rigor

With rampant mistakes, critical omissions, and below-grade-level expectations, it seems that the content in the Oklahoma science standards could not have been written—or vetted—by anyone with a working knowledge of the natural world.

Scientific Inquiry and Methodology

Oklahoma presents seven process strands: observe and measure; classify; experiment and inquiry (which becomes "experimental design" in sixth grade); interpret and communicate; inquiry (which first appears in fourth grade); model; and engineering design. (The last two appear only in the high school course standards.) With some small exceptions, the inquiry standards for Kindergarten through eighth grade are presented logically, and their content and rigor progress well from grade to grade.

For example, here is how an item on measurement evolves over the grades:

> **Observe and measure objects, organisms and/or events using developmentally appropriate nonstandard units of measurement (e.g., hand, paper clip, book); and**

Document(s) Reviewed

- *Priority Academic Student Skills: Science.* March 2011. Accessed from: http://sde.state.ok.us/Curriculum/PASS/Subject/science.pdf

International System of Units (SI) (i.e., meters, centimeters, and degrees Celsius). (grade 1)

Observe and measure objects, organisms, and/or events using developmentally appropriate International System of Units (SI) (i.e., meters, centimeters, grams, and degrees Celsius). (grade 3)

Observe and measure objects, organisms, and/or events (e.g., mass, length, time, volume, temperature) using the International System of Units (SI) (i.e., grams, milligrams, meters, millimeters, centimeters, kilometers, liters, milliliters, and degrees Celsius). Measure using tools (e.g., simple microscopes or magnifier, graduated cylinders, gram spring scales, metric rulers, metric balances and Celsius thermometers). (grade 5)

Identify qualitative and/or quantitative changes given conditions (e.g., temperature, mass, volume, time, position, length) before, during, and after an event. (grades 7 and 8)

At the high school level, however, the process strands tend to be vapid. For example, the chemistry student is to:

Interpret data tables, line, bard, trend, and/or circle graphs from existing science research or student experiments.

Determine if results of chemical science investigations support or do not support hypotheses.

Evaluate experimental data to draw the most logical conclusion. (high school chemistry)

The first of these is well below high school level; all three are vague to the point of uselessness—akin to asking someone to "read a novel and determine if it's good or bad."

Moreover, the process standards overwhelm the content standards. For example, as noted below, process standards take up four of the five-and-a-half pages devoted to high school physics.

In addition, among the seven process strands is one entitled "inquiry" that appears merely to restate skills and outcomes presented in the four strands that precede it. It would be better to eliminate this redundancy.

Finally, there is no mention of the historical or social aspects of science.

Physical Science

The physical science standards are rife with errors. For example, fourth graders are told that "electricity is the flow of electrical power or charge," which is simply wrong.

Adding confusion to the standard, fourth graders have not been expected to learn the term "charge."

Also in fourth grade, students are told that "increasing the temperature of any substance requires the addition of heat energy." Again, this is wrong; it can also be done by adding work.

And Oklahoma's Hispanic students will have a chuckle when they are introduced, in eighth grade, to El Ninõ and La Ninã. Perhaps only in Oklahoma can the tilde move so far to the right!

Other standards are vague or confusing. Take, for example, the following:

Heat results when substances burn, when certain kinds of materials rub against each other, and when electricity flows through wires. (grade 4)

What kinds of materials, exactly?

Similarly, students are told that "sound is a form of energy caused by waves of vibrations that spread from its source" (grade 4). What is meant by "waves of vibrations" is unclear.

In sixth grade, the distinction between kinetic and potential energy is introduced gratuitously and without context.

Chemical changes are introduced in eighth grade, following an introductory statement that has to do only with physical changes. But the introduction is a mere passing mention, in which the only new material is a mention of mass conservation in chemical reactions. Also in eighth grade is a brief section on motion and forces, in which the only new material is a mention that motion can be represented graphically. This is followed by a cryptic introduction of the law of inertia.

High School Physics

As mentioned above, vague process standards occupy four of the meager five-and-a-half pages devoted to high school physics (e.g., "interpret a model which explains a given set of observations"). And, while there are no errors, per se, the content presented is useless for any practical purposes. One standard covers force, including dynamics, gravitation, and electromagnetism. A second, without ever defining work or energy, covers energy conservation and, by implication, the second law of thermodynamics. The third standard attempts to define heat and covers all of waves, with a mention of machines and a definition of power tacked on. There is nothing about any other major areas of physics (e.g., modern physics).

High School Chemistry

The entirety of Oklahoma's high school chemistry standards amounts to a handful of inadequate generalities, half-thoughts, and errors, displayed on about a page and a half of text. Take, for example, the very first standard:

> **All matter is made from atoms. Its structure is made up of repeating patterns and has characteristic properties. The student will engage in investigations that integrate the process standards and lead to the *discovery of the following objectives*. (emphasis added) (high school chemistry)**

Of course, not all matter is made of repeating patterns, as evidenced by the existence of amorphous solids, liquids, and gases.

Furthermore, among the objectives students are meant to "discover" is the following:

> **Atoms are composed of subatomic particles (e.g., protons, neutrons, electrons, quarks). (high school chemistry)**

How, exactly, are students expected to discover subatomic particles? What's more, this is the first introduction that they've had to these subatomic particles. Surely protons, neutrons, and electrons should have been introduced in earlier grades.

Unfortunately, such problems are the rule, rather than the exception.

Finally, given the brevity of the standards, much important content is omitted, including: atomic models, spectra, electron transitions, metallic and hydrogen bonding, Lewis dot structures, molecular shapes and polarities, acids/bases, redox reactions, equilibrium, and carbon chemistry. The periodic law is nicely written, but there is no mention of the periodic table.

Earth and Space Science

Coverage of important earth and space science content is extremely thin. Astronomy, for example, is missing entirely. The word "star" never appears, nor do any cosmological topics. The standards include no description of the internal layering of Earth, though the word "crust" shows up a couple of times. The key topic of plate tectonics gets no more than a passing mention. And other topics are reduced to parenthetical lists, which are often incongruously different from or even irrelevant to the main statement. Take, for example, the following:

> **The processes of erosion, weathering, and sedimentation affect Earth materials (e.g., earthquakes, floods, landslides, volcanic eruptions). (grade 4)**
>
> **The solid crust of the earth consists of separate plates that move very slowly pressing against one another in some places and pulling apart in other places (i.e., volcanoes, earthquakes, mountain creation). (grade 7)**

None of these topics—erosion, weathering, sedimentation, earthquakes, floods, landslides, or volcanic eruptions—is developed in the standards, though students are expected to "engage in investigations that integrate the process standards and lead to the discovery of" some or all of them.

There is no high school earth and space science material, but only standards for a course in environmental science. The earth science content in that section is limited to the following:

> **Standard 1: The Physical Earth system – The Physical Earth system is determined by dynamic and static processes revealed through investigations of the geosphere, atmosphere, and hydrosphere. These interrelated processes are large-scale and long-term characteristics of the Earth that require knowledge of energy and matter. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:**
>
> **1. Composition and structure of the Earth is affected by an interaction of processes and events.**
>
> - **a. Geologic processes affect the Earth over time (e.g., plate tectonics, erosion).**
> - **b. Atmospheric processes affect the Earth over time (e.g., changes in daily weather conditions, convection/conduction/radiation, greenhouse effect, climate trends).**
> - **c. Hydrologic processes affect the Earth over time (e.g., water cycle, ocean currents, ground water transport).**
> - **d. Earth's current structure has been influenced by both sporadic and gradual events.**
>
> **2. Natural systems require a certain amount of energy input to maintain their organization (i.e., Laws of Thermodynamics). (high school environmental science)**

This omits or glosses over enormous swaths of important high school earth and space science content.

The environmental science standards do devote some attention to weather:

> **Weather exhibits daily and seasonal patterns (i.e., air temperature, basic cloud types – cumulus, cirrus, stratus, and nimbus, wind direction, wind speed, humidity, precipitation).**
>
> > **a. Weather measurement tools include thermometer, barometer, anemometer, and rain gauge. (grade 5)**

Unfortunately, while the barometer is mentioned in this passage, air pressure is not. Indeed, the word "pressure" does not occur before high school, and when it does appear at the high school level, it is not in this context.

Life Science

If other content areas stumble, life science falls flat. A significant amount of content is excluded. A student could graduate from high school in Oklahoma without knowing how lungs work or the basics of photosynthesis, for example. And there is no mention of physiology whatsoever.

Making matters worse, the content that is provided is often slipshod and inadequately covered. Genes, for example, are mentioned in passing just twice:

> **Characteristics of an organism result from inheritance and from interactions with the environment (e.g., genes, chromosomes, DNA, inherited traits, cell division). (grade 7)**
>
> **A sorting and recombination of genes during sexual reproduction results in a great variety of possible gene combinations from the offspring of any two parents (i.e., Punnett squares and pedigrees). (high school biology)**

And students must wait until high school to learn that:

> **In multicellular organisms, cells have levels of organization (i.e., cells, tissues, organs, organ systems, organs). (high school biology)**

The treatment of evolution—the central principle of life science—is essentially absent. Biological evolution is reduced to "diversity of species"; the term "natural selection" appears once in the standards (in high school biology), while the term "evolution" cannot be found at all. The closest Oklahoma comes to teaching evolution is this fourth-grade standard, which appears in earth science, not life science:

> **Fossils provide evidence about the plants and animals that lived long ago. (grade 4)**

Given the severe limitations noted above, Oklahoma can earn no higher than a paltry one out of seven for content and rigor. (See Appendix A: Methods, Criteria, and Grading Metric.)

Clarity and Specificity

Oklahoma's standards move at a painfully slow pace—repeating much content and often only changing a word or two as the standards progress from grade to grade.

Few standards are appropriately specific. What does it mean for fourth graders to "evaluate the design of a scientific investigation," or for sixth graders to "ask questions that can be answered through scientific investigation"?

And those standards that do attempt specificity often inject error. In high school chemistry, for example, the standards too often confuse more than they clarify. One standard uses the expression "molar weight proportions" without requiring students to know the mole concept. And the term "molar weight" is inaccurate; what was intended is either the microscopic term molecular weight—a term now supplanted by the more precise "molecular mass"—or perhaps the macroscopic term "molar mass." As noted above, there is no possibility of specificity in the extremely brief content standards for high school subjects.

Perhaps as a lagniappe, the overview of the Oklahoma standards presents the reader with a small (yet ignorant) Latin lesson:

> **Use of term i.e. means "in exactness"; use of the term e.g. means "example given."**

This would perhaps not be worth mentioning, were it not for the misuse of the abbreviations in the main text. As the following passage quoted in the earth and space science section above states: "Natural systems require a certain amount of energy input to maintain their organization (i.e., Laws of Thermodynamics)" (high school environmental science).

Given the almost complete uselessness of the Sooner State science standards, Oklahoma barely manages an average score of one out of three for clarity and specificity. (See Appendix A: Methods, Criteria, and Grading Metric.)