SCIENCE

Hawaii

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

REPORT CARD

Content & Rigor	**3.3**
Scientific Inquiry & Methodology	2
Physical Science	5
Physics	2
Chemistry	5
Earth & Space Science	2
Life Science	4
Clarity & Specificity	**1.3**

Average numerical evaluations

Overview

The Hawaii science standards are a case study in half-loaves and inconsistencies. At times the K-8 standards are reasonably rigorous and thorough. But the high school material in the Aloha State is woefully inadequate, including only rare islands of content floating in a sea of omission, confusion, and plain inaccuracy.

Organization of the Standards

Hawaii's science standards are presented in an online database that lists all standards by grade or course. For grades K-8, content and performance standards are divided into three strands: the scientific process; life and environmental science; and physical, earth, and space sciences. Each strand is then divided into two or three sub-strands (called standards) and finally into grade-specific benchmarks. In addition, for each benchmark the state provides a sample performance assessment and rubric that explain what student achievement would look like at each of four proficiency levels (advanced, proficient, partially proficient, and novice).

High school standards are similarly structured, but each high school course lists its own unique strands, in addition to course-specific benchmarks and performance assessments. Hawaii offers standards across eleven courses, including: physical science, biological science, earth space science, physics, chemistry, environmental science, marine science, plants and animals in Hawaii, human physiology, zoology, and botany.

In addition, Hawaii provides a *Curriculum Framework*, which offers additional information about how teachers might organize curriculum, assessment, and instruction.

Content and Rigor

The Hawaii science standards start out with clear, rigorous, and grade-appropriate statements; glaring content gaps and omissions become increasingly evident as the grade levels progress. The inadequacy of the writers' knowledge is distressingly evident in high school, when scientific content across nearly all disciplines is rife with misconceptions and errors. For physics in particular, the ignorance on display is shameful. Other disciplines, regrettably, fare little better.

Document(s) Reviewed

- *Hawaii Content and Performance Standards for Science*. 2007. Accessed from: http://standardstoolkit.k12.hi.us/index.html
- *Hawaii Curriculum Framework for Science*. 2008. Accessed from: http://165.248.30.40/hcpsv3/files/sc_122208_librarydocs_242.pdf

Scientific Inquiry and Methodology

The scientific inquiry and methodology standards are explained through two sub-strands of the scientific process strand: scientific investigation and nature of science. The latter is curiously defined as "understanding that science, technology, and society are interrelated." But the interpretation of this platitude is almost singularly concerned with a utilitarian view of techno-science with no mention of the historical development of science.

The benchmarks themselves are also problematic for two reasons. First, many are so brief that they fail to delineate the content that students must learn. For instance, second-grade students are asked to "develop predictions based on observations," and the standards indicate that this will be achieved by having the students make "predictions based on observations." Neither outlines what, precisely, students should know and be able to do, and the clarification unhelpfully conflates the goal with the method.

Second, there is little progression of content or rigor from grade to grade. For instance, in sixth grade, the state expects students to formulate a testable hypothesis and to "collect, display and analyze data." Then in seventh grade, students are asked to "design and safely conduct a scientific investigation to answer a question or test a hypothesis." Unfortunately, the seventh-grade benchmark does little more than combine the two sixth-grade benchmarks.

Physical Science

The physical science content is generally strong in the early grades. First graders are, for instance, expected to identify solids, liquids, and (perhaps ambitiously at this level) gases. At the same level, force and motion are appropriately introduced with the following expectation:

> **Describe how the motion of an object can be changed by force (push or pull).**
>
> - **The student: Explains the motion (change in speed and/or direction) of an object when he or she pushes or pulls that object. (grade 1)**

In third grade, students are asked to "define energy and explain that the sun produces energy in the form of light and heat." This is a good beginning, though (as is all too common) no definition of energy is either provided or suggested.

By sixth grade, however, the standards fail to include the requisite content that students would need to learn in order to accomplish the objectives listed. For instance, students are asked to describe "a variety of energy transformations (e.g., heat energy into mechanical energy; chemical energy into light energy; electrical energy into magnetic energy)." Unfortunately, the transformation of heat energy into mechanical energy involves heat engines, which require more detail than is given here. In addition, the last of the examples provided for this module is problematic; the writers likely didn't understand that the energy in the magnetic field around a current-carrying wire is not somehow converted from the energy required to keep the current flowing in the wire.

By high school, the content gaps become even greater. Take, for instance, the following:

> **Describe different examples of the concept of entropy.**
>
> - **The student: Describes different examples of the flow of energy coming from an energy source, demonstrating that while the total energy of the universe remains constant, matter tends to become steadily less ordered as various energy transfers occur. (high school physical science)**

Anyone who attempts to introduce the concept of entropy out of the blue, with no prior discussion of the laws of thermodynamics, succeeds only in demonstrating that he or she has no idea what entropy means.

Finally, the scope and sequence of material is often illogical. For instance, in the high school physical science course, students are asked to "describe the factors that affect the rate of chemical reactions." Unfortunately, there has been no prior discussion of what a chemical reaction is, or any examples of reactions. Illogically, that essential prerequisite content comes later. In this same course, the discussion of vectors, which is essential to the development of kinematics, is presented after Newton's laws, which have to do with dynamics. Fixing this glitch wouldn't be difficult, merely involving a swap in order, but the muddle speaks to the general lack of thought that went into creating this material.

High School Physics

The discussion of energy in the high school physics standards is fraught with problems. The treatment of the work-energy theorem (where, in fact, no mention of work occurs) and the items concerning energy are chaotic nonsense. At one point the student is expected to analyze an *inelastic* (i.e., non-energy-conserving) collision using energy conservation. Prior to the discussion of energy, however, there is no discussion of kinematics and dynamics (the logical first steps in any physics course) so that the abrupt presentation of kinetic energy as $\frac{1}{2} mv^2$ makes no sense at all.

High School Chemistry

Unlike physics, the high school chemistry standards are generally clear, thorough, and appropriately rigorous. They include such sophisticated tasks as balancing redox equations and calculating pH from the H^+ concentration. Unfortunately, some essential content is also missing, such as the Bohr and wave-mechanical models of the atom. Other concepts are introduced, but are not sufficiently defined or explained. Take, for example, this standard:

> **Apply gas laws to relationships between pressure, volume, and temperature of any amount of an ideal gas or any mixture of ideal gases using $PV = nRT$. (high school chemistry)**

Here, the ideal gas law is introduced concisely as an equation, but the standards never explicitly define the terms. In fact, while the quantities p, V, and T are implicitly defined, n (the number of moles), R (the universal gas constant), and the ideal gas itself are not.

Earth and Space Science

Hawaii's earth and space science content is particularly thin and underdeveloped, with but a few brighter spots here and there, including the standard asking students to describe "that the universe consists of billions of galaxies which are classified by shape and contain most of the visible mass of the universe" (grade 8). Likewise, high school students are asked to explain "how scientists use rock sequences, fossils, and radioactive dating to estimate the age of fossils and the age of Earth itself"—a solid request, albeit not perfectly worded (scientists use rock sequences to estimate the age of fossils as part of building a coherent story of the age of some rocks).

The Hawaii science standards make little use of the unique and interesting natural history of the islands themselves. The terms shield, basalt, and crater do not show up on a string search. The term magma comes up once in an eighth-grade standard asking students to "[describe] continental drift and how the Earth's crust is divided into plates that move on convection currents of magma in the mantle." But even this is incorrect, since the mantle is mostly solid rather than liquid magma. There are only two mentions of tsunamis. The first appears in a discussion of the effects of movements of crustal plates, and requires eighth-grade students to "[explain] the effects produced at each boundary (e.g., mountain building, earthquakes, tsunami), and the impact on society (e.g., natural disaster safety, building requirements)." (See the life science section of this state profile for the other occurrence of the word tsunami.) Though Hawaii is not at a plate boundary, it has a serious history of tsunami events; students should be asked to understand them.

The high school earth space science course presents an odd view of scientific theory and the current explanation for the origin of the universe. Say the standards: "Compare different theories concerning the formation of the universe," further explained in the sample performance assessment as: "The student: Compares the Big Bang Theory to another theory of the origin of the universe (includes supporting evidence for both theories and evidence that refutes the theories) and recommends which theory is more plausible." What other theory is to be considered? Religion or mythology aside, there are no other scientific theories for the origin of the universe that have not been abandoned because they do not account for observations. But this is the case for lots of abandoned theories (e.g., the caloric theory of heat or the phlogiston theory of chemical reactions); why choose cosmology for this exercise?

Life Science

Given the pedagogical opportunities presented by Hawaii's history of unique ecosystems largely overwhelmed by invasive species, the middling treatment of life science represents a missed opportunity. In the early grades, the content is thin and averse to specifics. In seventh grade, the notion of genes residing on chromosomes—and being responsible for heritable traits—appears, but there's nothing about what genes are and how they work. Fossils are also introduced in seventh grade as "providing evidence that life and environmental conditions have changed over time" but the standards say nothing about natural selection or common ancestry until high school.

There are misconceptions and howlers: Students, for example, are asked to explain "how organisms respond (e.g., some organisms adapt, some move out, others die) to changes in the physical environment, such as tsunamis and hurricanes" (grade 8). It's a little difficult to imagine organisms adapting quickly enough, or moving out quickly enough, to respond to a tsunami or a hurricane.

And there are errors, too: Sickle-cell and cystic fibrosis are cited as examples of chromosomal mutations, but in fact they are single-gene mutations.

With too many gaps and startling unevenness, Hawaii receives an average score of three out of seven for content and rigor. (See Appendix A: Methods, Criteria, and Grading Metric.)

Clarity and Specificity

Getting from one end of the Hawaii standards to the other feels like a fruitless journey. There is some mention of important technical and scientific terms, but just as much unspecific muddle. The clarity of the material is eroded by poor grade-by-grade development and weak presentation of the sciences as logical, structured bodies of knowledge. Typos and sloppy writing abound, which further obscure the intended meaning of the standards in many places. The treatment of dynamics commits far too many of these sins, with content that is disorganized and out of sequence.

The state also provides a rubric meant to add clarity by defining student mastery of each standard at four levels of proficiency. Unfortunately, this rubric too often confuses rather than clarifies. Students in high school chemistry, for example, are asked to "calculate the number of moles needed to produce a given gas, volume, mass, and/or number of moles of a product given a chemical equation." What this means is impossible to discern.

Sadly, the rubric adds little value, differentiating between achievement levels only by saying that advanced students do so with "correct computations," proficient students with increasing errors, and novice students with "serious errors in computation." In no way does this help clarify what is expected of students or how content could be scaffolded across proficiency levels.

Taken together, these drawbacks earn the Hawaii standards an average score of one out of three for clarity and specificity. (See Appendix A: Methods, Criteria, and Grading Metric.)