



SCIENCE

Maine

GRADE SCORES TOTAL SCORE

D

Content and Rigor 3/7
Clarity and Specificity 1/3

4/10

REPORT CARD

Content & Rigor 2.5

Scientific Inquiry & Methodology	5
Physical Science	3
Physics	0
Chemistry	0
Earth & Space Science	3
Life Science	4

Clarity & Specificity 1.0

Average numerical evaluations

Overview

Maine’s science and technology standards, and their performance indicators, are admirably concise—even terse. Unfortunately, the documentation shows how succinctness can easily devolve into shallowness. After reading these standards, it’s virtually impossible to discern what critical scientific content Maine students must learn before they graduate.

Organization of the Standards

Maine’s science standards are first divided into five “standards” (commonly thought of as strands): unifying themes, the skills and traits of scientific inquiry and technological design, the scientific and technological enterprise, the physical setting, and the living environment. Each strand is then broken down into a series of sub-strands, for which the state provides performance indicators (or standards) for four grade bands: preK-2, 3-5, 6-8, and 9-Diploma.

In addition, Maine supplies “descriptors” meant to clarify the content that students should master to demonstrate proficiency on each indicator. For example, an indicator for grades 3-5 asks students to “explain interactions between parts that make up whole man-made and natural things.” The two attached descriptors direct students to:

Give examples that show how individual parts of organisms, ecosystems, or man-made structures can influence one another.

Explain ways that things including organisms, ecosystems, or man-made structures may not work as well (or at all) if a part is missing, broken, worn out, mismatched, or misconnected. (grades 3-5)

No course-specific expectations are presented for high school biology, physics, or chemistry.

Content and Rigor

Maine’s motto is “I Lead,” but apparently not by example. These standards simply do not provide enough instances of concrete content upon which to base a curriculum. Great swaths are missing, including basically all of physics and chemistry. What does appear, however, tends to be adequately rigorous, grade-appropriate, and well

Document(s) Reviewed

► *Maine Learning Results: Parameters for Essential Instruction*. 2007. Accessed from: <http://www.maine.gov/education/lres/scitech/natlstandards.html>

stated—which only serves to highlight the many voids in the standards.

Scientific Inquiry and Methodology

Nearly two-thirds of the Maine standards are devoted to the process of science in its broadest sense—only about 40 percent of the material deals with traditional content. Not only does this inappropriately prioritize science *process* over content, but the process standards themselves are often inadequate. For instance, students in middle school are expected to “use mathematics to gather, organize, and present data” (grades 6-8) while in later grades they “use statistics to summarize, describe, analyze, and interpret results” (grades 9-Diploma). How these goals differ, or how the rigor is meant to increase through the grades, is impossible to know.

In middle school, students are expected to “communicate, critique, and analyze their own scientific work and the work of other students” (grades 6-8) but not to defend their ideas from such critiques. (A goal for ninth grade and beyond is to “describe how scientists defend their evidence and explanations using logical arguments and verifiable results.”) Surely, if students are expected to critique the claims of others, they must be able to defend their own!

The section on “history and nature of science” contains a few statements that give reason for pause and asks students to wade into the murky depths of the problem of demarcation between science and pseudoscience. This is a subject in itself, and it requires more background than these standards present or than schoolchildren can reasonably be expected to possess.

Physical Science/High School Physics/High School Chemistry

While these standards are not significantly marred by errors or confusions, that is largely because there is very little *content* in them. For example, in the grade band covering third through fifth grades, students are asked to “illustrate how many different substances can be made from a small number of basic ingredients.” What content is meant to be learned is a mystery.

There are a few flashes of competence. Take, for example, the following standards:

Use examples of energy transformations from one form to another to explain that energy cannot be created or destroyed. (grades 6-8)

Explain the relationship between kinetic and potential energy and apply the knowledge to solve problems. (grades 9-Diploma)

Unfortunately, these are the exception rather than the rule and, as a result, far too much content is glossed over or omitted entirely.

Earth and Space Science

As noted above, the earth and space sciences are lumped together with the physical sciences and, accordingly, this important content domain gets short shrift. For example, a characteristically poor standard requires students to “describe and analyze the effects of biological and geophysical influences on the origin and changing nature of Earth Systems” (grades 9-Diploma). Again, exactly what is expected of the student?

Contrasting with this overwhelming generality are some cogent, specific entries that detail important content students should learn. Take, for example, the following:

Explain how the tilt of Earth’s rotational axis relative to the plane of its yearly orbit around the sun affects the day length and sunlight intensity to cause seasons. (grades 6-8)

Or:

Describe Earth’s internal energy sources and their role in plate tectonics. (grades 9-Diploma)

But there is not enough of such specific material to overcome the vague generalities of the whole.

Life Science

Maine’s standards make a laudable early effort to include evolution. The concept of biological adaptation appears in third and fourth grades. Fossils are studied in fifth through eighth grades, and evolutionary biology appears in high school. But simplification and compression result in language that is potentially misleading or simply incomprehensible.

The same unfortunate constriction mars the “living environment” strand. The coverage is either too generalized or so compressed as to imply what is not necessarily true. For example, in high school students are asked to “describe the interactions that lead to cell growth and division (mitosis) and allow new cells to carry the same information as the original cell (meiosis)” (grades 9-Diploma). But it is not necessarily the case that in meiosis all new cells “carry the same information as the original cell.” Indeed, the reverse can be true, with important consequences.

With so many instances of such frustrations, and given the absence of any treatment of high school chemistry or physics, Maine's mean content score is a disappointing three out of seven for content and rigor. (See Appendix A: Methods, Criteria, and Grading Metric.)

In these instances, the close shave is as bad as a deep cut. The average score for clarity and specificity, a one out of three, reflects this disconnect. (See Appendix A: Methods, Criteria, and Grading Metric.)

Clarity and Specificity

The Maine standards lack both clarity and specificity. For starters, what little content exists in them is buried beneath a tangled and confusing web of strands and sub-strands, where important content from different areas of science—life science, earth and space science, physical science, and so on—are mingled, making it difficult for teachers to extract the guidance they need to provide rigorous, content-driven instruction.

Worse, this confusing presentation is grounded on the faulty premise that organizing standards by *theme*, rather than by content, will better “provide teachers and students with a scaffold on which to organize the details of the standards.” Of course, it's difficult to equate *theme* with *knowledge*, except in some loose way. And alluding to genuine knowledge vaguely or sketchily under some theme does not serve as a standard for teaching or learning.

Equally frustrating are the places where the standards are written so ambiguously that they provide virtually no indication of what, precisely, students should know and be able to do. In the physical science material, for example, the “matter and energy” section asks students to:

Describe how the number and arrangement of atoms in a molecule determines a molecule's properties, including the types of bonds it makes with other molecules and its mass, and apply this to predictions about chemical reactions. (grades 9-Diploma)

It would not be easy to come up with a more succinct summary of the purposes and content of all of modern chemistry. But what is the student really supposed to know? What about chemical bonds? And, in fact, which properties of a molecule are *not* germane to its actual or potential involvement in chemical reactions?

On another page comes this remarkable compression: “Describe the relationship between electric and magnetic fields and forces, and give examples of how this relationship is used in modern technologies” (grades 9-Diploma). Even without the obligatory nod to technology, a minimally cogent response would require a brilliant student to write a long and erudite essay *or* present a lengthy seminar.