SCIENCE

South Dakota

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

REPORT CARD

Content & Rigor	**1.3**
Scientific Inquiry & Methodology	2
Physical Science	2
Physics	0
Chemistry	0
Earth & Space Science	2
Life Science	2
Clarity & Specificity	**1.0**

Average numerical evaluations

Overview

South Dakota's extensive publication has plenty of words, but remarkably little scientific content. By no stretch of the imagination can it lead to a thorough and effective curriculum.

Organization of the Standards

The South Dakota standards are divided first into five strands: life science; earth and space science; physical science; nature of science; and science, technology, environment, and society. Each strand is then broken into "indicators," or sub-strands. Finally, grade-specific standards are provided for all grades, K-8. The high school standards are organized similarly, except that a single set of standards is provided for grades 9-12.

In addition, the state links each standard to a Bloom's Taxonomy level (comprehension, application, or analysis), a list of examples and supporting skills for the standard, and a series of performance descriptors that explain what student mastery should look like at advanced, proficient, and basic levels.

Content and Rigor

So much critical content is missing in every discipline that the gaps outnumber the useful material. And the latter, limited as it is, is marred by rampant error.

Scientific Inquiry and Methodology

The South Dakota standards begin by stating that science "is a process, not a recipe" and "is participatory, not passive knowledge acquisition." Perhaps so, but these bold claims are neutralized by the substance of the process standards presented. The "nature of science" standards offer precisely what has been rejected—a recipe consisting of bulleted lists of supporting skills. Teachers are urged to stay current with advances in science, as knowledge is "constantly changing and emerging." While it's certainly true that science teachers ought to pay attention to developments in the field, they should spend as much time, or more, learning about the history of science. Only by doing so will they be able to put into appropriate context any new discoveries.

Document(s) Reviewed[1]

- *South Dakota Content Standards: Science*. 2005. Accessed from: http://doe.sd.gov/ContentStandards/index.asp

[1] Fordham's 2005 evaluation also reviewed South Dakota'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, South Dakota's science grade dropped from a D to an F. The complete 2005 review can be found here: http://www.edexcellence.net/publications-issues/publications/sosscience05.html.

While they do mention the history of science, the standards here are confused and unclear. Second graders are expected to "explore scientific contributions made by people" (as opposed, perhaps, to those made by machines?). The state then gives four examples: Benjamin Franklin, Thomas Edison, George Washington Carver, and the Wright brothers. Of course, while Franklin was a scientist (among many other things), Edison was primarily an inventor, Carver a chemical and agricultural engineer, and the Wrights engineers and inventors. This selection suggests a degree of confusion between science and technology that ought not to be conveyed to students, who need to understand the real connections between them and the lives and work of actual scientists.

Another standard asks fourth graders to "identify people who have revolutionized scientific thinking." Yet here, too, the examples of Morse and Edison speak more to patriotism than to actual scientific revolution. Surely, even ten-year-olds can be introduced to Copernicus, Newton, Darwin, or Pasteur (to name but four obvious examples).

This inattention to singling out important contributors to science is further exemplified in eighth grade. Here students are given the laudable goal of evaluating "important contributions to the advancement of science from people of differing cultures, genders, and ethnicity," a goal not forwarded by the inclusion of Neil Tice [*sic*] for astronomy. We suspect that Neil deGrasse Tyson would be disappointed. What the writers do not seem to know is that Tyson, though he is both a superb popularizer of science—astronomy in particular—and also African American, is not one of those whose contributions to the advancement of astronomy put him into the category of great astronomers. Why not choose Benjamin Banneker, whose almanacs were of utmost importance to both the astronomers and navigators of his time, or high-energy solar astronomer Arthur Walker II? And there are plenty of first-rate women astronomers, including Caroline Herschel, Annie Jump Cannon, Henrietta Leavitt, Jocelyn Bell, Margaret Burbidge, Carolyn Porco, and Angela Olinto.

Physical Science/High School Physics/High School Chemistry

South Dakota's Kindergarten through eighth grade physical science standards touch on most necessary content. But there are problems with just about every entry. For example, molecules first appear in fifth grade, but atoms don't show up until sixth grade. Displacement, a concept fundamental to kinematics, is never mentioned; velocity is found only in the high school standards and in the glossary.

As is the case throughout the South Dakota standards, the physical science materials for Kindergarten through eighth grade are awash in pedagogical jargon. Here is a typical example from fifth grade:

> **5.P.2.1** Students are able to **identify** forces in specific situations that require objects to interact, change directions, or stop.
>
> **Webb Level:** 1
>
> **Bloom:** Knowledge
>
> **Verbs Defined:** Identify – to select from given information
>
> **Key Terms Defined:** Forces in specific situations – a push or pull caused by gravitational forces
>
> **Teacher Speak:** Students are able to identify (to select from given information) forces in specific situations (a push or pull caused by gravitational forces) that require objects to interact, change directions, or stop.
>
> **Student Speak:** I can select from given information (identify) a push or pull caused by gravitational forces (forces in specific situations) that require objects to interact, change directions, or stop. (grade 5)

It is possible (though tedious) to extract a bit of science out of this, but that bit is not much to challenge the intellect of a fifth grader.

The high school standards include a general physical science section that seems to include basic concepts of both chemistry and physics and that is appropriate to a ninth-grade physical science course. A separate "advanced" section includes standards for both chemistry and physics that seem intended for the traditional college-prep chemistry and physics courses. Unfortunately, the presentation within these sections is a mess. The few standards that address physics are often riddled with errors, such as:

> Explain methods of transferring charge.
>
> Examples: induction, conduction, friction, electron guns (grades 9-12)

Neither electrostatic nor electromagnetic induction transfers any charge at all. Sadly, such examples the norm, rather than the exception, and the treatment of other branches of physics is either inadequate (e.g., waves and optics) or absent (e.g., thermodynamics).

Chemistry, too, is very thin. Anything approaching a high school chemistry course is contained in the "advanced high school physical science standards." Even at the advanced level, here is the only coverage of stoichiometry:

Students are able to perform stoichiometric calculations.

- **Convert between moles, mass, particles, volume.**
- **Calculate empirical and molecular formulas from mass percents.**
- **Determine limiting and excess reactants and percent yield in chemical reactions. (grades 9-12)**

The other four indicators that comprise high school chemistry go no deeper.

Earth and Space Science

Earth and space science does not present a more attractive face. The few content statements are usually vague, leading in most cases to no obvious content direction but sometimes veering off into too many. Missing are such key topics as the history of the universe or the solar system, stellar evolution, absolute and relative dating techniques, plate tectonics (though there is brief treatment of some of its consequences), volcanism, and any detail about the processes underlying climate and weather.

Life Science

Life science fares somewhat better, although it tends to get thinner with each advancing grade level. Aside from a mention of fossils in third grade, here is all the standards have to say about evolution:

Students are able to describe how genetic recombination, mutations, and natural selection lead to adaptations, evolution, extinction, or the emergence of new species.

Examples: behavioral adaptations, environmental pressures, allele variations, bio-diversity

- **Use comparative anatomy to support evolutionary relationships. (grades 9-12)**

In addition, the high school standards haphazardly mention, though never expand upon, some critical content at the advanced level. But it is hard to see how these concentrated statements could be used to inform an actual high school biology course. Take, for example, the following:

High school students performing at the advanced level:

- **Explain the steps of photophosphorylation and the Calvin cycle;**
- **Analyze chemical reaction and chemical processes involved in the Calvin cycle and Krebs cycle;**
- **Predict the function of a given structure;**
- **Predict the outcome of changes in the cell cycle;**
- **Explain how protein production is regulated;**
- **Predict how homeostasis is maintained within living systems;**
- **Predict how traits are transmitted from parents to offspring;**
- **Construct an original dichotomous key. (grades 9-12)**

What connection might there be between, say, a dichotomous key and the Calvin cycle, or between the regulation of protein production and the transmission of traits? The writers seem to have taken an index from a biology textbook, cut the individual entries apart, shuffled them, and laid them out in random order.

Taken together, these drawbacks earn South Dakota a disappointing average score of one out of seven for content and rigor. (See Appendix A: Methods, Criteria, and Grading Metric.)

Clarity and Specificity

The South Dakota standards take 200 pages to say virtually nothing of substance. Standards are overly broad and vague, and the supplementary material that is meant to clarify expectations rarely adds value. For example, vocabulary words and important terms are offered, but the definitions and explanations, particularly in earth and space science, are vague, incorrect, or confusing.

In addition, the performance descriptors, which ought to show how student understanding deepens from the basic to the advanced levels, are confusing. Normally, of course, students at each level can do everything at the level immediately preceding it, and they are working toward mastery of the knowledge and skills at the level that follows. But the descriptors offered in these standards seem barely correlated. For instance, in first grade the proficient student can "compare objects in terms of heavier or lighter," but no corresponding descriptor exists at the advanced level. In second grade, the advanced student can "predict the casting of shadows," "describe interactions of magnetic poles," and "describe ways heat can be produced," but nothing like these skills is to be found for either the proficient or the basic level. What is supposed to be going on as the student progresses from one level of proficiency to the next? It is impossible to tell.

Sadly, these examples are the norm, thus earning South Dakota an average score of one out of three for clarity and specificity. (See Appendix A: Methods, Criteria, and Grading Metric.)