SCIENCE

North Carolina

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

REPORT CARD

Content & Rigor	**2.7**
Scientific Inquiry & Methodology	0
Physical Science	4
Physics	2
Chemistry	4
Earth & Space Science	2
Life Science	4
Clarity & Specificity	**1.4**

Average numerical evaluations

Overview

Despite promise in some areas, the North Carolina science standards cannot overcome several serious flaws. Chief among them is a general lack of detail that compromises the standards' utility as an educational framework. Even when specific content is present, it often is poorly developed, confusing, or misleading. The authors of the standards appear to have disregarded North Carolina's state motto of "esse quam videri"—"to be, rather than to seem"—when writing the material.

Organization of the Standards

North Carolina's science standards are presented through a series of documents, one for each grade, K-8, and for individual high school courses in physical science, biology, chemistry, physics, and earth/environmental. The state also presents a series of Advanced Placement course documents. Within each document, standards are presented first by strand. They are then broken down by "competency goal" and finally by "clarifying objectives." A "science as inquiry" section frames standards at each grade and discipline.

Content and Rigor

The North Carolina standards are crippled by their overemphasis on generality at the expense of concrete examples. And with so few details, the occasional gross errors and confusing statements stand out all the more starkly. The material does have strong moments: For example, the early grades in physical science and chemistry, as well as the life science section, have merit. But overall, the outcome is poor, and there is no reason to hope that a solid curriculum could emerge from the mess.

Scientific Inquiry and Methodology

The preamble to the process portion of the standards mentions "scientific inquiry" a total of four times, yet in no place in the standards does inquiry receive careful attention, and the promised "seamless integration" of science content and scientific inquiry is nowhere to be seen. What exists is a paragraph offering bromides (such as "research shows that young students work well in a cooperative learning environment") but little direction as to how concepts such as theory, hypothesis, and law are to be introduced or integrated with the content. While, as the high

Document(s) Reviewed

► *North Carolina Essential Learning Standards: Science*. 2009. Accessed from: http://www.ncpublicschools.org/acre/standards/new-standards/#science

school standards tell us, "student engagement in scientific investigation provides background for understanding the nature of scientific inquiry," this document offers little guidance as to how to incorporate inquiry in the classroom.

Physical Science

The physical science standards are reasonably thorough and rigorous in the early grades. Take, for example, the following introduction to mass conservation and phase changes:

> **Compare the amount (volume and weight) of water in a container before and after freezing. (grade 2)**

Similarly, the third-grade standards introduce the zeroth law of thermodynamics clearly and in a way that's entirely grade appropriate:

> **Recognize that energy can be transferred from a warmer object to a cooler one by contact or at a distance and the cooler object gets warmer. (grade 3)**

There is a sound introduction to the concept of energy in fourth grade:

> **Recognize the basic forms of energy (light, sound, heat, electrical, and magnetic) as the ability to cause motion or create change. (grade 4)**

The standards are also well-linked to other scientific disciplines in the early grades. Two examples, from second and fifth grades, respectively, are the following:

> **Understand the relationship between sound and vibrating objects.**
>
> - **Illustrate how sound is produced by vibrating objects and columns of air.**
> - **Summarize the relationship between sound and objects of the body that vibrate—eardrum and vocal cords. (grade 2)**
>
> **Explain how the sun's energy impacts the processes of the water cycle (including, evaporation, transpiration, condensation, precipitation, and runoff). (grade 5)**

Unfortunately, the coverage of important content becomes increasingly sketchy as the grades progress. By sixth grade and on through eighth grade the presentation is disorganized, illogically sequenced, and riddled with misconceptions and mistakes. For instance, the statement in sixth grade that matter is made of atoms is all the standards have to say on the subject. Similarly, only one sixth-grade standard—"explain the effect of heat on the motion of atoms through a description of what happens to particles during a change in phase"—lays out expectations for what students should learn about the connection between heat energy and molecular motion.

Further, the standards often present material inappropriate for the grade level in which it is introduced. Take, for example, the following fifth-grade standard:

> **Explain how factors such as gravity, friction, and change in mass affect the motion of objects. (grade 5)**

Change in mass? Why would one want to introduce the dynamics of bodies of non-constant mass in fifth grade? One suspects that what was really intended is the dependence of acceleration on the mass of the object to which a force is applied.

Similarly, the following high school physical science standard is a decidedly mixed bag, presenting kinematics, momentum, unspecified "investigations," and mathematical quantities all in one opaque mess:

> **Compare speed, velocity, acceleration, and momentum using investigations, graphing, scalar quantities, and vector quantities. (high school physical science)**

Sadly, these examples are but a few of many.

High School Physics

Most of the essential content is missing from the North Carolina high school physics standards—an unsurprising consequence, given that the standards barely fill two pages. What is presented varies in quality. After an excellent treatment of mechanics, a good start to electromagnetism descends into chaos. To give one example of this decline, consider the following standard and one of its clarifying objectives:

> **Analyze the nature of moving charges and electric circuits.**
>
> - **Explain Ohm's law in relation to electric circuits. (high school physics)**

But Ohm's law is a property of a class of circuit components (called ohmic or resistive elements) and the last five words of the sentence only confuse.

In another standard, students are asked to "differentiate the behavior of moving charges in conductors and insulators." Unfortunately, insulators are objects in which electric charge does not move. Another standard asks students to "compare the general characteristics of AC and DC systems without calculations." What that means in practice is anyone's guess.

Again, these examples are but a few of many. And then the document screeches to a halt. There is nothing at all about

light, sound (other than a very brief mention of waves in general), atomic or nuclear physics, or relativity.

High School Chemistry

Like physics, all of high school chemistry is outlined in only thirty-one clarifying objectives, spread out in a two-page table that renders the list of topics addressed incomplete. Missing topics include: hydrogen bonding, Lewis dot structures, molecular shape and polarity, the mole concept, oxidation/reduction, and carbon chemistry. Content that is included is frequently hidden in terse statements that are hopelessly general, as in:

> **Analyze the structure of atoms, isotopes, and ions. (high school chemistry)**
>
> **Analyze the stoichiometric relationships inherent in a chemical reaction. (high school chemistry)**

These objectives leave the reader guessing what the writer had in mind. To most chemistry teachers, "stoichiometric relationships" in the second example implies mole ratios, but the mole concept is not mentioned. For that, we must turn to another standard, which merely hints at it: "Infer the quantitative nature of a solution (molarity, dilution, and titration with a 1:1 molar ratio)" (high school chemistry).

Still, while most standards miss the mark, a few take more careful aim and address content adequately:

> **Compare the properties of ionic, covalent, metallic, and network compounds.**
>
> **Analyze quantitatively the composition of a substance (empirical formula, molecular formula, percent composition, and hydrates).**
>
> **Interpret the name and formula of compounds using IUPAC convention. (high school chemistry)**

Also, concepts of equilibrium and periodic table relationships are well covered.

Earth and Space Science

Earth science, astronomy, and environmental science are presented as a single subject—and cover a mere two pages. Given this lack of real estate, the North Carolina earth and space science standards often cram too much content into individual standards—especially at the high school level, as in the following example:

> **Explain the Earth's motion through space, including precession, nutation, the barycenter, and its path about the galaxy. (high school earth/environmental)**
>
> **Explain how the rock cycle, plate tectonics, volcanoes, and earthquakes impact the lithosphere. (high school earth/environmental)**

That's a lot of complex content to ask in less than twenty words each—one is reminded of Monty Python's "Summarize Proust In Thirty Seconds" routine. The brevity of the standards also can lead to confusion and oversimplification of ideas, as in the following:

> **Explain how crustal plates and ocean basins are formed, move, and interact using earthquakes, heat flow, and volcanoes to reflect forces within the earth. (grade 6)**
>
> **Explain how the Earth's rotation and revolution about the Sun affect its shape and is [*sic*] related to seasons and tides. (high school earth/environmental)**

In the case of the latter, the slight nonsphericity of the earth is indeed due to its rotation, but the importance of that effect hardly merits its grouping with seasons, while rotation alone does not account for the tides.

Often there are vast blanks where content is missing. At the high school level, there is nothing at all about extra-solar-system astronomy or cosmology, and coverage of plate tectonics is thin throughout.

Still, a search for our suggested content turned up a few nicely crafted statements. Fourth grade contains:

> **Explain how minerals are identified using tests for the physical properties of hardness, color, luster, cleavage, and streak. (grade 4)**
>
> **Classify rocks as metamorphic, sedimentary, or igneous based on their composition, how they are formed, and the processes that create them. (grade 4)**

Both of these are specific and appropriately rigorous, if a little too narrow in scope. The first could be improved by mentioning special properties such as magnetism and reaction to acid. The second could be improved by calling out the recycling of materials during those processes—how they form a rock cycle.

Life Science

The life science standards are equally brief—and the content coverage suffers here as elsewhere. Evolution is not introduced until eighth grade, and then it begins with this:

> **Understand the evolution of organisms and landforms based on evidence, theories, and processes that impact the Earth over time. (grade 8)**

All of biological and geological evolution in a single sentence! And then a single additional bit:

> **Summarize the use of evidence drawn from geology, fossils, and comparative anatomy to form the basis for biological classification systems and the theory of evolution. (grade 8)**

But there is no mention of natural selection, variation, and so forth.

High school biology also suffers from some glaring omissions, including organ systems and physiology. Still, for the most part, the subjects that are mentioned are sound, though their generality may confound teacher and student. Examples are as follows:

> **Explain how instructions in DNA lead to cell differentiation and result in cells specialized to perform specific functions in multicellular organisms.**
>
> **Explain how DNA and RNA code for proteins and determine traits.**
>
> **Explain how fossil, biochemical, and anatomical evidence support the theory of evolution. (high school biology)**

Perhaps a skilled educator could cobble together an effective curriculum from the North Carolina standards. But doing so would require an uncanny ability to imagine material that's missing from the document. With so many blank spots, the overall average score for content and rigor is just three out of seven. (See Appendix A: Methods, Criteria, and Grading Metric.)

Clarity and Specificity

Although reasonably well ordered and written in grammatical prose, the standards are far too vague to guide curriculum, instruction, or assessment development. Take, for example, this fifth-grade life science standard:

> **Explain why organisms are different from or similar to their parents based on the characteristics of the organism. (grade 5)**

This standard contains virtually no meaningful content or guidance. And sadly, such an example is the norm, not the exception. And there are some incomprehensible standards, such as:

> **Explain ways that organisms use released energy for maintaining homeostasis (active transport). (high school biology)**

Puzzling statements like these undermine the already-thin text and result in an overall score of one out of three for clarity and specificity. (See Appendix A: Methods, Criteria, and Grading Metric.)