INTRODUCTION: K-8 SCIENCE STANDARDS

CATALINA FOOTHILLS SCHOOL DISTRICT

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INTRODUCTION

Science and engineering – significant parts of human culture that represent some of the pinnacles of human achievement – are not only major intellectual enterprises but can improve people's lives in fundamental ways. Although the intrinsic beauty of science and a fascination with how the world works have driven exploration and discovery for centuries, many of the challenges that face humanity now and in the future – related for example, to the environment, energy, and health – require social, political, and economic solutions that must be informed deeply by knowledge of the underlying science and engineering.

- A Framework for K-12 Science Education

A Vision for K-12 Education in the Sciences and Engineering
The Science Standards articulate a vision for education in the sciences and engineering that reflect how real life scientists and engineers practice their craft. A fundamental goal of science education is to help students determine how the world works and make sense of phenomena in the natural world. Phenomena are events or situations that are observed to exist or happen. In the science classroom, a carefully chosen phenomenon can drive student inquiry and add relevance to science learning. To develop a scientific understanding of the natural world, students must be able to ask questions, gather information, reason about that information and connect it to scientific principles, theories, or models, and then effectively communicate their understanding and reasoning.

The Science Standards set the expectations for what all students need to know, understand, and be able to do as a result of their K-12 study of science. They are distinct from prior science standards in that they integrate three dimensions of learning within each standard (3-D Science). The three dimensions of science learning (Figure 1) are science and engineering practices (blue), crosscutting concepts (green), and core ideas for knowing and using science (orange). Each dimension works with the other to help students build a cohesive understanding of science over time. The interrelationships of the three dimensions that make up each standard emphasize what it means to think and learn like a scientist and engineer.

Science and Engineering Practices
There are eight science and engineering "practices," which encompass both the skills and knowledge required to do real science and engineering work. Learning science and engineering by engaging in the practices helps students understand how scientific knowledge develops and real-world engineering problems are solved. As students conduct investigations, they engage in multiple practices as they gather information to solve problems, answer their questions, reason about how the data provide evidence to support their understanding, and then communicate their understanding of phenomena.

Rather than a linear process from hypothesis to conclusion, the practices reflect science and engineering as they are practiced and experienced. What do they look like in action? The Arizona Science Standards include a progression matrix of elements for the practices that grow in complexity and sophistication. This clarifies student expectations for each practice as they progress from grade level to grade level.

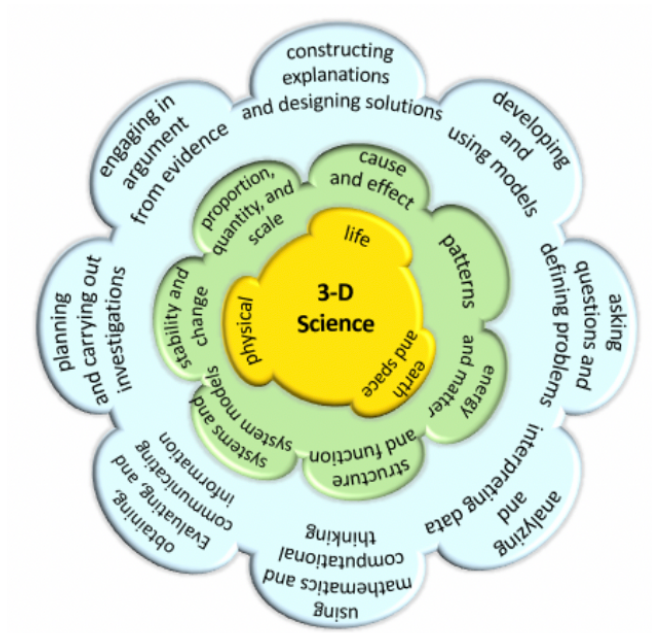

Figure 1: Three Dimensions of Science Learning
The "Flower"

The eight science and engineering practices, as identified in *A Framework for K-12 Science Education*, are critical to developing scientific literacy and should not be seen as teaching strategies or methodologies:

Science and Engineering Practices	
• Asking Questions (for science) and Defining Problems (for engineering)	• Using Mathematics and Computational Thinking
• Developing and Using Models	• Constructing Explanations and Designing Solutions
• Planning and Carrying Out Investigations	• Engaging in Argument Using Evidence
• Analyzing and Interpreting Data	• Obtaining, Evaluating, and Communicating Information

While the scientific method is still being widely used, and a part of academics, the science and engineering practices are expected to be integrated with the core ideas and crosscutting concepts across all grade levels and disciplines of science.

Core Ideas (for Knowing and Using Science)

There is deliberate organization of the science standards around 13 core ideas that spiral through the grade levels to build scientific literacy. There are 10 core ideas for KNOWING Science and 3 core ideas for USING Science, adapted from *Working with Big Ideas of Science Education.* The core ideas are "understandings" that students will develop over the course of their K-12 science education. The core ideas for Knowing Science focus on understanding the causes of phenomena in Physical, Earth and Space, and Life Sciences. The core ideas for Using Science focus on connecting scientific principles, theories, and models; engineering and technological applications; and societal implications to the content knowledge to support that understanding. All of the standards are derived from ONE core idea for Knowing Science and ONE core idea for Using Science. The core ideas provide the background knowledge for students to develop sense-making around phenomena in the natural world. They are at the heart of the discipline of science and must therefore be revisited again and again with increasing complexity over time.

Core Ideas for Knowing Science	Core Ideas for Using Science
Physical Science P1: All matter in the Universe is made of very small particles. P2: Objects can affect other objects at a distance. P3: Changing the movement of an object requires a net force to be acting on it. P4: The total amount of energy in a closed system is always the same but can be transferred from one energy store to another during an event. **Earth and Space Science** E1: The composition of the Earth and its atmosphere and the natural and human processes occurring within them shape the Earth's surface and its climate. E2: The Earth and our solar system are a very small part of one of many galaxies within the Universe. **Life Science** L1: Organisms are organized on a cellular basis and have a finite life span. L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms. L3: Genetic information is passed down from one generation of organisms to another. L4: The unity and diversity of organisms, living and extinct, is the result of evolution.	**U1:** Scientists explain phenomena using evidence obtained from observations and/or scientific investigations. Evidence may lead to developing models and/or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised. **U2:** The knowledge produced by science is used in engineering and technologies to solve problems and/or create products. **U3:** Applications of science often have both positive and negative ethical, social, economic, and/or political implications.

Crosscutting Concepts

Within every science topic, whether it's chemical reactions, the human body, or the solar system, there is an underlying set of big ideas that cut across science disciplines. The science standards include seven crosscutting concepts that have application across all domains of science. The standards are designed for students to develop their understanding of core ideas through the lens of one or multiple crosscutting concepts. The crosscutting concepts, as identified in *A Framework for K-12 Science Education,* are as follows:

Crosscutting Concepts
• **Patterns:** Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them. • **Cause and Effect: Mechanism and Prediction:** Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering. • **Scale, Proportion, and Quantity:** In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change. • **Systems and System Models:** A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. • **Energy and Matter: Flows, Cycles, and Conservation:** Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior. • **Structure and Function:** The way an object is shaped or structured determines many of its properties and functions. • **Stability and Change:** For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

Teaching for Transfer

CFSD's curriculum is deliberately structured to foster student understanding and transfer by design. The continuing expansion of scientific knowledge makes it unrealistic to teach all of the ideas related to a given discipline in extensive detail during the K-12 years. Given the abundance of information available today, virtually at a touch – an important role of science education is not to teach "all the facts," but to prepare students with sufficient knowledge and skills so that they can acquire additional information on their own and autonomously apply what they have learned to what they see in the world around them, throughout their lives.

By the end of high school, students should have gained sufficient knowledge of the practices, crosscutting concepts, and core ideas of science and engineering to engage in public discussions on science-related issues, be critical consumers of scientific information related to their everyday lives, and continue to learn about science throughout life. These goals are for all students, not just those who pursue careers in science, engineering, or technology or those who continue on to higher education.

CFSD's transfer goals for science describe autonomous applications of student learning. They are clearly rooted in scientific principles, but they are not bound by the discipline of science. The Science Standards and supporting materials are designed to assist students in achieving the goals. CFSD's long-term transfer goals establish what we value as a school district and are the target for preparing our students to lead successful, fulfilling lives.

CFSD Transfer Goals for Science:

By the end of 12th grade, students will be able to independently use their learning to...

- Make informed judgments and decisions with a balance of curiosity, skepticism, and social perspective.
- Communicate scientific ideas, arguments, and/or results for a variety of purposes and audiences.
- Make sense of problems or phenomena and construct solutions through disciplined trial and error.
- Employ the habits of a systems thinker to better understand situations, make effective decisions, and plan for the future (Systems Thinking).

Computer Science

A new addition to the "sciences" at grades K-8 is that of "computer science." Computing underpins every other science, technology, engineering, and mathematics (STEM) and non-STEM field as a highly versatile and sought-after skill-set. Computer science encourages problem solving, critical thinking, and design. It inspires students to think logically and analytically, and opens the doors for creativity. As computers continue to advance and embed themselves in everyday life, scaling up these skills becomes a necessity for the future.

Two "essential concepts" of computer science were intentionally integrated into K-8 science: *computational thinking* and *data and analysis*. Computational thinking – which is the logic, algorithmic thinking, and problem solving aspect of computer science – provides an analytical foundation that is useful for every student and in any career. The amount of digital data generated in the world, whether it's personal, transactional, web-based, or produced by sensors, is rapidly expanding. The need to process data effectively is increasingly important. Analysis of data, with the goal of discovering useful information, supporting decision-making, and informing conclusions, is used in all aspects of life. The skill-sets for computational thinking and data and analysis will be systematically developed as part of the science program.

CFSD Transfer Goals for Computer Science:

By the end of 12th grade, students will be able to independently use their learning to...

- Participate safely, legally, and ethically in the interconnected, digital world.
- Empower themselves and others by leveraging technology to achieve personal goals and address societal issues.
- Employ computational thinking to analyze problems, propose solutions, and make decisions.

Coding of the K-8 Science Standards

Each K-8 standard represents the intersection of core ideas for Knowing Science and Using Science. This intersection emphasizes that content in Physical, Earth and Space, and Life Sciences is not learned independently from ideas about the nature of science, applications of science, or the social implications of using science. The coding of the standard captures this intersection. For example, the standard below is an Earth and Space Science standard for grade 4. The first "4" in the numbering sequence designates the grade level. "E1" is the designated core idea for Knowing Science ("E" – Earth and Space Sciences, "1" – first core idea for this area of science). "U1" is the core idea for Using Science ("U" – Using Science, "1" – first core idea for Using Science). Each standard has one core idea for Knowing Science and one core idea for Using Science. The "8" at the end of the code is the number designated to the standard and does not imply instructional sequence or importance.

4.E1U1.8
Collect, analyze, and interpret data to explain weather and climate patterns.

For this fourth grade standard, these are the Core Ideas:

E1: Knowing Science – The composition of the Earth and its atmosphere and the natural and human processes occurring within them shape the Earth's surface and its climate.

U1: Using Science – Scientists explain phenomena using evidence obtained from observations and/or scientific investigations. Evidence may lead to developing models and/or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.