OREGON
DEPARTMENT OF
EDUCATION

2022 Oregon Science Standards

K-12 Science Education

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K-12 Science Education for Every Student: The Vision

A K–12 Framework Science Education (National Research Council, 2012) is a compilation of science education research identifying critical topics and best practices for youth to learn science that centers students' cultures, interests, and identities as they make sense of their world. The Framework highlights how "all science learning can be understood as a cultural accomplishment." Research shows that a cultural perspective can transform learning experiences to be more engaging and meaningful for learners. This is a fundamental shift from **learning about** a science topic, **to figuring out** why or how something happens. These instructional sequences are more coherent when students investigate compelling natural phenomena (in science) or work on meaningful design problems (in engineering) by engaging in science and engineering practices.

> "Equity in science education requires that all students are provided with equitable opportunities to learn science and become engaged in science and engineering practices; with access to quality space, equipment, and teachers to support and motivate that learning and engagement; and adequate time spent on science. In addition, the issue of connecting to students' interests and experiences is particularly important for broadening participation in science." (NRC, 2012).

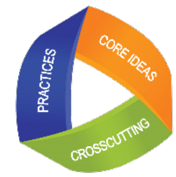
Figure 1

From the research publication of the Framework, the Next Generation Science Standards were developed in partnership with the coordination of 26 states, including Oregon, along with critical partners in science, science education, higher education, and industry. As part of the development process, the standards underwent multiple reviews, including two public drafts, allowing all who have a stake in science education an opportunity to inform the development of the standards. This included input from over 50,000 educators. In 2014, and again in 2022, based on the recommendation from the Oregon Science Standards Advisory Panels, **the Oregon State Board of Education adopted the NGSS as Oregon's K-12 Science Standards**.

There is no doubt that science - and therefore, **science education - is central to the lives of every community member**. Never before has our world been so complex and scientific literacy so critical to making sense of it all. Science is also at the heart of each community's ability to continue innovating, leading, and creating jobs for the future. That's why **all students** - regardless of whether they pursue college or STEM careers - **should have access to a high-quality K-12 science education**. (nextgenscience.org, 2013).

For more information on Next Generation Science Standards (NGSS) and supporting resources, please visit the NextGenScience website.

Three Dimensional Learning: Putting it Together



A K–12 Framework Science Education (National Research Council, 2012) describes a vision of what it means to be proficient in science; it rests on a view of science as both a body of knowledge and an evidence-based, model and theory building enterprise that continually extends, refines, and revises knowledge. It presents three dimensions that will be combined to form each standard. These three dimensions, **science and engineering practices**, **crosscutting concepts**, and the **disciplinary core ideas**, make up distinct but equally important components of what students should know and be able to demonstrate. The three dimensions are:

Dimension 1: Science and Engineering Practices

The practices describe behaviors that scientists engage in as they investigate and build models and theories about the natural world and the key set of engineering practices that engineers use as they design and build models and systems. *A Framework for K-12 Science Education* uses the term practices instead of a term like “skills” to emphasize that engaging in scientific investigation requires not only skill but also the knowledge that is specific to each practice. Part of the NRC’s intent is to better explain and extend what is meant by “inquiry” in science and the range of cognitive, social, and physical practices that it requires.

Although engineering design is similar to scientific inquiry, there are significant differences. For example, scientific inquiry involves the formulation of a question that can be answered through investigation, while engineering design involves the formulation of a problem that can be solved through design. Strengthening instruction involving engineering will clarify for students the relevance of science, technology, engineering, and mathematics (the four STEM fields) to everyday life.

- ***Asking Questions and Defining Problems***
  A practice of science is to ask and refine questions that lead to descriptions and explanations of how the natural and designed world(s) works and which can be empirically tested.

- ***Developing and Using Models***
  A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations. These tools include diagrams, drawings, physical replicas, mathematical representations, analogies, and computer simulations.

- ***Planning and Carrying Out Investigations***
  Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually. Their investigations are systematic and require clarifying what counts as data and identifying variables or parameters.

- ***Analyzing and Interpreting Data***
  Scientific investigations produce data that must be analyzed in order to derive meaning. Because data patterns and trends are not always obvious, scientists use a range of tools—including tabulation, graphical interpretation, visualization, and statistical analysis—to identify the significant features and patterns in the data. Scientists identify sources of error in the investigations and calculate the degree of certainty in the results.

- ***Using Mathematics and Computational Thinking***
  In both science and engineering, mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks such as constructing

simulations; solving equations exactly or approximately; and recognizing, expressing, and applying quantitative relationships.

- ***Constructing Explanations and Designing Solutions***
  The end-products of science are explanations and the end-products of engineering are solutions. The goal of science is the construction of theories that provide explanatory accounts of the world. A theory becomes accepted when it has multiple lines of empirical evidence and greater explanatory power of phenomena than previous theories.

- ***Engaging in Argument from Evidence***
  Argumentation is the process by which evidence-based conclusions and solutions are reached. In science and engineering, reasoning and argument based on evidence are essential to identifying the best explanation for a natural phenomenon or the best solution to a design problem.

- ***Obtaining, Evaluating, and Communicating Information***
  Scientists and engineers must be able to communicate clearly and persuasively the ideas and methods they generate. Critiquing and communicating ideas individually and in groups is a critical professional activity.

Dimension 2: Crosscutting Concepts

Crosscutting concepts have application across all domains of science. As such, they are a way of linking the different domains of science. They include: Patterns, similarity, and diversity; Cause and effect; Scale, proportion and quantity; Systems and system models; Energy and matter; Structure and function; Stability and change.

A Framework for K-12 Science Education emphasizes that these concepts need to be made explicit for students because they provide an organizational schema for interrelating knowledge from various science fields into a coherent and scientifically-based view of the world.

- ***Patterns***
  Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.

- ***Cause and Effect: Mechanism and Explanation***
  Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

- ***Scale, Proportion, and Quantity***
  In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system’s structure or performance.

- ***Systems and System Models***
  Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

- ***Energy and Matter: Flows, Cycles, and Conservation***
  Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.

- ***Structure and Function***
  The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.

- ***Stability and Change***
  For natural and built systems alike, conditions of stability and factors that control rates of change are critical elements to consider and understand.

Dimension 3: Disciplinary Core Ideas

Disciplinary core ideas have the power to focus K–12 science curriculum, instruction, and assessments on the most important aspects of science. To be considered core, the ideas should meet at least two of the following criteria and ideally all four:

- Have **broad importance** across multiple sciences or engineering disciplines or be a **key organizing concept** of a single discipline;
- Provide a **key tool** for understanding or investigating more complex ideas and solving problems;
- Relate to the **interests and life experiences of students** or be connected to **societal or personal concerns** that require scientific or technological knowledge;
- Be **teachable** and **learnable** over multiple grades at increasing levels of depth and sophistication.

Disciplinary ideas are grouped in four main core ideas (domains) and their subtopics: the earth and space sciences; engineering, technology and applications of science; the life sciences; and the physical sciences.

- ***Earth & Space Science***
  - ESS1 Earth's Place in the Universe
  - ESS2 Earth's Systems
  - ESS3 Earth and Human Activity
- ***Engineering, Technology, and the Application of Science***
  - ETS1 Engineering Design
  - ETS2 Links Among Engineering, Technology, Science, and Society
- ***Life Science***
  - LS1 From Molecules to Organisms: Structures and Processes
  - LS2 Ecosystems: Interactions, Energy, and Dynamics
  - LS3 Heredity: Inheritance and Variation of Traits
  - LS4 Biological Evolution: Unity and Diversity
- ***Physical Science***
  - PS1 Matter and Its Interactions
  - PS2 Motion and Stability: Forces and Interactions
  - PS3 Energy
  - PS4 Waves and Their Applications in Technologies for Information Transfer

Integration of K-12 Climate Change Education^

The adopted 2022 Oregon Science Standards include the foundational understanding of weather, climate, and human impacts on natural resources in Kindergarten through Grade 5. The standards also specifically identify global climate change and human impact on earth's system as a disciplinary core idea in middle school and high school.

With the adoption of the 2022 Oregon Science Standards, there are continual opportunities to elevate climate change education across grade levels and between disciplinary core ideas. This will provide learning progressions for students to make sense of the complex nature of climate change and learn the skills to develop and deploy solutions. A caret or up arrow (^) was added to those K-12 science standards that have proximal connections to climate change and human impact on earth's system. These standards were identified by utilizing a research analysis conducted by MADE CLEAR through a National Science Foundation Grant that could further support climate change education. For more information on climate change education and supporting resources, please visit the STEM Teaching Tools – Climate Learning website.

^ This performance expectation references a proximal connection to climate change and the disciplinary core ideas: Earth's Systems and Earth and Human Activity.

Integration of Engineering Design*

The NGSS represents a commitment to integrate engineering design into the structure of science education by raising engineering design to the same level as scientific inquiry when teaching science disciplines at all levels, from kindergarten to twelfth grade. It affirms the value of teaching engineering ideas, particularly engineering design, to young students.

The inclusion of engineering design within the fabric of the NGSS has profound opportunities for all students to acquire engineering design practices and concepts alongside the practices and concepts of science. The core idea of engineering design includes three component ideas:

- **Defining** and delimiting engineering problems involves stating the problem to be solved as clearly as possible in terms of criteria for success and constraints or limits.
- **Designing solutions** to engineering problems begins with generating a number of different possible solutions, then evaluating potential solutions to see which ones best meet the criteria and constraints of the problem.
- **Optimizing** the design solution involves a process in which solutions are systematically tested and refined and the final design is improved by trading off less important features for those that are more important.

It is important to point out that these component ideas do not always follow in order, any more than do the "steps" of scientific inquiry. At any stage, a problem solver can redefine the problem or generate new solutions to replace an idea that is just not working out. An asterisk (*****) was added to those K-12 science standards that have engineering design embedded within either the science and engineering practices or as a disciplinary core idea. For more information on engineering design and supporting resources, please visit Appendix I – Engineering Design in the NGSS.

***** This performance expectation integrates traditional science content with engineering through a practice or disciplinary core idea.

Grade 4 Science Standards

Earth & Space Science

4.ESS1 Earth's Place in the Universe

4.ESS1.1 **Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.** [Clarification Statement: Examples of evidence from patterns could include rock layers with shell fossils above rock layers with plant fossils and no shells, indicating a change from water to land over time; and, a canyon with different rock layers in the walls and a river in the bottom, indicating that over time a river cut through the rock.] [Assessment Boundary: Assessment does not include specific knowledge of the mechanism of rock formation or memorization of specific rock formations and layers. Assessment is limited to relative time.]

4.ESS2 Earth's Systems

4.ESS2.1 **Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.^** [Clarification Statement: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.] [Assessment Boundary: Assessment is limited to a single form of weathering or erosion.]

4.ESS2.2 **Analyze and interpret data from maps to describe patterns of Earth's features.** [Clarification Statement: Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.][Assessment Boundary: Assessment does not include tectonic plate movement (e.g. boundary types, fault types, volcano types, subducting plate movement, etc.]

4.ESS3 Earth and Human Activity

4.ESS3.1 **Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.^** [Clarification Statement: Examples of renewable energy resources could include wind energy, water behind dams, and sunlight; non-renewable energy resources that cannot be replaced are fossil fuels and fissile materials. Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning of fossil fuels.][Assessment Boundary: Assessment does not include the distribution of resources around the planet as a result of geologic processes such as volcanic or tectonic activity. Does not include specific scientific information about how natural resources are used to generate energy (e.g. chemical process of burning coal to generate energy).]

4.ESS3.2 **Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.*** [Clarification Statement: Examples of solutions could include designing an earthquake resistant building and improving monitoring of volcanic activity.] [Assessment Boundary: Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions.]

Engineering, Technology, and the Application of Science

4.ETS1 Engineering Design

4.ETS1.1 **Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.** [Clarification Statement: A design problem must be identified before solutions are developed. Solutions or designs identify the criteria for success and identify limitations and constraints.][Assessment Boundary: Assessment does not include limitations or criteria based on specific process or system boundaries (e.g. limitations of scientific principles or long-term societal and environmental impacts).]

4.ETS1.2 **Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.** [Clarification Statement: Emphasis is on researching a problem prior to designing a solution, plan for testing to evaluate how well it will perform under a range of likely conditions using scientific knowledge and communicating the design process.][Assessment Boundary: Assessment is limited to the design process and modeling.]

4.ETS1.3 **Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.** [Clarification Statement: Emphasis is on identifying the purpose of the investigation and specific evidence to collect, testing one criteria or constraint at a time, and record the data accordingly.][Assessment Boundary: Assessment is limited to proposing different solutions based on evidence collected and to determine which is best based on the criteria and the constraints.]

Life Science

4.LS1 From Molecules to Organisms: Structures and Processes

4.LS1.1 **Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.** [Clarification Statement: Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, and skin. [Assessment Boundary: Assessment is limited to macroscopic structures within plant and animal systems.]

4.LS1.2 **Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.** [Clarification Statement: Emphasis is on systems of information transfer.] [Assessment Boundary: Assessment does not include the mechanisms by which the brain stores and recalls information or the mechanisms of how sensory receptors function.]

Physical Science

4.PS3 Energy

4.PS3.1 **Use evidence to construct an explanation relating the speed of an object to the energy of that object.** [Clarification Statement: Examples of evidence relating speed and energy could include change of shape on impact or other results of collisions.] [Assessment Boundary: Assessment does not include quantitative measures of changes in the speed of an object or on any precise or quantitative definition of energy.]

4.PS3.2 **Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.** **^** [Clarification Statement: Emphasis is on gathering evidence through observations to explain how energy is transferred and transformed within a system (e.g. relative rate an ice cube melts on different surfaces or obtain observational data for what affects how to change the amount of electricity a solar panel makes.][Assessment Boundary: Assessment does not include quantitative measurements of energy.]

4.PS3.3 **Ask questions and predict outcomes about the changes in energy that occur when objects collide.** [Clarification Statement: Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact.] [Assessment Boundary: Assessment does not include quantitative measurements of energy.]

4.PS3.4 **Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.*** [Clarification Statement: Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and, a passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.] [Assessment Boundary: Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.]

4.PS4 Wavers and their Applications in Technologies for Information Transfer

4.PS4.1 **Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.** [Clarification Statement: Examples of models could include diagrams, analogies, and physical models using wire to illustrate wavelength and amplitude of waves.] [Assessment Boundary: Assessment does not include interference effects, electromagnetic waves, non- periodic waves, or quantitative models of amplitude and wavelength.]

4.PS4.2 **Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.** [Clarification Statement: Emphasis is a model to show the path that light traveled from the light source to your eye in the investigation (e.g. build a periscope to see around corners and over walls or trying to read or see objects in the dark).] [Assessment Boundary: Assessment does not include knowledge of specific colors reflected and seen, the cellular mechanisms of vision, or how the retina works.]

4.PS4.3 **Generate and compare multiple solutions that use patterns to transfer information. *** [Clarification Statement: Emphasis is on generation and comparison of multiple solutions. Examples of solutions could include drums sending coded information through sound waves, using a grid of 1’s and 0’s representing black and white to send information about a picture, and using Morse code to send text.][Assessment Boundary: Assessment does not include knowledge of electromagnetic spectrum or require students to have learned/memorized specific codes such as Morse or binary.]

*****This performance expectation integrates traditional science content with engineering through a practice or disciplinary core idea.

^This performance expectation references [a proximal connection to climate change] and the disciplinary core ideas: Earth’s Systems and Earth and Human Activity.