2018 Virginia Science Standards of Learning

Curriculum Framework

Board of Education

Commonwealth of Virginia

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The *2018 Virginia Science Standards of Learning Curriculum Framework* can be found on the Virginia Department of Education's website at http://www.doe.virginia.gov/testing/sol/standards_docs/science/index.shtml.

Introduction

The *2018 Virginia Science Standards of Learning Curriculum Framework* amplifies the *Science Standards of Learning for Virginia Public Schools* (SOL) and defines the content knowledge, skills, and understandings that provide a foundation in science concepts and practices. The framework provides additional guidance to school divisions and their teachers as they develop an instructional program appropriate for their students. It assists teachers as they plan their lessons by identifying enduring understandings and defining the essential science and engineering practices students need to master. This framework delineates in greater specificity the minimum content requirements that all teachers should teach and all students should learn.

School divisions should use the framework as a resource for developing sound curricular and instructional programs. This framework should not limit the scope of instructional programs. Additional knowledge and skills that can enrich instruction and enhance students' understanding of the content identified in the SOL should be included in quality learning experiences.

The framework serves as a guide for SOL assessment development. Assessment items may not and should not be a verbatim reflection of the information presented in the framework. Students are expected to continue to apply knowledge and skills from the SOL presented in previous grades as they build scientific expertise.

The Board of Education recognizes that school divisions will adopt a K–12 instructional sequence that best serves their students. The design of the SOL assessment program, however, requires that all Virginia school divisions prepare students to demonstrate achievement of the standards for elementary and middle school by the time they complete the grade levels tested. The high school end-of-course SOL tests, for which students may earn verified units of credit, are administered in a locally determined sequence.

Each topic in the framework is developed around the SOL. The format of the framework facilitates teacher planning by identifying the enduring understandings and the scientific and engineering practices that should be the focus of instruction for each standard. The categories of scientific and engineering practices appear across all grade levels and content areas. Those categories are: asking questions and defining problems; planning and carrying out investigations; interpreting, analyzing, and evaluating data; constructing

and critiquing conclusions and explanations; developing and using models; and obtaining, evaluating, and communicating information. These science and engineering practices are embedded in instruction to support the development and application of science content.

Science and Engineering Practices

Science utilizes observation and experimentation along with existing scientific knowledge, mathematics, and engineering technologies to answer questions about the natural world. Engineering employs existing scientific knowledge, mathematics, and technology to create, design, and develop new devices, objects, or technology to meet the needs of society. By utilizing both scientific and engineering practices in the science classroom, students develop a deeper understanding and competence with techniques at the heart of each discipline.

Engineering Design Practices

Engineering design practices are similar to those used in an inquiry cycle; both use a system of problem solving and testing to come to a conclusion. However, unlike the inquiry cycle in which students ask a question and use the scientific method to answer it, in the engineering and design process, students use existing scientific knowledge to solve a problem. Both include research and experimentation; however, the engineering design process has a goal of a solving a societal problem and may have multiple solutions. More information on the engineering and design process can be found at https://www.eie.org/overview/engineering-design-process.

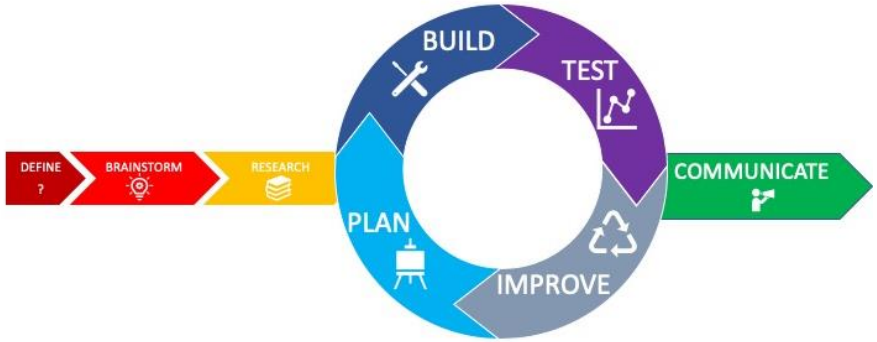

Figure 1: Engineering Design Process image based on the National Aeronautics and Space Administration (NASA) engineering design model.

The Engineering Design Process:

1. Define: Define the problem, ask a question
2. Imagine: Brainstorm possible solutions
3. Research: Research the problem to determine the feasibility of possible solutions
4. Plan: Plan a device/model to address the problem or answer the question
5. Build: Build a device/model to address the problem or answer the question
6. Test: Test the device/model in a series of trials
    a) Does the design meet the criteria and constraints defined in the problem?
        i. Yes? Go to Share (#8)
        ii. No? Go to Improve (#7)
7. Improve: Using the results of the test, brainstorm improvements to the device/model; return to #3
8. Share: Communicate your results to stakeholders and the public

Computational Thinking

The term *computational thinking* is used throughout this framework. Computational thinking is a way of solving problems that involves logically organizing and classifying data and using a series of steps (algorithms). Computational thinking is an integral part of Virginia's computer science standards and is explained as such in the *Computer Science Standards of Learning*:

> *Computational thinking is an approach to solving problems that can be implemented with a computer. It involves the use of concepts, such as abstraction, recursion, and iteration, to process and analyze data, and to create real and virtual artifacts. Computational thinking practices such as abstraction, modeling, and decomposition connect with computer science concepts such as algorithms, automation, and data visualization. [Computer Science Teachers Association & Association for Computing Machinery]*

Students engage in computational thinking in the science classroom when using both inquiry and the engineering design process. Computational thinking is used in laboratory experiences as students develop and follow procedures to conduct an investigation.

Structure of the *2018 Virginia Science Standards of Learning Curriculum Framework*

The framework is divided into two columns: Enduring Understandings and Essential Knowledge and Practices. The purpose of each column is explained below.

Enduring Understandings
The Enduring Understandings highlight the key concepts and the big ideas of science that are applicable to the standard. These key concepts and big ideas build as students advance in their scientific and engineering understanding. The bullets provide the context of those big ideas at that grade or content level.

Essential Knowledge and Practices
Each standard is expanded in the Essential Knowledge and Practices column. What each student should know and be able to do as evidence of understanding of the standard is identified here. This is not meant to be an exhaustive list nor is a list that limits what is taught in the classroom. It is meant to be the key knowledge and practices that define the standard. Science and engineering practices are highlighted with a leaf bullet (see footer).

The *2018 Virginia Science Standards of Learning Curriculum Framework* is informed by the Next Generation Science Standards (https://www.nextgenscience.org/).

Kindergarten

Using my senses to understand my world

In science, kindergarten students use their senses to make observations of the characteristics and interactions of objects in their world. Students study the characteristics of water and the basic needs of living things. They also study the relationship between the sun and Earth through shadows and weather. They determine how their actions can change the motion of objects and learn how they can make a difference in their world. Throughout the elementary years, students will develop scientific skills, supported by mathematics and computational thinking, as they learn science content. In kindergarten, students will develop skills in posing simple questions, conducting simple investigations, observing, classifying, and communicating information about the natural world.

Scientific and Engineering Practices

Engaging in the practices of science and engineering helps students understand how scientific knowledge develops; such direct involvement gives them an appreciation of the many ways to investigate, model, and explain the world. These scientific and engineering practices include the use of scientific skills and processes to explore the content of science as outlined in the *Science Standards of Learning*. The engineering design practices are the application of science content to solve a problem or design an object, tool, process, or system. These scientific and engineering practices are critical to science instruction and are to be embedded throughout the year.

K.1 The student will demonstrate an understanding of scientific and engineering practices by

a) asking questions and defining problems
- **ask questions based on observations**
- **identify a problem based on need**
- **make predictions based on observations**

b) planning and carrying out investigations
- **make observations to collect data**
- **identify characteristics and properties of objects by observations**
- **measure relative length and weight of common objects**
- **record information from investigation**

c) interpreting, analyzing, and evaluating data
- **describe patterns**
- **classify and/or sequence objects based on a single physical characteristic or property**

- **organize and represent data**
- **read and interpret data in object graphs, picture graphs, and tables**

d) constructing and critiquing conclusions and explanations
- **make simple conclusions based on data or observations**

e) developing and using models
- **distinguish between a model and an actual object**

f) obtaining, evaluating, and communicating information
- **communicate comparative measures (e.g., heavier, lighter, longer, shorter, more, less, hotter, colder)**
- **communicate observations using pictures, drawings, and/or speech**

Kindergarten Science Content

Force, Motion, and Energy

K.2 The student will investigate and understand that pushes and pulls affect the motion of objects. Key ideas include
- **a) pushes and pulls can cause an object to move;**
- **b) pushes and pulls can change the direction of an object; and**
- **c) changes in motion are related to the strength of the push or pull.**

Central Idea: Pushes and pulls can affect the movement of an object.

Vertical Alignment: This standard provides a foundation for the development of the concept of force by introducing the idea that pushes and pulls are required to move objects. The standard does not include non-contact pushes or pulls such as those produced by magnets (2.2).

Enduring Understandings	**Essential Knowledge and Practices**
Forces between objects can cause a change in motion. • Pushes and pulls (forces) can have different strengths and directions and can cause objects to move (K.2 a, b, c). • Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it (K.2 a, b).	In order to meet this standard, it is expected that students will make and communicate observations about how pushes and pulls affect the motion of everyday objects (K.2 a, b) predict and test how a push or pull will affect the motion of an object (K.2 a, b)

Enduring Understandings	Essential Knowledge and Practices
• When objects touch or collide, they push one another and can change motion (K.2 b, c). • A bigger push or pull makes things speed up or slow down more quickly (K.2 c).	compare the motion (fast/slow, close/far) of an object after pushing and pulling the same object with different strengths (K.2 c) plan and conduct an investigation to compare the effects of different strengths or directions of pushes and pulls on the motion of an object (K.2 c) determine if a design solution works as intended to change the speed or direction of an object with a push or pull (K.2 a, b, c).

Matter

K.3 The student will investigate and understand that physical properties of an object can be described. Properties include
- **a) colors;**
- **b) shapes and forms;**
- **c) textures and feel; and**
- **d) relative sizes and weights of objects.**

Central Idea: All objects have physical properties, which include color, shape or form, texture, and size. Properties are independent of each other.

Vertical Alignment: This is an introduction to physical properties of objects; it is elaborated upon in first grade to show that materials retain most physical properties regardless of the size of the material (1.3).

Enduring Understandings	Essential Knowledge and Practices
Objects can be described and compared by their properties.	In order to meet this standard, it is expected that students will

Enduring Understandings	Essential Knowledge and Practices
• Objects have properties that can be observed and described. These properties include color, shape, form, texture, feel, size, and weight (K.3 a, b, c, d). • Two different objects can have some of the same physical properties and some different physical properties (K.3 a, b, c,-d).	observe objects and describe their basic properties to include color, shape, texture, and relative size and weight (K.3 a, b, c, d) arrange a set of objects in sequence according to size (K.3 d) compare objects based on a single physical property (K.3 a, b, c, d) • describe the physical properties of objects both pictorially and verbally (K.3 a, b, c, d)

K.4 The student will investigate and understand that water is important in our daily lives and has properties. Key ideas include

a) water has many uses;
b) water can be found in many places;
c) water occurs in different phases; and
d) water flows downhill.

Central Idea: Water is an important resource for our daily lives and has specific properties.

Vertical Alignment: This standard is an introduction to water, one of the essential resources for all organisms' survival. The importance of water is revisited in other grade levels.

Enduring Understandings	Essential Knowledge and Practices
Energy and matter are required for all organisms to survive. Water is an important resource for our daily lives and has specific properties.	In order to meet this standard, it is expected that students will • describe several uses of water at school and at home (K.4 a) • identify several natural sources of water (K.4 b)

Enduring Understandings	Essential Knowledge and Practices
• Water is a very important resource and we use it for many things (K.4 a). • There are many places where we find water, including streams, rivers, lakes, oceans, and underground (e.g., wells) (K.4 b). • Water can be a solid (ice), liquid (liquid water), or gas (water vapor) (K.4 c). *Students are not responsible for understanding water as a gas.* • The phases of water can be changed by heating or cooling (K.4 c). • The natural flow of water is from a higher to a lower level. An example is seen as water in streams flows from higher elevations to lower elevations (K.4 d).	• classify examples of water as a solid or a liquid (K.4 c) • conduct an investigation to determine how water flows (K.4 d) • predict where a stream of water will flow (K.4 d) • find examples of how water flows in the classroom, school, or community (K.4 d).

Living Systems and Processes

K.5 The students will investigate and understand that senses allow humans to seek, find, take in, and react or respond to different information. Key ideas include

a) the five basic senses correspond to specific human body structures; and

b) senses are used in our daily lives.

Central Idea: Organisms possess physical features, including the five senses, which enable them to survive in their environment and obtain resources to meet their basic needs.

Vertical Alignment: The use of senses is important to an organism's survival. The use of our senses for observing and collecting data is critical to the development of science and engineering practices.

Enduring Understandings	Essential Knowledge and Practices
Organisms possess physical features that enable them to survive in their environment and obtain resources to meet their basic needs. • Humans have five basic senses: taste, touch, smell, hearing, and sight (K.5 a). • In humans, body structures are associated with particular senses: eye–sight, ear–hearing, nose–smell, tongue–taste, and skin–touch (K.5 a). • There are sensory descriptors that are associated with the senses that include, but are not limited to, the following**:** taste–sweet, sour, bitter, salty; touch–rough, smooth, hard, soft, cold, warm, hot; hearing–loud, soft, high, low; sight–bright, dull, color; smell–strong, faint, and pleasant (K.5 b).	In order to meet this standard, it is expected that students will • identify and describe the five basic senses (K.5 a) • match each human body structure with its associated sense (K.5 a) • provide examples of how the five senses are used to make observations (K.5 b) classify sensory descriptors with the senses (K.5 b).

K.6 The student will investigate and understand that there are differences between living organisms and nonliving objects. Key ideas include

a) all things can be classified as living or nonliving; and

b) living organisms have certain characteristics that distinguish them from nonliving objects.

Central Idea: Living and nonliving things have differences; recognition of these differences is essential to developing a deeper understanding of living systems.

Vertical Alignment: The understanding of what is living and what is nonliving is a precursor to understanding what affects living systems.

Enduring Understandings	Essential Knowledge and Practices
Classification relies on careful observation of patterns and similarities and differences. These similarities and differences can be used to sort living organisms from nonliving objects.	In order to meet this standard, it is expected that students will

Enduring Understandings	Essential Knowledge and Practices
• The term *living* is used to describe anything that is or has ever been alive (e.g., dog, flower, seed, log). The term *nonliving* is used to describe anything that is not now nor has ever been alive (e.g., rock, mountain, glass) (K.6 a). • Organisms have needs and life processes, which distinguish them from nonliving objects (K.6 b). • Some important life process of living organisms include growth, responding to the environment, and having offspring (K.6 b).	• identify living organisms and nonliving objects found at home and at school (K.6 a) classify objects as living or nonliving (K.6 a) • identify and describe the basic characteristics of living organisms (K.6 b).

K.7 The student will investigate and understand that plants and animals have basic needs and life processes. Key ideas include

a) living things need adequate food, water, shelter, air, and space to survive;
b) plants and animals have life cycles; and
c) offspring of plants and animals are similar but not identical to their parents or to one another.

Central Idea: Energy and matter are required for all organisms to carry out life process. Organisms have basic needs to carry out those life processes. These processes vary between plants and animals.

Vertical Alignment: The concept that plants and animals have basic needs to conduct life processes is introduced in kindergarten. The specific life processes are introduced in later grades.

Enduring Understandings	Essential Knowledge and Practices
Energy and matter are required for all organisms to survive. Organisms have basic needs, both in terms of energy and matter, which are used to carry out life processes. • Animals need adequate food, water, shelter, air, and space to survive (K.7 a).	In order to meet this standard, it is expected that students will • compare the basic life needs of plants and animals (K.7 a) use observations to describe what plants and animals need to survive (K.7 a)

Enduring Understandings	Essential Knowledge and Practices
• To survive, plants need water, air, light, and a place that has adequate space for them to grow (K.7 a). • If animals' needs are not met, they move to an area that does meet their life needs. If they cannot move, they will not survive. If a plant's needs are not met it will not survive (K.7 a). • Simple changes animals undergo during their life cycles may include changes in their body size, color, covering, or shape (K.7 b). *Students are not expected to recognize the different stages or sequences of specific life cycles.* • Simple changes plants undergo during their life cycles may include size, presence of leaves and branches, fruits, and seeds (K.7 b). *Students are not expected to recognize the different stages or sequences of specific life cycles.* • Many offspring of plants and animals are like their parents but not identical to them or to one another. Other offspring look very different from their parents (K.7 c).	predict what will happen to animals and plants if life needs are not met (K.7 a) • describe some simple changes that animals and plants undergo during their life cycles (K.7 b) • recognize similarities and differences between offspring and parents (K.7 c).

Earth and Space Systems

K.8 The student will investigate and understand that light influences temperature on Earth's surfaces and can cause shadows. Key ideas include

a) the sun provides light and warms Earth's surface;
b) shadows can be produced when sunlight or artificial light is blocked by an object; and
c) objects in shadows and objects in sunlight have different temperatures.

Central Idea: Repeating patterns in nature, or events that occur together with regularity, are clues to cause-and-effect relationships.

Vertical Alignment: Looking for patterns is an important tool in understanding and making predictions. This is an opportunity for students to start developing that skill, and to make observations about how light interacts with objects, both in terms of heating an object and in forming shadows.

Enduring Understandings	Essential Knowledge and Practices
Energy can be transferred in various ways and between objects. These energy transfers can be observed and form patterns. *Students are not responsible for the term* energy. • Sunlight warms Earth's surface. Components of Earth's surface, such as sand, soil, rocks, and water, become relatively warmer when exposed to sunlight (K.8 a). *Students should measure temperature in relative measures such as warmer/cooler only.* • A shadow is an image of an object created when light is blocked by that object. Shadows can occur whenever light is present (K.8 b). • Both natural (sun) and artificial (electric light, flashlight) sources of light can create shadows (K.8 b). • Objects in a shadow will be cooler than objects in the sun (K.8 c).	In order to meet this standard, it is expected that students will make observations and conduct an investigation to determine the effect of sunlight on Earth's surface (K.8 a) demonstrate how shadows change as the direction of the light source changes (K.8 b) • describe how shadows occur (K.8 b) • identify sources of light that can produce shadows (K.8 b) design and build a simple structure that will reduce the warming effect of sunlight on an area or an object (K.8 c) • compare the relative temperature of an object in sunlight vs. the same object in a shadow (K.8 c).

K.9 The student will investigate and understand that there are patterns in nature. Key patterns include
- **a) daily weather;**
- **b) seasonal changes; and**
- **c) day and night.**

Central Idea: Patterns exist all around us and can be observed in daily weather, seasons, and day and night.

Vertical Alignment: Kindergarten students are expected to see that there are patterns to the weather, seasonal changes, and day and night. Students will gain an understanding of why those patterns occur and the cause-and-effect aspect of the pattern in fourth grade (4.6).

Enduring Understandings	Essential Knowledge and Practices
Repeating patterns in nature, or events that occur together with regularity, are clues to cause-and-effect relationships. • Weather is the combination of sunlight, wind, snow or rain, and temperature in a region at a given time. People measure these conditions to describe and record the weather and to notice patterns over time (K.9 a). • A variety of weather conditions (sunny, cloudy, rainy, snowy, windy, warm, hot, cool, and cold) can be observed and described over time (K.9 a, b). • Predictions can be made using seasonal patterns. Temperature and type of precipitation vary throughout the seasons. Seasons occur in the same order every year (K.9 b).	In order to meet this standard, it is expected that students will identify patterns in nature (day and night, seasons, life cycles) (K.9 a, b, c) chart and graph daily weather conditions throughout the year to determine seasonal patterns (K.9 a) use and share observations of daily weather conditions to describe patterns over time (K.9 a) • describe the patterns in weather conditions that may be observed during the different seasons (K.9 b).

K.10 The student will investigate and understand that change occurs over time. Key ideas include
- **a) natural and human-made things change over time;**
- **b) living and nonliving things change over time;**
- **c) changes can be observed and measured; and**
- **d) changes may be fast or slow.**

Central Idea: Systems may exhibit stability and/or change depending on the conditions. These changes can be observed and measured. Some of the changes happen quickly, while others may happen so slowly it is hard to see the changes.

Vertical Articulation: In kindergarten students begin their observations about change. Students will investigate the changes in the weather in first grade (1.6).

Enduring Understandings	Essential Knowledge and Practices
Changes are all around us and occur over time.	In order to meet this standard, it is expected that students will

Enduring Understandings	Essential Knowledge and Practices
• Changes are all around us. Some examples of natural things changing over time include trees changing throughout the seasons, water in a stream washing away rocks and soil, rocks breaking off a mountain, and animals and plants growing, to include changes in height and weight (K.10 a, b, c). • Some examples of human-made things changing over time include buildings, roads, and monuments changing color or breaking due to weather (K.10 a, b, c). • Slow changes should be the kinds of familiar changes that occur over weeks, months, or seasons, (e.g., leaves falling off trees). Faster changes include a weather event such as a blizzard or tornado, an earthquake, or a fire (K.10 d).	• describe things in nature that change over time (K.10 a) • describe human-made things that change over time (K.10 a) • identify some changes that people experience over time (K.10 b) • use observations to describe the change of an object or living thing over time (K.10 c) • classify examples as fast changes or slow changes (K.10 d).

Earth Resources

K.11 The student will investigate and understand that humans use resources. Key ideas include
- **a) some materials and objects can be used over and over again;**
- **b) materials can be recycled; and**
- **c) choices we make impact the air, water, land and living things.**

Central Idea: Natural resources make up the common objects and materials that we use. These resources are limited and should be conserved. Humans can accomplish this by reusing, recycling, and conserving.

Vertical Alignment: This standard establishes a foundation for increasingly advanced conservation concepts developed in the primary standards.

Enduring Understandings	Essential Knowledge and Practices
Natural resources are limited and should be conserved. • Recycling, reusing, and conserving helps preserve resources for future use (K.11 a, b). • Resources last longer if we recycle, reuse, and reduce consumption (K.11 a, b). • Reusing materials means using them more than once. Reusing materials reduces the amount of trash and conserves resources. Examples include using dishes and utensils that are washed after use rather than using paper plates and plastic utensils and putting them in the trash (K.11 a). • Generally, materials such as paper, glass, aluminum cans, metals, some plastics, and cardboard can be recycled. The items that can or cannot be recycled are different based on the area recycling facility (K.11 b). • Things that people do to live comfortably can affect the world around them. People can make choices to reduce their impacts on the land, water, air, and other living things through recycling and reusing (K.11 c).	In order to meet this standard, it is expected that students will • describe the difference between *recycle* and *reuse* (K.11 a, b) • identify materials that can be reused (K.11 a) • give examples of objects that can be recycled (K.11 b) • explain why recycling and reusing resources is good for the community (K.11 c) • communicate solutions that will reduce the impact of humans on the land, air, water, and on other living things in the local environment (K.11 c).