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.

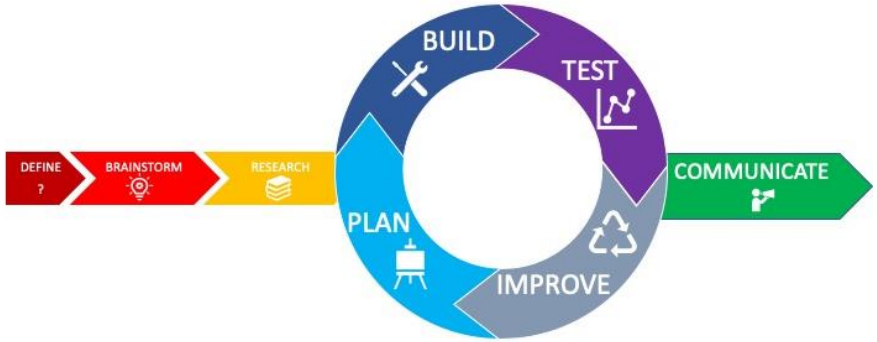

Figure 1: Engineering Design Process image based on the National Aeronautics and Space Administration (NASA) engineering design model.

The Engineering Design Process:

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

Grade Two

Change occurs all around us

Science in second grade builds on previous understandings of forces, water, weather, and plants and animals, as students explore these concepts through the lens of change. They examine how water changes phase, how visible and invisible forces change motion, how plants and animals change through their life cycles, and how weather changes the Earth. Students also examine how change occurs over a short or long period of time. Throughout the elementary years, students will develop scientific skills, supported by mathematics and computational thinking, as they learn science content. In second grade, students will develop skills in posing simple questions, planning and conducting simple investigations, observing, classifying, and communicating information about the natural world. Students engage in more aspects of the engineering design process at this level.

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.

2.1 The student will demonstrate an understanding of scientific and engineering practices by

a) asking questions and defining problems
- **ask questions that can be investigated**
- **make predictions based on observations and prior experiences**
- **identify a simple problem that can be solved through the development of a new tool or improved object**

b) planning and carrying out investigations
- **with guidance, plan and conduct simple investigations to produce data**
- **use appropriate tools to measure length, weight, and temperature of common objects using U.S. Customary units**
- **measure time intervals using proper tools**

c) interpreting, analyzing, and evaluating data
- **organize and represent data in pictographs and bar graphs**

- **read and interpret data represented in pictographs and bar graphs**

d) constructing and critiquing conclusions and explanations
- **make simple conclusions based on data or observations**
- **distinguish between opinion and evidence**
- **recognize unusual or unexpected results**

e) developing and using models
- **use models to demonstrate simple phenomena and natural processes**

f) obtaining, evaluating, and communicating information
- **communicate observations and data using simple graphs, drawings, numbers, speech, and/or writing**

Grade Two Science Content

Force, Motion, and Energy

2.2 The student will investigate and understand that different types of forces may cause an object's motion to change. Key ideas include

a) forces from direct contact can cause an object to move;

b) some forces, including gravity and magnetism, can cause objects to move from a distance; and

c) forces have applications in our lives.

Central Idea: Forces between objects can cause a change in motion. Objects can move because of a direct contact and from forces that are acting from a distance.

Vertical Alignment: Students investigate and learn that forces can be used to change the speed and the direction that an object moves in first grade (1.2). In third grade, the study of force is expanded as students investigate and understand that the direction and size of force affects the motion of an object (3.2).

Enduring Understandings	**Essential Knowledge and Practices**
Forces applied to an object can cause a change in motion. These forces may be direct forces or forces from a distance, such as magnetism and gravity.	In order to meet this standard, it is expected that students will • explain how forces can cause an object to move or cause an object to change its movement (2.2 a)

Enduring Understandings	Essential Knowledge and Practices
• A force may be applied by direct contact (a push or a pull) and can cause an object to move (2.2 a). • Gravity is an attraction between any two objects. Objects do not need to touch each other for the force of gravity to affect them (2.2 b). • Magnetism is a force in which one material exerts an attractive or repulsive force on certain other materials. Magnets are not attracted to all materials. Magnets attract and repel other magnets (2.2 b). • Forces can be seen in everyday applications, such as in moving vehicles, dropping objects, and refrigerator magnets (2.2 c).	• demonstrate contact and noncontact forces that cause objects to move (2.2 a) investigate the effect of contact and noncontact magnetic forces on the movement of objects (2.2 b) predict which materials will be attracted to magnets, test the predictions, and create a chart that shows the results, classifying materials as to whether they are attracted to magnets (2.2 b) investigate relationships of gravitational or magnetic interactions between two objects that are not in contact with each other (2.2 b) • identify examples of the effect of gravity (2.2 b) • describe applications of forces in everyday life (2.2 c) identify a simple problem that can be solved through the development of a new tool or an improved object that uses forces from direct contact or from a distance (2.2 c).

Matter

2.3 The student will investigate and understand that matter can exist in different phases. Key ideas include
- **a) matter has mass and takes up space;**
- **b) solids, liquids, and gases have different characteristics; and**
- **c) heating and cooling can change the phases of matter.**

Central Idea: Heating and cooling can change the phases of matter.

Vertical Articulation: Students investigate the physical properties of matter, and the properties of water are observed and tested in kindergarten (K.3, K.4). In first grade, students investigate materials and their physical properties (1.3).

Enduring Understandings	Essential Knowledge and Practices
Matter can be described and classified by its observable properties. The phase of a substance is a physical property. • *Matter* is anything that has mass and takes up space; all substances are made of matter. Matter most commonly occurs in three phases: solids, liquids, and gases. Different kinds of matter exist and many of them can be either solid or liquid, depending on the temperature (2.3 a). *Students are not responsible for knowing about additional phases of matter, such as plasma*. • Solids have a definite shape and volume (2.3 b). • Liquids have a definite volume and take the shape of their container (2.3 b) • Gases will completely fill any closed container (take the shape of their container) and assume the volume of their container (2.3 b). • Matter can change from one phase to another (2.3 c). • When matter changes from one phase to another, these changes are referred to as physical changes (2.3 c). *Students are not expected to identify physical or chemical properties or changes*. • Heating and cooling can change the phase of matter (2.3 c).	In order to meet this standard, it is expected that students will • define *matter* and provide examples (2.3 a) • describe the characteristics of a solid, liquid, and gas (2.3 b) • classify and compare materials as liquids, solids, or gases (2.3 b) • identify the phases of water and the uses of water in its various phases in the home and at school (2.3 b) • communicate observations of the transformation of matter from one phase to another (e.g., ice to liquid water and liquid water to gas) (2.3 b) • plan and conduct an investigation to determine basic factors that affect the evaporation of water (2.3 b) • predict changes in phase when water is heated or cooled (2.3 c) • investigate the effect of heat on the state of matter (i.e., ice to liquid water and liquid water to water vapor) (2.3 c) • discuss the effect of cooling on the state of matter (2.3 c).

Living Systems and Processes

2.4 The student will investigate and understand that plants and animals undergo a series of orderly changes as they grow and develop. Key ideas include

a) animals have life cycles; and

b) plants have life cycles.

Central Idea: Plants and animals undergo change throughout their lives as they grow and develop. These changes are reflected in an organism's life cycle.

Vertical Alignment: Students are introduced to living systems in kindergarten as they classify things as living and nonliving (K.6). The concept is expanded in first grade as students are introduced to the basic needs and life processes of plants and animals (K.7, 1.4, 1.5). Ecosystems and the relationships that exist among organisms to satisfy life needs is a focus in third grade (3.4, 3.5).

Enduring Understandings	Essential Knowledge and Practices
Patterns exist everywhere and can be seen in regularly occurring, repeating events such as life cycles. • Throughout their lives, plants and animals undergo a series of orderly and identifiable changes. These may include changing form or growing (2.4 a). • Changes in organisms over time occur in cycles and differ among various plants and animals (2.4 a, b). • Some animals do not resemble their parents at birth and go through distinct stages as they mature to adults. Other animals resemble their parents from birth to maturity and do not have distinct stages (2.4 a). • The basic stages in the life cycle of flowering plants include: seed, germination of the seed, growth of the stem and roots, growth of leaves, growth of flowers, fertilization (pollination) of the flowers, production of fruit/new seeds, and death (2.4 b). • Flowering plants produce seeds. Seeds can be dispersed in a variety of ways such as by wind, water, and animals, including humans (2.4 b).	In order to meet this standard, it is expected that students will • explain how animals and plants change as they grow (2.4 a, b) analyze a model of the life cycle of an insect and describe the changes that occur within the life cycle (2.4 a) analyze a model of the life cycle of a mammal and describe the changes that occur with the life cycle (2.4 a) • compare life cycles of an insect and a mammal (2.4 a) investigate the question, "What is the life cycle of a flowering plant?" and record observations using a table and/or graph; explain the results of the investigation (2.4 b) • compare life cycles of a plant and an animal (2.4 a, b) develop models to describe the concept that organisms have unique and diverse life cycles but they all have in common birth, growth, reproduction, and death (2.4 a, b).

Enduring Understandings	Essential Knowledge and Practices
• Although individual life cycles vary, all organisms have in common birth, growth, reproduction, and death (2.4 a, b).	

2.5 The student will investigate and understand that living things are part of a system. Key ideas include
- **a) plants and animals are interdependent with their living and nonliving surroundings;**
- **b) an animal's habitat provides all of its basic needs; and**
- **c) habitats change over time due to many influences.**

Central Idea: Living organisms interact with other living organisms and their surroundings. These interactions allow organisms to meet basic life needs.

Vertical Alignment: Students are introduced to the concept of living and nonliving as well as the basic needs of both plants and animals in kindergarten (K.6, K.7). The structures and functions of animals and plants that are necessary for satisfying these life needs are the focus of first grade (1.4, 1.5). Ecosystems and the relationships that exist among organisms to satisfy life needs is a discussed in third grade (3.4, 3.5).

Enduring Understandings	Essential Knowledge and Practices
A system is comprised of components that work together to form a complex whole. Living systems have both living and nonliving components that are affected by interactions, allowing organisms to meet basic life needs. • The interactions among living organisms and their nonliving surroundings are referred to as a *system* (2.5). • Living things include all organisms who are alive or were once alive. Nonliving things are not alive and have never been alive (2.5 a).	In order to meet this standard, it is expected that students will • explain how living things are part of a system composed of living and nonliving components (2.5 a) • analyze a model of a habitat and describe the living and nonliving components (2.5 b) • describe how a habitat provides for an animal's or plant's needs (2.5 b) • predict and describe natural changes in habitats and their effects on plants and animals (2.5 c) • describe the changes in a habitat due to various influences (2.5 c).

Enduring Understandings	Essential Knowledge and Practices
• Living organisms are dependent on other living organisms and their nonliving surroundings for survival (2.5 a). • An animal's habitat provides the animal's basic needs, including food, air, water, shelter or cover, and space. If any of the basic elements of an animal's habitat are absent, the animal's survival is threatened. The animal may adapt or leave the area (2.5 b). • Shelter/cover may be living, such as coral or a tree, or it may be nonliving, such as a cave or a brick house (2.5 a, b). • The habitats of living organisms may change due to natural influences. For example, plants and animals respond to seasonal changes, such as temperature and length of daylight (2.5 c). • The habitats of living organisms may change due to human influences. For example, an animal may need to change behavior or leave the area if its basics needs are not met, which may result when humans develop (build) an area (2.5 c).	

Earth and Space Systems

2.6 The student will investigate and understand that there are different types of weather on Earth. Key ideas include
- **a) different types of weather have specific characteristics;**
- **b) measuring, recording, and interpreting weather data allows for identification of weather patterns; and**
- **c) tracking weather allows us to prepare for the weather and storms.**

Central Idea: There are many types of weather on Earth; these types of weather have specific characteristics. Weather data can be used to identify and predict weather patterns and storms.

Vertical Alignment: Students collect data on weather and use this to understand seasonal changes in kindergarten and first grade (K.11, 1.6, 1.7). In third grade, students extend this knowledge as they determine impacts of natural weather events on ecosystems (3.8).

Enduring Understandings	**Essential Knowledge and Practice**
Patterns exist everywhere and can be seen in regularly occurring, repeating events such as weather. Models based on patterns in weather data are used to predict weather. • Common types of storms include hurricanes, tornadoes, blizzards, and thunderstorms. These storms have powerful winds, which may be accompanied by rain, snow, or other kinds of precipitation (2.6 a). • Common types of precipitation include rain, snow, and ice (sleet and hail) (2.6 a). • Extreme weather, such as too little or too much precipitation, can result in droughts or floods (2.6 a). • Scientists collect a variety of weather data such as precipitation, cloud cover, wind, and temperature (2.6 b). • Weather data is collected and recorded using instruments, such as a thermometer, rain gauge, and weather vane (2.6 b). *Students only need to measure weather data using U.S. Customary System units*. • By comparing current weather data to known patterns in weather, predictions can be made that allow us to prepare for storms and other weather conditions (2.6 c).	In order to meet this standard, it is expected that students will • identify and describe common types of storms, including the precipitation that may be associated with each (2.6 a) • compare droughts and floods (2.6 a) observe, describe, and record daily weather conditions using weather instruments; graph and analyze data to identify patterns; predict weather based upon identified patterns (2.6 b) observe and describe seasonal weather patterns and local variations (2.6 c) • describe how tracking weather data helps to prepare for storms and other weather conditions (2.6 c).

2.7 The student will investigate and understand that weather patterns and seasonal changes affect plants, animals, and their surroundings. Key ideas include

a) weather and seasonal changes affect the growth and behavior of living things;
b) wind and weather can change the land; and
c) changes can happen quickly or slowly over time.

Central Idea: Weather conditions and seasons affect plants, animals, and their surroundings.

Vertical Alignment: Students investigate and understand the relationship between seasonal change and weather in first grade. Important concepts include how plants, animals, and people respond to changes in light, temperature, and precipitation (1.7). The effects of natural events, including fire, flood, and erosion, on ecosystems is part of the third-grade standards (3.8).

Enduring Understandings	**Essential Knowledge and Practices**
Changes in weather and seasons affect both living organisms and their environment. • Living organisms respond to weather patterns and seasonal changes that can be reflected in changes in growth and behavior (2.7 a). • Adverse conditions of weather may slow the growth and development of plants and animals, whereas optimal weather conditions may accelerate the growth and development of plants and animals (2.7 a). • Dormancy is a state of reduced metabolic activity adopted by many organisms (both plants and animals) under conditions of environmental stress or when such stressful conditions are likely to appear, such as in winter. Many trees produce new leaves in the spring and lose them in the fall due to seasonal changes in temperature and light (2.7 a). • The outward coloration and coloration patterns of many animals are similar in appearance to the plants in the places in which they live. This similarity to background is referred	In order to meet this standard, it is expected that students will • identify growth and behavioral responses of plants and animals to weather and seasonal changes (2.7 a) • identify animals that migrate, hibernate, or show other changes due to seasonal weather changes (2.7 a) • compare the responses of plants and animals to weather and seasonal changes (2.7 a) • explain how an animal's behavior may change throughout the year due to food source availability (2.7 a) model the effects of weathering and erosion on the land surface (2.7 b) design and construct a model of a structure that can withstand changes in land due to erosion or weathering (2.7 b) • identify examples of weather and seasonal changes that happen slowly and quickly (2.7 c).

Enduring Understandings	Essential Knowledge and Practices
to as camouflage, and it enables animals to hide and avoid those that may eat or harm them (2.7 a). • Some animals (e.g., geese, monarch butterflies, tundra swans) travel from one place to another and back again (migration) in search of a new temporary habitat because of climate, availability of food, season of the year, or reproduction (2.7 a). • Some animals (e.g., groundhogs, bats) go into a resting state (hibernation) due to seasonal changes. Hibernation is a condition of biological rest or inactivity where growth, development, and metabolism slow down (2.7 a). • Some animals undergo physical changes (e.g., thickening of dog fur in the winter and shedding in the summer) from season to season (2.7 a). • Land surfaces can be changed by weathering and erosion. Land surfaces that are not covered with or protected by plants are more likely to be subject to the loss of soil by wind and water (2.7 b). • Weathering is the breaking down of rocks, which usually happens over long periods of time (2.7 b). • Erosion is the process by which the products of weathering are moved from one place to another. Erosion may happen quickly (e.g., during a flood or a hurricane) or over a long period of time (2.7 b). • Examples of weather and seasonal changes that happen quickly include mud slides and flooding. Examples of weather and seasonal changes that occur slowly include beach erosion and leaves changing color (2.7 c).	

Earth Resources

2.8 The student will investigate and understand that plants are important natural resources. Key ideas include
- **a) the availability of plant products affects the development of a geographic area;**
- **b) plants provide oxygen, homes, and food for many animals; and**
- **c) plants can help reduce the impact of wind and water.**

Central Idea: Plants have many roles in a system, which include providing for the basic life needs of animals and reducing the impact of weather on land.

Vertical Alignment: Students investigate natural resources and conservation in kindergarten and first grade (K.11, 1.8). Third grade explores the impact of humans and natural events on ecosystems and the availability of natural resources (3.8).

Enduring Understandings	Essential Knowledge and Practices
Natural resources are materials with different properties and are suited for different uses. Natural resources are limited and are distributed unevenly around the planet. • Plants provide many useful products and materials, which benefit human beings as well as other living organisms. Examples include cotton, spices, lumber, rubber, medicines, and paper (2.8 a, b). • Plants may grow well in certain geographic areas, thus enabling the production of plant products that allow humans to live in and thrive in those areas (2.8 a). • Many animals benefit from plants. Plants provide food, shelter, and oxygen. These are required to meet basic life needs (2.8 b). • Some examples of plants that grow in Virginia's geographic regions include o Coastal Plains (Tidewater)—peanuts, cotton, soybeans	In order to meet this standard, it is expected that students will • describe useful plant products and the region in which they are grown in Virginia (2.8 a) • identify where crops are grown in Virginia and predict the impact they have on the area's development (2.8 a) • explain the roles of plants in meeting the life needs of animals (2.8 b) compare different ways animals use plants as homes and shelters (2.8 b) construct and interpret a chart illustrating plant foods consumed by different animals (2.8 b) construct and interpret models as to how plants help reduce the impact of wind and water (2.8 c).

Enduring Understandings	Essential Knowledge and Practices
○ Piedmont—apples, tobacco, cabbage ○ Blue Ridge Mountains—evergreens, apples, corn ○ Valleys and Ridges—evergreens, apples, corn ○ Appalachian Plateau—tobacco (2.8 a). *Students are not responsible for identifying specific regions or matching the products to the region in second grade*. • Plants are important in the prevention of soil erosion. In addition, plants help reduce the effects of flooding (2.8 c). • Plants can be used to reduce the impact of high winds and blowing snow on roadways. Trees and vegetation can be planted along roadways to reduce the impact of wind; these are called windbreaks (2.8 c).	