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# Science Standards of Learning

for  
Virginia  
Public Schools



**Board of Education  
Commonwealth of Virginia**

**October 2018**

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## for Virginia Public Schools

**Adopted October 2018 by the  
Board of Education**

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## **Preface**

In 1995, the Virginia Board of Education published Standards of Learning in English, mathematics, science, and history and social science for kindergarten through grade 12. Subsequently, Standards of Learning were developed for all academic content areas. The Standards of Learning provide a framework for instructional programs designed to raise the academic achievement of all students in Virginia and to prepare students for post-secondary success. School divisions and teachers incorporate the standards in local curriculum and classroom instruction.

The Standards of Learning set reasonable targets and expectations for what teachers must teach and students must learn. The standards are not intended to encompass the entire curriculum for a given grade level or course or to prescribe how the content should be taught; the standards are to be incorporated into a broader, locally designed curriculum. Teachers are encouraged to go beyond the standards and select instructional strategies and assessment methods appropriate for their students.

The Standards of Learning were developed through a series of public hearings and the efforts of parents, teachers, representatives from higher education, science education organizations, and business and industry leaders. The standards set clear and concise academic expectations for young people. Parents are encouraged to work with their children to help them achieve these academic standards.

## Introduction

The *Science Standards of Learning* for Virginia Public Schools identify academic content for essential components of the science curriculum at different grade levels. The content of the standards, in conjunction with effective instruction, provide a platform for creating scientifically literate students. The *Science Standards of Learning* reflect a vertical progression of content and practices. The Standards of Learning contain content strands or topics that progress in complexity as they are studied at various grade levels in grades K-5 and are represented indirectly throughout the middle and high school courses. These strands are

- Scientific and Engineering Practices
- Force, Motion, and Energy
- Matter
- Living Systems and Processes
- Earth and Space Systems
- Earth Resources

Six critical components for achieving science literacy are 1) Goals; 2) Investigate and Understand; 3) Nature of Science; 4) Science and Engineering Practices; 5) K-12 Safety; and 6) Instructional Technology. These six components support the Profile of a Virginia Graduate and an integrated instructional approach that incorporates science, technology, engineering, and mathematics (STEM). It is imperative to science instruction that the local curriculum consider and address how these components are incorporated in the design of the K-12 science program.

## Goals

The *Science Standards of Learning* for Virginia Public Schools serve as a framework for educators to meet science education goals and support students' investigation of the natural world. The goals of science instruction include

- Use scientific processes to safely investigate the natural world;
- Develop the scientific knowledge, skills, and attributes to be successful in college, explore science-related careers and interests, and be work-force ready ;
- Develop scientific dispositions and habits of mind (collaboration, curiosity, creativity, demand for verification, open-mindedness, respect for logical and rational thinking, objectivity, learning from mistakes, patience, and persistence);
- Possess significant knowledge of science to be informed consumers with the ability to communicate and use science in their everyday lives and engage in public discussions;
- Make informed decisions regarding contemporary civic, environmental, and economic issues;
- Apply knowledge of mathematics and science in an authentic way using the engineering design process to solve societal problems; and
- Develop an understanding of the interrelationship of science with technology, engineering and mathematics (STEM).

## **Investigate and Understand**

Many of the standards in the *Science Standards of Learning* begin with the phrase “Students will investigate and understand.” This phrase communicates the wide range of science knowledge, skills, and practices required to effectively investigate and understand the natural world.

“Investigate” refers to scientific methodology and implies systematic use of the following inquiry and engineering skills:

- 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
- Obtaining, evaluating, and communicating information

“Understand” refers to the application of scientific knowledge including the ability to:

- apply understanding of key science concepts and the nature of science;
- use important information, key definitions, terminology, and facts to make judgments about information in terms of its accuracy, precision, consistency, or effectiveness;
- apply information and principles to new problems or situations, recognizing what information is required for a particular situation, using the information to explain new phenomena, and determining when there are exceptions;
- explain the information in one’s own words, comprehend how the information is related to other key facts, and suggest additional interpretations of its meaning or importance;
- think critically, problem-solve, and make decisions;
- analyze the underlying details of important facts and principles, recognizing the key relations and patterns that are not always readily visible; and
- arrange and combine important facts, principles, and other information to produce a new idea, plan, procedure, or product to solve problems.

Therefore, the use of “investigate and understand” allows each content standard to become the basis for a broad range of teaching objectives, which the school division will develop and refine to meet the intent of the *Science Standards of Learning*.

## **Nature of Science**

Science is not a mere accumulation of facts; instead, it is a discipline with common practices for understanding the natural world. The nature of science describes these common practices employed by scientists and it reflects the intrinsic values and assumptions of scientific knowledge. The nature of science explains the functioning of science, what science is, how it develops and builds the knowledge it generates, and the methodology used to disseminate and validate knowledge.

Regardless of the career that a student chooses to pursue, all students should be science literate with an understanding of the nature of science and the scientific knowledge and skills necessary to make informed decisions.

## 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 competences with techniques at the heart of each discipline.

## K-12 Safety

In implementing the *Science Standards of Learning*, teachers must be certain that students know how to follow safety guidelines, demonstrate appropriate laboratory safety techniques, and use equipment safely while working individually and in groups.

Safety must be given the highest priority in implementing the K-12 instructional program for science. Correct and safe techniques, as well as wise selection of experiments, resources, materials, and field experiences appropriate to age levels, must be carefully considered with regard to the safety precautions for every instructional activity. Safe science classrooms require thorough planning, careful management, and constant monitoring of student activities. Class enrollment should not exceed the designed capacity of the room.

Teachers must be knowledgeable of the properties, use, and proper disposal of all chemicals that may be judged as hazardous before their use in an instructional activity. Such information is referenced through Safety Data Sheets (SDS), which conform to the requirements of the Globally Harmonized System of Classification and Labeling of Chemicals (GHS), effective May 2012. The identified precautions involving the use of goggles, gloves, aprons, and fume hoods must be followed as prescribed.

The following sources offer further guidance on science safety:

- Occupational Safety and Health Administration;
- International Science and Engineering Fair rules;
- Virginia Department of Education (VDOE) Science Safety Handbook on the VDOE Science Instruction webpage;
- American Chemical Society (ACS) resources: *Safety in the Elementary Science Classroom*, *Chemical Safety for Teachers and their Supervisors*, and *Guidelines for Chemical Laboratory Safety* on the ACS webpage; and
- public health departments' and school divisions' protocols and chemical hygiene plans.

## Instructional Technology

The primary purpose of the use of instructional technology is to support effective teaching and learning. A secondary purpose is to aid in preparing students for life after their K-12 education by ensuring that they are skillful in using current technology tools and in learning how to use new tools that may benefit their personal and professional lives. As such, the use of current and emerging technology is essential to the K-12 science instructional program.

Effective use of instructional technology in the science classroom requires that technology is integrated throughout the curriculum, is seamless in its application, and includes instrumentation oriented toward the teaching and learning of science concepts, skills, and processes. In addition to traditional instruments of science, such as microscopes, lab ware, and data-collecting apparatus, the technology used should also include computers, robotics, video-microscopes, graphing calculators, probeware, geospatial technologies, online communication, software, appropriate hardware, and other applicable emerging technologies.

### Profile of a Virginia Graduate

The *2018 Science Standards of Learning* support the Profile of a Virginia Graduate through the development and use of communication, collaboration, critical thinking, and creative thinking skills and the applications of civic responsibility in the understanding and applications of science.

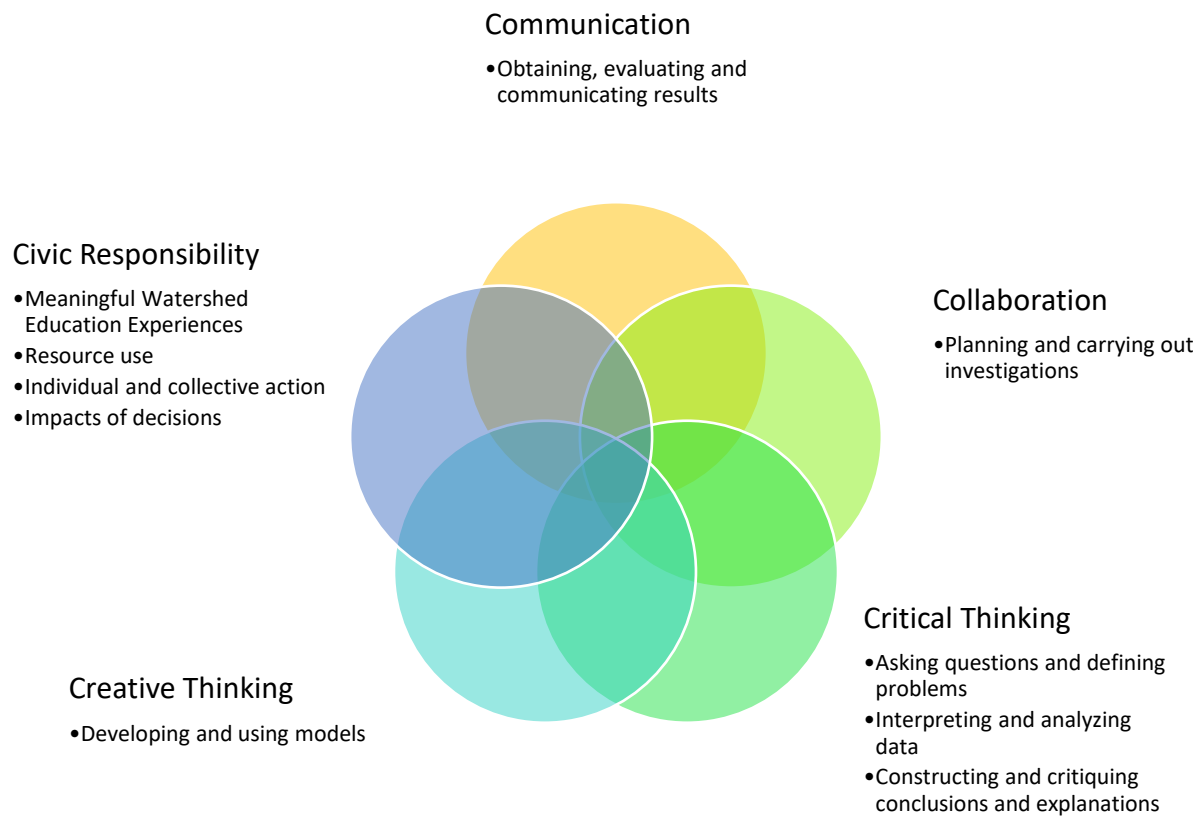


Figure 1: Visual representation of the science skills and processes aligned to the Profile of a Virginia Graduate



## Physical Science

The Physical Science standards stress an in-depth understanding of the nature and structure of matter and the characteristics of energy. Major areas covered by the standards include the particle nature of matter, the organization and use of the periodic table; physical and chemical changes; energy transfer and transformations; properties of longitudinal and transverse waves; electricity and magnetism; and work, force, and motion. The standards build on skills of systematic investigation with a clear focus on variables and repeated trials. Validating conclusions with evidence and data becomes increasingly important at this level. Mathematics, computational thinking, and experience in the engineering design process gain importance as students advance in their scientific thinking.

- PS.1 The student will demonstrate an understanding of scientific and engineering practices by
- a) asking questions and defining problems
    - ask questions that require empirical evidence to answer
    - develop hypotheses indicating relationships between independent and dependent variables
    - offer simple solutions to design problems
  - b) planning and carrying out investigations
    - independently and collaboratively plan and conduct observational and experimental investigations; identify variables, constants, and controls where appropriate and include the safe use of chemicals and equipment
    - evaluate the accuracy of various methods for collecting data
    - take metric measurements using appropriate tools and technologies
    - apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process or system
  - c) interpreting, analyzing, and evaluating data
    - construct and interpret data tables showing independent and dependent variables, repeated trials, and means
    - construct, analyze, and interpret graphical displays of data and consider limitations of data analysis
    - apply mathematical concepts and processes to scientific questions
    - use data to evaluate and refine design solutions to best meet criteria
  - d) constructing and critiquing conclusions and explanations
    - construct scientific explanations based on valid and reliable evidence obtained from sources (including the students' own investigations)
    - construct arguments supported by empirical evidence and scientific reasoning
    - generate and compare multiple solutions to problems based on how well they meet the criteria and constraints
    - differentiate between a scientific hypothesis, theory, and law

- e) developing and using models
    - construct, develop, and use models and simulations to illustrate and/or explain observable and unobservable phenomena
    - evaluate limitations of models
  - f) obtaining, evaluating, and communicating information
    - read scientific texts, including those adapted for classroom use, to determine the central idea and/or obtain scientific and/or technical information
    - gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication
    - construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning
- PS.2 The student will investigate and understand that matter is composed of atoms. Key ideas include
- a) our understanding of atoms has developed over time;
  - b) the periodic table can be used to predict the chemical and physical properties of matter; and
  - c) the kinetic molecular theory is used to predict and explain matter interactions.
- PS.3 The student will investigate and understand that matter has properties and is conserved in chemical and physical processes. Key ideas include
- a) pure substances can be identified based on their chemical and physical properties;
  - b) pure substances can undergo physical and chemical changes that may result in a change of properties;
  - c) compounds form through ionic and covalent bonding; and
  - d) balanced chemical equations model the conservation of matter.
- PS.4 The student will investigate and understand that the periodic table is a model used to organize elements based on their atomic structure. Key uses include
- a) symbols, atomic numbers, atomic mass, chemical groups (families), and periods are identified on the periodic table; and
  - b) elements are classified as metals, metalloids, and nonmetals.
- PS.5 The student will investigate and understand that energy is conserved. Key ideas include
- a) energy can be stored in different ways;
  - b) energy is transferred and transformed; and
  - c) energy can be transformed to meet societal needs.

- PS.6 The student will investigate and understand that waves are important in the movement of energy. Key ideas include
- energy may be transferred in the form of longitudinal and transverse waves;
  - mechanical waves need a medium to transfer energy;
  - waves can interact; and
  - energy associated with waves has many applications.
- PS.7 The student will investigate and understand that electromagnetic radiation has characteristics. Key ideas include
- electromagnetic radiation, including visible light, has wave characteristics and behavior; and
  - regions of the electromagnetic spectrum have specific characteristics and uses.
- PS.8 The student will investigate and understand that work, force, and motion are related. Key ideas include
- motion can be described using position and time; and
  - motion is described by Newton's laws.
- PS.9 The student will investigate and understand that there are basic principles of electricity and magnetism. Key ideas include
- an imbalance of charge generates static electricity;
  - materials have different conductive properties;
  - electric circuits transfer energy;
  - magnetic fields cause the magnetic effects of certain materials;
  - electric current and magnetic fields are related; and
  - many technologies use electricity and magnetism.