
Science Standards of Learning

for
Virginia
Public Schools



**Board of Education
Commonwealth of Virginia**

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Board of Education**

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Notice to Reader

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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.

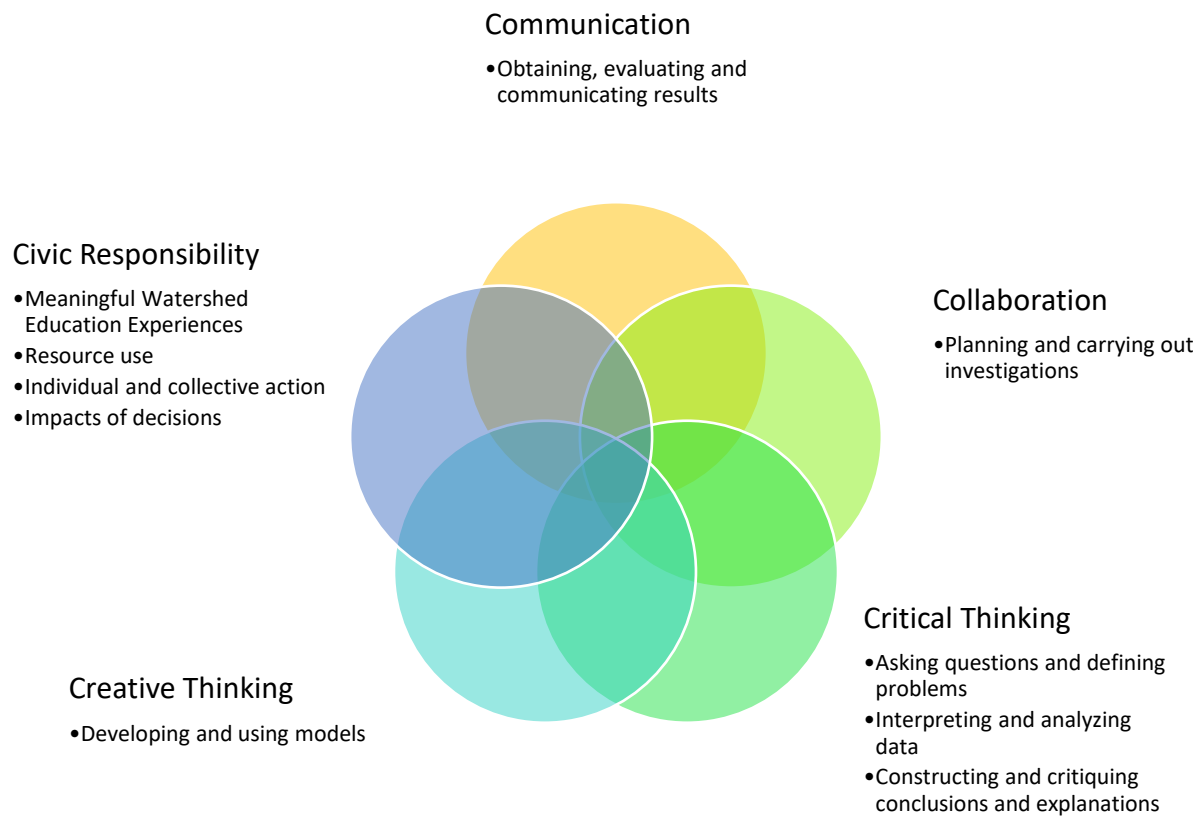


Figure 1: Visual representation of the science skills and processes aligned to the Profile of a Virginia Graduate

Biology

The Biology standards are designed to provide students with a detailed understanding of living systems. Students investigate biochemical life processes, cellular organization, mechanisms of inheritance, dynamic relationships among organisms, and the changes in organisms through time. Skills necessary to examine scientific explanations, conduct experiments, analyze and communicate information, and gather and use information in scientific literature continues to be important. The importance of scientific research that validates or challenges ideas is emphasized at this level. Tools and technology, including calculators, computers, probeware, and microscopes are used when feasible. Students will use chemicals and equipment safely. Mathematics, computational thinking, and experience in the engineering design process are important as students advance in their scientific thinking.

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

- a) asking questions and defining problems
 - ask questions that arise from careful observation of phenomena and/or organisms, from examining models and theories, and/or to seek additional information
 - determine which questions can be investigated within the scope of the school laboratory or field to determine relationships between independent and dependent variables
 - generate hypotheses based on research and scientific principles
 - make hypotheses that specify what happens to a dependent variable when an independent variable is manipulated
- b) planning and carrying out investigations
 - individually and collaboratively plan and conduct observational and experimental investigations
 - plan and conduct investigations or test design solutions in a safe and ethical manner including considerations of environmental, social, and personal effects
 - determine appropriate sample size and techniques
 - select and use appropriate tools and technology to collect, record, analyze, and evaluate data
- 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
 - use data in building and revising models, supporting an explanation for phenomena, or testing solutions to problems
 - analyze data using tools, technologies, and/or models to make valid and reliable scientific claims or determine an optimal design solution
- d) constructing and critiquing conclusions and explanations
 - make quantitative and/or qualitative claims regarding the relationship between dependent and independent variables

- construct and revise explanations based on valid and reliable evidence obtained from a variety of sources including students' own investigations, models, theories, simulations, and peer review
 - apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and design solutions
 - compare and evaluate competing arguments or design solutions in light of currently accepted explanations and new scientific evidence
 - construct arguments or counterarguments based on data and evidence
 - differentiate between a scientific hypothesis and theory
- e) developing and using models
- evaluate the merits and limitations of models
 - develop, revise, and/or use models based on evidence to illustrate or predict relationships
 - develop and/or use models to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems
- f) obtaining, evaluating, and communicating information
- compare, integrate, and evaluate sources of information presented in different media or formats to address a scientific question or solve a problem
 - gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and credibility of each source
 - communicate scientific and/or technical information about phenomena in multiple formats

BIO.2 The student will investigate and understand that chemical and biochemical processes are essential for life. Key ideas include

- a) water chemistry has an influence on life processes;
- b) macromolecules have roles in maintaining life processes;
- c) enzymes have a role in biochemical processes;
- d) protein synthesis is the process of forming proteins which influences inheritance and evolution; and
- e) the processes of photosynthesis and respiration include the capture, storage, transformation, and flow of energy.

BIO.3 The student will investigate and understand that cells have structure and function. Key ideas include

- a) the cell theory is supported by evidence;
- b) structures in unicellular and multicellular organisms work interdependently to carry out life processes;
- c) cell structures and processes are involved in cell growth and division;
- d) the structure and function of the cell membrane support cell transport; and
- e) specialization leads to the development of different types of cells.

BIO.4 The student will investigate and understand that bacteria and viruses have an effect on living systems. Key ideas include

- a) viruses depend on a host for metabolic processes;
- b) the modes of reproduction/replication can be compared;
- c) the structures and functions can be compared;
- d) bacteria and viruses have a role in other organisms and the environment; and
- e) the germ theory of infectious disease is supported by evidence.

BIO.5 The student will investigate and understand that there are common mechanisms for inheritance. Key ideas include

- a) DNA has structure and is the foundation for protein synthesis;
- b) the structural model of DNA has developed over time;
- c) the variety of traits in an organism are the result of the expression of various combinations of alleles;
- d) meiosis has a role in genetic variation between generations; and
- e) synthetic biology has biological and ethical implications.

BIO.6 The student will investigate and understand that modern classification systems can be used as organizational tools for scientists in the study of organisms. Key ideas include

- a) organisms have structural and biochemical similarities and differences;
- b) fossil record interpretation can be used to classify organisms;
- c) developmental stages in different organisms can be used to classify organisms;
- d) Archaea, Bacteria, and Eukarya are domains based on characteristics of organisms;
- e) the functions and processes of protists, fungi, plants, and animals allow for comparisons and differentiation within the Eukarya kingdoms; and
- f) systems of classification are adaptable to new scientific discoveries.

BIO.7 The student will investigate and understand that populations change through time. Key ideas include

- a) evidence is found in fossil records and through DNA analysis;
- b) genetic variation, reproductive strategies, and environmental pressures affect the survival of populations;
- c) natural selection is a mechanism that leads to adaptations and may lead to the emergence of new species; and
- d) biological evolution has scientific evidence and explanations.

BIO.8 The student will investigate and understand that there are dynamic equilibria within populations, communities, and ecosystems. Key ideas include

- a) interactions within and among populations include carrying capacities, limiting factors, and growth curves;
- b) nutrients cycle with energy flow through ecosystems;
- c) ecosystems have succession patterns; and
- d) natural events and human activities influence local and global ecosystems and may affect the flora and fauna of Virginia.