

VDOE Earth Science Instruction and Assessment Support Document

August 16, 2022

The 2018 *Science Standards of Learning* and the 2018 *Science Curriculum Framework* were adopted by the Virginia Board of Education (BOE) in October, 2018. These documents identify the academic content and essential components of the science curriculum at different grade levels for Virginia's schools. The full implementation of the 2018 *Science Standards of Learning* is required in all classrooms starting fall, 2022. At this time, all public school divisions in Virginia are expected to teach and assess the 2018 *Science Standards of Learning*. In addition, the federally mandated state assessments in science will reflect the 2018 *Science Standards of Learning* starting spring, 2023.

Currently, the federal government requires one state mandated assessment in science in elementary, middle, and high school (grades 9-12). Biology has been identified by the BOE as the *Standards of Learning* assessment for high school students. Although Biology is the mandated state assessment, both the Earth Science and Chemistry *Standards of Learning* assessments are available for students in order to earn a verified credit in science needed for graduation in Virginia public schools. Although instruction of the 2018 *Science Standards of Learning* is required of all schools in Virginia, the content of both the Earth Science and Chemistry assessment will reflect the 2010 *Science Standards of Learning*.

Although the content domains are identical between the two set of Earth Science standards, the ways that students demonstrate mastery, as referenced in the curriculum framework documents, have changed to include opportunities for students to apply Scientific and Engineering Practices when developing conceptual understanding that build towards scientific literacy. The emphasis of the 2018 *Science Standards of Learning and Curriculum Framework* is on concept building and application of practices with the goal of providing a foundation for students to use when making informed decisions in the future vs an emphasis on memorization of specific people or events.

The VDOE recognizes that a gap exists between the expectations of the 2010 and 2018 *Curriculum Framework* that reflect what is to be taught and assessed in Earth Science. The purpose of this document is to provide support to teachers to address these gaps when preparing students to take the Earth Science *Standards of Learning* assessment.

Points to consider when reviewing this document or adapting instruction to address gaps in content and expectations between the 2010 and 2018 *Earth Science Standards of Learning*:

1. How many students currently enrolled in Earth Science do not have a verified credit in science through passing the state mandated Biology assessment?
2. Of these students, did all take the Biology *Standards of Learning* assessment as required by federal legislation?

3. Does your division provide additional curriculum to address gaps in content and/or expectations between the 2010 and 2018 standards?

If division pathways allow for a high school course, such as Earth Science, to be taken in middle school, please refer to VDOE requirements below.

1. All students must be provided instruction based on the three sets of middle grades science standards (Sixth Grade Science, Life Science, and Physical Science) prior to advancing to a high school laboratory science course.
2. Student instruction on the middle grades science standards may be completed on a schedule established by the school division, generally three years or less, depending on how the middle grades curriculum is sequenced and prior to the end of grade eight. The *VDOE recommends that divisions instruct middle school science in three years in order to allow opportunities for students to engage in Scientific and Engineering Practices in rich learning environments.*
3. All students must take the middle grades *Science Standards of Learning* assessment. This must occur at the completion of instruction on the middle grades science standards and prior to enrolling in a high school laboratory science course.
4. Students must take the Earth Science *Standards of Learning* assessment when taking the course in middle school (. Students must also take the Biology *Standards of Learning* assessment in grades 9-12 in order to meet federal assessment mandates.

General changes evidenced in the Virginia 2018 *Science Standards of Learning*:

- The 2018 *Science Standards of Learning* have been restructured to support the development of concepts versus a focus on terminology. The introduction of terms as students develop conceptual understanding through engaging in science and engineering practices is a research based best practice in science instruction. The practice of introducing scientific terms and their definitions at the beginning of a unit is proven to be an ineffective instructional strategy in science education.
- The section Scientific Investigation, Reasoning, and Logic has been changed to Scientific and Engineering Practices. The expectation is that these practices are integrated to support and enhance the concepts within the standards. **Please refer to the leaves in the Essential Knowledge and Practices portion of the 2018 *Earth Science Curriculum Framework* for more information on the integration of the Scientific and Engineering Practices.**
- In studying the historical developments of current science concepts, instructional emphasis should be placed on the nature of science and the contributions that led to the development of the scientific concept, theory, or law versus the identification of specific scientists or events.

Summary of changes specific to Earth Science:

- The content of the previous ES.2 of the 2010 Standards was incorporated into the ES.1 of the 2018 Standards and throughout the other Earth Science standards to support content.
- The order of the standards was revised and the origin of the universe (ES.13) has been incorporated into ES.2.
- Global warming is explicitly addressed in ES.12 of the 2018 Standards and was not explicitly addressed in the 2010 Standards; however, evidence of climate change was interwoven throughout the 2010 Standards and Curriculum Framework.
- Greater emphasis on human influence on atmospheric composition and dynamics was added into ES.11.
- In the 2018 *Earth Science Curriculum Framework* students are expected to use classification tools to classify rocks and minerals. The expectation of the 2010 Standards was that students are expected to describe characteristics of different rocks and minerals.
- The 2010 *Earth Science Curriculum Framework* emphasizes specific people and events with the expectation that students describe these in respect to the Nature of Science, the 2018 *Earth Science Curriculum Framework* expects students to recognize that these events support an understanding the Nature of Science.

2010	2018
<p>ES.1 The student will plan and conduct investigations in which</p> <ul style="list-style-type: none"> a) volume, area, mass, elapsed time, direction, temperature, pressure, distance, density, and changes in elevation/depth are calculated utilizing the most appropriate tools; b) technologies, including computers, probeware, and geospatial technologies, are used to collect, analyze, and report data and to demonstrate concepts and simulate experimental conditions; c) scales, diagrams, charts, graphs, tables, imagery, models, and profiles are constructed and interpreted; d) maps and globes are read and interpreted, including location by latitude and longitude; e) variables are manipulated with repeated trials; and f) current applications are used to reinforce Earth science concepts. 	<p>ES.1 The student will demonstrate an understanding of scientific and engineering practices by</p> <ul style="list-style-type: none"> a) asking questions and defining problems <ul style="list-style-type: none"> • ask questions that arise from careful observation of phenomena, examination of a model or theory, or unexpected results, and/or to seek additional information • determine which questions can be investigated within the scope of the school laboratory or field experience • generate hypotheses based on research and scientific principles • make hypotheses that specify what happens to a dependent variable when an independent variable is manipulated • define design problems that involve the development of a process or system with multiple components and criteria b) planning and carrying out investigations <ul style="list-style-type: none"> • individually and collaboratively plan and conduct observational and experimental investigations • plan and conduct investigations to test design solutions in a safe and ethical manner including considerations of environmental, social and personal effects • select and use appropriate tools and technology to collect, record, analyze, and evaluate data c) interpreting, analyzing, and evaluating data <ul style="list-style-type: none"> • construct and interpret data

2010	2018
<p>ES.2 The student will demonstrate an understanding of the nature of science and scientific reasoning and logic. Key concepts include</p> <ul style="list-style-type: none"> a) science explains and predicts the interactions and dynamics of complex Earth systems; b) evidence is required to evaluate hypotheses and explanations; c) observation and logic are essential for reaching a conclusion; and d) evidence is evaluated for scientific theories. 	<p>Explicitly stated in Life Science. Students are responsible knowing for content learned in prior years of instruction. This topic is intended to be interwoven into all science disciplines.</p>

2010	2018
<p>ES.3 The student will investigate and understand the characteristics of Earth and the solar system. Key concepts include</p> <ul style="list-style-type: none"> a) position of Earth in the solar system; b) sun-Earth-moon relationships; (seasons, tides, and eclipses); c) characteristics of the sun, planets and their moons, comets, meteors, and asteroids; and d) the history and contributions of space exploration. <p>ES.13 The student will investigate and understand scientific concepts related to the origin and evolution of the universe. Key concepts include</p> <ul style="list-style-type: none"> a) cosmology including the Big Bang theory; and b) the origin and evolution of stars, star systems, and galaxies. 	<p>ES.2 The student will demonstrate an understanding that there are scientific concepts related to the origin and evolution of the universe. Key ideas include</p> <ul style="list-style-type: none"> a) the big bang theory explains the origin of universe; b) stars, star systems, and galaxies change over long periods of time; c) characteristics of the sun, planets and their moons, comets, meteors, asteroids, and dwarf planets are determined by materials found in each body; and d) evidence from space exploration has increased our understanding of the structure and nature of our universe. <p>ES.3 The student will investigate and understand that Earth is unique in our solar system. Key ideas include</p> <ul style="list-style-type: none"> a) Earth supports life because of its relative proximity to the sun and other factors; and b) the dynamics of the sun-Earth-moon system cause seasons, tides, and eclipses
<p>ES.4 The student will investigate and understand how to identify major rock-forming and ore minerals based on physical and chemical properties. Key concepts include</p> <ul style="list-style-type: none"> a) hardness, color and streak, luster, cleavage, fracture, and unique properties; and b) uses of minerals. 	<p>ES.4 The student will investigate and understand that there are major rock-forming and ore minerals. Key ideas include</p> <ul style="list-style-type: none"> a) analysis of physical and chemical properties supports mineral identification; b) characteristics of minerals determine the uses of minerals; and c) minerals originate and are formed in specific ways.

2010	2018
<p>ES.5 The student will investigate and understand the rock cycle as it relates to the origin and transformation of rock types and how to identify common rock types based on mineral composition and textures. Key concepts include</p> <ul style="list-style-type: none"> a) igneous rocks; b) sedimentary rocks; and c) metamorphic rocks. 	<p>ES.5 The student will investigate and understand that igneous, metamorphic, and sedimentary rocks can transform. Key ideas include</p> <ul style="list-style-type: none"> a) Earth materials are finite and are transformed over time; b) the rock cycle models the transformation of rocks; c) layers of Earth have rocks with specific chemical and physical properties; and d) plate tectonic and surface processes transform Earth materials.
<p>ES.6 The student will investigate and understand the differences between renewable and nonrenewable resources. Key concepts include</p> <ul style="list-style-type: none"> a) fossil fuels, minerals, rocks, water, and vegetation; b) advantages and disadvantages of various energy sources; c) resources found in Virginia; and d) environmental costs and benefits. 	<p>ES.6 The student will investigate and understand that resource use is complex. Key ideas include</p> <ul style="list-style-type: none"> a) global resource use has environmental liabilities and benefits; b) availability, renewal rates, and economic effects are considerations when using resources; c) use of Virginia resources has an effect on the environment and the economy; and d) all energy sources have environmental and economic effects.

2010	2018
<p>ES.7 The student will investigate and understand geologic processes including plate tectonics. Key concepts include</p> <ul style="list-style-type: none"> a) geologic processes and their resulting features; and b) tectonic processes. 	<p>ES.7 The student will investigate and understand that plate tectonic theory explains Earth’s internal and external geologic processes. Key ideas include</p> <ul style="list-style-type: none"> a) convection currents in Earth’s interior lead to the movement of plates and influence the distribution of materials in Earth’s layers, and may impact the magnetic field; b) features and processes occur within plates and at plate boundaries; c) interaction between tectonic plates causes the development of mountain ranges and ocean basins; and d) evidence of geologic processes is found in Virginia’s geologic landscape.
<p>ES.8 The student will investigate and understand how freshwater resources are influenced by geologic processes and the activities of humans. Key concepts include</p> <ul style="list-style-type: none"> a) processes of soil development; b) development of karst topography; c) relationships between groundwater zones, including saturated and unsaturated zones, and the water table; d) identification of sources of fresh water including rivers, springs, and aquifers, with reference to the hydrologic cycle; e) dependence on freshwater resources and the effects of human usage on water quality; and f) identification of the major watershed systems in Virginia, including the Chesapeake Bay and its tributaries. 	<p>ES.8 The student will investigate and understand that freshwater resources influence and are influenced by geologic processes and human activity. Key ideas include</p> <ul style="list-style-type: none"> a) water influences geologic processes including soil development and karst topography; b) the nature of materials in the subsurface affect the water table and future availability of fresh water; c) weather and human usage affect freshwater resources, including water locations, quality, and supply; and d) stream processes and dynamics affect the major watershed systems in Virginia, including the Chesapeake Bay and its tributaries.

2010	2018
<p>ES.9 The student will investigate and understand that many aspects of the history and evolution of Earth and life can be inferred by studying rocks and fossils. Key concepts include</p> <ul style="list-style-type: none"> a) traces and remains of ancient, often extinct, life are preserved by various means in many sedimentary rocks; b) superposition, cross-cutting relationships, index fossils, and radioactive decay are methods of dating bodies of rock; c) absolute and relative dating have different applications but can be used together to determine the age of rocks and structures; and d) rocks and fossils from many different geologic periods and epochs are found in Virginia. 	<p>ES.9 The student will investigate and understand that many aspects of the history and evolution of Earth and life can be inferred by studying rocks and fossils. Key ideas include</p> <ul style="list-style-type: none"> a) traces and remains of ancient, often extinct, life are preserved by various means in sedimentary rocks; b) superposition, cross-cutting relationships, index fossils, and radioactive decay are methods of dating rocks and Earth events and processes; c) absolute (radiometric) and relative dating have different applications but can be used together to determine the age of rocks and structures; and d) rocks and fossils from many different geologic periods and epochs are found in Virginia.

2010	2018
<p>ES.10 The student will investigate and understand that oceans are complex, interactive physical, chemical, and biological systems and are subject to long- and short-term variations. Key concepts include</p> <ul style="list-style-type: none"> a) physical and chemical changes related to tides, waves, currents, sea level and ice cap variations, upwelling, and salinity variations; b) importance of environmental and geologic implications; c) systems interactions; d) features of the sea floor as reflections of tectonic processes; and e) economic and public policy issues concerning the oceans and the coastal zone including the Chesapeake Bay. 	<p>ES.10 The student will investigate and understand that oceans are complex, dynamic systems and are subject to long- and short-term variations. Key ideas include</p> <ul style="list-style-type: none"> a) chemical, biological, and physical changes affect the oceans; b) environmental and geologic occurrences affect ocean dynamics; c) unevenly distributed heat in the oceans drives much of Earth’s weather; d) features of the sea floor reflect tectonic and other geological processes; and e) human actions, including economic and public policy issues, affect oceans and the coastal zone including the Chesapeake Bay.

2010	2018
<p>ES.11 The student will investigate and understand the origin and evolution of the atmosphere and the interrelationship of geologic processes, biologic processes, and human activities on its composition and dynamics. Key concepts include</p> <ul style="list-style-type: none"> a) scientific evidence for atmospheric composition changes over geologic time; b) current theories related to the effects of early life on the chemical makeup of the atmosphere; c) atmospheric regulation mechanisms including the effects of density differences and energy transfer; and d) potential changes to the atmosphere and climate due to human, biologic, and geologic activity. 	<p>ES.11 The student will investigate and understand that the atmosphere is a complex, dynamic system and is subject to long-and short-term variations. Key ideas include</p> <ul style="list-style-type: none"> a) the composition of the atmosphere is critical to most forms of life; b) biologic and geologic interactions over long and short time spans change the atmospheric composition; c) natural events and human actions may stress atmospheric regulation mechanisms; and d) human actions, including economic and policy decisions, affect the atmosphere.

2010	2018
<p>ES.12 The student will investigate and understand that energy transfer between the sun and Earth and its atmosphere drives weather and climate on Earth. Key concepts include</p> <ul style="list-style-type: none"> a) observation and collection of weather data; b) prediction of weather patterns; c) severe weather occurrences, such as tornadoes, hurricanes, and major storms; and d) weather phenomena and the factors that affect climate including radiation, conduction, and convection. 	<p>ES.12 The student will investigate and understand that Earth’s weather and climate are the result of the interaction of the sun’s energy with the atmosphere, oceans, and the land. Key ideas include</p> <ul style="list-style-type: none"> a) weather involves the reflection, absorption, storage, and redistribution of energy over short to medium time spans; b) weather patterns can be predicted based on changes in current conditions; c) extreme imbalances in energy distribution in the oceans, atmosphere, and the land may lead to severe weather conditions; d) models based on current conditions are used to predict weather phenomena; and e) changes in the atmosphere and the oceans due to natural and human activity affect global climate.