

Science
Module 7

Earth and Space Science: Earth Materials
and Systems

Module Goal

The goal of this module is to provide information that will help educators increase their knowledge of grade-appropriate science concepts, knowledge, and skills to support effective planning or modification of their existing science instructional units for students with significant cognitive disabilities. The module includes important concepts, knowledge, and skills for the following instruction:

- Earth's Systems (elementary)—Earth's major systems (i.e., geosphere, hydrosphere, atmosphere, and biosphere) interact in various ways to affect Earth's surface materials and processes. Interactions between Earth's geosphere, atmosphere, and hydrosphere result in water cycling through the systems (e.g., the water cycle). Interactions between the atmosphere, hydrosphere, and geosphere create patterns of weather. Earth's physical features occur in patterns, as do earthquakes and volcanoes. Maps can be used to locate features and determine patterns in those events.
- Earth's Systems (middle)—The energy flowing and matter cycling within and among Earth comes from the sun and Earth's hot center. The cycling of energy and matter (e.g., rock cycle) causes chemical and physical changes in Earth's materials. Interactions between sunlight and Earth's systems affect the weather and climate. Observable patterns in these interactions and resulting weather can help predict the weather. The gradual movements of Earth's plates explain earthquakes, mountain building, and sea floor spreading, as well as continental and oceanic features such as volcanoes, faults, and trenches. Fossil comparisons along the edges of continents demonstrate the gradual movement of Earth's crust (i.e., lithospheric plate movement).
- Earth and Human Activity (middle)— The formation of many minerals depends on movement of magma and movement and evaporation rates of surface and ground water. Fossil fuel resources are found where geologic heat and pressure were placed on decaying plants and animals covered by sediments on the ocean floor over millions of years. Groundwater resources are affected by the location of permeable and impermeable rock layers and the level of yearly precipitation.

Module Objectives

The content module supports educators' planning and implementation of instructional units in science by:

- Developing an understanding of the concepts and vocabulary that interconnect with information in the module units.
- Learning instructional strategies that support teaching students the concepts, knowledge, and skills related to the module units.
- Discovering ways to transfer and generalize the content, knowledge, and skills to future school, community, and work environments.

The module provides an overview of the science concepts, content, and vocabulary related to Earth and Space Science: Earth Materials and Systems and provides suggested teaching strategies and ways to support transference and generalization of the concepts, knowledge, and skills. The module does not include lesson plans and is not a comprehensive instructional unit. Rather, the module provides information for educators to use when developing instructional units and lesson plans.

The module organizes the information using the following sections:

- I. Tennessee Academic Standards for Science and Related Knowledge and Skills Statements and Underlying Concepts;

- II. Scientific Inquiry and Engineering Design;
- III. Crosscutting Concepts;
- IV. Vocabulary and Background Knowledge information, including ideas to teach vocabulary;
- V. Overview of Units' Content;
- VI. Universal Design for Learning (UDL) Suggestions;
- VII. Transference and Generalization of Concepts, Knowledge, and Skills; and
- VIII. Tactile Maps and Graphics.

Section I

Tennessee Academic Standards for Science and Related Knowledge and Skills Statements and Underlying Concepts

It is important to know the expectations for each unit when planning for instruction. The first step in the planning process is to become familiar with the identified academic standards and the Knowledge and Skills Statements (KSSs) and Underlying Concepts (UCs) covered in the module. The KSSs are specific statements of knowledge and skills linked to the grade-specific science academic standards. The UCs are entry-level knowledge and skills that build toward a more complex understanding of the knowledge and skills represented in the KSSs and should not be taught in isolation. It is important to provide instruction on the KSSs along with the UCs to move toward acquisition of the same knowledge and skills.

Table 1 includes the academic standards and related KSSs and UCs for Earth and Space Science: Earth Materials and Systems. While only the academic standards targeted for the Tennessee Comprehensive Assessment Program/Alternate (TCAP/Alt) are included, instruction on additional standards will aid in student understanding. Standards that are not included still represent important content for students to master. Therefore, the KSSs and UCs included in the table do not cover all the concepts that can be taught to support progress and understanding aligned to the standards.

Table 1. Tennessee Academic Standards for Science and Related KSSs and UCs ¹

Academic Standards	Knowledge and Skills Statements (KSSs)	Underlying Concepts (UCs) of the Academic Standard
<i>Earth's Systems (elementary)</i>		
<p>3.ESS2.1: Explain the cycle of water on Earth.</p>	<p>3.ESS2.1.a: Ability to identify relevant components (i.e., water [liquid, solid, and in the atmosphere], atmosphere, landforms, plants, and other living things) in a model of water cycling between oceans, the atmosphere, and land</p>	<p>3.ESS2.1.UC: Match phases of water as a solid, liquid, or gas to different forms such as ice, rain, snow, and water vapor.</p>
<p>3.ESS2.3: Use tables, graphs, and tools to describe precipitation, temperature, and wind (direction and speed) to determine local weather and climate.</p>	<p>3.ESS2.3.a: Ability to use data to describe weather conditions (e.g., temperature, precipitation, wind direction)</p>	<p>3.ESS2.3.UC: Identify various weather conditions (e.g., sunny or cloudy, hot or cold, windy or calm, rainy or dry) on a given day.</p>
<p>4.ESS2.2: Interpret maps to determine that the location of mountain ranges, deep ocean trenches, volcanoes, and earthquakes occur in patterns.</p>	<p>4.ESS2.2.a: Ability to use maps to locate different Earth features (i.e., mountain ranges, deep ocean trenches, volcanoes)</p>	<p>4.ESS2.2.UC: Identify different Earth features (i.e., land and water) using a map.</p>
<i>Earth's Systems (middle)</i>		
<p>6.ESS2.5: Analyze and interpret data from weather conditions, weather maps, satellites, and radar to predict probable local weather patterns and conditions.</p>	<p>6.ESS2.5.a: Ability to interpret weather information (e.g., weather map) to make predictions about future conditions (e.g., precipitation, temperature)</p>	<p>6.ESS2.5.UC: Use basic weather information to identify current weather conditions.</p>
<p>8.ESS2.3: Describe the relationship between the processes and forces that create igneous, sedimentary, and metamorphic rocks.</p>	<p>8.ESS2.3.a: Ability to identify and use features to classify igneous, sedimentary, and metamorphic rocks</p> <p>8.ESS2.3.b: Ability to identify processes or transformations of Earth materials as they progress through the rock cycle to form new sedimentary, metamorphic, and igneous rocks</p>	<p>8.ESS2.3.UC: Recognize that there are different types of rocks.</p>

Academic Standards	Knowledge and Skills Statements (KSSs)	Underlying Concepts (UCs) of the Academic Standard
<p>8.ESS2.5: Construct a scientific explanation using data that explains the gradual process of plate tectonics accounting for A) the distribution of fossils on different continents, B) the occurrence of earthquakes, and C) continental and ocean floor features (including mountains, volcanoes, faults, and trenches).</p>	<p>8.ESS2.5.a: Ability to identify the result of movements of sections of Earth’s crust (i.e., earthquakes, mountain building, volcanoes, and sea floor spreading, faults, and trenches)</p> <p>8.ESS2.5.b: Ability to identify how fossil comparisons along the edges of continents demonstrate lithospheric plate movement</p>	<p>8.ESS2.5.UC: Locate evidence of plate movement using maps.</p>
<i>Earth and Human Activity (middle)</i>		
<p>8.ESS3.1: Interpret data to explain that Earth’s mineral, fossil fuel, and groundwater resources are unevenly distributed as a result of geologic processes.</p>	<p>8.ESS3.1.a: Ability to use a map with a key to identify distributions of minerals, fossil fuels, and groundwater resources</p> <p>8.ESS3.1.b: Ability to identify an explanation of how minerals formed</p> <p>8.ESS3.1.c: Ability to identify an explanation of how fossil fuels formed</p> <p>8.ESS3.1.d: Ability to identify an explanation of how groundwater was collected</p>	<p>8.ESS3.1.UC: Recognize minerals, fossil fuels, or groundwater resources in a model of Earth.</p>

¹ Instruction is not intended to be limited to the concepts, knowledge, and skills represented by the KSSs and UCs listed in Table 1.

Section II

Scientific Inquiry and Engineering Design

It is important for students with significant cognitive disabilities to have the opportunity to explore the world around them and learn to problem solve during science instruction. This approach to science instruction does not involve rote memorization of facts; instead it involves scientific inquiry. A Framework for K-12 Science Education (2012) unpacks scientific inquiry, providing eight practices for learning science and engineering in grades K–12. These practices provide students an opportunity to learn science in a meaningful manner. Students should combine the science and engineering practices as appropriate to conduct scientific investigations instead of using a practice in isolation or sequentially moving through each practice. Support should be provided as necessary for students with significant cognitive disabilities to actively use the practices. A link to *Safety in the Elementary Science Classroom* is in the resources of this section. See Section VI. Universal Design for Learning Suggestions for support ideas. Following are the science and engineering practices (National Research Council, 2012) associated with the content of this module. Examples are provided for each practice.

- Asking questions (for science) and defining problems (for engineering).
Examples: What causes rain to fall from clouds? How do fossil records support the statement that Earth’s crust has moved over geologic time? Why are most volcanoes and earthquakes located along boundaries of oceans and continents? How do warm and cold fronts affect the weather? How can a sedimentary rock become a metamorphic rock? What type of windsock material is sensitive enough to detect wind direction and speed but sturdy enough to not be damaged by strong wind? What devices do humans have that can help predict and be prepared for natural disasters such as earthquakes and hurricanes?
- Developing and using models.
Examples: Create a model of a mini water cycle (e.g., <https://thewaterproject.org/resources/lesson-plans/create-a-mini-water-cycle>). Use a model of Earth’s mountains, ocean trenches, and volcanoes to determine location patterns and continental plate boundaries. Use a weather map to predict how a cold or warm front will influence the weather. Develop a model to demonstrate a rock cycle. Design a model that demonstrates how soil filters groundwater and identify the limitations for human consumption. Develop a model revealing the complexity of the interacting systems that control Earth’s ever-changing surface.
- Planning and Carrying Out Investigations
Examples: Collect observable weather data (e.g., temperature, precipitation, wind direction). Conduct an investigation to understand weather fronts by understanding movement of warm and cool air (e.g., <http://georgiaweatherschool.com/s/Modeling-Cold-Warm-Air-Movement.pdf>). Through planning and conducting investigations on various rocks, determine whether they are igneous, sedimentary, or metamorphic. Test two rain gauge designs to determine which best meets the requirements for success, investigating how well each performs under a range of likely conditions.
- Analyzing and interpreting data.
Examples: Analyze and interpret data to identify patterns in locations of mountains and deep ocean trenches. Compare and contrast weather data collected by two weather sources to determine similarities and differences. Construct and interpret graphical data showing the relationship between fronts and precipitation. Use data to evaluate and refine solutions for the reduction of the use of fossil fuels for heating homes. Analyze data, looking for patterns of earthquakes in relationship to

continental plate boundaries. Use maps and fossil locations to identify relationships that show how Earth's plates have moved great distances, collided, and spread apart. Analyze data, looking for patterns of change that can be used to make predictions about typical weather conditions for a particular region and time of year. Analyze and interpret data such as distributions of fossils and rocks and continental shapes to provide evidence of past plate motions.

- **Using Mathematics and Computational Thinking**
Examples: Organize a simple data set to show patterns of weather across a school year. Measure the amount of rainfall using a rain gauge. Determine if quantitative or qualitative data is the most effective in determining if a rock is igneous, sedimentary, or metamorphic. Use the mathematical process of revolutions per minute to measure wind speed (e.g., <https://www.scientificamerican.com/article/bring-science-home-wind-speed/>). Apply mathematical concepts to answer scientific questions about location of sea floor spreading and the movement of Earth's plates. Determine the best natural material (e.g., granite, slate, marble, sandstone) to use as a cutting board using the MoHs hardness scale. Multiple units of measurement (e.g., inches, °F, mph) are used when recording weather conditions such as temperature, types and amounts of precipitation, and wind direction and speed.
- **Constructing Explanations and Designing Solutions**
Examples: Apply the scientific idea of the water cycle to explain precipitation. Construct an explanation using quantitative and qualitative relationships between factors that affect predicting the weather. Construct an explanation of the distribution of ocean trenches on Earth. Use information on the characteristics of sandstone to design a prototype of a core sampling tool suggesting the elements of the design that need to be improved. Construct an explanation that includes qualitative relationships between variables to describe how Earth's plates have moved great distances, collided, and spread apart. By applying understanding of weather-related hazards, make a claim about the merit of a design solution that reduces the impacts of such hazards (e.g., barriers to prevent flooding, wind-resistant roofs, lightning rods).
- **Engaging in argument from evidence.**
Examples: Modify a claim or reasons as to why volcanoes are located around borders of oceans and continents when provided critiques from peers. Use reasoning to connect the relevant and appropriate evidence to support the claim that most water eventually returns to the ocean. Make an argument that supports or refutes the advertised performance of a groundwater mapping device. Make claims about the merit of a design solution that reduces the impacts of such hazards, using evidence to support claims. Given criteria, determine how well each solution reduces the effects of severe weather. Collect evidence about processes that change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) to construct a scientific explanation for how geoscience processes have changed Earth's surface at varying time and spatial scales.
- **Obtaining, evaluating, and communicating information.**
Examples: Read and compare two sources of information on the rock cycle. Communicate the current weather using maps and icons. Gather, read, and synthesize information from multiple sources to communicate information on the uneven distribution of Earth's minerals, fossil fuels, and groundwater. Obtain from reliable sources the economic viability of using groundwater to irrigate fields. Use books and other reliable media resources to collect weather and climate information for a given region. Obtain information from scientific texts adapted for classroom use to describe patterns of fossil similarities bordering continental plates. Students compare information found in two different texts and use information to answer questions about weather and climate.

Science Practices Resources²

- Safety in the Elementary Science Classroom provides safety information for teachers and students.
<https://www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/safetypractices/safety-in-the-elementary-school-science-classroom.pdf>
- This site categorizes inquiry into three types: structured inquiry, guided inquiry, and open inquiry. Each type provides a wide range of example lessons grouped by elementary and middle school.
<http://www.justsciencenow.com/inquiry/>
- Education.com provides a variety of Earth and Space Science resources.
<https://www.education.com/resources/earth+and+space+science/>
- This site provides information on introducing models to elementary students.
<http://seplessons.ucsf.edu/node/1760>

Section III

Crosscutting Concepts

Grade-level science content includes Crosscutting Concepts, which are concepts that connect information between different science strands and grade levels. The Crosscutting Concepts are intended to work together with the science inquiry and engineering practices, in addition to core content, to enable students to reason with evidence, make sense of phenomena, and design solutions to problems. Helping students make connections between these types of concepts and new content information supports comprehension of the concepts, knowledge, and skills as well as transference and generalization (see Section VII for more information). Crosscutting Concepts that are specific to this module connect to content across the units within the module as well as across modules.

Crosscutting Concepts are a common link between multiple standards and units of study. The Crosscutting Concepts, by being revisited and linked to multiple units of study, become a strong foundation of understanding and support the students in learning new concepts. Earth and Space Science focuses on Earth's systems, materials, and place in the solar system. For example, understanding that patterns can be used as evidence to support an explanation is a Crosscutting Concept that applies to the water cycle, weather changes, location of minerals, occurrence of natural hazards, Earth's orbit around the sun, etc. Crosscutting Concepts may apply across multiple content areas and instructional emphases (e.g., cause and effect in reading science texts). The Crosscutting Concepts of cause and effect and stability and change provide a framework for understanding Earth's processes.

This content module, Earth and Space Science: Earth Materials and Systems, addresses how energy flows and matter cycles within and across Earth's systems.

Teaching Crosscutting Concepts

The following strategies pulled from the principles of UDL (CAST, 2011) are ways in which to teach Crosscutting Concepts to help students understand the concepts and make connections between different curricular content. During instruction, highlight:

- patterns (e.g., point out patterns in the shape of a graph or repeating pattern on a chart),
- critical features (e.g., provide explicit cues or prompts, such as highlighting, that help students to attend to important features),
- big ideas (e.g., present and reinforce the “big ideas” that students should take and apply to the students' lives.), and
- relationships (e.g., make the connection between the unit concepts and how they apply to the students' lives).

Following are **Crosscutting Concepts** for this Content Module— Earth and Space Science: Earth Materials and Systems. According to *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (2012), these concepts help provide students with an organizational framework for connecting knowledge from the various disciplines into a coherent and scientifically based view of the world.

Crosscutting Concept Resources

- Grant Wiggins talks about “big ideas” in this article.
http://www.authenticeducation.org/ae_bigideas/article.lasso?artid=99
- A Framework for K-12 Science Education, Appendix G explains the crosscutting concepts and how the concepts help students deepen their understanding of the information.
<http://www.nextgenscience.org/sites/default/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf>
- Teacher Vision provides ten science graphic organizers that are free and printable.
<https://www.teachervision.com/graphic-organizers/science/52539.html>
- Utah Education Network provides a variety of student interactives for:
 - grades three through six. <http://www.uen.org/3-6interactives/science.shtml>
 - grades seven through twelve. <http://www.uen.org/7-12interactives/science.shtml>

Table 2. General Vocabulary Words

General Vocabulary —words that generalize to different animals, plants, organisms, and activities. Describe the word and provide examples (e.g., Circulate means moving continuously through a pathway. <i>Example: Water circulates from the ground, to the sky, and back to the ground.</i>).		
• atmosphere	• erupt	• pressure
• circulate/circulation	• evaporation	• rock
• climate	• fossils	• settling
• cloud/cloudy	• fossil fuels	• soil
• collect/collection	• heating	• storm/stormy
• compact	• landforms	• temperature
• condensation	• minerals	• transpiration
• continents	• mountain/mountain range	• trenches
• crystallization	• ocean	• volcano
• cycle	• ocean trenches	• water vapor
• earthquake	• precipitation	• weather
• erosion	• predict/prediction	• weathering

Table 3. Specific Content Words

Specific Content Words —words that specify a particular thing (e.g., sedimentary rock) or phenomena (e.g., effects of a warm front). Describe the word and when possible make the connection to a Crosscutting Concept (e.g., Rocks constantly change in what is called the rock cycle. The rock cycle is one way that matter is cycled.).		
• air pressure	• groundwater	• rock cycle
• barometric pressure	• hydrologic cycle	• sea floor spreading
• cold front	• igneous rock	• sediment
• Earth’s crust	• magma	• sedimentary rock
• Earth’s inner core	• metamorphic rock	• warm front
• Earth’s lithospheric plates	• molten rock	• water cycle
• Earth’s mantle	• Pacific Ocean	• weather map
• Earth’s outer core	• plate boundary	
• faults	• rain gauge	

Ideas to Support Vocabulary Learning

Table 4 includes ideas and examples for teaching vocabulary in ways to build conceptual understanding of the words. The examples include ideas on how to provide individualization, indicated in brackets, for unique student needs. These individualization ideas are provided to guide educators in ways to create access to vocabulary instruction for individual students.

Table 4. Ideas to Teach Vocabulary Effectively (Marzano, 2004)¹

Ideas	Examples
<p>Explain, describe, and/or give examples of the vocabulary word rather than formal definitions.</p>	<ul style="list-style-type: none"> • Provide a description and an example of atmosphere (e.g., The atmosphere is the layer of gases that surround Earth. The air we breathe is part of the atmosphere.).
<p>Have students restate the vocabulary word in their own words. Take this opportunity to help students connect new vocabulary, especially general vocabulary, to prior knowledge.</p>	<ul style="list-style-type: none"> • Have students state in their own words or give an example of an “earthquake” and a “volcano.” [Individualization idea: Record and label two voice output switches, one with “earthquake” and one with “volcano.” Have students select the correct switch when listening to descriptions and viewing pictures of each.]
<p>Have students represent vocabulary words in a variety of ways (e.g., pictures, symbols, graphic organizers, or models).</p>	<ul style="list-style-type: none"> • Have students complete a water cycle graphic (see Figure 1) by placing the terms in the correct order on the graphic organizer and by adding matching pictures. [Individualization idea: Place the pictures in the correct order and have students place the corresponding terms or place the terms and have students place the corresponding pictures.] • Have students sort a variety of rock samples into three categories: igneous, sedimentary, and metamorphic. [Individualization idea: Provide students alternate ways to sort the rocks such as verbally, pointing, eye gaze, etc.] • Using a model, have students place pictures of fossils on a world map and use the relevant terms (e.g., fossils, continents, Earth’s plates) to describe lithospheric plate movement.
<p>Provide multiple exposure to vocabulary words in a variety of ways. This does not suggest mass trials, but rather distributed trials in different ways or contexts. Reference http://projectlearn.net.org/tutorials/learning_trials.html for information on learning trials.</p>	<p>Expose students by incorporating vocabulary into daily activities when it is appropriate:</p> <ul style="list-style-type: none"> • Create a weather map using the daily weather forecast as a model. • Discuss the weather for the day, compare weather to the forecast, etc. • Have students complete an online interactive vocabulary activity (e.g., http://www.esolcourses.com/topics/weather-months-seasons.html).

Ideas	Examples
	<ul style="list-style-type: none"> • Have students review flash cards that include images and recorded definitions (e.g., https://quizlet.com/126657585/weather-flash-cards/ and https://quizlet.com/177570692/continental-drift-and-plate-tectonics-flash-cards/).
<p>Ask students to discuss the vocabulary words with each other.</p>	<ul style="list-style-type: none"> • Have older students show younger students maps illustrating Earth’s features and pointing out mountain ranges, volcanoes, and ocean trenches. • Have students share examples of words related to the water cycle, weather, Earth’s materials, etc. [Individualization Idea: Place examples of the vocabulary words on a voice output device and have students share with a classmate.] • Have students share their representations of a word with each other. [Individualization idea: Provide multiple pictures of words for students to choose which ones to share.]
<p>Play vocabulary word games with students.</p>	<ul style="list-style-type: none"> • Shine a flashlight on the science area of the classroom word wall and ask a student to define/describe the word. Next, that student shines the light on a different word and asks another student to define/describe the word. • Have students match a description or representative picture to a word (e.g., picture of mountain range to the word). • Complete online vocabulary activities on types of rocks https://quizlet.com/178448981/types-of-rocks-flash-cards/ and https://quizlet.com/192442119/types-of-rocks-flash-cards/
<p>Have students watch a dramatization or have them act out the vocabulary term.</p>	<ul style="list-style-type: none"> • View animation explaining weather fronts (e.g., https://www.youtube.com/watch?v= 8RjGKs_Vpk) or continental drift (e.g., http://www.tectonics.caltech.edu/outreach/animations/drift.html). • Dramatize the weather by having students dress up as weather conditions (e.g., sunny, cloudy, windy, a warm front, a cold front, etc.) and interview each one, asking them to

Ideas	Examples
	describe their weather condition (e.g., I'm the sun. I'm hot and help heat the air and dry the ground). [Individualization idea: Pre-record the answers for students to play using an adaptive switch.]

¹ Refer to Section VI, Universal Design for Learning (UDL) Suggestions for additional instructional strategies.

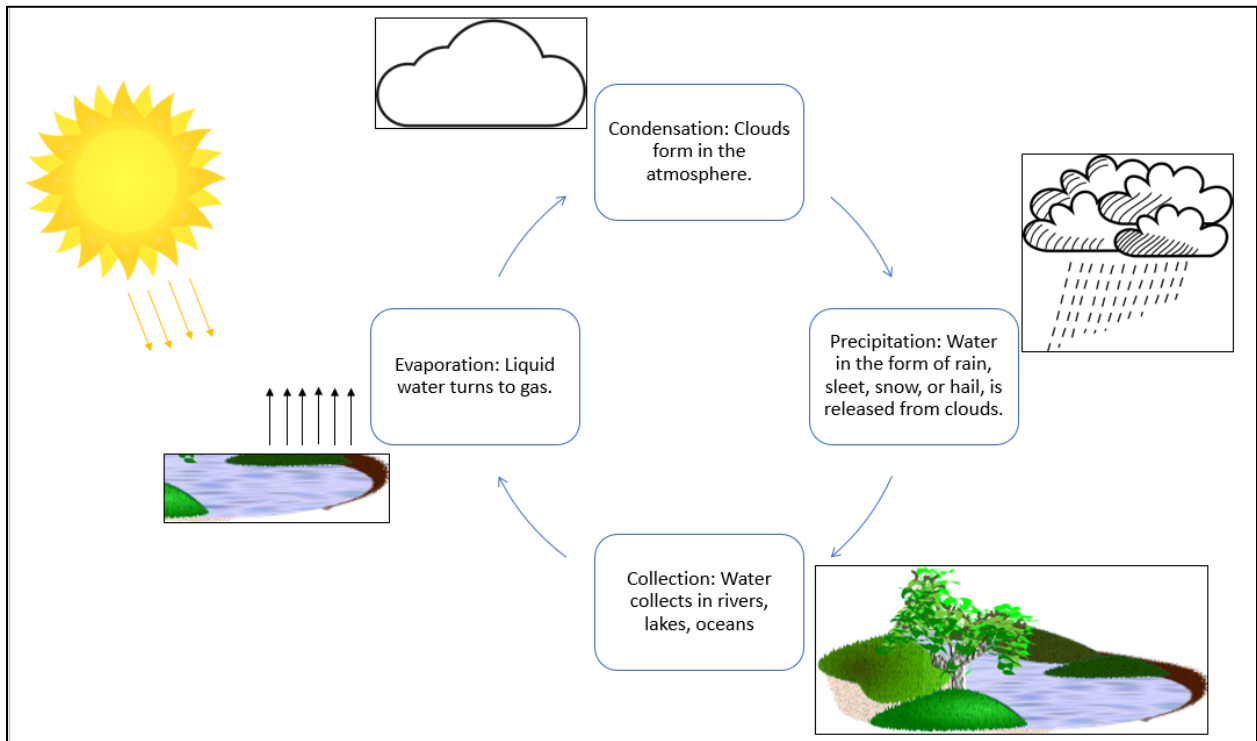
Vocabulary Example

Have students complete a water cycle graphic (see Figure 1) by placing the terms in the correct order on the graphic organizer and by adding matching pictures. [Individualization idea: Place the pictures in the correct order and have students place the corresponding terms or place the terms and have students place the corresponding pictures.]

National Center and State Collaborative (NCSC) resources are available and may prove helpful:

- Use systematic instruction as described in the NCSC Instructional Guide. <https://wiki.ncscpartners.org>
- Reference ideas in the NCSC Vocabulary and Acquisition Content Module. <https://wiki.ncscpartners.org>

Figure 1. Example Water Cycle Graphic



Vocabulary Resources

- Vocabulary.com provides explanations of words using real-world examples. Once signed in, an educator can create word lists for students. <http://www.vocabulary.com/>
- TextProject provides Word Pictures that are free for educators to use. Their site includes word pictures for core vocabulary and various content areas including science and social studies. This link will take you to the Word Pictures page where you can select the category of words you want to use. <http://textproject.org/classroom-materials/textproject-word-pictures/>
- The Science Penguin site provides ideas to teach science vocabulary. The vocabulary demonstration activity uses real objects to teach vocabulary terms. <http://thesciencepenguin.com/2013/12/science-solutions-vocabulary.html>

Section V

Overview of Units' Content

This section of the module contains additional content and references to support educators' understanding and instruction of the instructional units. The information reflects important content to address the KSSs and to build students' knowledge, skills, and abilities; however, it is not exhaustive and should be expanded upon as appropriate.

Earth's Systems (elementary)

Content

Cycling of Water on Earth

- Water can exist in three phases: solid, liquid, or gas.
- Liquid water is found on Earth in oceans, rivers, lakes, and ponds.
- Water vapor is found in Earth's atmosphere.
- Frozen water is found in glaciers.
- Earth has a limited amount of water that continually cycles, known as the water cycle.
- The water cycle is also referred to as the hydrologic cycle.
- In the water cycle, water evaporates, rises and condenses, and returns to the surface of Earth in the form of precipitation.
- Evaporation occurs when the heat of the sun causes water (e.g., from oceans, lakes, rivers) to turn into water vapor which rises into the atmosphere.
- Condensation occurs when the water vapor turns into liquid and forms clouds.
- Precipitation (e.g., rain, sleet, snow, hail) occurs when the water droplets in the clouds become too heavy for the air to hold them so they fall back to Earth's surface.
- The precipitation is collected in bodies of water (e.g., oceans, lakes, rivers) and the process repeats itself.
- Diagrams of the water cycle/hydrologic cycle can be used to describe the circulation of water through Earth's crust, oceans, and atmosphere.

Weather Conditions

- Weather can be observed (e.g., seeing, feeling, hearing).
- Weather conditions can be described (e.g., sunny or cloudy, hot or cold, windy or calm, rainy or dry).
- Weather forecasts can be used to make choices about clothing and/or outdoor activities.
- Data can be used to describe weather conditions:
 - temperature,
 - precipitation,
 - wind direction,
 - wind speed,
 - air/barometric pressure, and
 - rain amounts.
- Patterns in weather can be observed (e.g., cold and dry in the winter, hot and wet in the summer).

Location of Earth's Features

- Earth has physical features on land and water (e.g., mountain ranges, volcanoes, deep ocean trenches).
- Maps can be used to locate Earth's land and water features.
- Maps can be used to describe patterns:
 - major mountain ranges form inside continents or near their edges and under the ocean,
 - most earthquakes and volcanoes occur along the boundaries between continents and oceans, and
 - the deepest ocean trenches form a ring around the Pacific Ocean.

Earth's Systems (middle)

Content

Predicting Weather Conditions

- A weather map can be used to interpret weather conditions.
- Weather predictions can be made by matching a season with typical weather conditions (e.g., bar graph indicating hot weather on most days in the summer).
- Weather-related data (e.g., temperature, precipitation, wind direction) can be used to predict weather conditions.
- Weather patterns help people predict weather.
- Weather maps can be used to indicate movement of fronts and storms and predict their influence on local weather.
- Complex patterns of the changes and movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.

Processes and Forces of Earth Materials

- There are three main categories of rocks: igneous, sedimentary, and metamorphic.
- Rocks may change from one type to another, a rock cycle, through a series of processes (e.g., melting/cooling, sedimentation, metamorphosis) and over a long period of time.
- Igneous rocks form when magma cools below Earth's surface or when lava from a volcano cools at Earth's surface.
- Sedimentary rocks form when sediments (e.g., gravel, sand, silt, clay, pieces of other rocks) settle at the bottom of larger bodies of water and are compacted together.
- Metamorphic rocks form when an existing rock is changed by heat or pressure.
- The rock cycle's processes form three types of rocks:
 - Igneous rock—The temperature deep in Earth gets hot enough to melt rock. The melted rock or magma comes to Earth's surface and begins to cool. As it cools, crystals grow and form igneous rock.
 - Sedimentary rock—Water, wind, ice, and even plants and animals cause rocks, including igneous rocks, to wear down and over time break into smaller pieces called sediments. The sediments are carried by streams and rivers to larger bodies of water where they settle to the bottom. At the bottom of the body of water, they began to compact and cement together to form sedimentary rock.

- This site has information, instructional activities, maps, and graphic organizers on fossil fuels and its distribution and use.
<http://www.switchenergyproject.com/education/CurriculaPDFs/SwitchCurricula-Secondary-Oil/SwitchCurricula-Secondary-FossilFuelsToProducts.pdf>
- This site has information on the formation of fossil fuels.
<https://www.acaedu.net/cms/lib3/TX01001550/Centricity/Domain/389/5.7A%20Formation%20of%20Fossil%20Fuels.pdf>

Section VI

Universal Design for Learning (UDL) Suggestions

Three principles of the UDL—multiple means of representation, multiple means of action and expression, and multiple means of engagement—guide development of instruction, instructional materials, and assessments to provide access to learning to the widest range of students. A well-designed lesson using the principles of UDL reduces the need to make accommodations and modifications. However, some students with significant cognitive disabilities, especially students with visual and/or hearing impairments, physical disabilities, and students with complex communication needs, may require additional scaffolds, adaptations, and modifications to access content and support learning. UDL’s three guiding principles guide educators in creating instructional materials and activities in a flexible manner to address the needs of different types of learners. Utilizing the three principles of UDL as a framework when designing instruction allows for individualization when needed. Table 5 provides strategies and examples for the UDL Principle I, **Multiple Means of Representation**: presenting information in a variety of ways to address the needs of different types of learners. Table 6 provides strategies and examples for the UDL Principle II, **Multiple Means of Action and Expression**: providing a variety of ways for students to interact with the instructional materials and to demonstrate understanding. Table 7 provides strategies and examples for the UDL Principle III, **Multiple Means of Engagement**: providing a variety of ways to engage and motivate students to learn.

The strategies and examples provided in Tables 5 through 7 are based on UDL principles and can assist all students in understanding the basic concepts. The strategies and examples, as well as individualization ideas, should serve as a catalyst for ideas that can be individualized to meet the needs of each student. Some of the examples include activities that work exceptionally well for students with vision, hearing, and/or physical limitations as well as for all students. Each example has a code to indicate when it includes specific ideas or activities that meet these needs:

V = visually impaired (low vision, blind, or deaf-blind)

H = hearing impaired (deaf, hard of hearing, or deaf-blind)

P = physical disability (limited use of hands)

Table 5. Instructional strategy ideas using the UDL Principle: Multiple Means of Representation

Multiple Means of Representation	
Strategies	Examples
<p>Introduce information through a multi-sensory approach (e.g., auditory, visual, tactile).</p>	<p>Demonstrate wind direction using a classroom made weather vane and either wind or a fan (e.g., https://www.education.com/activity/article/wind_vane_first/). [Individualization idea: Have students use a switch-adapted fan to blow on the weather vane.] P</p> <p>Show a video on the water cycle (e.g., https://www.youtube.com/watch?v=R0K7VKkksyc). [Individualization idea: Provide students with tactile enhanced water cycle model (see Section VIII. Tactile Maps and Graphics for tips) and help students explore the stages of the cycle while listening to the video.] V</p> <p>Demonstrate weather fronts using an interactive model (e.g., http://www.phschool.com/atschool/phsciexp/active_art/weather_fronts/).</p> <p>Share maps that illustrate the pattern of earthquakes and volcanoes along continental plates (e.g., May require Internet Explorer or Firefox browser. https://authoring.concord.org/activities/7158/single_page/f9732897-8fbb-41ca-a945-ba4589c927bf). [Individualization idea: Using a print version of a map, outline the continents with thick, bold lines. Provide line drawings of earthquakes and volcanoes for students to place on the map as directed.] V</p> <p>Show maps of mountain ranges (e.g., https://www.pbslearningmedia.org/resource/buac17-35-sci-ess-glblmntnranges/global-patterns-of-mountain-ranges/#.W4gxIOgzodU).</p>
<p>Model content through pictures, dramatization, videos, etc.</p>	<p>Build a three-dimensional model of Earth’s surface features (e.g., http://www.cooks.com/rec/search/0,1-0,salt_dough_maps,FF.html). V</p> <p>Watch a video clip with information about air pressure and wind (e.g., http://studyjams.scholastic.com/studyjams/jams/science/weather-and-climate/air-pressure-and-wind.htm).</p> <p>Share pictures of types of rocks (e.g., https://geology.com/rocks/) or a video on types of rocks (e.g., https://www.youtube.com/watch?v=EGK1KkJdQY). [Individualization idea: Use igneous, sedimentary, and metamorphic rocks in place of or to supplement pictures.] V</p> <p>Share and explain animations of how the three types of rocks are formed (e.g., http://www.learner.org/interactives/rockcycle/change.html). [Individualization idea: Have students take turns starting each animation using a mouse or touch screen.]</p>

Multiple Means of Representation	
Strategies	Examples
	<p>Share an animation of plate movement over millions of years (e.g., http://www.tectonics.caltech.edu/outreach/animations/drift2.html).</p> <p>Demonstrate a model of a rock cycle using crayons (e.g., http://science-class.net/archive/science-class/Lessons/Geology/Rocks_Minerals/crayon_rock_cycle.pdf).</p> <p>[Individualization idea: Use a small fan to blow shavings, use an electric pencil sharpener to shave the crayons, an adapted test-tube clamp, etc.] P</p>
Present information using graphic organizers and models.	<p>Use an extended version of the KWHL: What do I Know? What do I Want to know about or wonder about (e.g., a phenomena)? How will I find out (e.g., determine how to organize investigations)? What have I Learned? What Action will I take (e.g., share with others, apply to daily life, etc.)? What new Questions do I have? More information can be found at http://langwitches.org/blog/2015/06/12/an-update-to-the-upgraded-kwl-for-the-21st-century/. [Individualization idea: Use strategies for the KWHL chart for accessibility ideas: https://nceo.umn.edu/docs/Teleconferences/tele14/CourtadeFlowers.pdf.]</p> <p>As a class complete a rock classification chart (e.g., https://www.teachengineering.org/content/csm/_activities/csm_asteroid/csm_asteroid_lesson05_data_table.pdf). [Individualization idea: Reduce the number of characteristics to test.]</p> <p>Have students categorize the types of Earth’s resources on a graphic organizer. [Individualization idea: Provide students with pictures of types of fossil fuels, minerals, and groundwater to complete the graphic organizer.]</p>
Provide appropriate and accessible text on the content for students to listen to or read.	<p>Have students read/listen to an online text about:</p> <ul style="list-style-type: none"> the water cycle (e.g., http://bookbuilder.cast.org/view.php?op=view&book=11984&page=1) and the rock cycle (e.g., http://bookbuilder.cast.org/view.php?op=view&book=64126&page=1). <p>Have students read articles on:</p> <ul style="list-style-type: none"> the water cycle (e.g., https://www.natgeokids.com/uk/discover/science/nature/water-cycle/), the rock cycle (e.g., https://www.ck12.org/c/earth-science/rock-cycle-processes/lesson/Rocks-and-Processes-of-the-Rock-Cycle-HS-ES/), groundwater (e.g., http://www.groundwater.org/get-informed/basics/groundwater.html), and

Multiple Means of Representation	
Strategies	Examples
	<ul style="list-style-type: none"> fossil fuels (e.g., https://www.acaedu.net/cms/lib3/TX01001550/Centricity/Domain/389/5.7A%20Formation%20of%20Fossil%20Fuels.pdf).
Teach information using songs, poems, or rhymes.	<p>Sing songs about the:</p> <ul style="list-style-type: none"> water cycle (e.g., https://www.youtube.com/watch?v=TWb4KIM2vts) and weather (e.g., https://www.youtube.com/watch?v=rD6FRDd9Hew or https://www.youtube.com/watch?v=e5UTaPV-Dlg).

Table 6. Instructional strategy ideas using the UDL Principle: Multiple Means of Action and Expression

Multiple Means of Action and Expression	
Strategies	Examples
Use technology/assistive technology to optimize student access and interaction with the instructional materials and content.	<p>Have students explore an interactive water cycle model (e.g., https://water.usgs.gov/edu/watercycle-kids-beg.html). [Individualization idea: Have an adult or peer read the pop-up information to the students.]</p> <p>Have students look at and read an online photo essay on Earth’s physical features (e.g., https://www.mixbook.com/photo-books/nature/earth-s-physical-features-1463919). [Individualization idea: Have students use an adaptive mouse.]</p> <p>Have students model current weather conditions using a weather forecast and an interactive weather map (e.g., http://www.glencoe.com/sec/science/activities/weather/).</p> <p>Have students access an interactive site on plate tectonics (e.g., May require Internet Explorer. https://www.learner.org/interactives/dynamicearth/drift.html). [Individualization idea: Have students use an adapted mouse and a screen reader.] P</p>
Allow for instructional materials that can be modified to provide access.	<p>Position printed text and pictures to provide ease of viewing and to encourage good posture (e.g., slant board). V/P</p> <p>Have students keep a weather journal using observation and create a weather report. Graph monthly precipitation amounts using local weather sources. [Individualization idea: Have students use interlocking stacking blocks to graph the precipitation amounts.] P</p> <p>Have students participate in an online lab activity to identify rock types (e.g., http://www.learner.org/interactives/rockcycle/index.html). [Individualization idea: Have the pop-up information read to the students.]</p>
Provide multiple means for students to make choices and select answers.	<p>Have student dictate answers. [Individualization idea: Place answer options in the student’s AAC device or on multi-select voice output switch.] P</p> <p>Provide answer choices. [Individualization idea: Have students use three switches with generic labels (e.g., a, b, c; red, blue, green; or three different textures) to which they listen, and then choose their answer.] V/P</p> <p>Ask open-ended questions (e.g., Why are minerals usually found around volcanic activity?) and ensure that students have the language to answer in their AAC system.</p>
Provide simulation activities.	<p>Have students create a mini water cycle (e.g., https://thewaterproject.org/resources/lesson-plans/create-a-mini-water-cycle). [Individualization idea: Provide visual cues (e.g., photos or icons) for each step of directions.]</p>

Multiple Means of Action and Expression	
Strategies	Examples
	<p>Explore weather and climate using hands-on activities, weather maps, and videos (e.g., http://teacher.scholastic.com/activities/wwatch/).</p> <p>[Individualization idea: Provide a tactile map of the US and add hurricane routes, reported tornados, or winter storms to the map for students to explore. V Have students use an adapted keyboard (e.g., high contrast, large print, color coded, on screen, etc.) V or alternate input device (e.g., head pointer, eye gaze, typing aid, etc.) P.]</p> <p>Have students explore an interactive rock cycle animation (e.g., http://www.classzone.com/books/earth_science/terc/content/investigations/es0602/es0602page02.cfm?chapter_no=investigation).</p> <p>[Individualization idea: Provide cues for students to click on the next animation and summarize the information for students.]</p>
Provide graphic organizers and templates.	<p>Have students sort pictures of rocks into the three types of rocks on a graphic organizer (e.g., https://us.corwin.com/sites/default/files/upm-binaries/18270_Tate_EtBGraphOrg_Gr4_Pages_37_39.pdf).</p> <p>[Individualization idea: Have students sort rocks instead of pictures by placing them in three labeled boxes.]</p> <p>Have students complete a plate tectonic puzzle (e.g., http://education.seattlepi.com/distribution-fossils-plate-tectonics-theory-5472.html).</p>

Table 7. Instructional strategy ideas using the UDL Principle: Multiple Means of Engagement

Multiple Means of Engagement	
Strategies	Examples
Provide a schedule.	<p>Provide personal schedules with tangible symbols. Have students select the next activity on the schedule and set the visual timer to indicate how long the student has before a break.</p> <p>Use a first/then schedule (e.g., https://www.autismclassroomresources.com/visual-schedule-series-first-then/).</p> <p>Provide a visual and/or auditory cue (e.g., http://pricklypearcoop.schoolwires.com/cms/lib07/MT08000619/Centricity/Domain/8/B.%20Strategies%20for%20Transitions%20in%20School.pdf) to prepare students to transition from one activity to another.</p>
Vary the challenge and amount of information presented at a time.	<p>Begin by having students make the connection between the clothing they are wearing and the current weather. Discuss the way the weather changes over seasons and how that affects what we wear and our activities. Then introduce weather reports and weather prediction.</p> <p>Introduce energy used in the school (e.g., furnace, lights, computer, fans, etc.) and explain or remind from previous instruction that an energy source is required to operate the devices. Present different fossil fuels (e.g., coal, petroleum, natural gas) and how they are used to operate devices, where they are mostly located, and that they are nonrenewable.</p>
Make connections to topics or activities that are motivating.	<p>Ensure activities are age and grade appropriate.</p> <p>Visit a news studio to view the way a weatherman predicts weather or invite a local meteorologist to visit the class.</p> <p>Use a mineral hardness chart that describes the minerals as super minerals (e.g., https://i.pinimg.com/originals/f6/e9/a0/f6e9a0b8450ecbc295270fc07b374ea8.jpg).</p>
Allow choices as possible.	<p>Allow students to choose where to work on a task, the tools to use for completing a task, type of reward or recognition for completing a task, etc.</p>
Provide opportunities to work collaboratively with peers.	<p>Provide opportunities for students to work in a general education classroom with peers when learning about predicting weather.</p> <p>Include students in general education classroom for all instruction on a topic, not just during experiments.</p> <p>Have general education peers provide support to students as co-learners instead of serving as a teacher.</p>
Teach student self-regulation skills.	<p>Provide communication symbols to request a break or express feelings and model how to use them appropriately.</p> <p>Provide students with stress balls, finger fidgets, etc.</p>

	Have an adult or peer model setting of goals and self-evaluation of identified goals.
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UDL Resources

- The National Center on Universal Design for Learning has a plethora of information on UDL along with examples and resources. www.udlcenter.org
- The UDL Curriculum Toolkit provides two applications for science. <http://udl-toolkit.cast.org/p/applications/l1>
- Perkins School for the Blind provides life science activities for students who are blind or have low vision. <http://www.perkinselearning.org/accessible-science/activities/life-science>
- This Perkins School for the Blind 20-minute video describes the techniques used to make science accessible for students who are blind and deaf-blind. <https://www.youtube.com/watch?v=tpAejot1-Ec>
- Symbaloo is a free online tool that allows an educator to create bookmarks using icons. It is easy to create and allows an educator to provide students links to sources of information that can be used for specific instructional units. www.symbaloo.com
- This site provides a brief description of Symbaloo and multiple ways to use the online tool. <https://www.theedublogger.com/2014/04/09/11-ways-to-use-symbaloo-in-the-classroom/>
- Perkins School for the Blind provides information on using tangible symbols to increase communication, create personal schedules, and provide choices. <http://www.perkinselearning.org/videos/webcast/tangible-symbols>

Section VII

Transference and Generalization of Concepts, Knowledge, and Skills

For learning to be meaningful for all students, including students with significant cognitive disabilities, it is important to intentionally make connections to future content, real-world application, and college and career readiness skills. For example, students can learn that the way they discover information through observation and investigation can also be used to problem solve daily living tasks. Additionally, the instruction of science concepts, knowledge, and skills may be the catalyst to developing other areas such as needed communication skills, reading/listening comprehension, mathematics skills, age-appropriate social skills, independent work behaviors, and skills in accessing support systems. Table 8 provides instructional ideas to help transfer and generalize concepts, knowledge, and skills and suggested opportunities to embed other skills into instruction.

Table 8. Transfer and Generalization Ideas

Area	Instruction	Opportunity to Embed Skills
Communication	Provide opportunities for students to participate in class discussion or answer questions during instruction and provide the tools (e.g., terminology on AAC device) to do so.	Use the context of the science instruction to increase language skills, work on articulation, or access alternative and augmentative communication (AAC) systems. Encourage students to ask and answer questions during science instruction.
Reading and Listening Comprehension	Vary how science instruction is presented to students, including reading or listening to science texts. Support comprehension of texts by previewing the text, asking and answering questions, rereading, making connections to familiar concepts, etc.	Introduce new science content vocabulary and provide multiple opportunities for students to use. Work on use of assistive technology to independently read online text using a screen reader.
Mathematics	Teach how to read and understand an outdoor thermometer and a rain gauge.	Provide practice on identifying that higher numbers typically indicate more, warmer, harder, etc.
Age-Appropriate Social Skills	Encourage age-appropriate classroom behavior during science instruction by developing and reading a social story (e.g., https://www.autism.org.uk/about/strategies/social-stories-comic-strips.aspx) or video modeling (e.g., http://www.watchmelearn.com/video-modeling/what-is-video-modeling) prior to instruction.	Use science instructional time to work on social skills with general education peers (e.g., taking turns, keeping hands to self, respecting other’s materials, etc.)
Independent Work Behaviors	Use completion checklists during group work time.	Help students evaluate quality of independent work by comparing to a correct model of finished task.
Skills in Accessing Support Systems	Encourage students to ask appropriately for more information on how to complete a task.	Use this time to have the student work on behavior and communication skills.

Graphic Organizers/Concept Maps

- It is best to present information to compare or make connections using a tactile graphic. A tactile graphic presents the information in a spatial display and aids in comparison better than a list.

Diagrams/Models

- Limit the number of areas, lines, and labels. Having more than five makes interpretation difficult.
- Consider pairing a tactile graphic with a 3-dimensional model.

Timelines

- Present timelines in the same direction every time (i.e., horizontal or vertical).

Maps

- Distinguish water from land using a consistent background texture for the water.
- Align the direction of the compass rose arrows with the lines of longitude and latitude on the map.

Creating Tactile Graphics

Following are some ways to create tactile graphics. Additional information can be found at www.tactilegraphics.org.

Commercial products:

- Capsule paper or swell paper for printing, and
- Thermoform.

Textured shapes can be made from:

- Sticky back textured papers found at craft stores,
- Corrugated cardboard,
- Fabric with texture (e.g., corduroy, denim),
- Silk leaves,
- Cork,
- Felt,
- Vinyl,
- Mesh tape (used for drywall), and
- Sandpaper.

Raised lines can be made from:

- Glue (best not to use water-based glue), and
- Wax pipe cleaners.

Resources

- The American Foundation for the Blind provides basic principles for preparing tactile graphics. <http://www.afb.org/info/solutions-forum/electronic-files-and-research-work-group/tactile-graphics/345>
- The Texas School for the Blind and Visually Impaired provides basic principles for preparing tactile graphics, element arrangement on a tactile graphic, resources for preparing quality graphics, etc. <http://www.tsbvi.edu/graphics-items/1465-basic-principles-for-preparing-tactile-graphics>
- Perkins School for the Blind has tips for reading tactile graphics in science with a focus on state assessment. <http://www.perkinselearning.org/accessible-science/blog/tips-reading-tactile-graphics-science-focus-state-assessment>

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Picture Citations

<https://openclipart.org/detail/193560/cloud> CC0 1.0

<https://openclipart.org/detail/193508/rainy-stick-figure-cloud-cluster> CC0 1.0

<https://openclipart.org/detail/20293/simple-scenery> CC0 1.0

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