Science

Module 9

Earth Science: Earth and the Solar System

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 Place in the Universe (elementary)—Earth is one of eight planets in our solar system and is included in the four inner planets that are closer to the sun, smaller in size, and rocky. The outer planets are farther from the sun, larger in size, and gaseous. Earth tilts on its axis and orbits around the sun, resulting in patterns of seasonal changes and length of daylight. Earth rotates on its axis once every 24 hours, which causes day and night. Changes in the length and direction of an object's shadow throughout a day provides evidence of Earth's rotation. Earth's moon orbits around Earth approximately once a month. The moon's appearance changes during a month due to the relative positions of Earth, the moon, and the sun.
- Earth's Place in the Universe (middle)—Gravity pulls matter together to make spherical stars and planets. The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. This model of the solar system can explain tides. Earth and the other planets orbit around the sun on circular paths as a result of this gravitational pull. Earth's gravity holds its moon in orbit around Earth.

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 Science: Earth and the Solar System 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 Science: Earth and the Solar System. 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)
Earth's Place in the Universe (Elementary)		
3.ESS1.1: Use data to categorize the planets in the solar system as inner or outer planets according to their physical properties.	**3.ESS1.1.a:** Ability to use data (e.g., model, diagram, tables) to identify the inner planets as closer to the sun and the outer planets as farther away **3.ESS1.1.b:** Ability to use data (e.g., model, diagram, tables) to identify the inner planets as smaller and rockier and the outer planets as larger and made up mostly of gas	**3.ESS1.1.UC:** Identify a planet in the solar system.
4.ESS1.2: Use a model to explain how the orbit of the Earth and sun cause observable patterns: a. day and night; b. changes in length and direction of shadows over a day.	**4.ESS1.2.a:** Ability to identify that day occurs when one side of Earth faces the sun and night occurs when one side of the Earth faces away from the sun **4.ESS1.2.b:** Ability to identify the relationship of the movement of an object's shadow on the ground to the position of the sun in the sky	**4.ESS1.2.UC:** Recognize that the sun can only be seen during the day.
5.ESS1.4: Explain the cause and effect relationship between the positions of the sun, Earth, and moon and resulting eclipses, position of constellations, and appearance of the moon.	**5.ESS1.4.a:** Ability to explain that the moon looks different during a month because the moon travels in an orbit around Earth	**5.ESS1.4.UC:** Recognize that the moon travels in an orbit around Earth while Earth travels in an orbit around the sun.
5.ESS1.5: Relate the tilt of the Earth's axis, as it revolves around the sun, to the varying intensities of sunlight at different latitudes. Evaluate how this causes changes in day-lengths and seasons.	**5.ESS1.5.a:** Ability to make relative comparisons between the amount of daylight between seasons (e.g., winter compared to summer) using data **5.ESS1.5.b:** Identify an Earth-sun model, which demonstrates that Earth's tilt and orbit around the sun cause changes in seasons	**5.ESS1.5.UC:** Identify characteristics of the four seasons.

Earth's Place in the Universe (Middle)		
8.ESS1.2: Explain the role of gravity in the formation of our sun and planets. Extend this explanation to address gravity's effect on the motion of celestial objects in our solar system and Earth's ocean tides.	**8.ESS1.2.a:** Ability to explain that objects in our solar system travel in a circular path as a result of the sun's gravity **8.ESS1.2.b:** Ability to describe that the spherical shape of the sun and planets is a result of gravity **8.ESS1.2.c:** Ability to explain that the moon's gravity is the primary reason that there are tides on Earth	**8.ESS1.2.UC:** Recognize that gravity pulls objects together.

[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 eight science and engineering practices (National Research Council, 2012) with added examples.

- Asking questions (for science) and defining problems (for engineering).
  Examples: Why does the amount of daylight change in the winter? What would happen if Earth's tilt changed? How does the moon affect the tides? How can the apparent motion of the sun, moon, and stars in the sky be predicted and explained? Are tides the same level each day of the month? When should companies work on a bridge that spans an intercoastal waterway without being disrupted by tides? Define the criteria for a successful solution to protect structures on a coastline from changing tides.

- Developing and using models.
  Examples: Use a model to describe what would happen to Earth's orbit around the sun if the mass of either Earth or the sun changed (e.g., https://phet.colorado.edu/en/simulation/gravity-and-orbits). Use a model to show how Earth's tilt and orbit around the sun cause changes in seasons. Create a model illustrating the position of the moon and Earth during a lunar cycle. Describe the limitations of classroom, commercial, and online Earth-sun and Earth-moon models in helping engineers model space flight orbits around Earth. Use a model to test an existing system (e.g., satellite launch, space station) and identify the strengths and limitations of its design. Create models of the day/night pattern caused by the daily rotation of Earth.

- Planning and carrying out investigations.
  Examples: Observe that shadows of stationary objects change length and direction throughout the day compared to the location of the sun to explain the rotation of Earth. Use a flashlight and globe of Earth to conduct an investigation on how Earth's tilt affects the solar energy and temperature. Conduct an investigation of rocket designs to determine the limitations on overcoming the effect of gravity (e.g., https://www.teachingchannel.org/video/paper-rocket-lesson-plan). Investigate seasons by simulating the position of Earth and its tilt as it revolves around the sun, using computer simulations, hands-on models, and videos.

- Analyzing and interpreting data.
  Examples: Use data to determine the characteristics (e.g., size, density) of the planets in the solar system. Use tidal data to graph tide levels and compare to moon phases. Create a bar graph showing the length of day (i.e., sunrise to sunset) over time to illustrate the change due to Earth's tilt and orbit around the sun. Analyze planetary data collected by different types of robotic spacecraft. Use

this data to identify the purpose and constraints of each robotic spacecraft. Collect and analyze data to describe patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

- Using mathematics and computational thinking.
  Examples: Measure the height of a shadow at different times of the day. Use computation to determine the elapsed time from sunrise to sunset each day to determine whether the lengths of the days are growing longer or shorter. Use mathematical concepts and/or processes to describe patterns of the apparent motion of the sun, moon, and stars in the sky. In a simulated activity on escaping Earth's orbit, determine the velocity required for a water balloon to escape the orbit around a person (e.g., https://www.teachengineering.org/activities/view/cub_mars_lesson04_activity1). Reason abstractly and quantitatively when analyzing and using data as evidence to describe phenomena such as: Earth's gravitational force pulls objects "down" (toward the center of Earth); patterns of change, such as the day/night cycle; the change in length and direction of shadows during the day; the apparent motion of the sun across the daytime sky and the moon across the nighttime sky; the changes in the appearance of the moon over a period of four weeks; and the seasonal changes in the position of the stars in the night sky.

- Constructing explanations (for science) and designing solutions (for engineering).
  Examples: Identify evidence in an explanation that supports that Earth rotates on its axis every 24 hours. Explain the relationship between the appearance of the moon and the moon's orbit around Earth. Describe the relationships and interactions between components of the solar system, including gravity as an attractive force between objects. Apply scientific ideas or principles to construct and test a design of a prototype of a rocket to launch equipment into space (e.g., https://www.jpl.nasa.gov/edu/teach/activity/straw-rocket/). Given a problem related to human needs (e.g., length of daylight at different latitudes vs. length of growing season), students use scientific information and principles to generate a design solution (e.g., a system to allow growers to manipulate nature and artificially control flowering cycles) that addresses the human needs and describes how well the solution meets the criteria and constraints (e.g., increased plant yield that comes from producing year-round, regardless of weather conditions and natural sunlight).

- Engaging in argument from evidence.
  Examples: Construct an argument explaining the cause of Earth's seasons using relevant and appropriate evidence. Compare and critique two arguments about how Earth's relationship to the sun affects the seasons and analyze similarities between the two arguments. Present an argument supported by empirical evidence to support or refute an Earth-moon-sun model. Make a claim about the accuracy of information on the outer planets provided by planetary satellites. Use observations as evidence to support an argument that the gravitational force exerted by Earth on objects is directed "down" (toward the center of Earth), no matter the height or location from which an object is released.

- Obtaining, evaluating, and communicating information.
  Examples: Effectively communicate information from reliable sources on the gravitational pull of the sun causing Earth's orbital cycle. Describe the shape of Earth's orbit. Obtain information from grade-appropriate texts and/or media and summarize to describe how Earth's tilt and orbit affect the seasons and length of daylight. Evaluate and communicate information regarding spacecraft recently developed to study space. Communicate information about solutions to human needs (e.g., staying cool in the shade) that allow people to live comfortably (e.g., a shade that mounts on a vehicle).

Science Practices Resources[2]

- 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 activities and experiments. https://www.education.com/resources/earth-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, seasonal appearance of some stars in the night sky, 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 patterns and cause and effect provide a framework for understanding Earth's systems and the impact humans have on them.

This content module, Earth Science: Earth and the Solar System, addresses the solar system and the phenomena of planets, moons, and other objects held together by gravity. The module addresses explanations for the cause and effect relationships of the aforementioned phenomena as rooted in the cycles occurring around Earth, the sun, or space as a whole.

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 the important features.),
- big ideas (e.g., Present and reinforce the "big ideas" that students should take and apply throughout their 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 Science: Earth and the Solar System. 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.

Patterns

Patterns

- Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. (e.g., day/night, seasonal changes, length of shadow).
- Patterns can be used to identify cause and effect relationships (gravity holding Earth in orbit, moon's gravity effect on tides, Earth's rotation causing day/night).
- Patterns can be used as evidence to support an explanation (e.g., shadow changes throughout a day, tidal levels across a day and a month, seasonal changes as Earth orbits the sun).

Causality

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural or designed systems (e.g., tide levels, moon phases, seasonal climate).

Systems

Systems and System Models

- Models can be used to represent systems and their interactions (e.g., solar system, Earth-sun model, Earth-moon model, moon phases).

Scale, Proportion, and Quantity

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small (e.g., inner and outer planets, Earth's orbit around the sun and seasonal changes, Earth's rotation and changes in shadows). For example, data on solar system objects (e.g., surface features, object layers, orbital radii) from various Earth- and space-based instruments allow for analysis and interpretation (e.g., transforming tabular data into pictures, diagrams, graphs, or physical models that illustrate changes in scale).

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 10 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

Section IV

Vocabulary and Background Knowledge

Vocabulary is critical to building an understanding of science concepts, knowledge, and skills. The vocabulary words that students gain through experiences provide ways for students to comprehend new information (Sprenger, 2013). Students can better understand new vocabulary when they have some background knowledge to which they can make connections. In addition, learning new vocabulary increases students' background knowledge. Therefore, it is important to teach vocabulary purposely when introducing new concepts, knowledge, or skills (e.g., Earth's orbit) and in the context of the specific content (e.g., Teach the terms "gravity," "circular," "sphere," "sun," "year," and "tilt" in the context of describing Earth's orbit, gravity, tilt, seasons, etc.

This module includes two types of vocabulary words, both equally important to teach. The first type, **general vocabulary words,** labels groups of words that generalize to a variety of animals, plants, organisms, and activities. For example, understanding the meaning of the word "temperature" helps students to understand related terms (e.g., spring, summer, winter, autumn, etc.). The second type, **specific content words,** represents groups of words that are associated with an organism, system, process, or phenomena. For example, the specific phrase "solar system" connects to the general words "sun," "planet," and "orbit" to help students understand our solar system. Providing exposure and instruction on general words provides background knowledge when introducing corresponding or related specific words.

Key Vocabulary for Instructional Units

Table 2 and Table 3 contain lists of key general vocabulary words and specific content words that are important to the units in this module. The vocabulary words span across grades three, four, five, and eight. Refer to the Tennessee Academic Standards for Science for grade specific words. Teach general vocabulary words to the student using a student-friendly description of the word meaning (e.g., Elliptical is an oval shape or motion.) and an example of the word (e.g., Earth orbits around the sun on an elliptical path.). Teach the specific content vocabulary using a student-friendly description of the word or phrase meaning (e.g., Mars is an inner planet.) and a possible connection to a general vocabulary word (e.g., Mars is a rocky planet.)

Do not teach memorization of vocabulary words; instead, place emphasis on understanding the word as a result of observation, investigation, viewing a model, etc. For example, a student should identify the Northern and Southern Hemispheres on a globe or map of Earth instead of having to give a formal definition.

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., An axis is a straight line through an object; the object rotates around the straight line. *Example: The axis of Earth is an imaginary line through Earth that it rotates around.*		
• axis	• matter	• size
• circular	• model	• sky
• composition	• month	• solar
• diameter	• moon	• sphere
• direction	• orbit	• star
• elliptical	• planet	• sun
• gas/gaseous	• rocky	• temperature
• gravity	• rotate/rotation	• tide
• latitude	• scale	• tilt
• length	• season	• year
• mass	• shadow	

Table 3. Specific Content Words

Specific Content Words—words that specify a particular thing (e.g., solar system) or phenomena (e.g., gravitational pull). Describe the word and when possible make the connection to a Crosscutting Concept (e.g., Our solar system includes eight planets that orbit around the sun. The planets orbit the sun on an elliptical path.).		
• autumn/fall	• Mars	• solar system
• Earth	• Mercury	• Southern Hemisphere
• gravitational pull	• Neptune	• spring
• inner planets	• Northern Hemisphere	• summer
• intensity	• outer planets	• Uranus
• Jupiter	• phases of the moon	• Venus
• lunar	• Saturn	• winter

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
Explain, describe, and/or give examples of the vocabulary word rather than formal definitions.	Provide a description and an example of gravity, (e.g., "Gravity is a force that keeps you on the ground and keeps Earth orbiting the sun.").
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.	Have students state in their own words what an orbit is (e.g., An orbit is the path of one thing around another thing. An example of an orbit is the moon orbiting Earth.) [Individualization ideas: Place necessary vocabulary on the students' alternative and augmentative communication (AAC) system. Provide a choice of several examples of orbit for the students to choose from.]
Have students represent vocabulary words in a variety of ways (e.g., pictures, symbols, graphic organizers, or models).	Have students complete a picture of a planet of their choosing to hang on the classroom museum wall. The picture could include a drawing/photo of the planet with the planet's name and facts about the planet written on a frame plaque. [Individualization idea: Provide students photos of the planets to choose from and paste onto the picture. Provide facts for students to choose from] (See Figure 1. Example Planet Museum Picture) • Have students view words paired with pictures and recorded definitions: ○ lunar cycle (e.g., https://quizlet.com/128217123/lunar-cycle-flash-cards/), and ○ gravity (e.g., https://quizlet.com/126017503/gravity-flash-cards/).
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://projectlearnet.org/tutorials/learning_trials.html for information on learning trials.	• Expose students to vocabulary by incorporating it into daily activities such as talking about the current season, the moon phase, shadows, etc. [Individualization idea: Provide students with vocabulary to talk about these topics in their AAC system.] • Read books or watch videos related to the vocabulary and concepts: ○ Earth's axis, rotation, and revolution (e.g., http://bookbuilder.cast.org/view.php?op=view&book=102276&page=1),

Ideas	Examples
	○ lunar phases (e.g., http://bookbuilder.cast.org/view.php?op=view&book=20939&page=1), and ○ gravity (e.g., https://www.youtube.com/watch?v=4yyb_RNJWUM). • Sign unit vocabulary along with description of each term (e.g., https://signsci.terc.edu/video/index.html).
Ask students to discuss the vocabulary words with each other.	Have students share and describe pictures of planets in the solar system and Earth's moon phases. [Individualization idea: Provide a recorded description on a switch-activated voice output device.] Have students work with an interactive word wall (e.g., http://nstacommunities.org/blog/2013/10/16/putting-science-words-on-the-wall/ and http://www.nsta.org/publications/news/story.aspx?id=53171).
Play vocabulary word games with students.	Have students play 20 questions with each other about unit vocabulary. [Individualization idea: Reduce the number of questions. Ensure students have the language to ask questions and guess the vocabulary by adding to the student's AAC system, interpreting for the student, providing cues for the student, etc.] Play an eye spy game in which students give clues about a picture or word posted on a word wall and peers guess the word.
Have students watch a dramatization or have them act out the vocabulary term.	Have students simulate Earth's orbit around the sun, Earth's rotation, and the moon's orbit around Earth.

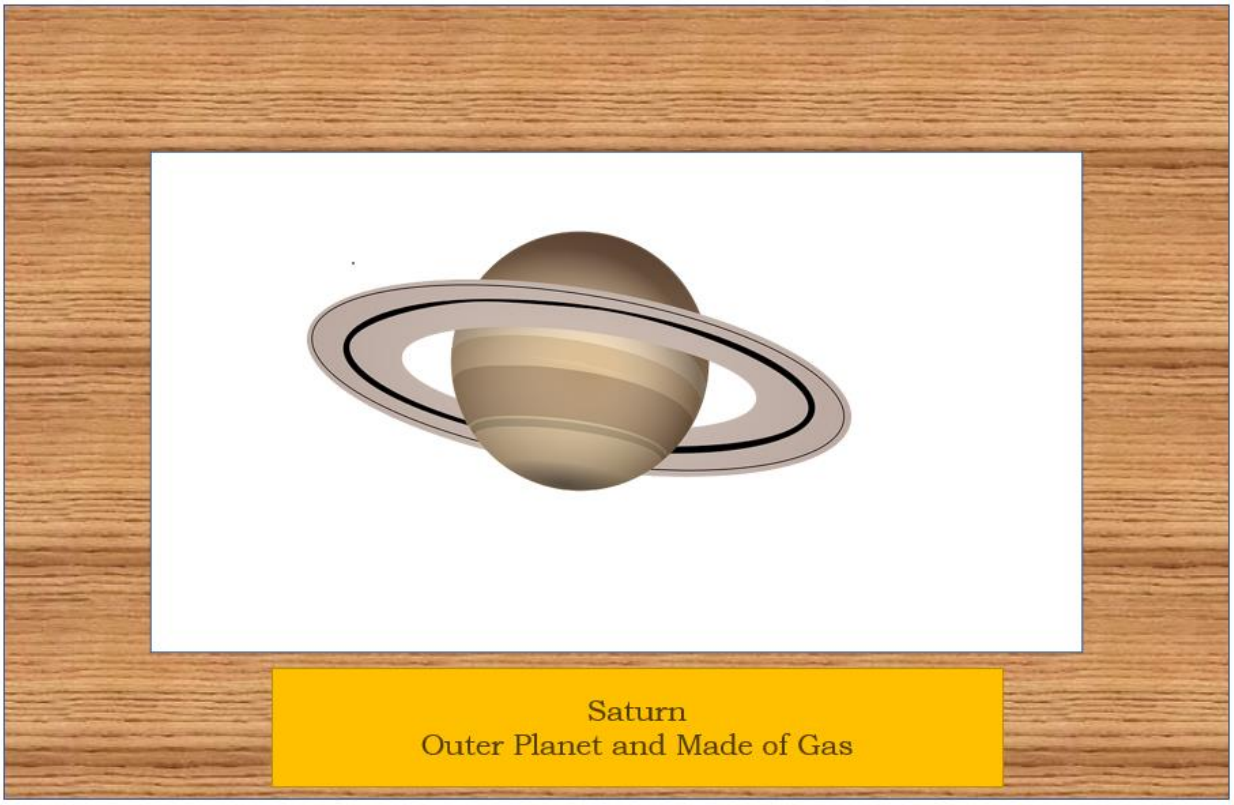
[1] Refer to Section VI, Universal Design for Learning (UDL) Suggestions for additional instructional strategies.

Vocabulary Example

Have students complete a picture of a planet of their choosing to hang on the classroom museum wall. The picture could include a drawing/photo of the planet with the planet's name and facts about the planet written on a frame plaque. [Individualization idea: Provide students photos of the planets to choose from and paste onto the picture. Provide facts for students to choose from.] (See Figure 1. Example Planet Museum Picture). Two 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 Planet Museum Picture



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 Place in the Universe (elementary)

Content

- Our solar system has eight planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.
- The inner planets are those closer to the sun and include: Mercury, Venus, Earth, and Mars.
- The inner planets, also known as terrestrial planets, are smaller and rockier than the outer planets.
- The outer planets are those farther from the sun and include: Neptune, Saturn, Jupiter, and Uranus.
- The outer planets, also known as gas giants, are made up mostly of gas.
- Earth rotates on its axis once each day (approximately 24 hours), which causes day and night.
- Daytime occurs on the side of Earth facing the sun.
- Nighttime occurs on the side of Earth facing away from the sun.
- Shadows on the ground of objects remaining in the same location change due to the movement of Earth.
- Shadows are longer in the morning and evening when the sun is low in the sky.
- Shadows are the shortest at noon when the sun is the highest in the sky.
- Earth-sun and Earth-moon models can demonstrate movement patterns and resulting phenomena (e.g., day, year, month, seasons, and eclipses).
- The moon travels on its orbit around Earth a little less than once a month.
- The appearance of the moon changes (moon phases) as it moves through its orbit due to the relative positions of Earth, the moon, and the sun.
- The phase of the moon you see depends on how much of the sunlit side of the moon faces Earth.
- Earth travels in an orbit around the sun.
- One complete orbit of Earth around the sun is called a year.
- The tilt of Earth on its axis along with its orbital pattern around the sun causes the seasons.
- Seasons have observable characteristics (e.g., temperature, precipitation, plant growth, length of daylight).
- When the Northern Hemisphere is tilted toward the sun, the Northern Hemisphere receives more direct sun rays, which results in summer and longer days.

- When the Northern Hemisphere is tilted away from the sun, the Northern Hemisphere receives less direct sun rays, which results in winter and shorter days.

Earth's Place in the Universe (middle)

Content

- Earth-sun and Earth-moon models can demonstrate movement patterns and resulting phenomena (e.g., day, year, month, seasons, and tides). When the Northern Hemisphere is tilted toward the sun, the Northern Hemisphere receives more direct sun rays/solar energy, which results in summer and longer days.
- When the Northern Hemisphere is tilted away from the sun, the Northern Hemisphere receives less direct sun rays/solar energy, which results in winter and shorter days.
- Gravity will affect any object with mass.
- Models can be used to represent the role of gravity in the motions and interactions within galaxies and the solar system.
- Gravity plays a role in the motions within galaxies and the solar system.
- Gravity is the force that holds together the solar system.
- The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.

Unit Content Resources

Planets in the Solar System

- Easy Science for KIDS provides information on the inner and outer planets of the solar system. https://easysciencеforkids.com/inner-and-outer-planets/
- These sites have lesson plans with accompanying materials including a data table on the inner and outer planets.
    - https://www.pdesas.org/ContentWeb/Content/Content/16191/Lesson%20Plan
    - https://www.pdesas.org/ContentWeb/Content/Content/16192/Lesson%20Plan
- CPALMS provides a lesson plan on the inner and outer planets. http://www.cpalms.org/Public/PreviewResourceLesson/Preview/30675
- Space Facts provides information on the inner and outer planets.
    - https://space-facts.com/terrestrial-planets/
    - https://space-facts.com/gas-giants/
- Universe Today has a graphic model of the planets. https://www.universetoday.com/34577/inner-and-outer-planets/
- This site has information on the planets with descriptions of the inner and outer planets. https://www.dkfindout.com/us/space/solar-system/

Earth, the Moon, and the Sun

- This site has information on Earth's rotation and shadows. https://k8schoollessons.com/earths-rotation/

- NASA has an activity using shadows to build understanding of Earth's movement. https://sunearthday.nasa.gov/2007/materials/changing_shadows.pdf
- Sciencing provides information on the day/night cycle on Earth. https://sciencing.com/causes-day-night-cycle-earth-15684.html
- This site has information on Earth's rotation and shadows. https://www.acaedu.net/cms/lib3/tx01001550/centricity/domain/389/5.8c%20earth%20rotation.pdf
- This site has lessons on Earth's rotation and shadows. https://hea-www.harvard.edu/ECT/the_book/Chap1/Chapter1.html
- Ducksters has information on the moon's phases. https://www.ducksters.com/science/phases_of_the_moon.php
- SPACE.com has information on how the moon phases work and a current lunar calendar. https://www.space.com/18880-moon-phases.html
- Stanford Solar Center has activities around the moon phases. http://solar-center.stanford.edu/activities/MoonPhases/
- These sites provide information on Earth's tilt and its seasons:
    - https://spaceplace.nasa.gov/seasons/en/
    - http://www.budgetastronomer.ca/index.php?page=th-tilt-of-the-earth-and-the-seasons
- This site provides information on the tilt of Earth and its seasons. https://www.ducksters.com/science/seasons.php
- NASA provides a lesson that has students actively modeling the movement of Earth around the sun. https://sdo.gsfc.nasa.gov/assets/docs/Kenestetic_Astronomy.pdf
- Kids Geography has information and a diagram on Earth's orbit around the sun and the seasons. https://kidsgeo.com/geography-for-kids/the-revolution-of-the-earth/

Gravitational Pull and the Planets, Earth and the Moon

- Space Place has information and hands-on activities on why planets travel on an orbit around the sun. https://spaceplace.nasa.gov/review/dr-marc-solar-system/planet-orbits.html
- This site provides information and graphics explaining the cause of a planet orbiting in space. http://www.qrg.northwestern.edu/projects/vss/docs/space-environment/1-what-causes-an-orbit.html
- This site has a lesson plan on Earth orbiting the sun. https://www.deltaeducation.com/SSIDEL/media/Downloads/DSM/Samples/solar_system_activity.pdf
- This site has information on Earth's orbit around the sun. http://curious.astro.cornell.edu/about-us/57-our-solar-system/planets-and-dwarf-planets/orbits/243-why-do-the-planets-orbit-the-sun-beginner
- NASA provides information on gravity and formation of stars. https://imagine.gsfc.nasa.gov/educators/lifecycles/LC_main3.html

- Scholastic has information on the moon. https://www.scholastic.com/teachers/articles/teaching-content/all-about-moon/
- This site has information on the moon's effect on ocean tides. https://www.timeanddate.com/astronomy/moon/tides.html
- Nature Bridge has a lesson on the moon and tides. https://naturebridge.org/sites/default/files/Gravity%20and%20Tides.pdf
- CPALMS has a lesson on graphing tides and comparing to moon phase. http://www.cpalms.org/Public/PreviewResourceLesson/Preview/121540

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**
Introduce information through a multi-sensory approach (e.g., auditory, visual, tactile).	Present a model showing the relationships between the sun and Earth and Earth and the moon (e.g., https://superstarfloraluk.com/9896532-Simple-Moon-and-Earth-Model.html). [Individualization idea: Create and have students explore a tactile model (e.g., http://www.perkinselearning.org/accessible-science/sun-earth-moon-system-model). **V** Have students listen to a podcast about the moon or gravity (e.g., http://www.astronomyforkids.com.au/). **V** Read a children's literature book related to the unit topics (e.g., http://www.kbs.msu.edu/wp-content/uploads/2017/02/NGSS-Interactive-Read-Alouds.pdf).
Model content through pictures, dramatization, videos, etc.	Have students create separate models of Earth's orbit around the sun, Earth's rotation on its axis, and the moon's orbit around Earth (e.g., http://digital.nsta.org/publication/?i=212724&article_id=1730470&view=articleBrowser&ver=html5#{"issue_id":212724,"view":"articleBrowser","article_id":"1730470"}). [Individualization idea: Have students complete all the activities. However, emphasize that the sun is stationary and the middle of our solar system; Earth orbits the sun; Earth rotates; and the moon orbits Earth.] Present an animation that demonstrates the rotation of Earth (e.g., https://www.youtube.com/watch?v=R8dLhdV6n00). Show a video that explains day/night and change of shadows (e.g., https://www.youtube.com/watch?v=R8dLhdV6n00). [Individualization idea: Present a representation of the sun (e.g., ball), a simple object (e.g., ruler), and a representation of each shadow direction and length included in the video. Move the sun and present the corresponding shadow as it is presented in the video and have students feel the orientation of the sun and feel the change of the shadow. Use the material to practice the concept.] **V** Show a video about moon phases (e.g., https://www.youtube.com/watch?v=yXe0yxzYkjo) and cause of the seasons (e.g., https://www.youtube.com/watch?v=Pgq0LThW7QA).
Present information using graphic organizers and models.	Use an extended version of the KWHL: What do I **K**now? What do I **W**ant to know about or wonder about (e.g., a phenomena)? **H**ow will I find out (e.g., determine how to organize investigations)? What have I **L**earned? What **A**ction will I take (e.g., share with others, apply to daily life, etc.)? What new **Q**uestions 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:

Multiple Means of Representation	
Strategies	**Examples**
	https://nceo.umn.edu/docs/Teleconferences/tele14/CourtadeFlowers.pdf.] Create a model of the solar system using a round placemat and buttons of different sizes to represent the sun and the planets (https://www.pinterest.com/pin/132996995224869628/). Keep and present a classroom moon calendar using a lunar report (e.g., https://www.timeanddate.com/moon/phases/usa/nashville). [Individualization idea: Provide icons representing each phase for students to select and paste onto the calendar.] Have students place pictures of the phases of the moon in the correct order on a graphic organizer (e.g., http://www.bookunitsteacher.com/blog/march2015/lunarphases.pdf). [Individualization idea: Create a digital version and have students drag and drop the images into the correct position.] **P**
Provide appropriate and accessible text on the content for students to listen to or read.	Paraphrase information to reduce text difficulty and length (e.g., http://textcompactor.com/) and write or type with a bold and plain font (e.g., Verdana, 18 pt. font) with good spacing between lines (e.g., 1.5 vs. single spacing). **V** Read online text about: • Earth's rotation (e.g., https://macmillanmh.com/ccssreading/imagineit/grade6/ccslh_g6_st_4_1a_l1.html) and • tides (e.g., https://www.ck12.org/earth-science/Tides/lesson/Tides-HS-ES/). [Individualization idea: Have students use a screen reader or have a peer read it to the student.]
Teach information using songs.	Have students listen to a song about the lunar phases (e.g., http://www.teachjunkie.com/sciences/21-super-activities-teaching-moon-phases/). [Individualization idea: Have students play the song using adapted switch]. **P** Have students listen to song about tides (e.g., https://www.youtube.com/watch?v=KFYf_it461s).

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.	Have students explore a site about the solar system (e.g., https://www.texasgateway.org/resource/earth-rotation-and-revolution). [Individualization idea: Have students use an adapted mouse to drag and drop the planets onto the graphic organizer in this site.] **P** Have students explore an interactive site on the moon's orbit around Earth (e.g., https://highered.mheducation.com/olcweb/cgi/pluginpop.cgi?it=swf::800::600::/sites/dl/free/0072482621/78778/Lunar_Nav.swf::Lunar%20Phases%20Interactive). Have students explore interactive sites on Earth, the sun, and moon (e.g., http://interactivesites.weebly.com/earth-moon-and-sun.html *May require Internet Explorer or Firefox*). Have students test model rockets and refine the design to improve height and distance (e.g., https://www.jpl.nasa.gov/edu/teach/activity/stomp-rockets/). [Individualization idea: Provide a variety of shapes and sizes of fins for students to choose to put on their rockets.]
Allow for instructional materials that can be modified to provide access.	Have multiple ways for students to interact with instructional materials (e.g., paper, digital, etc.) [Individualization idea: Provide a paper stabilizer (e.g., removable tape or glue, nonslip mat, clipboard, etc.) to prevent the paper from moving when the student is drawing, writing, reading, or pasting. Paste paper materials onto craft foam sheets or blocks to ease manipulation.] **P** Help students label models. [Individualization idea: Provide high contrast or tactile print for labels (e.g., http://www.visionaware.org/info/everyday-living/home-modification-/labeling-and-marking/125).] **V** Have students read or listen to texts about unit topics: • Orbit of Earth in the appropriate reading level (e.g., https://sites.google.com/a/spartanpride.net/middle-school-science/7th-grade-science/sun--earth), • Earth's orbit and rotation (e.g., https://extension.illinois.edu/treehouse/seasons.cfm?Slide=2), and • The seasons and the sun (e.g., http://bookbuilder.cast.org/view.php?op=view&book=84959&page=1).
Provide multiple means for students to make choices and select answers.	Record correct answers and distractors on a voice output multiple message switch or multiple voice output switches and have students answer questions using the switch. **P** Have student dictate answers. [Individualization idea: Place answer options in the student's AAC device or on multi-select voice output switch.] **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**

Multiple Means of Action and Expression	
Strategies	**Examples**
Provide simulation activities.	Have students conduct an activity in which they illustrate the spacing of the planets and identify the inner and outer planets (e.g., http://lasp.colorado.edu/education/outerplanets/lessons/grades3-5/Planetary%20Distances%20on%20the%20Playground.pdf). [Individualization idea: Have students use a walking wheel measuring tape (e.g., https://dnr.maryland.gov/education/Documents/MakeYourOwnMonitoringEquipment.pdf) when unable to pace the distance.] **P** Have students simulate the orbit and rotation of Earth using common objects (e.g., http://science-mattersblog.blogspot.com/2010/11/rotaterevolve-model.html). Have students explore an interactive simulation demonstrating gravity and orbits (e.g., https://phet.colorado.edu/en/simulation/gravity-and-orbits). Have students explore an interactive site illustrating shadows throughout the day (e.g., https://www.schoolsobservatory.org/learn/astro/esm/daynight/shadows). [Individualization idea: Model how to move the sun and point to the shadow as it changes.]
Provide graphic organizers and templates.	Have students create a model of the solar system using common items (e.g., https://www.pinterest.com/pin/132996995224869628/ or http://www.perkinselearning.org/accessible-science/activities/one-small-step-multi-sensory-tour-our-solar-system). Have students show evidence of Earth's rotation by measuring and recording shadow location throughout the day (e.g., https://www.giftofcuriosity.com/recording-the-earths-rotation-with-shadows/). [Individualization idea: Provide number stickers to place on the location of the shadow throughout the day.] Have students graph tidal levels using provided data (e.g., http://www6.grafton.k12.wi.us/ghs/teacher/rwilson/earth_science/documents/graphing_the_tides_fundy.doc or https://middleschoolscience.com/2015/02/10/graphing-spring-tides-neap-tides-moon-phases/). [Individualization idea: Have students use a bingo dauber to plot levels and icons of the moon phases to indicate the moon phase on the graph.]

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

Multiple Means of Engagement	
Strategies	**Examples**
Provide a schedule and visual timer.	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. Use a first/then schedule (e.g., https://www.autismclassroomresources.com/visual-schedule-series-first-then/). Provide students a choice chart along with a visual schedule. The choice chart provides students with choices of activities to do once they have completed academic tasks (e.g., https://www.thoughtco.com/visual-schedules-for-students-with-disabilities-3111100).
Vary the challenge and amount of information presented at a time.	Begin with having students identify the phases of the moon, then introduce the concept of the moon causing the tides. Finally, compare the moon phases to the tidal levels.
Make connections to topics or activities that are motivating.	Make connections between motivating seasonal activities (e.g., flying a kite in spring, playing in the snow in the winter) when learning about the cause of the seasons. Explore Google Moon (e.g., https://www.google.com/moon/).
Allow choices as possible.	Allow students to choose where to sit, whom to sit with, etc. Allow students to use preferred communication (e.g., high-tech device, low-tech device, gestures, etc.) to answer questions or participate in class discussion.
Provide opportunities to work collaboratively with peers.	Have students work with general education peers in an Earth and space unit, including instruction and projects. Assign specific roles for students within a group based upon their strengths (e.g., time keeper, making choices for presentation slides, etc.)
Teach student self-regulation skills.	Provide communication symbols to request a break or express feelings and model how to use them appropriately. Provide students with stress balls, finger fidgets, etc. Scaffold instruction on using self-regulation skills (e.g., modeling, cueing, fading support).

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/
- This site describes social bookmarking tools for educators and provides links to 28 free sites. https://elearningindustry.com/28-free-social-bookmarking-tools-for-educators
- 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	When students are engaging in Scientific Inquiry and Engineering Design practices (see Section II), help students make connections between science and daily life when constructing explanations and designing solutions (e.g., explaining a problem with a personal computer to tech support).	Work on increasing language skills, articulation, or accessing alternative and augmentative communication (AAC) systems in the context of content area instruction. Provide practice on motor skills (e.g., range of motion, pincer grasp, activating a switch) during science activities.
Reading and Listening Comprehension	Highlight key information and help students formulate big ideas when reading about unit topics.	Provide practice on social and behavioral skills (e.g., raising hand, waiting, taking turns) when the class is discussing a text on science.
Mathematics	Teach measuring and data collection during investigations (e.g., measuring shadow lengths).	Provide practice on number identification, quantity, elapsed time, etc.
Age-Appropriate Social Skills	Make connections between the Crosscutting Concepts and real-life experiences showing that patterns can be used to make predictions about both positive and negative consequences of behavior (e.g., I get help from friends when I ask calmly.)	Have students listen to social stories (e.g., https://www.autism.org.uk/about/strategies/social-stories-comic-strips.aspx) illustrating appropriate behavior during science instruction.
Independent Work Behaviors	Encourage and reinforce independent completion of tasks to build independent work skills.	Use positive behavior supports to encourage and reinforce independent work skills.
Skills in Accessing Support Systems	Encourage students to ask appropriately for accommodation needs (e.g., interpreter, large print, preferential seating, etc.).	Use this time to have the student work on behavior and communication skills.

Section VIII

Tactile Maps and Graphics

The maps and graphics guidelines will help create tactile versions of instructional maps, diagrams, models, and timelines to use with students who are blind or deaf-blind. The tactile maps and graphics may be beneficial to other students as well. A tactile graphic is a representation of a graphic (e.g., picture, drawing, diagram, map, etc.) in a form that provides access through touch. It is not an exact copy of the graphic. The section provides basic guidance and links to more comprehensive resources.

Importance of Tactile Maps and Graphics

It is important to provide tactile graphics for young readers (BANA, 2010). It helps students understand and gain information when presented with science concepts, knowledge, and skills. Science instruction often presents diagrams (e.g., water cycle) and two-dimensional models of living and nonliving things (e.g., model of cell) to teach the related concepts. The following guidance includes information to build upon when creating tactile graphics.

Tactile Graphic Guidance

1. **Determine need for graphic:** When encountering graphics in instructional materials, determine if the graphic is essential to understanding the concept. The Braille Authority of North America (2010) provides a decision tree to help in this determination. It can be accessed online at http://www.brailleauthority.org/tg/web-manual/index.html by selecting "Unit 1 Criteria for Including a Tactile Graphic."
2. **Consult with the local educator trained to work with students with visual impairments.**
3. **Determine the essential information in the graphic.** Read the surrounding information and the caption to determine which information in the graphic to exclude. For example, a model to illustrate the cell wall, nucleus, chloroplast, and vacuole would not need to include the nuclear membrane, Golgi body, and ribosomes.
4. **Reduce unnecessary detail in the graphic.** Identify details that are not necessary for interpreting the information in the graphic. For example, a model of the water cycle may show crevices on the mountains, leaves on a tree, and waves in an ocean. Eliminate unnecessary details, as they are difficult to interpret tactilely.
5. **Remove frames or image outlines if they serve no purpose.** Ensure that all lines are necessary (e.g., the lines showing the river), and remove any that are not (e.g., ripples in the water).
6. **Modify the size of the graphic.** Modify the graphic as needed to reduce clutter and allow a blank space between adjacent textures. Additionally, consider the size of the student's hand.
7. **Use solid shapes as feasible.** When solid shapes do not clearly represent the information, use clear solid lines.
8. **Systematically teach exploration and interpretation of tactile graphics.** Systematic instruction and repetition are important when teaching a student to understand a tactile graphic. Pairing the tactile graphic with a 3-dimensional object may help (e.g., pair a raised line drawing of a plant, an example of plants and their parts, with a real plant).

Specific Graphic Type Guidance

Following is information for specific types of graphics that may support instruction in science.

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

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[2] All resources provided for this module only. Mention does not imply endorsement, recommendation, or approval by the Tennessee Department of Education.

Prepared by edCount, LLC in collaboration with Educational Testing Service as part of the TCAP/Alt Science and Social Studies contract.