Science

Module 8

Earth Science: Human Impacts on Earth 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 and Human Activity (Elementary)—Earth has natural processes (e.g., fires, landslides, earthquakes, volcanic eruptions, floods) that can result in natural hazards (e.g., flooding homes). People cannot prevent the natural processes but can take steps to minimize the hazards (e.g., build flood walls). Resources (e.g., materials, energy, and fuels) people use come from Earth's natural resources. Some of the natural resources are renewable (e.g., sunlight, wind, and water) and some are not (e.g., fossil fuels and minerals).
- Earth and Human Activity (Middle)—Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources, including air, water, soil, minerals, metals, energy, plants, and animals. Some of these resources are renewable over human lifetimes, and some are nonrenewable (mineral resources and fossil fuels) or irreplaceable if lost (extinct species). Human dependence on Earth's natural resources can be sustained when monitored closely. Fossil fuels and minerals are nonrenewable natural resources with a limited supply and it is important to protect these. Additional natural resources (e.g., trees, sustainable agriculture, water, sunlight, etc.) are renewable and readily available. The use of both renewable and nonrenewable natural resources has advantages and disadvantages.

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: Human Impacts on Earth 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 Science: Human Impacts on Earth 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)
Earth and Human Activity (elementary)		
3.ESS3.1: Explain how natural hazards (fires, landslides, earthquakes, volcanic eruptions, floods) impact humans and the environment.	**3.ESS3.1.a:** Ability to identify problems (for humans or for the environment) caused by natural hazards (i.e., fires, landslides, earthquakes, volcanic eruptions, floods)	**3.ESS3.1.UC:** Identify natural hazards (i.e., fires, earthquakes, volcanic eruptions, floods).
4.ESS3.1: Obtain and combine information to describe that energy and fuels are derived from natural resources and that some energy and fuel sources are renewable (sunlight, wind, water) and some are not (fossil fuels, minerals).	**4.ESS3.1.a:** Ability to identify examples of renewable fuel sources (i.e., sunlight, wind, water) of energy derived from natural resources and nonrenewable fuel sources (i.e., fossil fuels, minerals) of energy derived from natural resources	**4.ESS3.1.UC:** Recognize that humans use energy and fuels to meet their daily living needs.
Earth and Human Activity (middle)		
6.ESS3.1: Differentiate between renewable and nonrenewable resources by asking questions about their availability and sustainability.	**6.ESS3.1.a:** Ability to identify that renewable resources (e.g., trees, sustainable agriculture, water, sunlight, etc.) are readily available	**6.ESS3.1.UC:** Identify a way to protect a natural resource (e.g., reducing, reusing, and recycling).

Academic Standards	Knowledge and Skills Statements (KSSs)	Underlying Concepts (UCs)
	and can be replaced in a relatively short period of time **6.ESS3.1.b:** Ability to identify that nonrenewable resources (e.g., coal, oil, natural gas, minerals) have a limited supply and take a very long time to be replaced	

[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: How can people protect their homes from wildfires? Does this location have strong and steady enough wind to power our school with wind power? How can we stop buildings from being damaged during an earthquake? How have humans changed their environment to survive and make life more comfortable and convenient? *A cause for the collapse of a building is linked to an earthquake. Elements of the building are identified as contributing to the collapse or helping to prevent the collapse.*

- Developing and using models
  Examples: Develop and/or use a model to describe how wind power converts and supplies electricity to communities (e.g., https://www.mdgreen.org/resources/the-basic-facts-about-wind-energy/. Use models to generate iterative testing of landslides (e.g., https://www.teachengineering.org/activities/view/cub_natdis_lesson05_activity1) *to increase understanding and help design safe structures. Design a model air pollution detector and modify the design to reach optimal function (e.g., http://tryengineering.org/sites/default/files/lessons/pollutionpatrol.pdf). Develop a model to predict and manage current and future human impacts on Earth's spheres.*

- Planning and carrying out investigations.
  Examples: Conduct an investigation to determine how to build a structure that best withstands a simulated earthquake. Conduct investigations to determine the effectiveness of tools/techniques for cleaning water (e.g., http://tryengineering.org/lesson-plans/filtration-investigation). Investigate where the dirty water that drains out of homes and schools goes and where the clean water used comes from. Plan and carry out investigations using models and observe the effects of Earth processes in the natural environment; learn to identify patterns of change; recognize cause and effect relationships among the forces that cause change in rocks, soil, and landforms; and construct explanations of changes that occur over time to Earth materials.

- Analyzing and interpreting data
  Examples: Use data on forest fires in Tennessee (e.g., Daily Fire Report https://www.tn.gov/agriculture/forests/protection/wildfire.html) and compare to the topography and climate of Tennessee to determine logical reasons for observed patterns. Use data on fossil fuel consumption over decades to identify patterns and trends. Compare and analyze data on the effect a dam has on the river's aquatic life and the efficiency for creating power to determine if there is a

need for a redesign of a dam. Build an understanding that human activities affect Earth by examining data showing the causes of the uneven distribution of resources on Earth. Write an informative text to explain the causes of uneven distributions of Earth's mineral, energy, and groundwater resources.

- Using mathematics and computational thinking
  Example: Create a graph comparing the cost of materials of various solar cooker designs and the time to cook a given food item using a computer spreadsheet. Use the graphed data to determine the best solar cooker design option. Compute the number of particles detected in classroom developed air pollution detectors by counting the number of particles in five random squares and taking the average (e.g., http://tryengineering.org/sites/default/files/lessons/pollutionpatrol.pdf). Compare results to determine the best design solution. Use appropriate tools and units of measure when collecting and recording weather and climate data. Model with mathematics when organizing data into scaled bar graphs, pictographs, and tables.

- Constructing explanations (for science) and designing solutions (for engineering)
  Examples: Construct an explanation of observed relationships between occurrences of wildfires and topography. Use evidence from data collection to explain which design solution is the most cost-effective and time-effective. Construct a scientific explanation based on valid and reliable evidence to explain why fossil fuels are considered nonrenewable. Design and develop a windmill out of everyday items; evaluate the design for performance and durability of materials. Investigate connections among Earth's spheres to spark a series of design problems to help protect freshwater reservoirs and minimize human impacts on the environment, including ways to mitigate flooding and erosion, naturally filter water, and prevent contamination of water reservoirs. Design a device to cook using renewable resources that are time and cost-efficient (e.g., https://sciencing.com/science-projects-solar-cooking-egg-sun-23697.html).

- Engaging in argument from evidence
  Examples: Compare and refine an argument regarding the need for the use of earthquake-resistant building materials. Respectfully provide and receive critiques about a presentation on the use of dams and waterpower to provide electricity. Evaluate evidence to make a claim that the long-term benefits of using wind power outweigh the cost of building wind turbines and the danger presented to birds. Use evidence to support the claim that as human populations and per capita consumption of natural resources increase, so do the
  negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

- Obtaining, evaluating, and communicating information
  Examples: Read or listen to grade-appropriate complex texts on methods to control wildfires and present using multimedia. Combine qualitative and quantitative information regarding the benefits and disadvantages of using nonrenewable energy sources. Determine the scientific information from an adapted text to describe patterns of earthquakes that harm people and communities. Use classroom investigations and information from reliable sources to communicate building designs that withstand earthquakes.

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, 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: Human Impacts on Earth Systems, addresses ways in which Earth's surface processes affect and are affected by human activities. Specifically, humans depend on all the planet's systems for a variety of resources, some of which are renewable or replaceable and some of which are not. In addition, natural hazards can alter human populations and activities. While, human activities, in turn, can contribute to the frequency and intensity of some natural hazards.

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 Science: Human Impacts on Earth 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.

Patterns

Patterns

- Patterns of change can be used to make predictions (e.g., The consumption rate of nonrenewable natural resources can be used to predict when the resources could be depleted. The pattern of occurrence of earthquakes and volcanic eruptions can be used to predict when they will occur again.).

Causality

Cause and Effect

- Cause and effect relationships are routinely identified and used to explain change (e.g., An increase of communities located in forest areas with dry, windy weather causes more people and communities to be harmed by forest fires, therefore increasing research into fire-resistant building materials. An increase in population results in an increased use of nonrenewable fossil fuel energy, which causes people to use alternative fuel sources.).

Systems

Systems and System Models

- Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems (e.g., Models of solar panels, wind turbines, and hydroelectric plants can illustrate how sunlight, wind, and water are used as renewable natural fuel sources.).

Scale, Proportion, and Quantity

- Natural objects and/or observable phenomena exist from the very small to the immensely large or from very short to very long time periods (e.g., Fossil fuels are formed over a timescale beyond human lifetimes. Some volcanoes remain inactive for very long periods of time, while others erupt very often causing natural hazards.)

Energy and Matter

- Earth is a system with multiple sources of energy available. The sun can provide external inputs of resources such as wind and water. As the global human population increases and people's demands for better living conditions increase, resources considered readily available in the past, such as land or agriculture or drinkable water, are becoming scarce and more valued.

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

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., natural resources) and in the context of the specific content (e.g., Teach the terms "solar power," "wind power" and "waterpower" while students are viewing pictures of each, investigating alternate energy forms, exploring models of each, 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 "lightning" helps students understand storm safety, weather reports, and a cause of fires. The second type, **specific content words**, represents groups of words that are associated with an organism, system, process, or phenomena. For example, the specific term "nonrenewable resource" connects to the general words "coal," "oil," and "natural gas" when learning about fossil fuels and protecting natural resources. 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, and six. 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., Recycling is when materials are processed and used again.) and an example of the word (e.g., Recycled computer paper can be made into napkins.). Teach the specific content vocabulary using a student-friendly description of the word meaning (e.g., A renewable resource is a resource that can be replaced through natural processes.) and a possible connection to a general vocabulary word (e.g., Sunlight, wind, and water are examples of renewable resources.).

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 learn to identify a volcano as a natural hazard instead of defining it.

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., Conserve means to be careful not to let something run out. *Example: People can conserve minerals by recycling and reusing everyday items.).*		
• ash	• hurricane	• reduce
• atmosphere	• impact	• reuse
• climate	• landslide	• solar power
• coal	• lava	• tornado
• conserve	• lightning	• volcano
• earthquake	• minerals	• waterpower
• electricity	• natural gas	• weather
• energy	• natural resource	• wildfire
• flood	• oil	• wind power
• fuel	• population	
• hazard	• recycle	

Table 3. Specific Content Words

Specific Content Words—words that specify a particular thing (e.g., sedimentary rock) or phenomena (e.g., biodiversity). Describe the word and when possible make the connection to a Crosscutting Concept (e.g., Sustainable agriculture is when crops are grown with little waste of water, harm to the soil, or harm to the environment. Sustainable agriculture will help Earth's natural resources to be more stable.		
• barometer	• groundwater	• renewable resource
• biosphere	• natural hazard	• society
• conservation	• natural resource	• sustainable agriculture
• fossil fuel	• nonrenewable resource	

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.	• Explain what natural resources are by sharing pictures of and describing the resources (e.g., Show pictures of water and talk about the water people wash their hands with and drink, then explain that water is a natural resource because it is found in nature and is used by people. [Individualization idea: Add objects when possible to supplement pictures (e.g., bowl of water to feel, fan blowing to represent wind, rocks, etc.)] **V**
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 describe and give an example of "reuse" (e.g., "Reuse means to use something more than one time. I bring my water in a water bottle that we wash and use again each day."). [Individualization idea: Allow students to use multiple communication modes to describe and/or give examples of vocabulary words (e.g., Student holds up his water bottle and says, "This all week.")]
Have students represent vocabulary words in a variety of ways (e.g., pictures, symbols, graphic organizers, or models).	• Have students complete a cloze activity for natural hazard vocabulary (see Figure 1. Example Cloze Strategy). [Individualization idea: Attach vocabulary word cards to a three-dimensional block to ease manipulation and practice the same cloze activity each day.] **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://projectlearnet.org/tutorials/learning_trials.html for information on learning trials.	• Watch videos related to the vocabulary and concepts. (e.g., https://www.youtube.com/watch?v=VlRVPum9cp4). [Individualization idea: Interpret (e.g., ASL) the video.] **H** • Have students access online texts about recycling (e.g., http://bookbuilder.cast.org/view.php?op=view&book=103677&page=1.) • Have students complete a sorting activity with pictures or objects by sorting each into a trash category and/or recycling category. • Have students communicate the benefits of recycling to their parents, school, or community. [Individualization idea: Provide multiple ways for students to communicate the information: using icons/pictures, developing a slide show, recording a message, using ACC system, etc.].

Ideas	Examples
Ask students to discuss the vocabulary words with each other.	• Have students identify a vocabulary word from their science notebook and present and describe the word to the class or small group. [Individualization idea: Have students play a recording that describes the vocabulary word using a single switch.] **P** • Have students compare and describe similarities and differences of natural resources (e.g., Coal and sunlight are similar because they both can produce heat; they are different because coal is nonrenewable, and sunlight is renewable.). [Individualization idea: Present one description at a time related to two natural resources and ask, "Is this the same for both natural resources?" and place in the appropriate area of a Venn diagram.]
Play vocabulary word games with students.	• Adapt an existing board game by making cards with pictures of different natural resources. Have students draw a card and discuss if it is a renewable or nonrenewable resource. If it is renewable, the player moves forward according to the number of spaces printed on the card. If it is nonrenewable, the player moves back the number of spaces printed on the card. • Have students practice natural hazard vocabulary using online flash cards (e.g., https://quizlet.com/151579030/natural-hazards-flash-cards/).
Have students watch a dramatization or have them act out the vocabulary term.	• Have students represent natural hazards through actions (e.g., shaking for earthquake, arms up and around for volcano, hands in a wavy motion with each wave getting higher for flood).

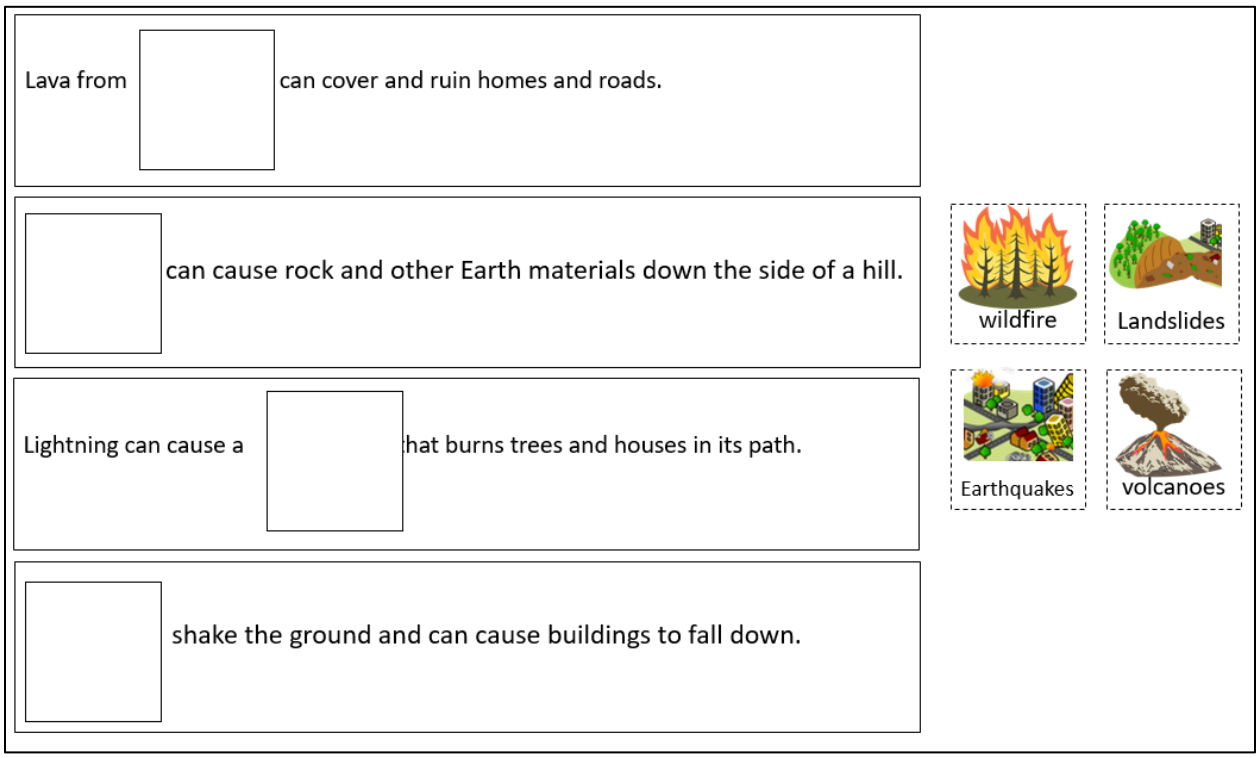
[1] Refer to Section VI, Universal Design for Learning (UDL) Suggestions for additional instructional strategies.

Vocabulary Example

Have students complete a cloze activity for natural hazard vocabulary (see Figure 1. Example Cloze Strategy). [Individualization idea: Attach vocabulary word cards to a three-dimensional block to ease manipulation and practice the same cloze activity each day.] **P** 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 Cloze Strategy



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 and Human Activity (elementary)

Content

Natural Hazards

- Natural hazards are major events caused by natural processes of Earth that can harm people due to location, severity, and frequency.
- Examples of natural hazards include wildfires, earthquakes, volcanic eruptions, storms, and floods.
- Some natural hazards are weather related. Examples include:
  - heavy rains with flooding and/or landslides,
  - lightning that causes fires, and
  - high winds or tornadoes.
- Impacts of Natural Earth Processes on Humans:
  - Flooding can damage roads and buildings and harm people.
  - Fires can burn homes and other buildings; people can be harmed by the fires.
  - Earthquakes can cause structures (e.g., roads, bridges, buildings) to shake and collapse; people can be hit or covered by structures that are broken apart.
  - Landslides can bury roads, structures, and people.
  - Lightning can strike a house or a tree in the forest causing a fire; lightning can strike and electrocute people.
  - Strong winds (e.g., tornadoes) can tear apart buildings; people can be harmed by the flying debris.
  - Volcano eruptions spread lava, ash, and rock which can burn buildings and harm people.

Natural Resources – Renewable and Nonrenewable

- People use energy and fuels for daily living needs.
- People use both renewable and nonrenewable fuel sources.
- Renewable fuel sources come from resources that can be replaced or cannot be depleted.
- Some fuel sources are renewable including:
  - solar,
  - wind, and
  - water.
- The sun produces solar energy that can be used as heat energy or converted to electricity.
- The kinetic energy of wind can be converted to mechanical and electrical energy.
- The energy from moving water can be converted to electricity.

- Nonrenewable fuel sources come from resources that may be depleted and cannot be replenished.
- Fossil fuels are nonrenewable including:
  - coal,
  - oil, and
  - natural gas.

Earth and Human Activity (middle)

Content

- People need natural resources in their daily lives (e.g., food, school supplies, drinking water).
- Renewable natural resources (e.g., sustainable agriculture, trees, water, groundwater, sunlight) can be replenished over relatively short periods of time.
- Many renewable resources are readily available.
- Nonrenewable natural resources (e.g., minerals, fossil fuels) are resources that exist in a fixed amount and cannot be replaced on a human timescale.
- People can protect natural resources (renewable and nonrenewable) by:
  - reducing the use of natural resources,
  - reusing natural resources when possible (e.g., washable sandwich containers),
  - recycling materials (e.g., aluminum cans, plastic, and paper),
  - planting trees,
  - conserving water usage, and
  - practicing agriculture that can economically sustain itself (e.g., enough income to pay workers) and sustain the environment (e.g., minimizing water usage, using environmentally friendly pesticides, maintaining good soil health, reducing soil erosion).

Unit Content Resources

- Interactive Sites for Education provides a wide variety of topics that include interactive animations. http://interactivesites.weebly.com/science.html

Natural Hazards

- Teaching Engineering has multiple lessons on natural hazards. https://www.teachengineering.org/curricularunits/view/cub_natdis_curricularunit
- Weather Wiz Kids has information on several different natural hazards. http://www.weatherwizkids.com/weather-hurricane.htm
- This site has information on natural hazards including safety information and a game. https://www.ready.gov/kids/know-the-facts
- PBS has information on the hazards cause by volcanoes. http://pbs.panda-prod.cdn.s3.amazonaws.com/media/assets/wgbh/ess05/ess05_int_volcanerupt/02_Hazard.htm#
- Scholastic has basic information on severe weather and natural disasters. http://teacher.scholastic.com/activities/wwatch/severe.htm
- Duckster has information on forest fires. https://www.ducksters.com/science/earth_science/forest_fires.php

- Tree Removal has a plethora of links to resources regarding forest fires. http://www.treeremoval.com/kids-guide-to-forest-fires/#.W5pzGuj24dU
- National Geographic Kids has information on earthquakes. https://kids.nationalgeographic.com/explore/science/earthquake/#earthquake-houses.jpg
- This site has photos of and activities about natural disasters. http://homeschoolden.com/wp-content/uploads/2016/05/Natural-Disaster-Worksheets-Notebook-Pages-and-Hands-On-Activities.pdf
- This site includes an article on the human impact on river organisms. https://www.sciencelearn.org.nz/resources/440-human-impact-on-rivers
- These sites provide information about how natural occurrences affect ecosystems:
  - https://sciencing.com/natural-changes-can-affect-ecosystem-6777.html
  - https://www.lpi.usra.edu/education/step2012/participant/catastrophic_events_impact_on_the_ecosystem_nxpowerlite.ppt
  - STEM-Works has activities for planning for natural disasters. http://stem-works.com/subjects/8-earthquakes/activities/148

Natural Resources – Renewable and Nonrenewable

- Education.com provides a lesson plan on renewable and nonrenewable energy. https://www.education.com/lesson-plan/renewable-and-non-renewable-energy/
- Alliant Energy Kids has information, lesson plans, and games on renewable energy. http://www.alliantenergykids.com/EnergyandTheEnvironment/RenewableEnergy/022400
- Go SEEK has information on solar energy. http://goseek.weebly.com/elementary-school.html
- Ducksters has information on solar energy. https://www.ducksters.com/science/environment/solar_power.php
- Try Engineering has lesson plans that include hands-on activities on:
  - wind energy http://tryengineering.org/lesson-plans/working-wind-energy, and
  - solar energy http://tryengineering.org/sites/default/files/lessons/herecomesthesun.pdf.
- This site has information on wind energy. http://www.energyarchive.ca.gov/energyquest/story/chapter16.html
- Teach Engineering has a lesson plan on waterpower. https://www.teachengineering.org/activities/view/cub_environ_lesson09_activity3
- National Geographic has information on fossil fuels, including the advantages and disadvantages of each. https://www.nationalgeographic.org/encyclopedia/non-renewable-energy/
- eSchool Today has information on nonrenewable energy. http://www.eschooltoday.com/energy/non-renewable-energy/what-is-non-renewable-energy.html

Protecting Natural Resources

- Teach Engineering provides lessons on identifying and conserving natural resources:
  - https://www.teachengineering.org/lessons/view/cub_environ_lesson03 and
  - https://www.teachengineering.org/activities/view/cub_environ_lesson03_activity1.
- CPALMS has a lesson plan on renewable or nonrenewable resources. http://www.cpalms.org/Public/PreviewResourceLesson/Preview/30758

- Better Lesson provides a lesson plan that has students look at natural resources and natural hazards to determine where to build a society. https://betterlesson.com/lesson/639004/where-should-we-land-this-ship?from=cc_lesson
- Classzone has information on natural resources. https://www.classzone.com/science_book/mls_grade7_FL/299_306.pdf
- This site has activities on renewable and nonrenewable resources. http://www.wasp.edu.au/course/view.php?id=2
- This site has activities to encourage recycling. https://pmm.nasa.gov/education/lesson-plans/water-conservation
- These sites have information and lesson plans on conserving water:
  - https://wateruseitwisely.com/kids/ and
  - https://pmm.nasa.gov/education/lesson-plans/water-conservation.
- These sites have information on sustainable agriculture:
  - http://gilbertosalazarescoboza.com/blog/kids-and-sustainable-agriculture/,
  - http://www.sustainabletable.org/246/sustainable-agriculture-the-basics, and
  - http://asi.ucdavis.edu/programs/sarep/about/what-is-sustainable-agriculture.
- PBS Kids provides activities about caring for the planet. http://meetthegreens.pbskids.org/episode5/

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).	Help students make a tactile recycling information board using local items/litter (e.g., http://www.perkinselearning.org/accessible-science/activities/environmental-science-bulletin-board). **V** Take students to visit a local farm using sustainable agriculture or show them a video about sustainable agriculture (e.g., https://www.youtube.com/watch?v=4UYsaRPeOkw). [Individualization idea: Provide students with a picture of money, water, soil, and air. Have students hold up or point to the appropriate picture anytime a related aspect of sustainable agriculture is mentioned.] Have students listen to a podcast discussing the future of fuel (e.g., https://www.brainson.org/shows/2017/06/16/the-future-of-fuel-and-the-problem-of-exhaust-road-trip-pt-2). **V**
Model content through pictures, dramatization, videos, etc.	Have student assist in a hands-on activity demonstrating processes for cleaning water (e.g., https://www.scientificamerican.com/article/time-to-clean-your-water/). [Individualization idea: Place a rubber band around the measuring cup to mark ½ cup. **V** Add pictures to the labels on the data chart. Use number stamps to record times on the data chart. **P**] Demonstrate earthquake-resistant designs on model buildings using a hand-powered shake table (e.g., https://www.scientificamerican.com/article/earthquake-rollers/). Show a video of natural hazards (e.g., https://www.youtube.com/watch?v=9hQZCiZ21fk and https://www.youtube.com/watch?v=krJLnXpemtQ). Show a video on sources of energy (e.g., https://www.youtube.com/watch?v=wMOpMka6PJI).
Present information using graphic organizers and models.	Make a classroom chart listing natural resources, identifying each resource as renewable or nonrenewable, and listing uses for each resource. [Individualization idea: Have students select and use pictures to complete the chart.] Use a KWHL to help students make connections between what they already **K**now, **W**hat they want to know, **H**ow they can find out, and finally, what they **L**earn. (Here's a slide show explaining the use of the KWHL chart and how it was made accessible for students with significant cognitive disabilities: https://nceo.umn.edu/docs/Teleconferences/tele14/CourtadeFlowers.pdf). **V/H/P** 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

Multiple Means of Representation	
Strategies	**Examples**
	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: https://nceo.umn.edu/docs/Teleconferences/tele14/CourtadeFlowers.pdf.]
Provide appropriate and accessible text on the content for students to listen to or read.	Provide an online article on wildfires (e.g., http://www.weatherwizkids.com/weather-wildfire.htm). [Individualization idea: Have students read using a screen reader.] Provide online books that have an embedded text reader (e.g., http://bookbuilder.cast.org/view.php?op=view&book=28747&page=1 *(requires free account)*) or create books on the unit topics (e.g., http://bookbuilder.cast.org/). [Individualization idea: Have students use an adapted mouse to turn the pages of the online book.] **P**
Teach information using songs, poems, or rhymes.	Teach about renewable and nonrenewable natural resources using songs (e.g., free download from https://www.teacherspayteachers.com/Product/Song-to-teach-renewable-and-non-renewable-resources-303628). [Individualization idea: Add motions to the song.] Help students create a poem (e.g., acrostic, http://www.acrosticpoem.org/ or Haiku, http://www.kidzone.ws/poetry/haiku.htm) about content topics (e.g., energy sources). [Individualization idea: Provide word and phrase choices for students to choose from.]

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 an interactive site showing the connection between a source of energy and how it is used in their homes (e.g., http://www.alliantenergykids.com/FunandGames/OnlineGames/KIDS_GAME_FLOW_OF_ENERGY). [Individualization idea: Take turns clicking "next" and model the use of an adapted switch to do so.] **P** Have students play an online game about water conservation (e.g., http://www.discoverwater.org/use-water-wisely/) and recycling (e.g., https://www3.epa.gov/recyclecity/games.htm).
Allow for instructional materials that can be modified to provide access.	Provide age-appropriate books on renewable energy and fuel sources. [Individualization idea: Place paper clips in a staggered format on pages of a book to help students with fine motor difficulties turn the pages.] **P** Provide flexibility in how students can obtain and communicate content information. [Individualization idea: Provide links to appropriate web sites using a visual bookmarking tool (e.g., https://www.educatorstechnology.com/2017/05/10-good-bookmarking-tools-for-teachers.html.] Have students read articles online on: • floods (e.g., https://kids.nationalgeographic.com/explore/science/flood/#flood-house.jpg) and • conserving nonrenewable energy resources (e.g., https://sciencing.com/three-ways-conserving-nonrenewable-energy-resources-20189.html). [Individualization idea: Pair students with general education students to read the articles.] Have students complete a science notebook on natural hazards using pictures (e.g., http://homeschoolden.com/wp-content/uploads/2016/05/Natural-Disaster-Worksheets-Notebook-Pages-and-Hands-On-Activities.pdf). [Individualization idea: Have students first sort pictures into the types of natural hazards, next place each on a separate page of the notebook, then dictate information about each or choose from an array of choices what information to add to each page.]
Provide multiple means for students to make choices and select answers.	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** Allow multiple ways to indicate an answer when working with paper materials. [Individualization idea: Allow students to select answer using touch, large pencil grip, paper stabilizer, eye gaze board, etc.] **P**
Provide simulation activities.	Have students complete an activity that simulates renewable and nonrenewable energy (e.g.,

Multiple Means of Action and Expression	
Strategies	**Examples**
	http://www.aquariumofpacific.org/downloads/ed_3ss_EnergySources.pdf). [Individualization idea: Use cubes in place of poker chips to ease manipulation.] **P** Have students build a solar cooker (e.g., https://sciencing.com/science-projects-solar-cooking-egg-sun-23697.html). [Provide two to three designs for students to choose from. Provide the steps to complete the solar cooker concisely and with added pictures.] Have students experiment with building models of earthquake-proof structures (e.g., http://stem-works.com/external/activity/575).
Provide graphic organizers and templates.	Have students gather information on advantages and disadvantages of using nonrenewable energy sources (e.g., https://www.senteacher.org/downloads/science/44/Free-Recycling-Education-Game.html). Have students sort pictures of items that can and cannot be recycled onto a graphic organizer. [Individualization idea: Complete an online version (e.g., https://www.senteacher.org/downloads/science/44/Free-Recycling-Education-Game.html.]

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

Multiple Means of Engagement	
Strategies	**Examples**
Provide a schedule.	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/). Prepare students for a change in their schedule by using a "change card" to place over the scheduled activity (e.g., https://www.iidc.indiana.edu/pages/change-is-good-21-supporting-students-on-the-autism-spectrum-when-introducing-novelty).
Vary the challenge and amount of information presented at a time.	Introduce familiar natural resources (e.g., rocks, water, sunlight, wind, trees, etc.). Then begin connecting those and other natural resources to the things they make (e.g., food, clothing, school supplies, heat, electricity, etc.). Finally, explain that some resources are renewable, and some are nonrenewable.
Make connections to topics or activities that are motivating.	Use a fairy-tale format to tell about protecting the environment (e.g., https://www.youtube.com/watch?v=fKWQuU0sHPw). Help students make the connection between natural resources and items or activities that are relevant to the student (e.g., connection between the magazine/pamphlet a student likes, and the natural resource used to make it, or the video game and the electricity used to operate it).
Allow choices as possible.	Allow students to choose whether to look at or listen to a book (e.g., http://bookbuilder.cast.org/view.php?op=view&book=89103&page=1) or watch a video about recycling (e.g., https://www.youtube.com /watch?v=5WD9hTmL22Q).
Provide opportunities to work collaboratively with peers.	Have students play games (e.g., https://www.flocabulary.com /vocabulary-mini-games/) related to unit content topics together. Have students work in cooperative groups with mixed abilities. [Individualization ideas: Present instructions and group expectations using a task checklist and group rules. Develop and read a social story about working in a group to the students. Provide the students with the necessary communication tools to participate in the group activity. Assign specific pieces of the task to each student.]
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. Have students self-evaluate on acquisition of skills and knowledge using a simple chart such as an "I Can . . . " where the skills and knowledge (e.g., identify a natural resource) are listed and the students color in a smiley face or check the box when they are able to

	perform the skill or demonstrate knowledge of the skill (e.g., http://www.sparklebox.co.uk/class-management/targets-monitoring/i-can-sheets/#.W6E3_uj24dU).

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	When teaching vocabulary, make connections to real-life or future opportunities to use the words (e.g., discussion around a current natural disaster). Sign ASL STEM terms to provide students with vocabulary needed for science labs and future employment.	Use the context of the content area instruction to increase language skills, work on articulation, or access alternative and augmentative communication (AAC) systems.
Reading and Listening Comprehension	Reinforce Crosscutting Concepts of patterns and cause and effect relationships when reading books that include information about natural hazards or natural resources (e.g., in social studies texts).	Provide practice on communication skills when students are answering questions about information in the book or article. Provide practice on identifying sight words while reading science texts.
Mathematics	Teach adding data and creating a graph in a digital spreadsheet.	Practice number identification and relative quantity.
Age-Appropriate Social Skills	Provide instruction on appropriate ways to gain attention when asking questions and communicating information while working on Science and Engineering Practices.	Provide opportunities to work alongside same age peers to practice age-appropriate social skills and serve a vital role in the group.
Independent Work Behaviors	Provide a task checklist and a time to support independent work behaviors.	Use this time to have the student work on following self-evaluation skills.
Skills in Accessing Support Systems	Encourage students to ask appropriately for assistance from peers and adults when researching information on the effects natural disasters have on people.	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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Prepared by edCount, LLC in collaboration with Educational Testing Service as part of the TCAP/Alt Science and Social Studies contract.