Science

Module 5

Physical Science: Definitions of Energy

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:

- Energy (elementary) – Various forms of energy are constantly being transformed into other types without any net loss of energy from the system: sources and forms.
- Energy (middle) – Various forms of energy are constantly being transformed into other types without any net loss of energy from the system: forms of energy involved and the properties of the materials involved influence energy transformations and the mechanisms by which energy is transferred.

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 Physical Science: Definitions of Energy 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. Science Academic Standards and Related Alternate Assessment Targets and Underlying Concepts;
II. Scientific Inquiry and Engineering Design;
III. Connecting 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

Science Academic Standards and Related Alternate Assessment Targets 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 related Alternate Assessment Targets (AATs) and Underlying Concepts (UCs) covered in the module. The AATs are specific statements of knowledge and skills linked to the grade-specific science academic standards. The UCs are basic key ideas or concepts linked to specific AATs. UCs are a basis for developing a more complex understanding of the knowledge and skills represented in the AAT and should not be taught in isolation. It is important to provide instruction on the AAT along with the UC in order to move toward acquisition of the same concepts, knowledge, and skills.

Table 1 includes the academic standards and related AATs and UCs for Physical Science: Definitions of Energy. 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 AATs and UCs included in the table do not cover all of the concepts that can be taught to support progress and understanding aligned to the standards.

Table 1. Science Academic Standards and Related AATs and UCs [1]

Academic Standards	Alternate Assessment Targets (AAT)	Underlying Concepts (UC)
Energy can be moved from place to place by moving objects, or through sound, light, or electrical currents. Energy changes to and from each type can be tracked through physical or chemical interactions.		
0307.10.1 Use an illustration to identify various sources of heat energy.	Identify representations of various sources of heat energy.	Identify a representation of hot or cold (e.g., fire or ice).
0407.10.1 Identify different forms of energy, such as heat, light, and chemical.	Identify energy forms and examples (i.e., heat, light, and chemical).	Match observable changes to a substance that are a result of heating or cooling.
0607.10.2 Interpret the relationship between potential and kinetic energy.	Identify potential energy (stored energy) and kinetic energy (motion of objects), as different types of energy.	Identify the relationship between motion and energy (i.e., the faster a given object is moving, the more energy it possesses).
0607.10.3 Recognize that energy can be transformed from one type to another.	Identify real-world applications where energy is transformed (e.g., A television changes electrical energy into sound and light energy).	Identify real-world applications where heat energy is transferred (e.g., A stove transfers heat to a pan).
0607.10.4 Explain the Law of Conservation of Energy using	Use the Law of Conservation of Energy to identify the	Identify real-world outcomes of the transfer of potential to kinetic energy (e.g., When a

Academic Standards	Alternate Assessment Targets (AAT)	Underlying Concepts (UC)
data from a variety of energy transformations.	relationship of kinetic to potential energy.	rubber band is stretched and waiting to be released).

[1] Instruction is not intended to be limited to the concepts, knowledge, and skills represented by the AATs 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, rather 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. 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: Where does the energy go when water boils? How does a roller coaster get the energy to go up the second hill? Which race car is using more energy? How is an egg in a frying pan able to cook?
- Developing and using models.
  Examples: Develop a model of a roller coaster using paper tubes or pool noodles to demonstrate potential and kinetic energy. Develop and label a model showing how energy is transformed when using a flashlight. Develop a model of a ramp using cars of different masses to demonstrate the relationship between motion and energy.
- Planning and carrying out investigations.
  Examples: Conduct experiments with everyday objects (e.g., hair dryer, electric light, flashlight, radio) to determine what energy transformation is occurring. Conduct investigations with objects moving at different speeds to determine the relationship between motion and energy.
- Analyzing and interpreting data.
  Examples: Analyze data of the height of a ball dropped in relationship to the height of the bounce. Use a ramp and marble to investigate the conservation of mechanical energy (e.g., potential energy at the top of the ramp compared to the kinetic energy at the bottom of the ramp). Analyze data of how the height of a ramp impacts a model car's speed and distance.
- Using mathematics and computational thinking.
  Examples: Measure the distance objects with different masses travel when rolled down a ramp. Measure the distance of stretch of a rubber band at rest and the distance the rubber band traveled

once released. Determine if energy was conserved as a ball rolls down a ramp by calculating and comparing values of potential and kinetic energy.

- Constructing explanations (for science) and designing solutions (for engineering).
  Examples: Explain how heat is transferred to other objects. Explain how one source of energy is transformed into another source. Design a solar water heater using a cardboard box, aluminum foil, and plastic wrap. Design a tool that will allow an object to be pulled from one location to another.
- Engaging in argument from evidence.
  Examples: Use reasoning to connect the relevant and appropriate evidence and construct an argument that energy can be transformed from one type to another. Connect an object's movement (kicked soccer ball) with the directional force (pushed or pulled).
- Obtaining, evaluating and communicating information.
  Examples: Communicate the idea that energy cannot be created or destroyed. Communicate that potential and kinetic energy do not exist in isolation.

Science Practices Resources

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/

A variety of sites that provide information on experiments, models, and simulations:

- Science-class has energy activities that include models and lab sheets:
  - http://science-class.net/archive/science-class/Physics/energy.htm
  - http://science-class.net/archive/science-class/Physics/force_motion.htm
- The Teachers' Cafe has a variety of energy experiments.
  www.theteacherscafe.com/Science/Hands_On_Activity/Energy_Activities.php
- Kids and Energy provides example of sources that include images and models.
  http://www.kids.esdb.bg/basic.html
- Scientific American provides a lesson plan that has students launch and measure the distance of rubber bands to determine potential energy. http://www.scientificamerican.com/article/bring-science-home-rubber-bands-energy/

Section III

Connecting Concepts

Grade-level science content includes Connecting Concepts, which are concepts that connect information between different science strands and grade levels. The Connecting 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). Connecting Concepts that are specific to this module connect to content across the units within the module as well as across modules.

A Connecting Concepts is a common link between multiple standards and units of study. The Connecting 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. Physical sciences focus on physical and chemical principles that explain mechanisms of cause and effect in systems and processes. For example, understanding that cause-and-effect relationships may cause change is a Connecting Concept which applies to the effect of wind and water movement on Earth's surface, competition of organisms within an environment, applied force on the motion of an object, and the transformation of energy. Some Connecting Concepts may apply across multiple content areas and instructional emphases (e.g., cause and effect in reading science texts).

This science module, Physical Science: Definitions of Energy, covers the various forms of energy that are constantly being transformed into other types of energy without any loss of energy from the system. It addresses the sources and forms of energy, the two types of energy, and the transformation and conservation of energy.

Teaching Connecting Concepts

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

- patterns (e.g., Recognizing patterns is a large part of working with data. Students may examine patterns of daily and seasonal use of electrical power.),
- critical features (e.g., Emphasize that moving objects have energy because of their motion.),
- big ideas (e.g., Energy cannot be created or destroyed.), and
- relationships (e.g., Make the connection between mass and height of an object and the gravitational potential energy the object has.).

For example, when learning about sources of heat energy, point out the cause and effect relationship that explains the change of energy. In addition, build connections between familiar and new information (e.g., Use everyday items such as a flashlight, hairdryer, adaptive switch to demonstrate the energy source and transfer of energy.).

Following are **Connecting Concepts** for this Content Module - Physical Science: Definitions of Energy.

Understand

Patterns

- Patterns can be used to determine similarities and differences.
- Patterns in rates of change and cycles can be used to make predictions.
- Patterns can be observed and used as evidence.
- Patterns can be used to identify cause-and-effect relationships. (e.g., What features of a ramp affect the speed of a given ball as it leaves the ramp?).

Cause and Effect

- Events that occur together with regularity might or might not have a cause-and-effect relationship.
- Some events that occur together are correlated versus causal relationships.
- Some phenomena may have more than one cause.
- Cause-and-effect relationships may explain change.

Scale, proportion, and quantity

- Natural objects and observable phenomena exist from the very small to the immensely large.
- Standard units can be used to measure and describe physical quantities such as weight, time, temperature, and volume.
- Models using scale can be used to study systems that are too large or too small.
- Models can be used to represent systems and their interactions (E.g., energy and matter flow within systems).
- Proportional relationships (e.g., kinetic energy is proportional to the mass of the moving object) can be used to gather information about the magnitude of properties.

Systems and System Models

- A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot.
- System parts work together.
- Energy may transfer into or out of a system and it may change forms, but the total energy cannot change.

Structure and Function

- Different materials have different substructures, which can sometimes be observed.
- Substructures of different materials have shapes and parts that serve functions.
- The function of complex and microscopic structures and systems depends on the shapes, composition, and relationships among its parts.
- Different forces are responsible for the transfer of the different forms of energy.

Energy and Matter

- Objects may break into smaller pieces, can be put back together, and may change shape.
- Matter is made of particles and energy that can be transferred in various ways and between objects.
- Energy drives the motion and/or cycling of matter.
- Energy may take on different forms (heat, light, chemical).
- The sun is a source of energy that lights and warms Earth.

Stability and Change

- Some things stay the same while some things change.
- Things may change slowly or rapidly.
- Some systems appear stable, but change over time.
- Changes in one part of a system might cause large changes in another part.
- Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.
- Matter is conserved because atoms are conserved in physical and chemical processes.

Connecting 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

TeacherVision provides ten science graphic organizers that are free and printable.
https://www.teachervision.com/graphic-organizers/science/52539.html

Utah Education Network provides a variety of student interactives for:

- grades three through six. http://www.uen.org/3-6interactives/science.shtml
- grades seven and eight. http://www.uen.org/7-12interactives/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., energy) and in the context of the specific content (e.g., Teach the terms heat energy, light energy, and chemical energy while interacting with everyday energy sources.).

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 "fuel" helps students to understand heat, light, chemical, and electrical energy. The second type, **specific content words,** represents groups of words that are associated with an organism, system, process, or phenomena. Specific content words (e.g., kinetic energy) connect to general words (e.g., transfer, motion, speed, and mass). 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 through eight; refer to the TN science standards for grade specific words. Teach general vocabulary words to the student using a student-friendly description of the word meaning (e.g., Friction happens when you rub two objects against each other. The two objects warm up because of friction.) and an example of the word (e.g., When you rub your hands together they warm up because of friction.). Teach the specific content vocabulary using a student-friendly description of the word meaning (e.g., Energy transformation is when one source of energy turns into another type of energy. Energy can be transferred from one object to another.) and a possible connection to a general vocabulary word (e.g., When you turn on a hair dryer, it turns electrical energy into heat energy.).

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 a source of heat energy rather than defining the term.

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., Temperature is how hot or cold something is. *Example: The temperature of water gets hotter when it is on a hot stove.).*		
• chemical	• fuel	• particles
• conductor	• heat	• sound
• degree	• insulator	• speed
• electric	• light	• temperature
• energy	• mass	• transfer
• force	• matter	• velocity
• friction	• motion	• transformation

Table 3. Specific Content Words

Specific Content Words – words that specify a particular thing (e.g., chemical energy) or phenomena (e.g., physical phenomenon involving electricity). Describe the word and when possible make the connection to a Connecting Concept (e.g., Chemical energy provides power such as food, batteries, and fuel. When wood in a camp fire burns, the chemical energy stored in the wood releases other forms of energy: heat and light.).		
• Celsius	• energy transformation	• law of motion
• chemical energy	• Fahrenheit	• mechanical energy
• electric current	• heat/thermal energy	• light/radiant energy
• electrical energy	• kinetic energy	• potential energy/stored energy
• energy transfer	• law of conservation of energy	• state of matter

Ideas to Support Vocabulary Learning

Table 4 includes ideas and examples for teaching vocabulary in ways to build conceptual understanding of the words.

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 particles, "Particles are tiny bits of matter that we can't always see. When water is heated, the water particles move more quickly and the energy increases."
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 (verbally or using alternative and augmentative communication [AAC] system) what potential energy is and give examples of potential energy such as a ball at the top of a slide.

Ideas	Examples
Have students represent vocabulary words in a variety of ways (e.g., pictures, symbols, graphic organizers, or models).	• Have students complete a graphic organizer using pictures representing types and forms of energy. See Figure 1 for an example.
Provide multiple exposure to vocabulary words in a variety of ways. This does not suggest mass trials, 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 words by incorporating vocabulary into daily activities such as identifying different forms of energy throughout the school. • Read books or watch videos related to the vocabulary and concepts. ○ Online texts about energy transformation (e.g., http://www.wiley.com/legacy/Australia/PageProofs/SQ8_AC_VIC/c10_TransferringAndTransformingEnergy_WEB.pdf). • Match word, definitions, and pictures about energy (e.g., http://www.learnnc.org/lp/media/uploads/2012/07/definition_cards_assessment.pdf). • Watch a video about potential and kinetic energy (e.g., https://www.youtube.com/watch?v=vl4g7T5gw1M).
Ask students to discuss the vocabulary words with each other.	• Have students use their preferred mode of communication to share their favorite content word and why they like it. Adapt by placing the vocabulary word description on a voice output device and have the student share with a classmate.
Play vocabulary word games with students.	• Have students use their communication system to describe a word and have peers guess what it is. • Have students match a description or representative picture to a word. • Have students play an online vocabulary game about heat energy terminology (e.g., http://www.learninggamesforkids.com/heat-energy-games.html).
Have students watch a dramatization or have them act out the vocabulary term.	• Act out the law of conservation of energy (e.g., https://www.youtube.com/watch?v=8GLtFNaiMH8).

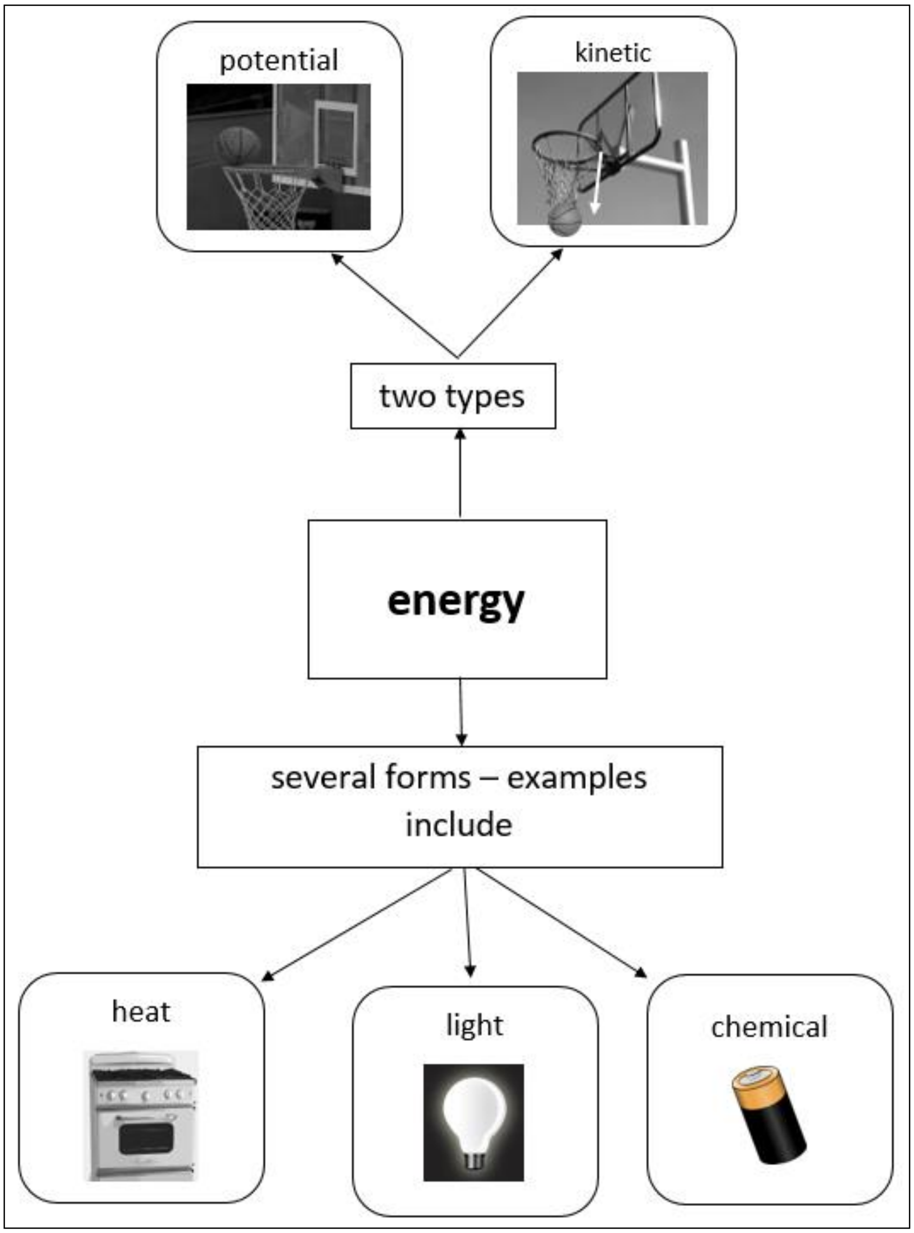
[1] Refer to Section VI, Universal Design for Learning (UDL) Suggestions for additional instructional strategies.

Vocabulary Example

Have students build an understanding of energy and types and forms of energy by completing a graphic organizer using representative pictures (see Figure 1). Educators may support, modify, or adapt steps as needed for individual students. For example, place pictures on small blocks to help students with fine motor limitations and add the content terminology to the student's AAC system, etc. 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/index.php/Instructional_Resources
- Reference ideas in the NCSC Vocabulary and Acquisition Content Module. https://wiki.ncscpartners.org/index.php/Vocabulary_and_Acquisition_Content_Module

Figure 1. Example Energy Graphic Organizer



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/

Text Project provides Word Pictures that are free for educators to use. It 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/

This site provides effective strategies for teaching science vocabulary. http://www.learnnc.org/lp/pages/7079

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

This site provides a wide range of science graphic organizers, including some that are vocabulary specific. http://www.actedu.in/wp-content/uploads/2016/03/Science-Graphic-Organizers.pdf

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 AATs and to build students' knowledge, skills, and abilities; however, it is not exhaustive and should be expanded upon as appropriate.

Energy (elementary) – Various forms of energy are constantly being transformed into other types without any net loss of energy from the system: sources and forms.

Content:

- Heat is a form of energy.
- There are multiple examples of heat energy:
  - the sun,
  - burning fuel (e.g., wood, coal, oil, gasoline, natural gas),
  - electricity
- Heat is transferred from one object to another; heat moves from warmer objects to cooler objects.
- The transfer of heat energy may produce changes in the state of a substance (e.g., melt ice, turn water into gas, etc.).
- Changes take place because of the transfer of energy.
- Different forms of energy include:
  - heat (e.g., sources of heat: sunlight, stove, hair dryer, etc.),

- light (e.g., flashlight, lamp, traffic light, etc.),
- sound (e.g., vibrating objects), and
- chemical (e.g., gas, coal, food, etc.).

Energy (middle) – Various forms of energy are constantly being transformed into other types without any net loss of energy from the system: potential/kinetic, transformed, and conservation.

Content:

- Kinetic energy is the energy to move or change something and can be transferred from one moving object to another (e.g., sound energy, electricity, light energy, and motion).
- Kinetic energy is determined by speed/velocity and mass.
- Potential energy is stored energy and cannot be transferred.
- Chemical energy and gravitational energy are forms of potential energy.
- Potential energy is determined by height or distance and mass.
- Potential energy can be converted into kinetic energy.
- Energy transforms from one form to another, but these transformations are not always reversible.
- Transfer of energy from one object to another is caused by the exertion of a force.
- Law of conservation of energy: energy cannot be created or destroyed, only transformed from one form to another.

Unit Content Resources:

Energy

- Slideshare provides a slide show that has information on forms of energy and the transfer of energy. http://www.slideshare.net/GEMalone/energy-what-every-5th-grader-should-know
- This site provides information and videos on types of energy. http://burnanenergyjournal.com/forms-of-energy-motion-heat-light-sound-2/
- This site has an interactive slide show on energy forms, potential and kinetic energy, and how it is transferred. http://www.childrensuniversity.manchester.ac.uk/interactives/science/energy/what-is-energy/
- This lesson plan for middle school on energy has information and materials (including picture examples that would be useful for elementary students as well) on forms, transfer, and transformation of energy. http://www.learnnc.org/lp/pages/7534

Sources and forms of energy

- Science NetLinks provides a lesson plan on the sources of heat energy. http://sciencenetlinks.com/lessons/when-things-start-heating-up/
- Brainpop provides classroom activities for teaching about heat, energy, and temperature. https://educators.brainpop.com/lesson-plan/heat-activities-for-kids/
- This site contains lesson plans, content explanations, units, and resources. http://www.cpalms.org/Public/PreviewResourceLesson/Preview/46550

Potential and kinetic energy

- This site provides a graphic showing potential and kinetic energy. http://kids.britannica.com/elementary/art-180888/Potential-energy-is-stored-energy-whereas-kinetic-energy-is-the
- This has a narrated slide show on potential and kinetic energy. https://www.youtube.com/watch?v=E2pfTVcdtJ8
- This site contains information, facts, and ideas for lessons. http://www.ducksters.com/science/physics/potential_energy.php
- This site has lessons in potential and kinetic energy that can be done with minimal supplies. www.kidsdiscover.com/teacherresources/a-lesson-in-potential-and-kinetic-energy/

Transformation of energy and law of energy conservation

- Teaching Channel has a video showing a lesson on transforming energy. https://www.teachingchannel.org/videos/middle-school-science-lesson
- This site provides examples of energy transformation. https://www.reference.com/science/20-examples-energy-transformation-943fee1193194bae
- This site explains the law of conservation of energy and distinguishes it from energy conservation. http://www.explainthatstuff.com/conservation-of-energy.html
- This site contains information, facts, lesson ideas on energy. http://www.ducksters.com/science/energy.php

Section VI

Universal Design for Learning (UDL) Suggestions

Three principles of UDL guide development of instruction, instructional materials, and assessments to provide access to learning to the widest range of students. Students with significant cognitive disabilities, especially students with visual and/or hearing impairments and students with complex communication needs, require additional scaffolds, adaptations, and modifications to access content and support learning. The three principles of UDL establish a framework for providing these. UDL provides guiding principles to create instructional materials and activities in a flexible manner to address the needs of different types of learners. Additionally, the flexibility allows for further individualization.

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.

These strategies can assist all students in understanding the basic concepts. Some of the examples include adaptation ideas for students with vision, hearing, and/or physical limitations. Each example has a code to indicate when it includes specific adaptation ideas for 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).	Create a solar-powered oven out of a pizza box to demonstrate solar energy, emphasizing the multiple sensory experiences involved (e.g., http://www.perkinselearning.org/activity-bank/create-solar-powered-oven-out-pizza-box). Demonstrate energy transformation emphasizing the new sensory that is experienced (e.g., electrical energy of a hair dryer transforms energy to heat energy when turned on).
Model content through pictures, dramatization, videos, etc.	Watch an animated video explaining heat energy (e.g., https://www.youtube.com/watch?v=xgOlB4TmbBY). Provide pictures, drawings, and/or diagrams along with verbal directions for completing an investigation. **H**
Present information using modified graphic organizers (e.g., simplified organizers with pictures) and models (e.g., tactile and pictures).	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. (slide show explaining the use of the KWHL chart and how it was made accessible for students with significant cognitive disabilities: http://www.cehd.umn.edu/nceo/teleconferences/tele14/CourtadeFlowers.pdf). **V/H/P** Adapt a graphic organizer on energy (e.g., http://science-class.net/archive/science-class/Lessons/Energy/energy_g_o1.pdf) by using pictures, or objects. **V**
Provide appropriate and accessible text on the content for students to listen to or read.	Paraphrase information from a textbook on large sticky notes. Place the sticky note over the original text, leaving the graphics. 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** Provide students with an online text on energy (e.g., http://tarheelreader.org/2011/04/11/energy/) or potential energy (e.g., http://www.ck12.org/physical-science/Potential-Energy-in-Physical-Science/lesson/Potential-Energy-MS-PS/?referrer=featured_content). Have students read using a screen reader. **V**
Teach information using songs.	Sing songs about: • heat (e.g., http://www.learninggamesforkids.com/heat-energy-games/heat-energy-song.html) and • law of conservation and other energy information (e.g., https://www.youtube.com/watch?v=_uLSFigtLKg).

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

Multiple Means of Action and Expression	
Strategies	**Examples**
Use assistive technology to allow the student to interact with the instructional materials and content.	Have students use adapted keyboard or mouse or a single switch to advance slides showing heat sources (e.g., http://www.slideshare.net/JessiLaRae/heat-sources). **P** Set up an adaptive keyboard or a computer access switch to allow students to record data. **P**
Present instructional materials in a manner that provides access.	Place printed text and pictures on a slant board. **V/P** Provide students science experiment directions that have been adapted using simple text and pictures. Measure the distance a ball rolls down different grade of ramps using photocopies of rulers, cut the ruler off at the length measured, and help students paste each ruler directly onto a chart to graph the data. Emphasize the relationship between potential energy and kinetic energy by analyzing the data on the chart.
Provide voice output devices for students to select an answer.	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 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 select the correct answer. **V/P** Ask questions that can be answered with yes/no or with answer choices.
Provide simulation activities.	Have students observe an interactive roller coaster which shows when potential and kinetic energy occur (e.g., http://www.pbslearningmedia.org/resource/hew06.sci.phys.maf.rollercoaster/energy-in-a-roller-coaster-ride/ or https://phet.colorado.edu/en/simulation/energy-skate-park).
Create a digital graphic organizer that allows drag and drop.	Have students work with an interactive sequence graphic organizer showing energy transformation (e.g., http://www.glencoe.com/sites/common_assets/science/virtual_labs/E04/E04.html). Use an adapted keyboard or mouse for students to independently select choices. **P**

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 (e.g., http://www.perkinselearning.org/videos/webcast/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. Have students assist in setting up their daily schedule. Use a first/then schedule (e.g., http://www.autismclassroomresources.com/visual-schedule-series-first-then/).
Vary the challenge and amount of information presented at a time.	Introduce concepts of energy in small chunks using hands-on activities. Reduce the physical effort required to complete an energy activity (e.g., handwriting) to allow for more attention to the concepts of energy.
Make connections to topics or activities that are motivating.	Increase authenticity by helping students take and print pictures of energy sources and energy transformation found in their environment. Post on the wall or in science notebooks to review. Make connections about potential and kinetic energy to fun activities (e.g., https://www.youtube.com/watch?v=Ehx1P4adv6I).
Allow choices as possible.	Allow students to choose whether to look at/listen to a book or watch a video about energy during independent work time.
Provide opportunities to work collaboratively with peers.	Provide opportunities for students to work in a general education classroom with peers when learning about energy or have peer tutors come into the special education classroom to work on a project on energy.
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.

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 video, 20 minutes long, describes the techniques used to make science accessible for students who are blind and deaf-blind. https://www.youtube.com/watch?v=tpAejot1-Ec

DO-IT has information on making science labs accessible to students with disabilities. http://www.washington.edu/doit/making-science-labs-accessible-students-disabilities

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, mathematic 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	While teaching vocabulary, make connections to real-life or future opportunities to use the words (e.g., while cooking) or understand the concepts (e.g., when operating appliances).	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	Provide information through reading books and articles on science concepts while working on reading comprehension.	Provide practice on communication skills when students are answering questions or telling about the book or article.
Mathematics	Teach measuring and graphing during investigations.	Provide practice on number identification, sequence, relative

Area	Instruction	Opportunity to Embed Skills
		quantity, size, or speed (e.g., which one has more mass; which one has more kinetic energy?), etc.
Age-Appropriate Social Skills	Make connections between the Connecting Concepts and real-life experiences showing how they can help students make decisions (e.g., understanding that energy can be transferred helps students understand cause and effect relationships).	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	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 assistance from peers and adults when working on the content.	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 and social studies 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. Social studies instruction often uses maps and timelines to illustrate where and when people existed and events occurred. 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 map to illustrate location of key countries would not need state lines and capital cities and may not need all of the surrounding countries.
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., line that indicates a body of water), and remove any that are not.
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 pencil, an example of goods, with a pencil).

Specific Graphic Type Guidance

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

Graphic Organizers/Concept Maps

- It is best to present information to compare or make connections in 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 – print

- 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)
- Sandpaper

Raised lines can be made from:

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

Resources

Creating Tactile Graphics, created by the High Tech Center Training Unit, provides basic principles of tactile graphics, characteristics of good tactile graphics, the planning process, guidelines for designs, and more. http://www.htctu.net/trainings/manuals/alt/Tactile_Graphics.pdf

The Texas School for the Blind and Visually Impaired provided 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 short videos that explain the importance of tactile graphics and information on spatial relationships and graphic literacy, moving from models to graphics, and strategies for reading tactile graphics. http://www.perkinselearning.org/videos/webcast/teaching-tactile-graphics

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