SCIENCE ACADEMIES FOR GRADES K–4

CONTENT RESOURCES

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Content Resources

Energy

It is important for students to understand that heat, light, and sound energy exist all around them even though the forms of energy may not be observed the same way by all people. Many students may have been told they have energy or that food gives them energy but will have no understanding of what energy means scientifically. Energy is the ability to do work.

Heat

Heat is a quantity of energy transferred from one object to another because of temperature differences. Heat moves from hot to cold. (Cold cannot move.) Heat is measured by temperature in units called degrees.

Thermal energy is the result of moving particles in matter. The faster the particles move, the hotter the solid, liquid, or gas. The slower the particles move, the colder the solid, liquid, or gas. Increasing thermal energy will cause particles to move faster, causing things to heat up. Decreasing thermal energy will cause particles to slow down, causing things to cool or possibly freeze. Examples of thermal energy are the Sun and baking cookies in an oven. When thermal energy transfers, that is called heat.

The root word *therm* means heat. A Thermos® and thermal underwear keep things warm by insulating the object and decreasing the transfer of heat energy.

Note: To avoid teaching misconceptions, do not use microwave ovens as an example of heat energy. Microwave ovens use electromagnetic radiation—specifically microwaves—not heat energy. When used to cook food, microwaves (of the electromagnetic spectrum) speed up the vibrations of water molecules. For example, the lesson uses a hot air popper to pop popcorn. In a microwave oven, this happens quite differently. Each popcorn kernel has water inside. The microwaves speed up the water particles, whereas an air popper or a stove uses thermal energy to heat the water. The heated water turns to steam, building up pressure. When there is enough pressure inside, the kernel explodes into popcorn.

Measurement: Thermometers

Students will predominantly use the metric system as they move into higher grade levels. The metric system is a universal language for scientists around the world. Although scientists use the metric measure of temperature, °C, students will be asked to record the temperature in degrees Celsius (°C) and Fahrenheit (°F) to help them see how the two are related. For example, by comparing 23 °C to 74 °F, students will have a frame of reference for temperatures measured in Celsius because they are probably most familiar with temperature measured in degrees Fahrenheit. Students should have experience reading and measuring with a thermometer before they apply this skill.

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Light

Light energy is given off by anything that lights up. Light is a form of electromagnetic radiation (visible light, infrared, and ultraviolet rays are all specific kinds of electromagnetic radiation). Light can travel through outer space (unlike sound) because it does not need a medium through which to travel. The Sun, flashlights, and lamps have light energy. Some objects reflect light, such as a mirror or the Moon, but do not emit light. Decreasing light energy makes seeing and differentiating colors difficult. Increasing light energy makes seeing easier and causes colors to be perceived as brighter.

Sound

Vibrations produce sound. Sound travels through matter (a medium) and can move through solids, liquids, and gases. Sound cannot travel through outer space because space is a vacuum with no medium on which to vibrate. Musical instruments, timers, basketballs bouncing on a court, or anything that makes noise generates sound energy. Increasing sound energy will cause the volume of the sound to get louder. Decreasing sound energy will cause the volume of the sound to get quieter and may cause the sound to completely stop.

Mechanical Energy

Mechanical energy is energy due to motion or position. If an object is moving, it has mechanical energy. Objects have mechanical energy not only if they are moving but also if they are in a position to move, such as a ball in your hand before you drop it or a wagon at the top of a hill. A bicycle, a windup toy, and a merry-go-round have mechanical energy. Mechanical energy is acquired by objects as the result of work being done on them (the scientific definition of work).

Electrical Energy

Electrical energy is the motion of charges. We are familiar with the current electricity that powers our homes and electrical energy in the form of lightning. Elementary students need to be able to identify examples of electrical energy and differentiate it from other forms of energy. For the Grade 4 lesson, students investigate electrical energy by building a circuit and examining how objects in the circuit emit light, sound, and heat.

Electric Circuits, Conductors, and Insulators

Electricity travels through a closed circuit. Electrical energy, transferred from batteries or other energy sources, travels through wires to the light bulb, where it is transformed into light energy. If the circuit is closed, the light bulb lights up. If the circuit is open, the light bulb does not light up because the electricity cannot flow through the circuit. A switch allows you to open and close the circuit. When you open the switch, it creates a gap in the circuit, which stops the flow of electricity.

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Energy

Conductors allow electricity to flow through a circuit without much difficulty. Metals are good conductors because the atoms that make up metals easily give up electrons, allowing electricity to flow. Insulators greatly reduce the flow of electrical energy through a circuit. The atoms of materials that are insulators hold on to their electrons and do not give them up easily, so the electricity cannot move very readily. Examples of insulators include glass, plastic, wood, rubber, and cloth.

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Force and Motion

Force

A force is a push or a pull. Forces include magnetism, gravity, and friction.

Magnetism

Magnets have two poles on opposite sides of the magnet. One is the south pole and the other is the north pole. Magnets repel when like poles face each other, such as two north or two south poles. Repelling magnets may flip over, spin around, or push away from each other. Magnets attract when two different poles face each other, such as a north pole and a south pole.

Magnetic metals include iron, nickel, and cobalt. Other metals are not attracted to magnets. Glass, plastic, and wood are not attracted to magnets.

Gravity

Gravity causes a pull between two objects. For example, Earth pulls objects toward its surface. Earth has a huge gravitational pull because it has an enormous mass. The amount of mass an object has determines how much gravitational pull the object possesses. A pencil falls to Earth because Earth has a huge mass and therefore a very strong gravitational pull.

Friction

Friction is a force that occurs when two objects rub against each other. Friction causes motion to slow down or stop. For example, when brakes are applied to car wheels, the wheels slow their rotation. Skiers wax their skis so they have less friction and can go faster. Surfers use a different kind of wax to increase friction between their boards and bodies to prevent them from slipping into the water.

Work

Scientifically speaking, work means to use a force to move an object to a new location. Work can be calculated by multiplying the force applied to an object by the distance it moves. An example of work is kicking a soccer ball in a game because the kicker uses a pushing force to move the ball to a new location on the field. When doing work, the force is in the same direction as the motion of the object.

Some nonexamples of work include pushing on a wall or pressing on a table with your pinkie finger because the wall and the table to do not move. Trying to pull a large tree from the ground is not work because the tree does not move.

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Force and Motion

Spring Scales

Spring scales are tools that measure force. We use the metric unit of newtons (N) to measure force. Before using a spring scale, always check that the scale reads zero (0) with no force applied. When measuring forces in motion, do not record the initial reading, because it will usually be higher. Instead, record the ring once you have the object in motion.

Simple Machines

A simple machine is a tool that makes work easier. A wheel and axle and a pulley are both examples of simple machines. In the case of a single pulley, it takes the same force to lift an object, but the pulley changes the direction in which you exert a force. More complicated pulley systems allow you to use less force over a longer distance to do work. We use wagons, bicycles, cars, and wheelbarrows to move or carry objects from place to place. We could use pulleys to raise flags up flagpoles, in which case it is much easier and more convenient to pull down than it would be to pull up to lift the flag.

Motors

How the motor works: The battery sends an electric current through the wires when they touch the metal supports (or to the coil of wires inside a hobby motor). There is a magnetic field around any wire carrying a current. The coil of wire is magnetized by the current flowing through it. The coil of wire is attracted to and then repelled by the magnet of the motor, causing the coil of wire to spin. The more current running through the wire, the faster the motor turns.

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Scientific Investigations

Students are expected to design and conduct an experiment in Grade 4.

Question: An investigation begins with a question you want answered.

Hypothesis: After doing some research, you can write a hypothesis and decide how you want to test your hypothesis. A hypothesis is a prediction (or an educated guess) you make that tells what you think will happen in the experiment.

Procedure: A procedure is a set of instructions that tells you how to do the experiment. Within the procedure, repeat the investigation multiple times to make sure your data is reliable. Compare data from different trials to make sure your results are similar. Repeated investigations are called trials.

Results: Scientists examine their data and summarize their results.

Conclusion: A conclusion is drawn after all the trials are complete and results are analyzed. Scientists reflect on their predictions, or hypotheses, to see if the data supports their hypothesis.

Next Steps: Scientists list the things that were done well in the experiment as well as the things that could have been done differently or better. Based on the conclusions, you may plan future experiments that build on your results.

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The 5E Lesson Model

An effective lesson provides the most impact on student achievement by ensuring that students are actively engaged in learning. It also allows students to reflect upon their learning to make sense of their activities. Students are provided with opportunities to use, extend, and apply what is learned. The Five E (5E) instructional model developed and modified by Roger W. Bybee, past executive director of the National Research Council and Center for Science, Mathematics, and Engineering Education, provides such a model. Learning something new or understanding something familiar in greater depth involves making sense of both our prior experiences and first-hand knowledge gained from new explorations.

The Components of the 5E Instructional Model:

ENGAGE: The instructor initiates the Engage by asking well-chosen questions, defining a problem to be solved, or by showing something intriguing, such as a discrepant event. The activity is designed to interest students in the concept and to provide opportunities for making connections to past and present learning.

EXPLORE: The Explore provides the opportunity for students to become directly involved with the key concepts of the lesson through guided exploration that requires them to probe, inquire, and discover. As we learn, the puzzle pieces (processes and concepts necessary to solve the problem) begin to fit together or have to be broken down and reconstructed several times. In this stage, instructors observe and listen to students as they interact with each other and the materials used in the activity. Instructors provide probing questions to help students clarify their understanding of major concepts and redirect their questions and thinking when necessary. The exploration stage provides students with a set of common experiences and social interactions as they begin making sense of the new concept.

EXPLAIN: In the Explain, collaborative learning teams begin to sequence logically the events/facts from the investigation and communicate these findings to each other and the instructor. The instructor, acting in a facilitation role, uses this phase to offer further explanations and provide additional meaning or information, such as correct terminology. Giving labels or correct terminology is far more meaningful and helpful in retention if it is done after the learner has had a direct experience. The explanation stage is used to record the learner's development and grasp of the key processes and concepts of the lesson.

ELABORATE: The Elaborate allows students to apply, extend, and expand their understanding of the processes and concepts of the lesson. Students can then connect this knowledge with their prior learning to create understanding. During the elaboration stage, students are encouraged to use the terms and definitions provided previously. It is critical that instructors verify students' understanding during this stage.

EVALUATE: Throughout the learning experiences, the ongoing process of evaluation allows the instructor to determine whether the learner has reached the desired level of understanding of the key processes and concepts. In the Evaluate, both the teacher and the student check the student's understanding of the learning goal of the lesson.

Instructional Strategies

Anchor Chart

An anchor chart is an organizational chart that is often created as a shared or interactive writing activity between the teacher and the students. By constructing the chart together, the children will remember the experience, which helps *anchor* their understanding of the concepts presented. When completed, the chart is displayed in the classroom and serves as a reference for all who use it.

Documentation Panel

A documentation panel is a section of a classroom bulletin board or a three-sided science board used to document the artifacts and evidence from class activities during a unit of study. Photographs, student drawings, or peer-generated lists comprise a few examples of the possible contents of the panel. For example, during the course of a 5E lesson, a teacher may use photographs to document an activity from each stage of the lesson. Because documentation panels are highly engaging, children often revisit the panel to answer questions posed by classroom visitors. As such, these panels have the potential of providing an ongoing method of reviewing and reinforcing content knowledge and could be considered for any of the Evaluate portions of the lessons.

Interactive Notebook

An interactive notebook is a notebook used to document and organize information from class discussions. Interactive notebooks typically use the right side of the page for recording information presented by the teacher (often referred to as input).The left side of the notebook is used for students to personally process information (often referred to as output). A defining characteristic of interactive notebooks is the use of informational text features, such as a table of contents, titles on pages, and page numbers. In Kindergarten or first grade, the teacher might use a large spiral-bound chart that has been turned on its side to function as an interactive Big Book. Information specific to a unit of study can be collected in the Big Book and then later added to the Big Book Center, Library Center, or Work Station.

Sentence Frame/Starters

A sentence frame or starter is a visual display of phrases (sentence starters) and well-formed sentences (sentence frames) that provide the language needed to talk or write about a given topic. Sentence frames help English Language Learners (ELLs) expand their proficiency of the language by familiarizing students with the vocabulary and sentence structure needed for a given topic. Students can practice generating sentences with greater grammatical complexity than they are able to do without support of a sentence frame.

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Instructional Strategies

Word Bank

A word bank is a list of words related to a unit of study, organized by category. For example, in the Kindergarten energy lesson, words could be organized by spatial concepts (before, behind, below, beside, etc.) and by forms of energy (heat, light, sound, etc.). Children categorize the vocabulary words and then keep these lists for future reference.

Word Wall (Science Concepts)

A word wall is a wall or pocket chart on which to place vocabulary word cards with pictures of concepts introduced in a given unit of study. After new vocabulary words are introduced within the context of a lesson, the words are placed on the wall or in the pocket chart. With younger children, words should be placed in alphabetical order along with the upper and lower case letters so that the child has an organizational structure for finding new words. Students revisit the words and their meanings throughout the 5E lesson. For older primary students and beyond, students may find it useful to copy these words in their own notebooks to use as a reference. Using a concept word wall might be especially helpful for ELLs and provide stronger support for the English Language Proficiency Standards (ELPS) targeting content-area vocabulary.