# Science Technology/Engineering (STE)

# Earth and Space Science, Grades 6–8

| LEARNING STANDARD | IDEAS FOR DEVELOPING INVESTIGATIONS AND LEARNING EXPERIENCES |
|---|---|
| **Mapping the Earth** | |
| **1. Recognize, interpret, and be able to create models of the earth's common physical features in various mapping representations, including contour maps.** | Choose a small area of unpaved, sloping ground in the schoolyard or a park. Create a scale contour map of the area. Include true north and magnetic north. |
| **Earth's Structure** | |
| **2. Describe the layers of the earth, including the lithosphere, the hot convecting mantle, and the dense metallic core.** | Use a Styrofoam ball and paint to construct a cross-section model of the earth. |
| **Heat Transfer in the Earth System** | |
| **3. Differentiate among radiation, conduction, and convection, the three mechanisms by which heat is transferred through the earth's system.** | Investigate the movement of a drop of food coloring placed in water, with and without a heat source, and in different positions relative to a heat source. |
| **4. Explain the relationship among the energy provided by the sun, the global patterns of atmospheric movement, and the temperature differences among water, land, and atmosphere.** | Note the relationship between global wind patterns and ocean current patterns. |
| **Earth's History** | |
| **5. Describe how the movement of the earth's crustal plates causes both slow changes in the earth's surface (e.g., formation of mountains and ocean basins) and rapid ones (e.g., volcanic eruptions and earthquakes).** | • Use the Pangaea map to understand plate movement.<br>• Research and map the location of volcanic or earthquake activity. Relate these locations to the locations of the earth's tectonic plates. |
| **6. Describe and give examples of ways in which the earth's surface is built up and torn down by natural processes, including deposition of sediments, rock formation, erosion, and weathering.** | • Observe signs of erosion and weathering in local habitats and note seasonal changes.<br>• Visit local sites following storm events and observe changes. |

# Earth and Space Science, Grades 6–8

| LEARNING STANDARD | IDEAS FOR DEVELOPING INVESTIGATIONS AND LEARNING EXPERIENCES |
|---|---|
| **Earth's History (cont.)** | |
| **7. Explain and give examples of how physical evidence, such as fossils and surface features of glaciation, supports theories that the earth has evolved over geologic time.** | Make a timeline showing index fossils. Discuss which of these fossils are actually found in New England. Discuss why some may be missing from local rocks. |
| **The Earth in the Solar System** | |
| **8. Recognize that gravity is a force that pulls all things on and near the earth toward the center of the earth. Gravity plays a major role in the formation of the planets, stars, and solar system and in determining their motions.** | Observe the speed at which objects of various mass drop from a common height. Use a chronometer to accurately measure time and plot the data as mass versus time necessary to reach the ground. |
| **9. Describe lunar and solar eclipses, the observed moon phases, and tides. Relate them to the relative positions of the earth, moon, and sun.** | Use globes and a light source to explain why high tides on two successive mornings are typically about 25 hours (rather than 24) apart. |
| **10. Compare and contrast properties and conditions of objects in the solar system (i.e., sun, planets, and moons) to those on Earth (i.e., gravitational force, distance from the sun, speed, movement, temperature, and atmospheric conditions).** | Using light objects such as balloons or basketballs, and heavy objects such as rocks, make models that show how heavy a 1 kg pumpkin would seem on the surfaces of the moon, Mars, Earth, and Jupiter. |
| **11. Explain how the tilt of the earth and its revolution around the sun result in an uneven heating of the earth, which in turn causes the seasons.** | |
| **12. Recognize that the universe contains many billions of galaxies, and that each galaxy contains many billions of stars.** | Count the number of stars that can be seen with the naked eye in a small group such as the Pleiades. Repeat with low-power binoculars. Repeat again with telescope or powerful binoculars. Research the number of stars present. Discuss the meaning of the research and its results. |

# Physical Sciences (Chemistry and Physics), Grades 6–8

| LEARNING STANDARD | IDEAS FOR DEVELOPING INVESTIGATIONS AND LEARNING EXPERIENCES |
|---|---|
| **Properties of Matter** | |
| **1. Differentiate between weight and mass, recognizing that weight is the amount of gravitational pull on an object.** | Determine the weight of a dense object in air and in water. Explain how the results are related to the different definitions of mass and weight. |
| **2. Differentiate between volume and mass. Define density.** | |
| **3. Recognize that the measurement of volume and mass requires understanding of the sensitivity of measurement tools (e.g., rulers, graduated cylinders, balances) and knowledge and appropriate use of significant digits.** | Calculate the volumes of regular objects from linear measurements. Measure the volumes of the same objects by displacement of water. Use the metric system. Discuss the accuracy limits of these procedures and how these limits explain any observed differences between the calculated volumes and the measured volumes. |
| **4. Explain and give examples of how mass is conserved in a closed system.** | Melt, dissolve, and precipitate various substances to observe examples of the conservation of mass. |
| **Elements, Compounds, and Mixtures** | |
| **5. Recognize that there are more than 100 elements that combine in a multitude of ways to produce compounds that make up all of the living and nonliving things that we encounter.** | Demonstrate with atomic models (e.g., ball and stick) how atoms can combine in a large number of ways. Explain why the number of combinations is large, but still limited. Also use the models to demonstrate the conservation of mass in the modeled chemical reactions. |
| **6. Differentiate between an atom (the smallest unit of an element that maintains the characteristics of that element) and a molecule (the smallest unit of a compound that maintains the characteristics of that compound).** | Use atomic models (or Lego blocks, assigning colors to various atoms) to build molecules of water, sodium chloride, carbon dioxide, ammonia, etc. |
| **7. Give basic examples of elements and compounds.** | Heat sugar in a crucible with an inverted funnel over it. Observe carbon residue and water vapor in the funnel as evidence of the breakdown of components. Continue heating the carbon residue to show that carbon residue does not decompose. Safety note: sugar melts at a very high temperature and can cause serious burns. |
| **8. Differentiate between mixtures and pure substances.** | |

# Physical Sciences (Chemistry and Physics), Grades 6–8

| LEARNING STANDARD | IDEAS FOR DEVELOPING INVESTIGATIONS AND LEARNING EXPERIENCES |
|---|---|
| **Elements, Compounds, and Mixtures (cont.)** | |
| **9. Recognize that a substance (element or compound) has a melting point and a boiling point, both of which are independent of the amount of the sample.** | |
| **10. Differentiate between physical changes and chemical changes.** | Demonstrate with molecular ball-and-stick models the physical change that converts liquid water into ice. Also demonstrate with molecular ball-and-stick models the chemical change that converts hydrogen peroxide into water and oxygen gas. |
| **Motion of Objects** | |
| **11. Explain and give examples of how the motion of an object can be described by its position, direction of motion, and speed.** | |
| **12. Graph and interpret distance vs. time graphs for constant speed.** | |
| **Forms of Energy** | |
| **13. Differentiate between potential and kinetic energy. Identify situations where kinetic energy is transformed into potential energy and vice versa.** | |
| **Heat Energy** | |
| **14. Recognize that heat is a form of energy and that temperature change results from adding or taking away heat from a system.** | |
| **15. Explain the effect of heat on particle motion through a description of what happens to particles during a change in phase.** | |
| **16. Give examples of how heat moves in predictable ways, moving from warmer objects to cooler ones until they reach equilibrium.** | Place a thermometer in a ball of clay and place this in an insulated cup filled with hot water. Record the temperature every minute. Then remove the thermometer and ball of clay and place them in an insulated cup of cold water that contains a second thermometer. Observe and record the changes in temperature on both thermometers. Explain the observations in terms of heat flow, including direction of heat flow and why it stops. |

# Technology/Engineering, Grades 6–8

***Please note:*** The number(s) in parentheses following each suggested learning activity refer to the related grades 6–8 Technology/Engineering learning standard(s).

| LEARNING STANDARDS | SUGGESTED LEARNING ACTIVITIES |
|---|---|
| **1. Materials, Tools, and Machines**<br>*Central Concept*: Appropriate materials, tools, and machines enable us to solve problems, invent, and construct. | |
| **1.1 Given a design task, identify appropriate materials (e.g., wood, paper, plastic, aggregates, ceramics, metals, solvents, adhesives) based on specific properties and characteristics (e.g., strength, hardness, and flexibility).**<br>**1.2 Identify and explain appropriate measuring tools, hand tools, and power tools used to hold, lift, carry, fasten, and separate, and explain their safe and proper use.**<br>**1.3 Identify and explain the safe and proper use of measuring tools, hand tools, and machines (e.g., band saw, drill press, sander, hammer, screwdriver, pliers, tape measure, screws, nails, and other mechanical fasteners) needed to construct a prototype of an engineering design.** | • Conduct tests for strength, hardness, and flexibility of various materials (e.g., wood, paper, plastic, ceramics, metals). (1.1)<br>• Design and build a catapult that will toss a marshmallow. (1.1, 1.2, 1.3)<br>• Use a variety of hand tools and machines to change materials into new forms through the external processes of forming, separating, and combining, and through processes that cause internal change(s) to occur. (1.2) |
| **2. Engineering Design**<br>*Central Concept*: Engineering design is an iterative process that involves modeling and optimizing to develop technological solutions to problems within given constraints. | |
| **2.1 Identify and explain the steps of the engineering design process, i.e., identify the need or problem, research the problem, develop possible solutions, select the best possible solution(s), construct a prototype, test and evaluate, communicate the solution(s), and redesign.**<br>**2.2 Demonstrate methods of representing solutions to a design problem, e.g., sketches, orthographic projections, multiview drawings.**<br>**2.3 Describe and explain the purpose of a given prototype.**<br>**2.4 Identify appropriate materials, tools, and machines needed to construct a prototype of a given engineering design.**<br>**2.5 Explain how such design features as size, shape, weight, function, and cost limitations would affect the construction of a given prototype.**<br>**2.6 Identify the five elements of a universal systems model: goal, inputs, processes, outputs, and feedback.** | • Given a prototype, design a test to evaluate whether it meets the design specifications. (2.1)<br>• Using test results, modify the prototype to optimize the solution (i.e., bring the design closer to meeting the design constraints). (2.1)<br>• Communicate the results of an engineering design through a coherent written, oral, or visual presentation. (2.1)<br>• Develop plans, including drawings with measurements and details of construction, and construct a model of the solution to a problem, exhibiting a degree of craftsmanship. (2.2) |

# Technology/Engineering, Grades 6–8

| LEARNING STANDARDS | SUGGESTED LEARNING ACTIVITIES |
|---|---|
| **3. Communication Technologies**<br>*Central Concept*: Ideas can be communicated though engineering drawings, written reports, and pictures. | |
| **3.1 Identify and explain the components of a communication system, i.e., source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination.**<br>**3.2 Identify and explain the appropriate tools, machines, and electronic devices (e.g., drawing tools, computer-aided design, and cameras) used to produce and/or reproduce design solutions (e.g., engineering drawings, prototypes, and reports).**<br>**3.3 Identify and compare communication technologies and systems, i.e., audio, visual, printed, and mass communication.**<br>**3.4 Identify and explain how symbols and icons (e.g., international symbols and graphics) are used to communicate a message.** | |
| **4. Manufacturing Technologies**<br>*Central Concept*: Manufacturing is the process of converting raw materials (primary process) into physical goods (secondary process), involving multiple industrial processes (e.g., assembly, multiple stages of production, quality control). | |
| **4.1 Describe and explain the manufacturing systems of custom and mass production.**<br>**4.2 Explain and give examples of the impacts of interchangeable parts, components of mass-produced products, and the use of automation, e.g., robotics.**<br>**4.3 Describe a manufacturing organization, e.g., corporate structure, research and development, production, marketing, quality control, distribution.**<br>**4.4 Explain basic processes in manufacturing systems, e.g., cutting, shaping, assembling, joining, finishing, quality control, and safety.** | |
| **5. Construction Technologies**<br>*Central Concept*: Construction technology involves building structures in order to contain, shelter, manufacture, transport, communicate, and provide recreation. | |
| **5.1 Describe and explain parts of a structure, e.g., foundation, flooring, decking, wall, roofing systems.**<br>**5.2 Identify and describe three major types of bridges (e.g., arch, beam, and suspension) and their appropriate uses (e.g., site, span, resources, and load).** | Design and construct a bridge following specified design criteria (e.g., size, materials used). Test the design for durability and structural stability. (5.3) |

# Technology/Engineering, Grades 6–8

| LEARNING STANDARDS | SUGGESTED LEARNING ACTIVITIES |
|---|---|
| **5. Construction Technologies (cont.)** | |
| **5.3 Explain how the forces of tension, compression, torsion, bending, and shear affect the performance of bridges.**<br>**5.4 Describe and explain the effects of loads and structural shapes on bridges.** | |
| **6. Transportation Technologies**<br>*Central Concept*: Transportation technologies are systems and devices that move goods and people from one place to another across or through land, air, water, or space. | |
| **6.1 Identify and compare examples of transportation systems and devices that operate on or in each of the following: land, air, water, and space.**<br>**6.2 Given a transportation problem, explain a possible solution using the universal systems model.**<br>**6.3 Identify and describe three subsystems of a transportation vehicle or device, i.e., structural, propulsion, guidance, suspension, control, and support.**<br>**6.4 Identify and explain lift, drag, friction, thrust, and gravity in a vehicle or device, e.g., cars, boats, airplanes, rockets.** | • Design a model vehicle (with a safety belt restraint system and crush zones to absorb impact) to carry a raw egg as a passenger. (6.1)<br>• Design and construct a magnetic levitation vehicle (e.g., as used in the monorail system). Discuss the vehicle's benefits and trade-offs. (6.2)<br>• Conduct a group discussion of the major technologies in transportation. Divide the class into small groups and discuss how the major technologies might affect future design of a transportation mode. After the group discussions, ask the students to draw a design of a future transportation mode (car, bus, train, plane, etc.). Have the students present their vehicle designs to the class, including discussion of the subsystems used. (6.1, 6.3) |
| **7. Bioengineering Technologies**<br>*Central Concept*: Bioengineering technologies explore the production of mechanical devices, products, biological substances, and organisms to improve health and/or contribute improvements to our daily lives. | |
| **7.1 Explain examples of adaptive or assistive devices, e.g., prosthetic devices, wheelchairs, eyeglasses, grab bars, hearing aids, lifts, braces.**<br>**7.2 Describe and explain adaptive and assistive bioengineered products, e.g., food, bio-fuels, irradiation, integrated pest management.** | Brainstorm and evaluate alternative ideas for an adaptive device that will make life easier for a person with a disability, such as a device that picks up objects from the floor. (7.1) |

## Local Wonders

Adapted from the *Building Big Activity Guide*, pp. 36–37 (www.pbs.org/wgbh/buildingbig)

**Technology/Engineering, Grades 6–8**

After building newspaper towers and talking about structures and foundations, sixth-graders at the Watertown, Massachusetts Boys and Girls Club brainstormed a list of interesting structures in their town. They selected St. Patrick's, an elaborate church across the street from the clubhouse, as the focus for an investigation about a "Local Wonder."

The students began their investigation by brainstorming questions about their Local Wonder. Questions that focused on engineering included the following:

- When was it built?
- What is it made of?
- Why did the builders choose that material?
- What is underneath the building?
- What holds it up?
- What keeps it from falling down?
- How was it built?
- Were there any problems during construction and how were they solved?

Questions with a social/environmental focus included the following:

- Why was it built?
- Who built it?
- What did the area look like before it was built?

Next, the students participated in hands-on activities that explored basic engineering principles such as force, compression, tension, shape, and torsion. They toured the church, took photographs, researched the structure, interviewed long-time community members about their memories about the structure, and interviewed engineers, architects, and contractors who worked on the construction project. They conducted research at the library, the Historical Society, and the Watertown Building Inspector's office, where they acquired the building's plans and copies of various permits. They used this information to develop a timeline of the building's history.

Students used the following method to estimate the size of the church: First, they selected one student, Josh, and measured his height. Then Josh stood next to the church, while the rest of the club members stood across the street. The teacher asked each student to close one eye and use his or her fingers to "stack" Josh's height up to the top of the church. The each student multiplied the number of times he or she stacked Josh's height, to find the total estimated height of the church.

Small groups of students met and prepared final reports, using the following generic outline:

I Name of group submitting report
II Name and description of structure (identify the type of structure, such as a bridge or skyscraper, and describe and explain its parts)
III Location of structure
IV Approximate date structure was completed
V Approximate size of structure
VI Why we chose this particular Local Wonder
VII What's important about our Local Wonder

VIII Things we learned about our Local Wonder (include information such as type of construction, engineering design concepts, and forces acting on the structure)
IX Interesting facts about our Local Wonder

*Your community may not have an Eiffel Tower or a Hoover Dam, but for your Local Wonder you can choose any structure in your community that is significant because of its appearance, uniqueness, or historical or social impact. Consider local bridges, tunnels, skyscrapers or other buildings, domes, dams, and other constructions. You can e-mail the American Society of Civil Engineers at buildingbig@asce.org to connect with a volunteer civil engineer for this activity. To help select your Local Wonder, have the class brainstorm a list or collect some photographs for discussion.*

*Any group that completes this project can submit its investigation to pbs.org/buildingbig. Send them your complete report, including photographs or original drawings of your local wonder. Students should be encouraged to draw the structure from a variety of different perspectives. Students can also share their reports with other classes in their school or at a local town meeting.*

**Assessment Strategies**

- Share examples of other previous groups' completed investigations with your students at the beginning of the project. Discuss and develop criteria for effective reports, and identify what constitutes quality work.
- Students can record their learning in an engineering journal. Students can write down each day what they have learned, questions that they may have, resources they found helpful, and resources they need to consult. The teacher should read the journals to monitor students' progress and levels of participation, and to identify what topics the students have mastered and which areas of learning need to be reinforced by additional instruction.
- Post your Local Wonder report on your school district website, on the town website, or on a town agency's website (e.g., the Chamber of Commerce). Include an e-mail address and encourage feedback.
- At the end of the unit, provide the students with a photograph of a similar structure from another town or area. Ask them to write a final paper that compares this structure to their own Local Wonder. How are they alike? Different? Compare the materials, designs, and purposes of these structures.

**Engineering Design Learning Standards**

**Grades 6–8**

2.2 Demonstrate methods of representing solutions to a design problem (e.g., sketches, orthographic projections, multi-view drawings).

2.5 Explain how such design features as size, shape, weight, function, and cost limitations would affect the construction of a given prototype.

**Construction Technologies Learning Standards** (Applicable standards may depend on structure selected.)

**Grades 6–8**

5.1 Describe and explain parts of a structure (e.g., foundation, flooring, decking, wall, roofing systems).

5.2 Identify and describe three major types of bridges (i.e., arch, beam, and suspension) and their appropriate uses (e.g., based on site, span, resources, and load).

5.3 Explain how the forces of tension, compression, torsion, bending, and shear affect the performance of bridges.

5.4 Describe and explain the effects of load and structural shape on bridges.