Unit Essential Question

How do we use and control thermal energy in a system?

Introduction

Scientists and engineers make and use models as helpful tools for exploring and sharing new ideas. While scientists develop and use models to define boundaries and to understand and test ideas about the natural world, engineers use models to find solutions to real-world problems. Engineers know that building a "rapid prototype" is a great way to test a new idea. Scientific models include drawings, physical replicas, mathematical representations, analogies, and computer simulations.

In this task, students will think and act like engineers. They will build a flashlight and reflect on their process. In the end, students will understand what a system is and how to make a model of a system as applied to a flashlight.

It is important to note that although the flashlight does involve the flow of electrical energy, electrical energy is not the focus of the Lift-Off Task. The rest of the Energy Unit will focus on kinetic energy, thermal energy, and thermal energy transfer.

Objectives

Students will be able to

Content

- Explain how a flashlight is a system.

Science and Engineering Practices

- Design, build, and create a model of a working flashlight.
- Create a model of an electrical system.

Equity and Groupwork

- Give reasons for design choices.

Language

- Communicate ideas and listen actively.
- Read the displayed ideas from each group and the Culminating Project.
- Use the academic vocabulary in ideas, discussions, and notes.
- Write their ideas in their science notebook and Individual Project Organizer.

Emerging →	Expanding →	Bridging →
Listen for, identify, and restate words and phrases about energy, models, systems, and the instructions for building a flashlight. Ask and answer yes-no questions about the task. Respond using simple phrases.	Describe the task in sequence using words and phrases about energy, models, systems, and the instructions for building a flashlight. Ask questions about the task and use complete sentences. Add information when possible.	Paraphrase and summarize the task in sequence using words and phrases about energy, models, systems, and the instructions for building a flashlight. Ask questions about the task and use complete sentences. Affirm others, and build on their responses.

Assessment

1. Students have now created a flashlight and will be using the same engineering process to create a prototype for their client.
2. Have students turn to the Culminating Project section of their Student Edition. Give students time to read over the whole project in their small group. Ask for brief summaries from each group.
3. Connect the Culminating Project to the Energy Unit. In the Culminating Project, students will design, model, test, and re-design a system just as they did in the flashlight task. In the long run, students will apply what they learn about the science of energy to create a system that maximizes or minimizes thermal energy transfer.
4. Have students complete the Individual Project Organizer. To complete the Individual Project Organizer, students may discuss the questions provided, but they should **individually** write, in complete sentences, their own interpretation of the group discussion. Students may complete the Individual Project Organizer as homework or in class, depending on students' needs or class scheduling.
5. Collect and assess each student's Individual Project Organizer using the "Developing and Using Models" row of the Science and Engineering Practices Rubric.
6. Return the Individual Project Organizers, and give students time to make revisions. ELLs may need additional time.

Academic Vocabulary

- collection
- construct
- design
- energy
- function
- model
- system

Language of Instruction

- add
- brainstorm
- client
- label
- Patent Application
- Recorder
- sketch

ELL SCAFFOLD

- Display the academic vocabulary on the board or wall.
- Support students' use of their own words (everyday language) to understand and explain the concepts.
- Highlight the academic vocabulary during the digital slide presentation and debriefs.
- Encourage students to use academic vocabulary during their discussions and writing.
- Acknowledge students who use the academic vocabulary in context and make connections in their own words.

Timing

This task can be completed in 4 class periods (based on 45-minute periods).

- Part I • Introduction to Systems (1 class period)
- Part II • Build a Flashlight (1 class period)
- Part III • Debrief the Flashlight System (1 class period)
- Part IV • Connect to the Culminating Project and Assessment (1 class period)

Student Materials

per group

- 2 size D batteries
- 2 lengths of #22 insulated wire (5" each), with the insulation stripped off both ends
- Toilet tissue roll cut into a 4" length, or 4" x 8" piece of heavy paper or card stock rolled and taped to create a 4" tall cylinder with the same diameter as the batteries
- 3 volt flashlight bulb
- 2 brass paper fastener
- 1" x 3" cardboard strip
- Paper clip
- Small paper cup
- Clear tape

NOTE

Show and name each object aloud.

Teacher Materials

- "Collections, Systems, and Models" digital slide presentation
- Student Participation Observations form
- Stamp (to record student participation)

Background Knowledge

The Lift-Off Task enables students to explicitly discuss a system and design and label a model.

What is a system?

- A group of interacting, interrelated, or interdependent elements forming a complex whole
  Example: an organism ("The elephant's entire system seems to be affected by the disease.")

- A group of physiologically or anatomically related organs or parts
  Examples: the digestive system; a root system

- A group of interacting mechanical or electrical components
  Example: the cooling system in a house

- An arrangement or configuration of classification or measurement
  Examples: the periodic table; the metric system

- A naturally occurring group of objects or phenomena
  Examples: a cave system; a weather system

What is a model?

- A model is a tool used to make a part of the world easier to understand, define, quantify, visualize, or simulate. A model can be created in many forms. A model can be conceptual, mathematical, graphical, or operational. Models can include diagrams, drawings, physical replicas, mathematical representations, analogies, and computer simulations. Models help others better visualize, understand, and scientifically explain a subject or phenomenon.

What is the connection between systems and models?

- Scientists use system models to construct scientific explanations in order to predict behaviors of a system.

What is the goal of engineering?

- The goal of engineering is to find a systematic solution to a problem that is based on scientific knowledge and mimics the material world.

STUDENT CONNECTION

Guillermo González Camarena was a Mexican man who invented the first color television. It all started when he was a little boy—he made electrically propelled toys, studied at the National Polytechnic Institute, and at 17 transformed a collection of scrap and parts from broken radios to make the first black and white TV camera in Mexico. On September 15, 1942, at age 23, he obtained the world's first patent for color television. His "chromoscopic adapter for television equipment" converted black and white TV to color. He continued to refine his work on color television as an adult. González believed that the advent of the color TV could revolutionize education, and proposed the creation of a network that would allow lessons to be broadcast from Mexico City to remote areas of the country. Three years after his death in 1965, the network became a reality, and today it meets the needs of hundreds of thousands of high school students in Mexico.

An Wang, a Chinese-born American computer scientist, is best known for founding Wang Laboratories in 1951. It started as a one-man electrical fixtures store and grew to be one of the worlds' most prominent computer manufacturers. In 1948, at age 28, Wang invented a doughnut-shaped ring of iron that served as a computer memory core and that was crucial to the development of digital information technology. It was after this invention that he went on to found Wang Laboratories, which manufactured digital calculators, word processors, and computers. He holds over 40 patents, and was inducted into the National Inventors Hall of Fame in 1988.

Margaret Knight was a prolific inventor in the late 19th century. When she was 12 years old, while visiting her brothers working in a textile mill she saw a shuttle break free from its spool of thread and stab a young boy. It was then that Knight came up with her first invention: a safety device for textile looms. However, it wasn't until Knight was working at a paper bag company that she received her first patent: a machine that cut, folded, and glued flat-bottomed paper shopping bags. In her lifetime she received some 27 patents for her inventions, including a shoe-manufacturing machine, a "dress shield" to protect garments from perspiration stains, a rotary engine, and an internal combustion engine. Knight was sometimes compared to her better-known male contemporary Thomas Edison, and at her death in 1914 was honored in an obituary as "the lady Edison."

Part I • Introduction to Systems

Whole-Class Discussion

1. Place students in their project groups. Designate student roles and review the norms.
2. Ask the Materials Manager to make sure the correct materials are at the table (see materials list).
3. Distribute one Student Participation Observations form to each table. As you circulate among the groups, use the stamp to indicate when students contribute ideas to the group as the group works on and discusses their flashlight. Encourage all students to contribute. The goal by end of class is to have at least one or two stamps per student. Alternative strategies may be used to encourage student involvement.
4. Give students a few minutes to discuss the whole-class discussion questions. Help students come to the conclusion that the materials on their table are a collection of unrelated things. The materials are not connected or interacting at this point.
5. Have students discuss the Whole-Class Discussion questions.
   - The parts in a collection do not interact, but in a system the parts work together to produce a function completely different from the parts alone. For the flashlight, the parts worked together for one purpose, to create light.
6. Show the "Collections, Systems, and Models" digital slide presentation. Introduce the concepts of system and model. Compare a collection to a system and relate the system to a model. The goal of the digital slide presentation is to give students definitions and examples without relating the information to the flashlight. Students will later apply the system and model concepts to their own flashlight. Note: The diagram of M. E. Knight's Paper Feeding Machine connects with the Student Connection about Margaret Knight.

STUDENT CONNECTION

Ask students to identify examples of systems or models in their homes.

ELL SCAFFOLD

- Display all academic vocabulary on the board.
- Go to each group and listen actively to students' ideas.
- Display students' ideas from each group on the board.
- Elicit students' ideas about what they think a system is, drawing from their background (e.g., language is a system).
- Highlight academic vocabulary (e.g., *system*, *model*).
- Provide students with sentence frames such as the following for the group discussions and for writing:
  - I think a system is _____.
  - I would define a system as _____.
  - I would define a system as _____ because _____.
  - A collection is _____. A system is _____.
  - A collection is _____ because _____, but a system is _____ because _____.
  - I think that a collection is _____, due to the fact that _____. In contrast, a system is _____ because _____.
- Clarify the language of instruction (e.g., *brainstorm*, *label*, *add*, *Recorder*, and *sketch*).

Part II • Build a Flashlight

1. Instruct students to build a working flashlight.
   - The following website provides you with additional information, if you need to provide students with some guidance: http://www.chromebattery.com/battery-kids/projects/build-a-flashlight.
   - Helpful building hints:
     - The ends of the batteries need to touch + to –.
     - The + end of the battery needs to touch the bulb.
     - The bare end of the wire needs to be between the end of the battery and the end of the bulb, not around the end of the bulb.

2. Have students work in small groups to draw their flashlight model and answer the group discussion questions. Optional: If a student group finishes building and drawing the flashlight quickly and has a good understanding of the system, give them an additional task: designing and constructing a flashlight that is brighter, has an on/off switch, or works without batteries. These new requirements correspond to question 4 in the Student Edition.

ELL SCAFFOLD

- In each group, encourage all students to share their ideas while drawing the diagram individually.
- Check that students' diagrams and flashlights reflect an understanding of a system and a model.
- Connect students' words and ideas to the concepts of system, model, and energy.
- Support students' use of academic vocabulary (e.g., *system*, *model*, and *energy*) while expressing their ideas. Recast their statements (expanding from a phrase to a complete sentence using the academic vocabulary).
- If you are not hearing terms used, orally use sentence frames to prompt students.

3. Reiterate what a model is, as well as the various forms scientists and engineers use to model a system. Possible discussion points:
   - How do scientists and engineers use models? (Scientists use models to represent, explain, and predict. Engineers use models to develop solutions.) Reiterate how, like engineers, students used a model to develop solutions and, like scientists, students used the model to show how a system works or does not work.
   - Discuss the fact that models can be two-dimensional (e.g., drawings, diagrams, maps), three-dimensional (e.g., physical replicas), and even verbal (e.g., analogies). Make the connection to the digital slide presentation, the examples of different types of models, and your explanation of a model. It is important that students understand that they have engaged in making both two-dimensional and three-dimensional models, thus helping them understand the term *model* better. Ask students explicitly about this idea.
   - Remind students that a simple model would be just the drawing of the parts. A more sophisticated (if using this word, make it clear that it means "more complex") model would include arrows to represent where the energy comes from and where the energy goes. Have students consider their drawings with these definitions in mind.

Part III • Debrief the Flashlight System

1. Start by asking students probing questions about the process of designing and building a flashlight:
   - Did your group create a working flashlight on the first try? Did your group have to try out different designs before the flashlight worked?
   - What decisions did your group make to assemble the parts in a certain way to make a working flashlight? What were your decisions based on?
   - What information did you "collect" to decide if the flashlight worked well enough? (In this case, probably the flashlight just either did or did not light up.)
   - What did your group do if your flashlight did not light up? What changes did you make?

   ELL SCAFFOLD
   - Display students' ideas on the board or wall, highlighting their words as well as academic vocabulary.
   - Identify ideas brought forth related to the flow of energy and parts of a flashlight.
   - Make observations about how students worked together:
     - Identify levels of group participation based on the Student Participation Observations form (one or two stamps)
     - Identify and discuss what worked well in each group.

2. Debrief the flashlight system experience, highlighting these concepts:

   - **Question 1**
     Systems: Apply the definition of a system to the flashlight.
     In a system, the parts are a group of interacting, interrelated, or interdependent elements forming a complex whole. In a flashlight, each part is necessary for the flashlight to work.

   - **Question 2**
     What are the parts of the flashlight system?
     Discuss the parts of the flashlight and ask students what the importance of each part is to the flashlight system. Extension questions: What are the boundaries of the system? Are the parts of the system limited to just the mechanical parts, or do the parts of the system include anything else, besides the parts you used to make the flashlight? What about your hand? (It is needed to position the light and push the on/off button!)

   ELL SCAFFOLD
   - Display students' ideas on the board or wall.
   - Revoice or repeat students' ideas of how their model of the flashlight works as a system.
   - Repeat students' use of academic vocabulary to explain their ideas.
   - Display a good exemplar of a sophisticated model.
   - Ask for students' suggestions on improving one flashlight model (a model that is not working or just needs improving).

Part IV • Connect to the Culminating Project and Assessment

1. Students have now created a flashlight and will be using the same engineering process to create a prototype for their client.

2. Have students turn to the Culminating Project section of their Student Edition. Give students time to read over the whole project in their small group. Ask for brief summaries from each group.

3. Connect the Culminating Project to the Energy Unit. In the Culminating Project, students will design, model, test, and re-design a system just as they did in the flashlight task. In the long run, students will apply what they learn about the science of energy to create a system that maximizes or minimizes thermal energy transfer.

4. Have students complete the Individual Project Organizer. To complete the Individual Project Organizer, students may discuss the questions provided, but they should **individually** write, in complete sentences, their own interpretation of the group discussion. Students may complete the Individual Project Organizer as homework or in class, depending on students' needs or class scheduling.

   ELL SCAFFOLD

   Ensure ELLs know what a client is. Provide students with sentence frames such as the following for group discussions and for writing:

   - Our client is _____ and she/he needs this device because _____.
   - However, there are several challenges involved, including _____.
   - In order to find the solution, it is first necessary to know _____. Then, _____. Followed by _____.
   - Finally, _____.

5. Collect and assess each student's Individual Project Organizer using the "Developing and Using Models" row of the Science and Engineering Practices Rubric.

6. Return the Individual Project Organizers, and give students time to make revisions. ELLs may need additional time.