PLTW Launch

Materials Science: Properties of Matter Teacher Resources

Related Documents

See “Files” section in the LMS.

Preface

Students will investigate and classify different kinds of materials by their observable properties, including color, texture, and heat conduction. After analyzing data from materials testing, the students will design an insulating cover for an ice pop to prevent melting.

All materials have a melting point, or a temperature at which a solid becomes a liquid. The melting point for water is 32 degrees Fahrenheit. Ice pops have a slightly lower melting point, but both water and ice pops are liquid at room temperature because room temperature is above the melting point of the substance.

Every material has unique properties of insulation. The better a material is at insulating, the more it will keep an object at the starting temperature. This means a cup made from a good insulator, such as Styrofoam, will keep hot liquids hot and cold liquids cold better than a cup made from a poor insulator such as paper.

Engineers and designers select materials which have properties that are best suited for an intended purpose. Properties such as color, texture, and heat conduction may influence design choices.

Transfer

Students will be able to independently use their learning to …

1. Evaluate a problem in a novel situation.
2. Apply a step by step design process to solve a problem.
3. Identify observable properties of real world objects.

Understandings

Students will understand that:

1. The design process is a step by step method used to guide people in developing solutions to problems.
2. Engineers and designers create new products or improve existing products and technology to meet human needs and wants.
3. Engineers ask questions, make observations, and gather information about a situation people want to change.

4. The shape of an object can help it perform as needed to solve a given problem.
5. Products may be analyzed by comparing objects designed to solve the same problem.
6. Engineers keep and organize all of their work in an engineering notebook.
7. Engineers share their work and get feedback from others during the design process.
8. Materials may be classified and described by a variety of different observable properties.
9. Matter is anything that has mass and takes up space.
10. Some changes caused by heating or cooling can be reversed and some cannot.
11. Engineers and designers select materials which have the properties that are best suited for an intended purpose.
12. Properties of materials such as color, texture, and heat transfer may influence design choices.

Knowledge

It is expected that students will:

- List products created by engineers and designers that were created to meet a human need or want.
- State questions engineers may ask when gathering information about a situation people want to change.
- Identify the differences between a new object and an improved object.
- List observable properties of common materials, including color, texture, and heat conduction.
- Recognize states of matter as solid, liquid, or gas.
- Describe the changes between states of matter as a result of temperature change.

Skills

It is expected that students will:

- Follow a step by step method to solve a problem.
- Examine how other people have tried to solve a design problem.
- Gather information about a situation people want to change.
- Describe how the shape of a structure helps it function as needed to meet a human need or want.
- Brainstorm possible solutions and select one solution to develop, taking into account strengths and weaknesses of each design.
- Build and test a physical model of an improved object or tool designed to meet a human need or want.
- Collect and analyze data from two models and compare the strengths and weaknesses of how each performed.
- Organize and maintain an engineering notebook to document work.
- Share findings and conclusions with others.

- Describe and classify a variety of objects according to observable physical properties.

- Defend the statement that some changes caused by heating and cooling can be reversed and some cannot.
- Describe the properties of a material that make it the best choice for an intended purpose.
- Design a tool utilizing materials that are best suited for the intended purpose.

Essential Questions

Students will keep considering:

1. Is it more important when designing a consumer product (toy, tool, or tennis shoe) to select a material that looks good, a material that will last a long time, or a material that doesn't cost too much? Why?
2. Why can some changes caused by heating or cooling not be reversed?

Day-by-Day Plans

Time: 10 hours

NOTE: *In preparation for teaching this module, it is strongly recommended that the teacher read the Materials Science: Properties of Matter Teacher Resources document, including the Understandings, Knowledge, and Skills addressed in the module. Day 1 requires advanced preparation of a frozen ice pop. The resealable bag can be filled and frozen with water, colored water, juice, yogurt, or other liquids and should be labeled as for demonstration only.*

Part 1: Young Inventors
120 minutes

- The teacher reads aloud the Materials Science: Properties of Matter Introduction. This is a fictional story that describes the problem three friends are having keeping ice pops cold during a soccer game.
- After the story the students ask what they would want to know about the situation. Students may suggest things such as ice pop size, shape, or outside temperature. These questions are not meant to be answered, only posed at this time.
- At the end of the story, the characters ask the question *What is an engineer?*
- The teacher revisits this question from the introduction, asks the students the question *What is an engineer?*, and records the responses. Although the students will not have access yet, the teacher may use the discussion feature in the Learning Management System (LMS) to capture students' responses by entering them in the threaded discussion titled *What is an engineer?* for later reference.
- The teacher then asks the students to list their favorite desserts. Students will describe the dessert. Descriptive words such as melted, hot, frozen, cold, gooey, etc. should be noted and recorded. This discussion may also be documented with the discussion feature in the LMS.

- The teacher shows the students a frozen ice pop either store bought or made in the resealable bag and describes attributes of the ice pop that make it an appealing treat. The teacher then sets down the ice pop and leaves it at room temperature. The ice pop may need to be set under a heat lamp to speed up the melting process.
- The teacher leads a discussion on how students think different desserts were invented and guides this conversation to a larger discussion on objects around the classroom that were invented by individuals. The teacher facilitates the discussion to lead to the conclusion that everything in the room that is not a part of the natural world, such as a class pet or plant, was invented or designed by a person.
- The teacher returns to the question What is an engineer? by presenting the What Is an Engineer? presentation. The presentation introduces the following concepts:
    - Engineer – A person who is trained to use technology and science to solve problems.
    - Engineering Notebook – a place to write all notes, drawings, and information. During the presentation the teacher distributes the Materials Science: Properties of Matter Launch Logs, and students fill in the current date in the Table of Contents next to Activity 1.1.
        - More information the teacher may wish to share with students: Keeping notes for every class that you take is something you have come to expect. You have learned in mathematics class, for example, that a record of your work helps you to explain to your teacher the steps that you took when you solved a mathematics problem. The same is true with engineers. They must keep a record of the work they complete while developing a solution, the processes they use in creating the solution, and a record of their solutions. The engineering notebook is so important that it is considered a legal document.
    - Sketch – A drawing showing the main features of an object.
- Students complete their first entry in the Launch Log by sketching the before and after of the ice pop demonstrated by the teacher. The frozen ice pop should be allowed to sit at room temperature for at least 30 minutes to show a noticeable difference. The teacher can use a tablet as document camera with the Stage™ document camera application or similar app to project an image of the ice pop. After sketching the ice pop, students attempt to explain what happened to create the change they observed in the ice pop over time.
- The teacher introduces students to the Learning Management System and assists students with the login process. For the remainder of the module, the students will access the assignments in the LMS and record their work in the Materials Science: Properties of Matter Launch Log.
- The teacher guides the students to Activity 1.1 Young Inventors and reads the introduction with the students.

- The teacher leads the class through the Design Process presentation, and students complete the steps in the Launch Log as they view the presentation about the invention of the crayon holder.
- After the students complete their Launch Log entries on the design process and the crayon holder, the teacher continues the presentation showing other young inventors.
- The students discuss the inventions.
- Optional: Students may continue to research the inventions in class or as homework. The teacher may choose to have the students use the Popplet app to document the invention they researched.
- The students read procedure steps 3 and 4 about the invention of the Popsicle® ice pop. The students may view the original patent for the crayon holder and Popsicle.
- The teacher discusses the purpose of a patent as a way for inventors to document their original work and receive credit for inventing a new product or process. The teacher may wish to explain the difference between a primary and secondary source.
- The conclusion questions may be answered individually in the Launch Log or discussed in large or small groups. Conclusion question 2, "List improvements to Frank Epperson's original Popsicle design that you have seen or would like to see," may be answered with text or a sketch.
- The teacher guides the students on the logout procedure for the Learning Management System. Students should logout of the Learning Management System at the conclusion of each session.

Part 2: Properties of Matter: Color and Texture
80 minutes

- In Activity 1.2 Properties of Matter: Color and Texture, students will be introduced to the concepts of matter and the physical properties of color and texture by exploring features and materials of toy monster trucks. The students will also classify the trucks in a variety of ways, including color.
- The teacher presents the PowerPoint titled *Color and Texture* and asks the students to describe the objects on slide 2 first to a partner and then to the class. The teacher will record the descriptive words the students use either electronically or on chart paper and keep as a reference. Words that describe the color, texture, material, hardness, or flexibility should specifically be recorded.
- Optional: The teacher may choose to use common objects similar to those in the presentation to assist students in experiencing the texture of the objects.
- The teacher then presents the remaining slides.
- The teacher distributes a monster truck toy to each pair of students, and the class completes Activity 1.2 Properties of Matter: Color and Texture together.

- The teacher leads small and large group discussions as the students work through Steps 1 – 4. For Step 5 the teacher may choose to conduct a class discussion about how to group the trucks. As a class students will group the trucks by observable properties, such as color or other features.
- During the activity the teacher can lead the students to consider the following:
    - Why are the trucks bright colors?
    - Why are the tires bumpy?
    - Why is the windshield transparent or see through?
    - Why is the body of the truck smooth and hard?
- Optional: To help the students focus on texture, the teacher may choose to put unknown objects in a bag and instruct students to describe the object using only the sense of touch. Possible items include sand paper, fleece, a squeaky pet toy, salt, and crepe paper.
- The conclusion questions may be answered individually in the Launch Log or discussed in large or small groups.
- Conclusion question 3, the favorite toy sketch and description, may be assigned as a possible homework assignment to allow students to sketch as they see the item in person rather than sketching from memory.

Part 3: States of Matter
80 minutes

- In Activity 1.3 States of Matter, students will observe and describe reversible and non-reversible changes in matter as a result of temperature change.
    - Optional resources that may be useful during this module and used as a classroom resource are *What is the World Made of? All About Solids, Liquids, and Gases* by Kathleen Weidner Zoehfeld and Paul Meisel and *Many Kinds of Matter: A Look at Solids, Liquids, and Gases* by Jennifer Boothroyd.
- For demonstration:
    - 3 resealable bags containing:
        - 1 Bag with a crayon
        - 1 Bag with water
        - 1 Bag with air
    - Permanent marker
    - Teacher computer and projector
    - Leaves (either collected by students or teacher)
    - Freezer or ice and cooler
- Introduction to states of matter

    - The teacher reviews the term “matter” and asks students to give examples of things that are and are not matter.
    - The teacher uses the tablet document camera application to show 3 resealable bags: one with water, one with a crayon, and one with air. The students discuss the states of matter, and the teacher labels each bag as a solid, liquid, or gas with a permanent marker. During the discussion the teacher refers to the Key Terms for each state.
    - Using a computer and projector, the teacher goes to the following site: http://www.sciencekids.co.nz/gamesactivities/gases.html and, as a class activity, works through the categorizing activity. After completing the class activity, the students complete the matching portion of Activity 1.3 States of Matter in their Launch Logs. After the teacher works through the liquid and gas portion of the animation, the students draw water as a solid, a liquid, and a gas in their Launch Logs.
    - The teacher may wish to review the Activity 1.3 States of Matter Answer Key prior to teaching this activity.
- The teacher provides each pair of students with a leaf from a tree or flower; do not use conifer plants as they are resistant to freezing. The students touch, look at, and draw the leaf. The teacher may also ask the students to bring in leaves or walk around the outside of the school to collect leaves. If there are no leaves available, leaves from indoor plants or baby spinach will work as well.
- The teacher places the leaves in a freezer overnight or in a cooler with ice. The resealable bag with the water, crayon, and air are also placed in the freezer or cooler.
- The teacher reads the book *Snowmen All Year* by Caralyn Buehner and leads a discussion on why the snowman could not possibly participate in the events described in the book. Students should suggest that the snowman would melt when temperatures rose above freezing or more generally when the weather became warm in spring and summer.
- The students inspect the leaves the next day as part of a lesson on reversible and non-reversible changes due to temperature change. Students document the changes in the leaf, the crayon, water, and air in their Launch Logs.
- The teacher presents the presentation titled Changes in Matter. Slide 3 directs the teacher to present the animation found at http://www.bbc.co.uk/schools/scienceclips/ages/9_10/changing_state.shtml
- After the animation, the teacher continues with the presentation.
- The teacher hands out the frozen and thawed leaves, and students complete the drawings for the leaves. The leaves should be limp because ice takes up more space than liquid water. As the water in the plant cells freezes and forms crystals, the cells rupture and break through the cell walls in the leaf.
- The teacher leads a short discussion on essential question 2.
    - Why can some changes caused by heating or cooling not be reversed?

- The conclusion questions may be answered individually in the Launch Log or discussed in large or small groups.

Part 4: Insulators and Conductors
120 minutes

- In Project 1.4 The Heat is On, students will investigate the material property of heat conduction. Students will test a variety of materials and classify the material either as good or poor at conducting heat. This project is an inquiry experience. The teacher will guide the students to an understanding of heat conduction and insulation at the conclusion of the assignment.
- The teacher will determine if students require an introductory lesson and practice with the thermometers before beginning the project.
- The teacher will prepare the following materials for each group:
    - 1 Hand warmer
    - 1 Thermometer
    - Equal size samples of: aluminum foil, paper plate, and foam plate
    - Optional: cup of room temperature water to cool thermometer
- Note: The hand warmers will continue to heat up over a period of 30 minutes and stay warm for several hours; the teacher may wish to activate the warmers prior to beginning the project.
- The teacher shows the students the presentation titled Insulators and Conductors. The teacher presents slides #1-6, and students begin the assignment.
- Students complete Part 1 and answer the questions in their Launch Logs. The teacher may wish to have students test additional materials such as plastic sandwich bags, tee shirt material, or paper towels.
- To reduce waiting time between trials, the teacher may wish to supply a cup of room temperature water and paper towels. Students may dip the thermometer in the water to quickly reduce the temperature reading on the thermometer.
- The teacher reads *The Mitten* by Jan Brett and leads a discussion with the students about why the mitten was a good place for the animals to stay warm.
- The teacher presents part 2 of the presentation titled Conductors and Insulators, slides 8-11. Students complete the Launch Log Part 2 as a class entry, recording class data and creating a bar graph for the temperature of the different materials.
- Students complete the conclusion questions as a class or individually in their Launch Logs.

Part 5: Save the Ice Pop!
200 minutes

- In the Problem 1.5 Save the Ice Pop! Design Challenge, students will design, prototype, and test a product to insulate a frozen dessert. Using technology, the

students will document and describe the process they used to design and test their ice pop cover.

- Design Problem 1.5: Save the Ice Pop!
    - The teacher reads the fictional story of the friends and reminds students of the original design problem.
    - The students access the assignment *Problem 1.5 Save the Ice Pop! Design Challenge* on the LMS.
- **Ask**
    - The teacher guides a discussion asking the students to again consider what the problem is and information they need to solve the problem.
    - The students complete this section in their Launch Logs.
    - The teacher guides the students as they complete the self-assessment after the second question. The students may write Yes or No in the box next to the statement or draw a check mark to indicate they can complete that skill successfully.
    - Student responses and self-assessment provide opportunities for the teacher to evaluate how students view their progress and can be used to guide a conversation with students on their progress through the first step.
- **Explore**
    - As the students work through this step of the design process, they will consider essential question 1:
        - Is it more important when designing a consumer product (toy, tool, or tennis shoe) to select a material that looks good, a material that will last a long time, or a material that doesn't cost too much? Why?
    - During this step the students write or sketch their thoughts on how to solve the design problem in their Launch Logs.
    - The students discuss the designs with their partner and circle one idea they think will best solve the problem.
    - The students discuss, with possible teacher assistance, which design to choose or how to modify some possible solutions to create a single, high-quality design.
    - The students complete the self-assessment regarding Step 2: Explore.
- **Model**
    - Students sketch a cover to keep their ice pop cold and solid.
    - The students bring in necessary items to build their covers. They may wish to design around an empty or fluid-filled resealable bag.
    - *Note: the teacher will need to freeze one resealable bag per group plus one control prior to beginning the next section.*
- **Evaluate**

    - To evaluate the ice pop cover, design students cover a frozen resealable bag with their device and allow the ice pop to sit at room temperature or under a heat lamp for at least 30 minutes. After this time the students measure liquid from the partially melted ice pops by opening and pouring liquid into a graduated cylinder.
    - Students document student and class data. The teacher may wish to have students record and graph data with respect to time. Students will compare their graphs with classmates' graphs and discuss the steepness illustrated on the graphs, which represents the rate of melting.
    - As the students are waiting for the ice pops to melt, the teacher may explain the process for communicating their design.
- **Explain**
    - The teacher guides the students on how to use an app such as Educreations™ or Popplet Lite to document the design challenge. The students insert photos of the frozen resealable bag before, covered, and after, as well as the graduated cylinder with liquid. Students will narrate their presentation.
    - Additionally, the teacher may wish to have the students complete the Launch Log to document the design process.
- At the conclusion of the module, the students complete the Materials Science: Properties of Matter Check for Understanding.

National and State Standards Alignment

Common Core English Language Arts

- RI.2.1 Ask and answer such questions as who, what, where, when, why, and how to demonstrate understanding of key details in a text.
- RI.2.3 Describe the connection between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text.
- RI.2.8 Describe how reasons support specific points the author makes in a text.
- W.2.7 Participate in shared research and writing projects (e.g., read a number of books on a single topic to produce a report; record science observations).
- W.2.8 Recall information from experiences or gather information from provided sources to answer a question.

Common Core Mathematics

- 2. MD.D.10 Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph.
- MP.4 Model with mathematics.
- MP.5 Use appropriate tools strategically.

Next Generation Science Standards

- 2-PS1-1. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.
- 2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.
- 2-PS1-4. Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot.
- K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.
- K-2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
- K-2-ETS1-3. Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.