

Materials Science: Form and Function

Teacher Resources

Related Documents

See “Files” section in the LMS.

Preface

Engineers and designers select materials which have properties that are best suited for an intended purpose. Students will continue their investigation of materials science by exploring properties of matter, including flexibility, hardness, strength, and absorbency. Students will apply this knowledge to a design problem involving the dispersal of seeds across a large area.

As students prepare for the design problem, they will learn about pollination, seed dispersal by animals, and seed germination. Students will also learn how nature has inspired product design, including the invention of VELCRO® brand fasteners. This popular hook-and-loop fastener was developed by a Swiss engineer after observing how burrs, or tiny seeds covered in hooks, became attached to his dog while on a walk.

Students will be introduced to the design problem through the three fictional characters who are planting a wildflower garden at their school. The students are faced with the problem of how plants are already growing in the cleared area and how they will quickly and efficiently disperse wildflower seeds once the area is cleared again.

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 function by observing the form of an object.

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. Engineers and designers mimic forms found in nature when addressing human needs and wants.
9. Animals disperse seeds and pollinate plants in a variety of ways.
10. Materials may be classified and described by a variety of different observable properties.
11. Properties of materials such as color, texture, flexibility, absorbency, and heat transfer may influence design choices.
12. Engineers and designers select materials which have the properties that are best suited for an intended purpose.

Knowledge

It is expected that students will:

- List products created by engineers and designers that were designed 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.
- Describe the form and function of tools informed by nature.
- Describe the process of pollination, seed germination, and plant growth.
- List observable properties of common materials, including color, texture, hardness, and flexibility.

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.
- Compare and contrast the variety of ways animals disperse seeds and pollinate plants.

- Describe and classify a variety of objects according to observable physical properties.
- 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. How does the function of an object influence its form?
2. How does nature influence design?

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: Form and Function Teacher Resources document, including the Understandings, Knowledge, and Skills addressed in the module.*

Part 1: Form and Function

80 minutes

- The teacher reads aloud the Materials Science: Form and Function Introduction. This is a fictional story that describes the problem three friends are having as they are presented with the problem of planting a wildflower garden at school.
- After the story the students ask what they would want to know about the situation. Students may wonder how the other plants got into the field or how wildflowers are usually planted. These questions are not meant to be answered, only posed at this time.
- The teacher assists students in accessing the Materials Science: Form and Function module in the Learning Management System. For the remainder of the module, the students will access the assignments in the LMS and record their work in the Materials Science: Form and Function Launch Log.
- The teacher guides the students to Activity 2.1 Form and Function and reads the introduction with the students.
- In this activity students review properties of matter, including color and texture. Students are introduced to the concepts of form and function and how each informs design.
- In Parts 1 and 2 students will observe both a natural and human-made object. The natural object may be a flower, and the human-made object may be one of the kitchen utensils used in Project 2.4. If a live flower is not available, a silk flower from Activity 2.2 may be used instead.
- As the students observe the objects, they are asked to consider the colors, texture, form, and function of the objects. The teacher can lead a class or small group discussion with these questions or ask the students to respond in writing or by submitting a video response.

- The teacher asks the following questions to engage students in thinking about form and function. These questions are not meant to be fully answered at this time, only to generate discussion and interest as well as to activate prior learning.
 - What human-made objects could be inspired by the form or function of a flower?
Student answers may include the flower inspiring the form of a vase to capture water or colorful decorations that capture the attention of people. Flowers are brightly colored to attract insects in the same way that posters, advertisements, or cartoons are colorful to attract attention.
 - What natural objects could have inspired the form or function of the kitchen utensil?
Student answers may include that the spoon is similar to the shape of human hands as they scoop water or dig in sand. Some animals such as the platypus and birds such as the spoonbill have flat, spoon-shaped bills to dig in mud as they look for food.
- In Part 3 students will reflect on using nature in design after viewing a presentation in the Canvas app that describes the invention of the VELCRO® brand hook-and-loop fastener.
- The conclusion questions may be answered individually or discussed in large or small groups. The teacher may wish to assign only one of the two provided questions for the students to respond to in their Launch Logs.
 - Think about a human-made object that has the same form or function as something in nature. Describe both the human-made and natural objects and explain why their form or functions are the same.
Answers may vary. Students may describe an aircraft wing as similar to a bird's wing or an excavator's claw as similar to an animal that digs holes such as a dog or badger.
 - Think about something that you could design to make catching a ball or hanging up your jacket easier. What object in nature could help you with your design?
Answers may vary. Students may describe something like a spider's web to help them catch a ball or a tree with low branches to help them hang up a jacket.
- For additional examples of how nature has been used to inspire design, the teacher may wish to research the term biomimicry, the practice of studying nature's best ideas and then imitating those designs to solve a human need or want.
- The teacher guides the students on the logout procedure for the Canvas app. Students should logout of the Canvas app at the conclusion of each session.

Part 2: Pollen

80 minutes

- In Activity 2.2 Pollen, students explore the variety of ways that animals disperse pollen. Students begin their exploration learning about the form and function of pollen as well as the role pollen plays in the development of a seed and plant.
- To begin the activity, students learn about pollen and pollination as they view a presentation on the Canvas app entitled Pollen.
- After viewing the presentation, students practice pollinating silk flowers as the teacher demonstrates the process outlined below:
 - Each pair of students will need 1 silk flower, 1 pipe cleaner, and a small amount of flour, powdered sugar, or other fine powder.
 - The teacher may wish to organize these materials on paper plates.
 - Students dip the anthers of the flower into the powder to coat the anthers with the “pollen.” Teachers may wish to complete this step before distributing the materials. If desired, the anthers of the silk flower may be coated in glue before being dipped in powder. If you choose this method, allow ample drying time.
 - Students work in groups of four and practice transferring pollen from the anthers of one flower to the stigma of another flower using a pipe cleaner. A small paintbrush or cotton-tipped stick would also work.
 - The teacher reinforces the concept that pollination must occur for a seed to form and for a new plant to be created. Fruit, vegetables, nuts, and other seeds eaten by humans are dependent on this process.
- Students complete Activity 2.2 and share what they learned with their classmates in small or large groups.
- The conclusion questions may be answered individually in the Launch Log or discussed in large or small groups.
- Conclusion question 3 asks students to describe pollination. Students may write or draw their answer on Page 4 of the Launch Log. Steps that students are expected to include are:
 - An insect or bird rubs against the stamen of the flower, transferring pollen to their body. Students may specify that the anther is the part of the stamen that produces the pollen.
 - The insect or bird flies to another flower of the same kind, and the pollen on their body is transferred to the pistil of that flower.
 - The pollen travels down the pistil of the second flower. A seed or seed pod begins to form.

Part 3: Seeds

120 minutes

- In preparation for this activity, the teacher will need to soak the Lima bean seeds in water overnight.

- In Activity 2.3 Seeds, students explore the variety of ways animals disperse seeds. Students begin their exploration learning about the form and function of seeds as well as seed germination and plant growth.
- In Part 1 students learn about seeds, plant structures, and growth as they view a presentation on the Canvas app entitled *Seeds*.
- In Part 2 students make daily observations of a germinating Lima bean seed. The students observe the seeds for a total of 7 days. The observation of the seeds can carry on through the project and problem if desired. The teacher may also choose to begin this observation on the first day of the module.
- In Part 3 students document their observations of the seed germination by creating a Popplet with the images they captured. Students will add labels to each image.
- As students observe the process of seed germination, the teacher will read aloud the book *How a Seed Grows*, by Helene Jordan.
- The conclusion questions may be answered individually in the Launch Log notebook or discussed in large or small groups.

Part 4: Properties of Matter

120 minutes

- To bridge the gap between how seeds are dispersed and the creation of the device in Problem 2.5, students learn more about properties of matter. The focus of this module is both on seed dispersal and germination and form and function in design. Engineers and designers select materials which have properties that are best suited for an intended purpose. Students will continue their investigation of materials science by exploring properties of matter, including flexibility, hardness, strength, and absorbency.
- In Project 2.4 Properties of Matter: Hardness, Flexibility, Absorbency, and Strength, students work in small groups to identify observable properties of common materials such as wood, stainless steel, nylon, marble, silicon, and cloth. The students explore and document observable properties of these materials.
- To prepare for Part 1, the teacher will need to provide each group with three kitchen utensils. These will consist of three different materials: wood, plastic, and metal. The teacher will provide three different utensils, such as a spatula, a spoon, and a whisk.
- Students record their observations in their Launch Logs for parts 1 and 2 as they observe properties of materials, including flexibility, hardness, strength, and absorbency.
 - For example, in the first chart students may rank the materials in the following order for flexibility: wood, 3 (least flexible); metal, 2; plastic, 1 (most flexible).
 - In part 2 students answer yes or no to the question “Did the material absorb water?” The results from this test may be used to inform the discussion on the essential questions.

- The teacher leads a discussion around the two essential questions:
 - How does the function of an object influence its form?
 - How does nature influence design?
- Students complete the conclusion questions as a class or individually in their Launch Logs.
 1. Do you think any of the kitchen items you observed were modeled after an idea that came from nature? Explain.
Answers may vary. Students may suggest items from nature that are not based on animals. For example, the students may suggest that the spatula could have been inspired by flat leaf or smooth rock.
 2. Think about something that you could design to make catching a ball or hanging up your jacket easier. What properties of matter would you want for flexibility, hardness, absorbency, and strength? Explain.
Answers may vary. Students may suggest that something that could catch a ball should be flexible, but a hook or hanger designed to hang up a jacket would need to be less flexible and strong enough to support the jacket.

Part 5: Dispersing Seeds

200 minutes

- In Problem 2.5 Dispersing Seeds, students design, build, and test a device that mimics one of the ways animals either disperse seeds or pollinate plants. Students will reflect on the efficiency of their design and how it was informed by nature.
- To review how animals disperse seeds, the teacher reads aloud the book *Who Will Plant a Tree?*, by Jerry Pallotta.
- Design Process

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

- 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 device to disperse seeds that mimics the ways animals disperse seeds.
- The teacher directs the students on specifics related to building the model.
- The students complete the self-assessment regarding Step 3: Model.

Evaluate

- Students evaluate the seed dispersal device by testing the ability of each device to spread seeds using excess lima beans, dried beans, or seeds.
- The teacher may choose to set up a grid system using masking tape on the classroom floor or outside pavement consisting of a 5 foot by 5 foot area split into 1 foot by 1 foot sections. The students would then stand in the center spot and use their device for a set amount of time (10-30 seconds). The students would then count and record the amount of squares to which they were able to disperse seeds and the quantity of seeds they dispersed.
- The teacher may wish to have the students submit videos through the Canvas app, or students may use an app such as Educreations or Popplet to document the steps of the design process they experienced through this problem.

Explain

- The teacher guides the students on how to use an app such as Educreations or Popplet to document the design challenge.
- 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: Form and Function 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 in order 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 found 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 scientific 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-LS2-2. Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.
- 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.