Design and Build a Better Candy Bag

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Lesson Focus

Demonstrate how product design differences can affect the success of a final product -- in this case a bag for holding candy. Students work in pairs to evaluate, design, and build a better candy bag.

Lesson Synopsis

The Design and Build a Better Candy Bag activity encourages students to work in pairs to design, build, and test a candy bag. Students will predict the volume and strength of their original design, sketch the design, create a model candy bag, and then test their bag using weight. After testing, students redesign their bag to improve it, and then retest. Student pairs make predictions, compare results, and discuss their findings.

Age Levels

8-18.

Objectives

- Learn how design impacts product performance.
- Design a better candy bag using science, mathematics, and engineering concepts and applications.
- Build a better candy bag using science, mathematics and engineering design concepts and applications.
- Use the engineering design process to solve the problem.
- Employ the use of data collection and analysis to help solve the problem.

Anticipated Learner Outcomes

As a result of this activity, students should develop an understanding of:

- engineering design process
- teamwork in the design process
- making and testing predictions
- product design challenges

Lesson Activities

Student teams will design a candy bag, and predict the volume and strength of their design. Students then build a model of their design, redesign it, build an improved bag, retest using weight, discuss findings, and share results.

Resources/Materials

- Teacher Resource Documents (attached)
- Student Worksheets (attached)
- Student Resource Sheets (attached)

Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

- TryEngineering (www.tryengineering.org)
- Project Lead the Way (www.pltw.org)
- ITEA Standards for Technological Literacy: Content for the Study of Technology (www.iteaconnect.org/TAA)
- National Science Education Standards (www.nsta.org/publications/nses.aspx)
- National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (www.nctm.org/standards)

Recommended Reading

- Margaret Knight: Girl Inventor, by Marlene Targ Brill (Millbrook Press, ISBN: 0761317562)
- Packaging Prototypes: Design Fundamentals, by Edward Denison and Richard Cawthray (Rotovision, ISBN: 2880463890)
- 50 Trade Secrets of Great Design: Packaging, by Stafford Cliff (Rockport Publishers, ISBN: 1564968723)

Optional Writing Activity

- Write an essay (or paragraph) explaining how a cardboard milk carton has been designed to be strong enough to hold its liquid contents.

References

Pam Newberry, Project Lead the Way (www.pltw.org)
Doug Gorham, IEEE

Design and Build a Better Candy Bag

For Teachers:
Teacher Resources

◆ **Materials**

- Student Worksheet
- Sketch paper and pencil
- 8” x 12” pieces of thin, plastic material (we suggest cutting either a plastic painters drop cloth or plastic sheeting)
- Masking tape
- Twine
- Rulers
- Scissors
- Crayons
- Scale, such as spring scale
- Measuring cups
- Books, various sizes of small bottles filled with water, bags of candy, blocks, or other objects to be used as weights
- Items to check for weight, such as rice or candy

◆ **Time Needed**

Two Class Periods

◆ **Procedure**

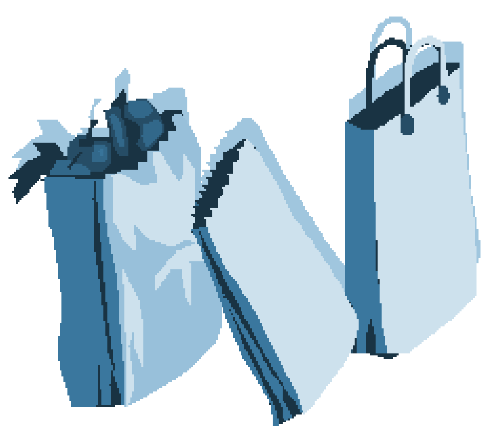
1. Divide students into pairs and provide the Student Reference Sheet to each. (Note: This sheet can be provided as a reading homework assignment for the prior evening.)
2. Discuss the manufacture of paper bags, and provide several examples of bag designs to share. Ask students to compare the bag designs and guess which might hold the most volume and the most weight.
3. Provide each student with the Student Worksheets and review the project with the teams. Teams will:
   - design a candy bag
   - create a model of their bag design
   - predict the bag's volume and weight capacity
   - test the bag for volume and weight capacity
   - force the bag to fail with too much weight
   - redesign their bag with a goal of holding more weight
   - build a model of the improved design
   - test the second model
   - complete the student worksheet
   - present their finding to the class and compare/contrast results

Student Resource:
Paper Bag History and Inventors

◆ Paper Bag History and Inventors

Over the years a variety of designs for candy bags have been created. They are built of a variety of materials (paper, plastic, cardboard) and are designed in a variety of shapes. A woman inventor from York, ME, named Margaret Knight (1838-1914) is credited with inventing a process for automatically folding and gluing paper to form the square or rectangular bottom of a paper bag. As a child, Margaret was often designing, or redesigning mechanical p arts for everything fro m kites to sleds. When she grew up, she initially worked at the Columbia Paper Bag Company in Springfield, MA. At the time, paper bags were folded and glued much like envelopes. After her work hours, Margaret began to design a machine part that would automatically fold and glue the square or rectangular bottoms needed for paper bags.

Finally, she came up with a design that she thought would work. She had a Boston machinist create an iron model of the part so that she could apply for a design patent. Initially, her design was ignored as the workmen in the factory questioned what a "woman would know about machine design." Margaret Knight did receive a patent for her machine in 1870, but she had to go through a lawsuit first with a man named Charles Annan who had attempted to steal her design and patent the machine himself! Now, Margaret Knight is often considered the mother of the grocery bag. She eventually partnered with a Newton, MA man and started a company in Hartford, CT in 1870 with her invention: the Eastern Paper Bag Company. Now, Margaret's machine is on display at the Smithsonian Institution in Washington, DC. Visit www.smithsonianlegacies.si.edu/objectdescription.cfm?ID=92 to view a photo of her machine.



Student Resource:
Student Challenge

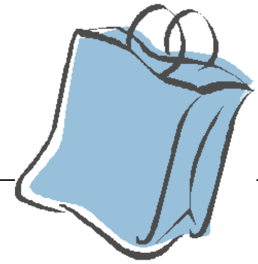
◆ Student Challenge

You and your partner are employees of the Sweet-Tooth Candy store. Recently your boss has learned that customers would like to have a candy bag that is attractive and more functional than the one they currently use when they shop in the store. Your boss has asked you to design and build a new and improved candy bag that is sturdy, functional, and attractive. She is interested in a candy bag that is able to hold maximum weight and that is attractive, but she has not specified minimum dimensions or the amount of weight the bag must hold.

You have learned that the design and construction method as well as materials used will determine the strength of a bag. You will want to test the strength of your candy bag and will redesign and retest as needed. Measurements may be taken to determine how to improve the strength of your candy bag and to estimate the volume or weight the bag will hold.

The Task

1. As a team, discuss and agree upon a design for your candy bag (Note: If you decide to cut the bag, remove no more than 2” from the height of the bag)
2. Draw a sketch of your design in the attached Student Worksheet
3. Build a prototype candy bag based on your design
4. Calculate the approximate volume of the bag
5. Predict how much weight the bag might hold (Note: One 8 oz. bottle of water weighs 9.7 ounces)
6. Test the strength of your candy bag by holding the bag by the handles and placing weight in the bag until it breaks
7. Discuss and agree upon a redesigned candy bag
8. Draw a sketch of your new design in the attached Student Worksheet
9. Rebuild your prototype bag based on your agreed upon redesign
10. Test the strength of your improved candy bag design
11. Present your groups' findings to the class



Student Worksheet:
Design a Better Candy Bag

◆ **Candy Bag Designs**

In the box below, draw the candy bag your team agreed upon for your first design. Include how large it will be, a list of materials needed to construct it, and your estimate of how much weight it will hold.

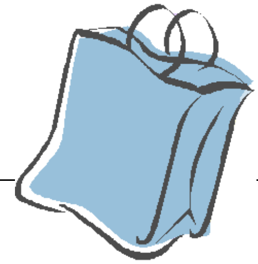
Materials Needed:

Estimated Volume:

Estimated Weight The Bag Can Hold:

Actual Volume:

Actual Weight The Bag Can Hold:



Student Worksheet:
Design a Better Candy Bag

◆ **Candy Bag Designs**

After you have tested your original design and added enough weight to break the bag, redesign your bag, and draw the new design in the box below.

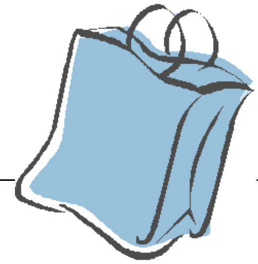
How did this design differ from the prior design?

New Estimated Volume:

New Estimated The Bag Can Hold:

Actual Volume:

Actual Weight The Bag Can Hold:



Student Worksheet:
Design a Better Candy Bag

◆ Results

Once you have built your candy bag and tested it, complete the questions below.

1. When you tested your prototype, what was the approximate volume of the bag?

2. How much weight did your bag hold?

3. Did you have to redesign your initial prototype?
    If so, why? What did you discover because of your redesign?
    If not, why do you believe your prototype worked so well the first time?

4. The one thing I liked about our design was…

5. The one thing I didn't like about our design was…

6. The one thing I would change about our design based on my experience is …

7. What technology, science, and mathematics concepts did you use when you designed the prototype?

Design and Build a Better Candy Bag

For Teachers: Alignment to Curriculum Frameworks

Note: Lesson plans in this series are aligned to one or more of the following sets of standards:

- U.S. Science Education Standards (http://www.nap.edu/catalog.php?record_id=4962)
- U.S. Next Generation Science Standards (http://www.nextgenscience.org/)
- International Technology Education Association's Standards for Technological Literacy (http://www.iteea.org/TAA/PDFs/xstnd.pdf)
- U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (http://www.nctm.org/standards/content.aspx?id=16909)
- U.S. Common Core State Standards for Mathematics (http://www.corestandards.org/Math)
- Computer Science Teachers Association K-12 Computer Science Standards (http://csta.acm.org/Curriculum/sub/K12Standards.html)

◆National Science Education Standards Grades K-4 (ages 4 - 9)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- ✦ Abilities necessary to do scientific inquiry
- ✦ Understanding about scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of the activities, all students should develop an understanding of

- ✦ Properties of objects and materials

◆National Science Education Standards Grades 5-8 (ages 10 - 14)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- ✦ Abilities necessary to do scientific inquiry
- ✦ Understandings about scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop an understanding of

- ✦ Properties and changes of properties in matter

◆Next Generation Science Standards Grades 2-5 (Ages 7-11)

Matter and its Interactions

Students who demonstrate understanding can:

- ✦ 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.

Engineering Design

Students who demonstrate understanding can:

- ✦ 3-5-ETS1-1.Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- ✦ 3-5-ETS1-2.Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- ✦ 3-5-ETS1-3.Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Design and Build a Better Candy Bag

For Teachers: Alignment to Curriculum Frameworks

◆Next Generation Science Standards Grades 6-8 (Ages 11-14)

Engineering Design

Students who demonstrate understanding can:

- MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

◆Principles and Standards for School Mathematics (ages 6 - 18)

Data Analysis and Probability Standards

- Instructional programs from prekindergarten through grade 12 should enable all students to:

- formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them.
- develop and evaluate inferences and predictions that are based on data.

◆Common Core State Standards for School Mathematics Grades 3-8 (ages 8-14)

Measurement and data

- Solve problems involving measurement and estimation.
  - CCSS.Math.Content.3.MD.A.2 Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l).1 Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem.2
- Geometric measurement: understand concepts of volume.
  - CCSS.Math.Content.5.MD.C.3 Recognize volume as an attribute of solid figures and understand concepts of volume measurement.
  - CCSS.Math.Content.5.MD.C.5 Relate volume to the operations of multiplication and addition and solve real world and mathematical problems involving volume.

◆Standards for Technological Literacy - All Ages

Design

- Standard 8: Students will develop an understanding of the attributes of design.
- Standard 9: Students will develop an understanding of engineering design.
- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.