



TryEngineering

A Century of Plastics



Provided by TryEngineering - www.tryengineering.org

Lesson Focus

Lesson focuses on how plastics of all sorts have been engineered in to everyday products over the past century, with emphasis on materials selection and engineering.

Lesson Synopsis

The Century of Plastics activity explores how the development of plastics -- and the engineering of plastic components into everyday products -- has impacted the world. Students learn about the history of plastics, what plastics engineers do, and how many products have been enhanced through the addition of plastic components. Students work in teams to identify products without plastic, and products they think could not exist in a pre-plastic world. They work as teams of "engineers" to see if they can redesign a product to use 50% less plastic components than in current designs.

Age Levels

8-18.

Objectives

- ✦ Learn about plastics.
 - ✦ Learn about how plastics have been engineered into so many common products.
 - ✦ Learn about teamwork and the engineering problem solving/design process.
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Anticipated Learner Outcomes

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

- ✦ plastics
 - ✦ materials and plastics engineering
 - ✦ impact of engineering and technology on society
 - ✦ engineering problem solving
 - ✦ teamwork
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Lesson Activities

Students learn about how the development of plastics and the engineering of plastics into everyday products have impacted our world. Topics examined include problem solving, teamwork, and the engineering design process. Students work in teams to identify products which they think could not exist without plastics and redesign to use fewer plastic components to make it easier to recycle, then present to class.

Resources/Materials

- ✦ Teacher Resource Documents (attached)
- ✦ Student Resource Sheet (attached)
- ✦ Student Worksheets (attached)

Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

- ✦ TryEngineering (www.tryengineering.org)
- ✦ History of Plastics (www.bpf.co.uk/Plastipedia/Plastics_History/Default.aspx)
- ✦ The History of the Pen (www.rickconner.net/penspotters/history.html)
- ✦ 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)

Recommended Reading

- ✦ American Plastic: A Cultural History by Jeffrey L. Meikle (ISBN: 0813522358)
- ✦ Plastics Engineering by R J Crawford (ISBN: 0750637641)
- ✦ Plastic: The Making of a Synthetic Century by Stephen Fenichell (ISBN: 0887308627)

Optional Writing Activities

- ✦ Write an essay or a paragraph describing whether you think spaceflight would be possible without the introduction of plastics. Give examples to support your point of view.
- ✦ Write an essay or a paragraph describing how recycling works in your town. Give examples of how engineers incorporate recycled materials into new products.

A Century of Plastics



For Teachers: Teacher Resources

◆ Lesson Goal

Explore how the development of plastic -- and subsequent engineering of products and machines with plastic component parts -- has impacted our world. Students learn about plastics, explore how plastics are in just about every product, and work as an "engineering" team to redesign a product to see if it could be made with less plastic than in the original product to improve how it might be recycled.

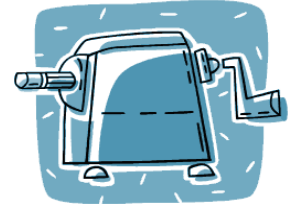
◆ Lesson Objectives

- ✦ Students learn about plastics.
- ✦ Students learn about how plastics have been engineered into so many common products.
- ✦ Students learn about teamwork and the engineering problem solving/design process.



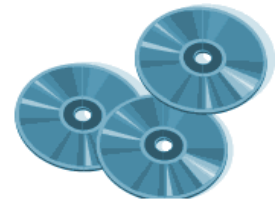
◆ Materials

- Student Resource Sheets
- Student Worksheets



◆ Procedure

1. Show students the various Student Reference Sheets. These may be read in class or provided as reading material for the prior night's homework. They may also be directed to look for examples of products that do not include any plastic from their kitchen and bathroom.
2. Divide students into groups of 3-4 students. Ask students to work as a team to complete the student worksheets: the first allows students to brainstorm on how plastics have been engineered into so many everyday products, the second has students work in teams as "engineers" to redesign a product to see if it could be made with fewer plastic component parts than the original product to improve its ability to be recycled.
3. Each student group presents their product to the class.



◆ Time Needed

One to two 45 minute sessions.

A Century of Plastics



Student Resource: What are Plastics?

◆ A Century of Plastics

The 19th Century saw enormous advances in polymer chemistry. However, it required the insights of chemical engineers during the 20th Century to make mass produced polymers a viable economic reality. When a plastic called Bakelite was introduced in 1908 it launched the "Plastic Age." Bakelite was engineered into many products from electric plugs, to hairbrushes, to radios, clocks, and even jewelry. The bakelite products from this era are now highly collectible! Today, plastics are found in almost every product. It's difficult to find many machines that do not incorporate several types of plastic.



◆ What Are Plastics?

Plastics are polymers: long chains of atoms bonded to one another. Plastic is a term that actually covers a very broad range of synthetic or semi-synthetic polymerization products. They are composed of organic condensation or addition polymers and may contain other substances to make them better suited for an application with variances in heat tolerance, how hard it is, color, and flexibility. Plastics can be molded or formed into particular hard shapes, or be developed as a films or fibers. At some stage in its manufacture, every plastic is capable of flowing. The word plastic is derived from the fact that many forms are malleable, having the property of plasticity. Engineers often turn to a plastic as component parts in many products because it is lightweight, relatively inexpensive, and durable. It has reduced the cost of many products, and many products would not exist today without plastic.

◆ Plastics Engineers

The development of plastics launched a new field of work: Plastics Engineers! They study the properties of polymer materials, and develop machines that can shape plastic parts. They explore ways to mold plastics to meet the needs of other engineers who need parts, such as cell phone covers, soles of shoes, and backpack wheels. They also work to improve the performance of plastics, looking for new materials that react better to high or low temperature or repetitive motion.

◆ Short Timeline

- 1907: the first plastic based on a synthetic polymer -- Bakelite -- was created by Leo Hendrik Baekeland. Bakelite was the first plastic invented that held its shape after being heated.
- 1908: Cellophane was discovered by Swiss chemist Jacques Brandenberger.
- 1920's: Cellulose acetate, acrylics (Lucite & Plexiglas), and polystyrene are produced.
- 1957: General Electric develops polycarbonate plastics.
- 1968: Consumption of man-made fibers tops natural fibers in U.S.
- 1987: Nipon Zeon develops plastic with "memory" so that it can be bent and twisted at low temperatures, but when heated above 37 Celsius it bounces right back to its original shape!
- 1990's: Plastics recycling programs are common, offering new use for old plastics.

A Century of Plastics



Student Resource: Pre-Plastic History of Everyday Objects

◆ Toothbrush

The earliest known toothbrush was a "chew stick" made of chewed or mashed twigs. This style of dental hygiene dates back thousands of years. More recently, toothbrushes were manufactured with bone handles with the bristles or hair of pigs wound together using wire.



This style was popular from as early as the 1600's well into the mid 1800's, though the handle was sometimes made of wood. The next major design change was prompted by the introduction of Nylon. This synthetic material was first applied to the toothbrush around 1938. By 1939 engineers began to develop electric toothbrushes to improve the effectiveness of brushing. The first real electric toothbrush was developed in Switzerland in 1939. In the United States, Squibb introduced an electric toothbrush in 1960, followed by General Electric introducing a rechargeable cordless toothbrush in 1961. A rotary action electric toothbrush was introduced by Interplak in 1987. Even dental floss, which originally was made of silk threads wasn't popularized until the advent of plastics and synthetic materials.

◆ Pen

For the first three thousand years since the invention of paper, the writing instrument most people used was a quill of a bird -- usually a goose -- which was dipped in a well of ink. Mass-produced steel pen points began to appear in the early 1800s, which provided more control over the line. During World War I, pens began to be made of a hard, usually black, rubber substance known as vulcanite. Early colored plastics were introduced in the 1920's. Sheaffer introduced pens made from celluloid in different colors. These were very expensive, but proved so popular that within a few years most fountain pen manufacturers were offering pens in the new synthetic material, replacing some metal and wood designs. However, it was the widespread use of plastics and the engineering of the non-leaky ball point pen that brought the cost of fine writing instruments down and within reach of most people. By the 1960s, disposable, ball point pens took over, and while fountain pens remain available, they have only a very small share of the market today.



◆ Eyeglasses

Eyeglasses were originally crafted of metal and glass. If someone required a particularly strong prescription, however, the glass would be very heavy resting on the nose. Plastics revolutionized glasses, by replacing the glass lens with lighter weight material, and replacing most of the metal in the frames with lighter, colorful, plastics. There is still metal in the frame however, as most hinges are still made of metal. And, of course, there would be no contact lenses without the development of synthetic materials.



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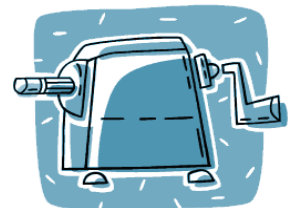
Student Worksheet: Plastic Hunt!

Step One: As a team think about items you can find in your home, classroom, or on the playground. Can you identify any items that have no component parts made of plastic?

Kitchen Items	Bathroom Items	Classroom Items	Sports Equipment

Questions:

1. Was it harder than you thought to find products that contained no plastic?

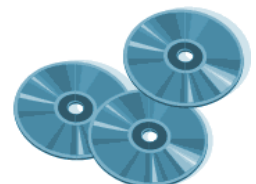


2. Of the products you found with no plastic, what did they have in common?



3. If you were reengineering one of the products you found, would you change any of the component parts to plastic? Why? Why not?

4. Do you think CDs would be possible without plastics? Why? Why not?



5. Why is recycling important?

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Student Worksheet: You Are the Engineer

Step One: As a team, come up with a list of four machines or products that you think would be impossible without the invention of plastics. For each, answer the questions below:

	What % of product is plastic?	Why would this be impossible without plastic?	How has this machine or product impacted the world?
1-			
2-			
3-			
4-			

Step Two: Your challenge is to work as a team of "engineers" to replace some of the plastic in any of the four products or machines you identified in the first part of this worksheet to make them easier to recycle. Discuss what materials you will use instead, how it will impact performance, price, or aesthetics. Then present your ideas to the class including the following:

- describe what your product does, and the percentage of it you think is plastic.
- explain which components you will replace with other materials, describe how you selected the replacement materials and how the new materials will impact weight, cost, and functionality of the product.
- predict whether this product will be as effective as the current design, whether it might cost more to manufacture, and how it would be easier to recycle.
- describe how your team believes that the engineering of plastics into common products has impacted the world.

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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 B: Physical Science

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

- ✦ Properties of objects and materials

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- ✦ Abilities of technological design
- ✦ Abilities to distinguish between natural objects and objects made by humans

CONTENT STANDARD F: Science in Personal and Social Perspectives

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

- ✦ Types of resources
- ✦ Changes in environments

CONTENT STANDARD G: History and Nature of Science

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

- ✦ Science as a human endeavor

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

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

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- ✦ Abilities of technological design
- ✦ Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

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

- ✦ Risks and benefits
- ✦ Science and technology in society

CONTENT STANDARD G: History and Nature of Science

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

- ✦ History of science

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For Teachers: Alignment to Curriculum Frameworks (continued)

◆ National Science Education Standards Grades 9-12 (ages 14-18)

CONTENT STANDARD B: Physical Science

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

- ✦ Structure and properties of matter

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- ✦ Abilities of technological design
- ✦ Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

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

- ✦ Environmental quality

CONTENT STANDARD G: History and Nature of Science

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

- ✦ Historical perspectives

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

Matter and its Interactions

- ✦ 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.

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

Engineering Design

Students who demonstrate understanding can:

- ✦ MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- ✦ MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

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For Teachers: Alignment to Curriculum Frameworks (continued)

◆ Next Generation Science Standards - Grades 9-12 (Ages 14-18)

Engineering Design

Students who demonstrate understanding can:

- ✦ HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

◆ Standards for Technological Literacy - All Ages

The Nature of Technology

- ✦ Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Technology and Society

- ✦ Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.
- ✦ Standard 5: Students will develop an understanding of the effects of technology on the environment.
- ✦ Standard 7: Students will develop an understanding of the influence of technology on history.

Design

- ✦ Standard 8: Students will develop an understanding of the attributes of design.
- ✦ Standard 9: Students will develop an understanding of engineering design.

Abilities for a Technological World

- ✦ Standard 13: Students will develop abilities to assess the impact of products and systems.

The Designed World

- ✦ Standard 19: Students will develop an understanding of and be able to select and use manufacturing technologies.