Sticky Engineering Challenge

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Lesson Focus

Lesson focuses on how engineers work to solve problems and impact daily life through new and improved products. As engineers do, teams of students select adhesive options to help them meet a construction goal. They work in teams to build a simple structure that must hold weight, and have to determine the best glue for the job.

Lesson Synopsis

The Sticky Engineering Challenge explores how engineers work in a team to solve problems. Students learn how different adhesives are selected for different applications, and how individual component choice can impact the success or failure of a product. Students work in teams to design a structure which must withhold the weight of a can of soup or soda using simple materials which must be glued together. Students determine material choice, execute their plan, and evaluate the strategies employed all student teams.

Age Levels

8-18.

Objectives

- Learn how component selection impact engineering results.
- Learn how adhesives are developed for different applications.
- Learn how engineering teams address problem solving.
- Learn about teamwork and working in groups.

Anticipated Learner Outcomes

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

- structural engineering and design
- adhesive history and application
- problem solving
- teamwork

Lesson Activities

Students learn how components must be evaluated when engineers develop a new product or solve a problem. Students work in teams to construct a device to hold a can of soup or soda with simple materials and a variety of glue choices. Optional activities provide an option for students to create their own glues working or expanding on recipes provided.

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)
- Wikipedia: Adhesive (https://en.wikipedia.org/wiki/Adhesive)
- 3M Post-it Note History: (https://www.post-it.com/3M/en_US/post-it/contact-us/about-us/)

Recommended Reading

- The Complete Guide to Glues and Adhesives (ISBN: 0873418204)
- Adhesion and Adhesives Technology (ISBN: 1569903190)

Optional Writing Activity

- Write an essay or a paragraph offering real world examples of how engineers have created products that are either more cost effective or more efficient because glues or adhesives are incorporated in the product.

For Teachers:
Teacher Resource

Lesson Goal
Explore engineering problem solving by working in teams to determine which glues will work better to meet the challenge of building a structure out of popsicle sticks and paperclips that can hold the weight of a full soup or soda can and have the can be at least two inches or 5 centimeters above a surface. Students explore the properties of different adhesives and through trial and error determine which adhesive meets their needs.

Lesson Objectives
- Learn how component selection impact engineering results.
- Learn how adhesives are developed for different applications.
- Learn how engineering teams address problem solving.
- Learn about teamwork and working in groups.

Materials
- Student Resource Sheet
- Student Worksheets
- One set of materials for each group of students:
  - 30 popsicle sticks, 10 paper clips, and 2 sheets of paper
  - a variety of glue options (school or washable glue, wood glue, rubber cement, glue sticks) (extension idea -- have students create their own glues at school or at home -- recipes provided) (Safety Note: Super Glue or Crazy Clue is not recommended for this project as it can adhere to skin.)
  - standard weight (identical cans of soup or soda - about 10 oz or 300 grams)

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.
2. Divide students into groups of 2-3 students, providing a set of materials per group.
3. Explain that students must develop a structure that will withhold the weight of a can of soup or soda. The can must be at least 2 inches or 5 centimeters above the surface of a desk or other flat surface. The teams must determine which glue to use (only one glue at a time) to solve the problem. They may not use tape, tacks, or other methods of attachment.
4. Students meet and develop a plan for their structure. They agree on materials they will need, write or draw their plan, and then present their plan to the class. They may want to test different glues on sample materials to make a glue selection.
5. Student groups next execute their plans. They may choose to start all over with a different glue choice.
6. Each student group evaluates the results (did their structure succeed?), completes an evaluation/reflection worksheet, and presents their findings to the class.
7. Teachers may consider adding the challenge of having each team make their own glue (see recipe sheet) and have students determine whether home-made or manufactured glues are more effective, and why.

Time Needed
Two to three 45 minute sessions

For Teachers:
Teacher Resource

◆ **Glue Recipes**
For optional extension activities you may wish to have students develop their own glues, or recipes for glues. Some of these recipes would require the use of a stove and so would require adult supervision and extra safety precautions.

Glue Recipe 1 (no heat)

1. Mix 1/2 cup of flour with 1/4 cup of water.

Glue Recipe 2 (no heat)

1. Mix 2 cups flour with one 1 cup of cold water and 1 cup of hot tap water

Glue Recipe 3 (requires heat)

1. Mix in a saucepan: 1 cup flour, 1 cup sugar, 1 tsp. alum, 4 cups water
2. Cook until clear and thick. Add 30 drops oil of cloves or wintergreen (etc.) and store covered.

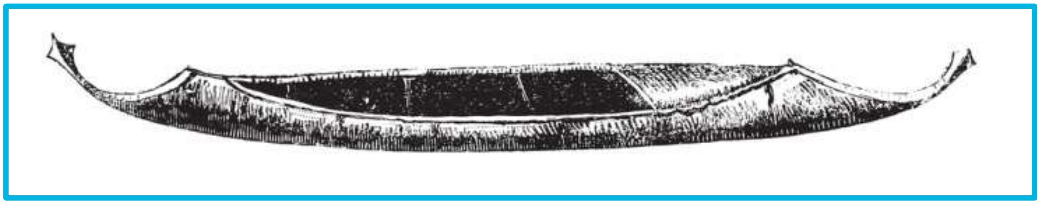
Glue Recipe 4 (requires heat)

1. Mix 3/4 cup water, 3 tablespoons sugar, and 1 teaspoon white vinegar in small saucepan. Bring to a rolling boil.
2. In a separate bowl, mix 1/2 cup cornstarch or corn flour and 3/4 cup water, mix over a very low heat.
3. Add cornstarch mixture slowly to water/sugar/vinegar mixture. Stir continually for two minutes.
4. Take off heat and let cool completely before using as glue

Student Resource: Adhesive History and Engineering Implications

◆ Adhesives through the Ages

The first adhesives were natural gums and other plant resins. Archaeologists have found 6000-year-old ceramic vessels that had broken and been repaired using plant resin. Most early adhesives were animal glues made by rendering animal products such as the Native American use of buffalo hooves. Native Americans in what is now the eastern United States used a mixture of spruce gum and fat as adhesives and as caulk to waterproof seams in their birch bark canoes.



During the times of Babylonia, tar-like glue was used for gluing statues. Also, Egypt was one of the most prominent users of adhesives. The Egyptians used animal glues to adhere tombs, furniture, ivory, and papyrus. Also, the Mongols used adhesives to make their short bows.

In Europe in the Middle Ages, egg whites were used to decorate parchments with gold leaves. In the 1700s, the first glue factory was founded in Holland, which manufactured hide glue. Later, in the 1750s, the British introduced fish glue. As the modernization continued, new patents were issued by using rubber, bones, starch, fish, and casein. Modern adhesives have improved flexibility, toughness, curing rate, temperature and chemical resistance.

◆ Will it Stick?

Whether a glue or adhesive "sticks" depends on more than just the glue formulation. It also depends on the materials being "stuck" together, how they are structured or attached, and how much load they must carry. For example, even the strongest glue connecting two popsicle sticks could not withstand the weight of a television set. And, some glues, though stronger, might increase the cost of a product to the point that a consumer would not buy it.

◆ Engineering Considerations

As engineers develop new products (or seek to improve existing ones) they have to determine which materials to use -- in many cases including the selection of appropriate adhesives or glues to meet the demands of the job. They will also need to develop a plan for how the materials will fit and stay together, and a method for attaching the parts in a way so that the parts will stay together while in normal use. Usage factors such as temperature, humidity, force, and anticipated damage will also be evaluated and tested prior to mass manufacturing.

Student Resource:
Sticky Notes -- Engineering Trial and Error

◆3M and the Post-it Note

A Post-it note (or simply Post-it), invented and manufactured by 3M, is a piece of stationery with a re-adherable strip of adhesive on the back, designed for temporarily attaching notes to documents, computer displays, and so forth. While now available in a wide range of colors, shapes, and sizes, the most common size of Post-it note is a 3-in (7.5-cm) square, trademark canary yellow in color. The notes use a unique low-tack adhesive that enables the Post-its to be easily attached and removed without leaving marks or residue. The names "Post-it" and "Post-it note"—as well as the canary yellow color—are trademarks of 3M, the company which invented and manufactures them. Accepted generic terms for competitors include "sticky notes" or "repositionable" or "repositional notes;" nonetheless, Post-it note is frequently used as a generic term for any such product.

◆It All Began with a Mistake

The Post-it note was invented in 1968 by Dr. Spencer Silver, a 3M scientist who stumbled upon a glue that was not sticky enough. In 1974, a colleague of his, Arthur Fry, was singing in a church choir and frustrated that his bookmarks kept falling out of his hymnal. In a moment of insight, Fry realized that Silver's reusable adhesive would provide precisely what he needed, and the Post-it note concept was born. If it could be coated on paper, Silver's adhesive would hold a bookmark in place without damaging the page on which it was placed. Fry requested a sample of the adhesive that Silver developed and began experimenting. He coated only one edge of the paper so that the portion extending from a book would not be sticky. Fry used some of his experiments to write notes to his boss. Both Silver and Fry eventually both won 3M's highest honors for research and numerous awards within the international engineering community.

3M launched the product in 1977 but it failed as consumers had not yet tried the product and could not easily visualize how they might use it. A year later 3M swamped Boise, Idaho with samples. 90% of people who tried them said that they would buy the product. By 1980 the product was sold nationwide and a year later they were launched in Canada and Europe.

More Post-it note history is available at
www.post-it.com/3M/en_US/post-it/contact-us/about-us/.

Student Worksheet: Make it Stick

◆ You are a team of engineers which has to tackle the challenge of building a structure to hold a can of soup or soda at least two inches or five centimeters above a surface. Your materials include popsicle sticks, paper clips, paper, and glue -- but you'll have to figure out which glue works best!

◆ Research/Preparation Phase

1. Review the various Student Reference Sheets.

◆ Planning as a Team

1. Your team has been provided with some "building materials" by your teacher. These are to be made into a structure to hold a can of soup or soda at least two inches or five centimeters above a surface.

2. Now, meet with your team and devised a plan to build your structure. Think about the different glues available to you -- you may only select one type of glue.

3. Test the different glues for strength using a few different scenarios. These tests will help you decide which glue to select for your building structure. Come up with a method that will be consistent for each type of glue. It might involve a strength test using a gauge or a simple string or weight test to see if a glue can hold a certain weight for a prior of time (such as overnight).

4. Write or draw your plan in the box below, including the number of Popsicle sticks and paper clips you plan to use. Present your design to the class, and explain your choice of glue. You may choose to revise your teams' plan after you receive feedback from class.

Student Worksheet: Construction and Evaluation

◆ Construction Phase

5. Give it a try! Execute your plan and see if your design worked. If it fails in progress, you may choose another glue choice and start over.

6. Evaluate your teams' results, complete the evaluation worksheet, and present your findings to the class.

◆ Evaluation Phase

Use this worksheet to evaluate your teams' results in the Sticky Engineering Challenge!

1. Did you succeed in creating a structure to hold the can? If so, why do you think your design worked? If not, why did it fail?

2. How did you test your glues to make your glue selection? Did your testing process work well and provide you with the information/research you needed to make a decision?

3. How important was the selection of glue to your structure's success or failure?

4. If you had to do it all over again, what would you do differently? Why?

5. What designs or methods did you see other teams try that you thought worked well?

6. Did you find that there were many designs in your classroom that met the project goal? Can you think of examples of everyday products that do the same job but look or perform very differently?

7. Do you think you would have been able to complete this project easier if you were working alone? Why? Why not?

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

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
- Understanding about science and technology
- Abilities to distinguish between natural objects and objects made by humans

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 A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do 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

CONTENT STANDARD E: Science and Technology

As a result of activities in grades 5-8, all students should develop

- Abilities of technological design
- Understandings about science and technology

CONTENT STANDARD G: History and Nature of Science

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

- History of science

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

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry

For Teachers:
Alignment to Curriculum Frameworks

◆**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 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

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.

◆**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.

For Teachers:
Alignment to Curriculum Frameworks

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

Abilities for a Technological World

- Standard 11: Students will develop abilities to apply the design process.
- 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.