Straw Bridges

Grade Level: 5-8

Duration: 40-60 minutes

Classification: Classroom AND/OR STEM Spark

Subject(s): Civil engineering, Physics,

Categories (STEM): Engineering, Technology

Keywords: statics, geometry, bridges, design

Introduction

- Summary: Students will learn about how to build different types of strong bridges by creating their own straw bridges.

Online Resource: https://thestemlaboratory.com/straw-bridges/

Vocabulary

- **Civil engineering -** Design, build, and maintain infrastructure projects and systems in the public and private sector, including roads, buildings, airports, tunnels, dams, and bridges
- **Statics -** Branch of mechanics that is concerned with the analysis of loads (force and torque, or "moment") acting on physical systems that are stationary
- **Compression -** The force generated by compressing or squeezing the object
- **Tension -** The force generated by pulling on an object in opposite directions
- **Tensile strength -** The resistance of a material to breaking under tension

Materials

Materials	Quantity	Reusable?
Small paper cup	1 per classroom	Yes
Pennies	200-300 per classroom	Yes
Wooden support structure (or use two desks)	1 per classroom	Yes
Balance for weighing pennies (optional, or you can count them)	1 per classroom	Yes
Plastic drinking straws (not bendy type)	20 per group of 3-4 kids	No
Scotch tape	2 rolls per classroom	No
Scissors	1 per group of 3-4 kids	Yes
Measuring stick or ruler	1 per classroom	Yes

Directions

Getting Started

1. For bridge testing, place two desks ~10 inches (25 cm) apart.
2. Gather materials and make example square and triangle shapes with tape and straws as shown below
3. Divide the class into groups of 3-4 students each.

Opening Discussion

1. Discuss truss bridges with students. Ask students to vote by a show of hands to the following question, "Which shape is more stable, triangles or squares?" Explain with visual demonstrations that squares are less stable than triangles. Stand the shapes up on a desk and push down on the top of them. With very little force applied, the open square shape twists, while the square shape composed of inner triangles withstands much more force.

2. There are many different types of bridges. Who can name a type of bridge? (Answers include: Beam, truss, arch, suspension, and cable-stayed.) Each type of bridge has a different way that it distributes force via compression and tension so that it can withstand lots of weight.

3. Tell the class that, we are civil engineers competing to create the best bridge design!

    a. Design Objective: Make a bridge that spans the river and supports the most weight. It must span across a 10 inch river (which means it **must be longer than 10 inches)**, and the bridge that can hold the most pennies wins. Your bridge must have a place to securely hold a small cup in the center of the span.

Bridge Building

1. To each team, pass out 20 straws, scotch tape, scissors and a ruler. Think carefully about what your design will look like. When we test your bridge, the cup will be placed on the bridge and will be filled with pennies until the bridge collapses from the weight. That amount of pennies and its cup will be weighed.
2. Other "design constraints" to consider are that no part of the bridge may touch the "water" (or bottom of the wooden support structure) and the bridge cannot be taped to the wooden support structure.
3. Materials are limited. While you can cut your straws to any length you want, you will not be given any additional (or replacement) straws even if you accidentally cut them to lengths you don't want. Think, sketch and measure before you cut.
4. **A bundle of straws taped together does not satisfy the "spirit" of this bridge-building activity.** However, it is not necessary to have bridges look as if small cars could go over them. If necessary, show students example truss designs as examples of the approach to take (not to copy).

5. Give the student teams time to create their bridges. Give students time to brainstorm ideas, draw sketches, and make plans and calculations before doing any cutting and taping with their limited number of straws.

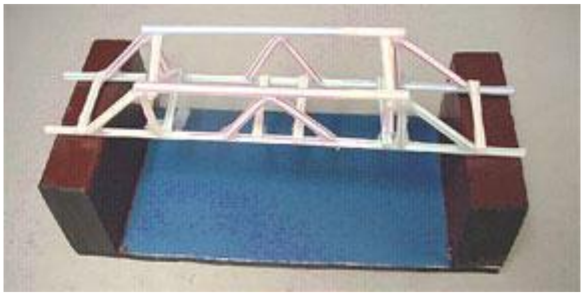

Figure 1. Example of a straw bridge design

Strength Testing

1. Position a small paper cup on the bridge at the center of the span. Gradually fill the cup with pennies until the bridge collapses or the cup falls off. Weigh the cup and the pennies on the balance (or count them). Repeat to test all bridges and record each as you go. The winning bridge is the one that supports the most weight, and meet design criteria.

Troubleshooting Tips

1. Use plastic straws that are not the flexible or "bendy neck" type. If only flexible type straws are available, cut off the straw ends that contain the flexible sections. Since this reduces the straw length, give students 25 straws per group.
2. If rulers are not available, measure the span by marking its width on another piece of paper as a handy reference. Or, explain how students can obtain simple measurements using full sheets of copy paper (8 ½ x 11 inches).

<u>Activity Extension</u>

Add financial costs to each material so that students have to make the strongest bridge with the lowest cost.

Repeat the challenge again, but give them even less materials.

After testing, let them redesign their bridges to be stronger and test them again (engineering problem solving process).

<u>Discussion Questions</u>

- How would they improve their bridge design? Have students from each engineering team describe what they would do to make their bridges stronger.
- How did you use your resources wisely? Which material did you find to be the most valuable?
- Review: what is a compression force? What is a tension force?

- What is the engineering problem solving process?
    - The steps of the design process include: 1) Define the problem, 2) Come up with ideas (brainstorming), 3) Select the most promising design, 4) Communicate the design, 5) Create and test the design, and 6) Evaluate and revise the design. Have students reflect upon the bridge-making activity and list what they did for each step of the design process.
- Truss patterns are used for more than bridge design. Ask students to note all the real-world applications in which they see truss systems used during one week.
    - Possible examples: the structural members found in roofs (look up into your garage or basement), floors, ceilings and construction of other structures, plus ramps, radio towers, crane arms, and components of other types of bridges.

What is happening?

- In a beam bridge, compressive forces act on the top portion of the beam and bridge deck, shortening these two elements. Tensile forces act on the bottom portion of the beam, stretching this element.
- In a truss bridge, the beams are substituted by simple trusses, or triangular units, that use fewer materials and are simple to build

Applications:

- Majors
    - Civil engineering, Physics, Construction engineering, Materials engineering, Mechanical engineering, Architecture
- Jobs
    - Civil engineer, construction engineer
    - Architect
- Hobbies
    - Legos
    - Bicycling (bicycle frames use truss forces and triangle geometry)
- Real world applications
    - To design bridges and buildings, engineers perform careful analysis of geometries and the anticipated applied loads so that they can determine the exact place of the reaction forces. Engineers also consider the most effective materials to achieve a balance of tension and compression.

WiSE PROGRAM FOR WOMEN IN SCIENCE AND ENGINEERING

This activity was last updated in fall 2020 by Student Role Models.