INNOVATION GENERATION
Making an Impact

VOLUNTEER-LED ACTIVITY: TENSILE BUBBLES

ACTIVITY

Can you build a geometric bubble wand that mimics tensile structures?

Objective

In this activity, students will investigate tension-carrying, or "tensile", structures by building inverted architectural designs with three-dimensional bubble wands.

Materials

- Straws (5–10 per student)
- Pipe cleaners (5–10 per student)
- Bubble solution (you can choose to buy bubble solution or make your own with dish soap and water)
- Ruler (one per group)
- Different sized containers for bubble solution (Tupperware, old paint trays, etc.—try to have one container of solution for every 4-5 students)
- Scissors (1 pair per student)

How-to

1. Get students curious by asking a series of questions (you can add in your own if you'd like!):
   - **a.** Some of the earliest known examples of tents were built 40,000 years ago[1]—what makes tents so useful and what situations/events do we use them for today?
   - **b.** What keeps suspension bridges (like the Golden Gate bridge[2]) from falling? It may be helpful to share an image using a tablet or presentation screen.
   - **c.** Have you ever wondered what the buildings of the future might look like?

[1] https://www.pastemagazine.com/articles/2015/08/time-travel-the-intense-history-of-tents.html

[2] https://www.popularmechanics.com/technology/infrastructure/g2383/the-worlds-most-impressive-bridges/

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2. Explain that tents, bridges, and some of the most cutting-edge architecture of the day all rely on the same force: tension.
    a. Elaborate by sharing a few facts about tension[3]:
        i. The word "tension" comes from a Latin word that means "to stretch".
        ii. Tension is a force that occurs along a flexible medium, like a rope or cable.
        iii. Tension is an outward, pulling force—you can't push a rope!
        iv. The force of tension in a rope has to equal the weight of the mass it supports. You might recognize this as a form of Newton's third law: for every action, there is an equal and opposite reaction.
3. Have students think back to the Golden Gate bridge for a minute. Now that we know a little more about tension, let's look at how it comes into play in keeping a suspension bridge up through the use of special materials and clever weight distribution:
    a. Materials:
        i. The cables that hold up the bridge are made from steel wires[4].
        ii. The steel cables are "flexible connectors", which means that they can move and shift under the force of weight[5]. If you hold two ends of the string without pulling, it will sag in the middle. The same thing would happen with the cables on the bridge if they weren't pulled tightly by the weight of the bridge.
        iii. The steel cables and resulting flexibility have another important feature: they allow the bridge to jostle up to 16 feet! This is especially important since San Francisco, the bridge's home, is prone to earthquakes[6].
    b. Weight distribution:
        i. The steel cables that hold up the bridge are secured in giant anchor points that are built into the ground on either side. The cables are also supported by two central towers that fly 750 feet above the water[7].
        ii. The bridge weighs well over 400,000 tons. This weight is distributed by a series of cable riggings that connect to the two main suspension wires. Because of this cable system, each linear foot of the bridge can support weight up to 4,000 pounds![8]

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[3] https://phys.libretexts.org/Bookshelves/College_Physics/Book%3A_College_Physics_(OpenStax)/04._Dynamics%3A_Force_and_Newton's_Laws_of_Motion/4.5%3A_Normal%2C_Tension%2C_and_Other_Examples_of_Forces

[4] http://goldengatebridge.org/research/factsGGBDesign.php

[5] https://phys.libretexts.org/Bookshelves/College_Physics/Book%3A_College_Physics_(OpenStax)/04._Dynamics%3A_Force_and_Newton's_Laws_of_Motion/4.5%3A_Normal%2C_Tension%2C_and_Other_Examples_of_Forces

[6] http://goldengatebridge.org/research/factsGGBDesign.php

[7] http://goldengatebridge.org/research/factsGGBDesign.php

[8] http://goldengatebridge.org/research/factsGGBDesign.php

4. Now, it's time to get hands-on!

a. Provide each student with a good amount of the materials listed (to save time, you can work with your educator to distribute materials before students arrive).

b. Tell students that the objective of the activity is to create "tensile" bubbles—or, bubbles that have structures inside them that distribute weight.

c. Start by guiding students through the construction of a pyramid bubble wand:

i. Cut a straw into three sections of about 1–2 inches each.

ii. Grab a section of straw and thread it onto the middle of a pipe cleaner.

iii. Bend either side of the pipe cleaner up so that the straw stays in place.

iv. Thread another section of straw onto either side of the pipe cleaner, so that there are three sections total.

v. Twist the ends of the pipe cleaner together to form a triangle.

vi. If there is enough pipe cleaner left, thread more straw sections onto the end. If there isn't, add more pipe cleaner as necessary to make another triangle from the straws. Make sure enough is left at the end to add two straw pieces that connect the triangles together and form a pyramid!

vii. Give everything one more twist to make sure the structure is secure. You can use another pipe cleaner and straw to make a handle for the bubble wand if you need to.

viii. Dip the wand in the bubble solution and slowly remove it. You should see a bubble with "joints" in the middle! These joints function like the cables of the Golden Gate bridge—they distribute the weight of the bubble to make it more structurally stable! Tell students to wiggle and bend the triangle shape slightly, the bubbles should flex without breaking.

ix. Blow the bubble and see what geometric shapes and chains result. Where are there tensile facets?

5. Once you've guided students through the exemplar pyramid bubble wand design, provide students with 10–15 minutes to create their own three-dimensional bubble wand. Other shapes that work well include cubes and hexagons. As students work, walk around the classroom to assist as needed and call out any especially creative designs you see!