3M Young Scientist Lab

Lesson Plan | Grades 3-5

Strong As Newspaper

GUIDING QUESTION

How does design or the strength of a material affect how much weight a structure can support?

LEARNING OBJECTIVES

Students will be able to:

- work with a partner to construct a triangular pyramid out of sheets of newspaper.
- use uniform weights to test their pyramid for strength.
- discover applications in construction that use the same principle as their pyramid.

OVERVIEW

Architecture is a practical application of design and engineering, which utilizes applied math and science principles. In this lesson, students create a simple but strong structure from tubes made from rolled-up newspaper. Once constructed, students use weights to measure how strong their structure really is. At home, students will demonstrate their building skills to their parents and together they will construct more structures out of newspaper for a different purpose.

NEXT GENERATION SCIENCE STANDARDS

- ETS1.A: Defining and Delimiting an Engineering Problem
  - Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1) (secondary to 4-PS3-4)
- ETS1.B: Developing Possible Solutions
  - Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3)

- Testing a solution involves investigating how well it performs under a range of likely conditions. (secondary to 4-ESS3-2)

- ETS1.C: Optimizing the Design Solution
  - Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3) (secondary to 4-PS4-3)

LESSON TIME FRAME

Two Sessions:

- One 20-minute session to engage students
- One 50-minute session for students to complete the investigation

BACKGROUND INFORMATION

Structures obtain their strength from the materials of which they are constructed and the way those materials are put together. Generally, building materials such as lengths of wood (2×4s), beams, posts, and rods are strongest along their length and will hold up to pressure better at the ends than when pushed in the middle. A pressing-together force is usually referred to as compression and a pulling-apart force is referred to as tension. The linear structural material young scientists will make out of a sheet of newspaper rolled into a tube is amazingly strong in tension and compression, especially given the flimsy nature of a sheet of newspaper. The tube is not strong however when pushed or pulled from the sides. Engineers and architects take advantage of this linear strength by joining three linear members in the shape of a triangle. With its base resting on a flat surface, a triangle can support a relatively large force, which is often referred to as a load. Combined in a variety of ways, triangles are the basic shape found in numerous manmade structures from roof trusses to railroad bridges.

MATERIALS

Teacher Materials/Prep

- Home Connection Resource
- Five finger Summary
- Two or three full sheets of newspaper (reuse 3 sheets of paper of paper that are the same size)
- Small pieces of Scotch® Tape or 3M™ Masking Tape
- Demonstration table or floor

Materials per Student

- Five finger Summary or Science Journal
- Home Connection Resource

Materials per Student Pairs

- At least six full sheets of newspaper or reuse 6 sheets of paper that are the same size
- Small pieces of masking tape
- Table or floor space
- Plastic bag or small tub (must fit inside the structure being built)
- String (50 cm per group)
- Weight (batteries, heavy washers, pennies etc. Groups could share these if necessary.

CLASSROOM ACTIVITY

Day 1

Engage

1. Ask students if anyone has ever been to an attic (or basement) of a house, seen parts of an apartment that help hold the building up, or noticed the structures holding bridges up over bodies of water. How is it that some pieces of wood or metal can make a house or building stand up and hold so much weight on the inside? How many have seen a house or building being built and noticed the framing or skeleton of the building before the outside or skin is added? Invite discussion about why structures people build and live in are so strong. Are some structures stronger than others and why? What part do the materials play in this strength? Set a student chair on a front table and suggest to students that this is a structure strong enough to hold up a student and even a teacher. In a brief discussion about the strength of the chair, students might bring up the fact that parts of it are made of metal and metal is strong. If students don't mention this, bring it up yourself as a lead-in to the next part.
2. Bring out a newspaper, open it up, and pretend to read it. Pull out one section and crumple it into a small ball and toss it aside. Ask students if they think a piece of newspaper could ever be strong enough to build something that would stand up on its own and even hold up some weight. Tell students they are going to get a chance to find this out in this lesson.

Explain

3. Using the same newspaper you pretended to read, pull out one page (a full sheet) and wave it in front of students. See if students believe that this would be good for building anything. Lay the full sheet flat on a table and arrange students so they can watch you. Begin at one corner. Carefully and tightly start rolling the sheet on the diagonal into a cylinder or tube. The tighter you roll the sheet, the stronger the resulting tube will be because of the number of layers of paper. When you reach the opposite corner, use a small piece of Scotch® Tape or 3M™ Masking Tape to secure the flap so the tube doesn't come unrolled. At this point, you should have a hollow cylinder or tube that's about 85 cm long and quite strong.

Day 2

Explore

1. Ask students how many of these tubes would be needed to make a triangle and suggest that they work with a partner to make three tubes. (For students having some trouble rolling the tube tightly, it helps to begin rolling the newspaper around a pencil. When finished, the pencil can be poked out of the tube with a long skinny object or slightly loosen the tube and it will fall out.)
2. When the team of two students has made three tubes, show them how to tape the ends of the tubes together to form a triangle. Let them feel and hold the resulting triangle to see how strong it is. Caution students that the tubes can be easily weakened if they are pushed from the side and bent; try to avoid this.
3. The team should make three more tubes so they can make a triangular pyramid. Using the original triangle as a base, tape the last three tubes to the vertices of the triangle then join the opposite ends together at the top to complete the pyramid. Again, feel how rigid the structure is but be careful not to bend any of the tubes.
4. Next students should set their pyramid on a flat surface like the floor. Tie a string to the top vertex, letting the string hang down inside the pyramid. Secure a plastic bag or small tub to the string, inside the pyramid, suspended above the floor. One at a time, add a battery or other weight to the bag or tub to see if the pyramid will support the weight. Continue adding weights to see how strong the pyramid is. Students need not add so much weight that they destroy their structure. If the pyramid does collapse, allow students to make another.

Extend

5. Students could try making the tubes with two sheets of newspaper to create one tube. Does this modification make the pyramid stronger? Built this way, does it support twice as much weight as the original pyramid?
6. Once students have made a tube, have them wrap it lengthwise in a spiral with Scotch® Tape or 3M™ Masking Tape. Does this change the strength of the tube and any structures made with the tubes? Does the design of the tape wrap affect the strength of the tube?
7. Build a cube from newspaper tubes. Will this cube be stronger, weaker, or the same in strength as the triangular pyramid?
8. Students can be challenged to find examples of real structures that make use of the same design principles as their pyramids. (Examples could include bridges and attics that make use of trusses, gates that incorporate a diagonal support beam, etc.)

Evaluate

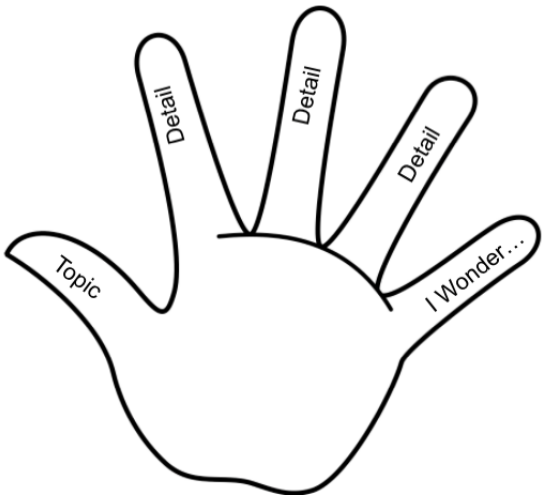
***Teacher Note:** Depending on grade level- you may need to lead this part of the activity and complete it in more of a whole-group setting.

9. How many line segments or tubes are needed to make a triangular pyramid? A: 6 tubes
10. What geometric shape is used in structures to make them light but strong? A: A triangle is used to make structures strong.
11. Name two man-made structures that make use of triangles in their basic design. A: most bridges, many roofs of houses.

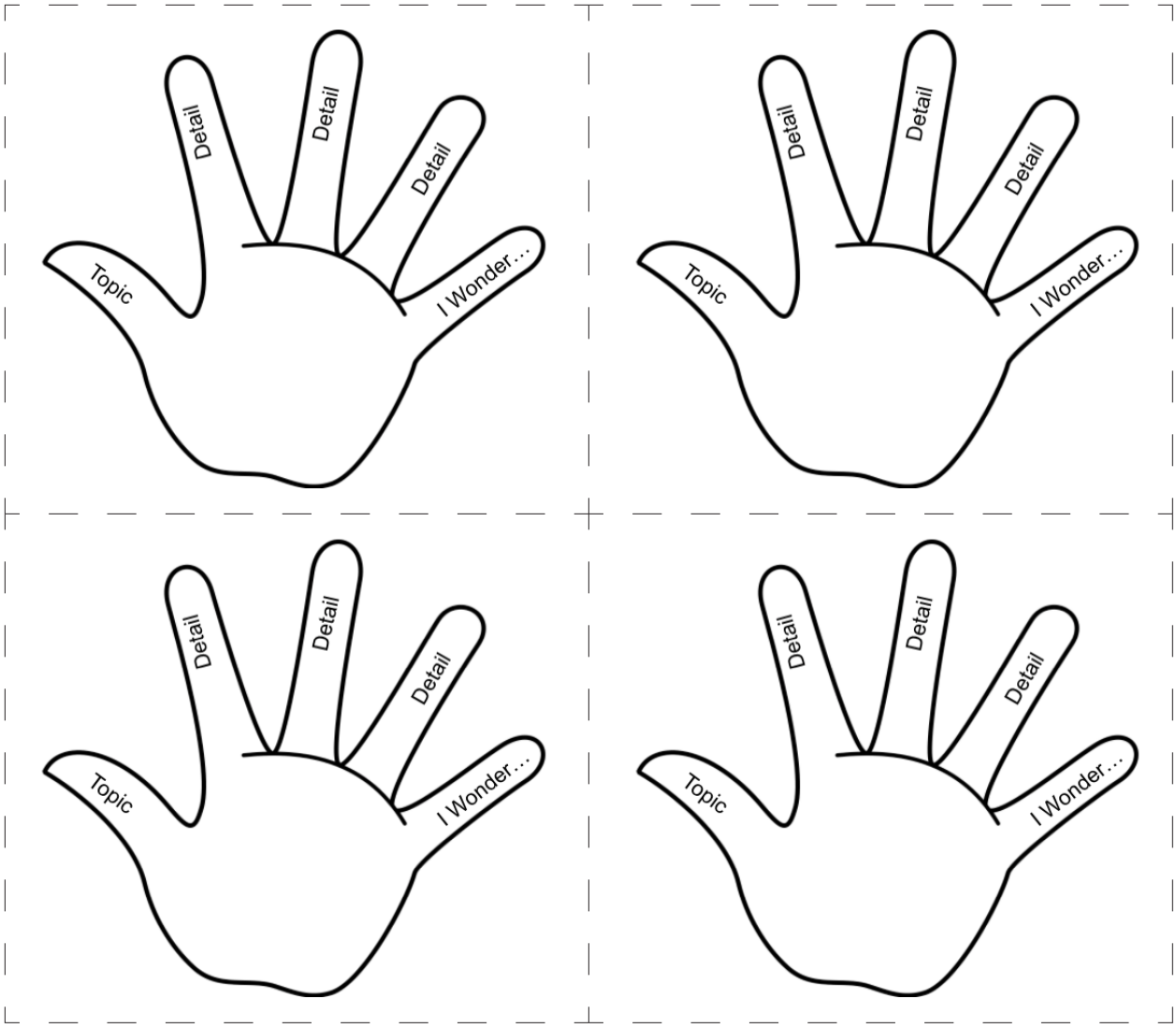
REFLECTION

Students will reflect on their learning by completing the Five Finger Summary. Print off the Five Finger Summary Resource, cut them up, and distribute one to each student. Alternatively, students may trace their hand on a piece of paper or in their science journal.

Students will fill in each finger as shown below:



FIVE FINGER SUMMARY



HOME CONNECTIONS

Dear Parent or Guardian,

Your child has been learning how materials that seem to be weak can be used to create strong structures. Today young scientists made a simple but strong structure of tubes made from rolled-up newspaper. Once constructed, students used weights to measure how strong their structure really was. Select one of the following tasks to complete together with your child to help reinforce and apply their understanding of science concepts:

- Ask your young scientist to show you how they made triangular structures out of newspaper tubes at school.
- Try building other shapes or structures using newspaper tubes: brides, towers, containers, etc.
- Use other building materials such as wood, plastic, or cardboard.
- If you have an attic or can see some of the cross beams in your building and can safely access the area, take your child there to examine the truss sections that support the roof or support the floor. Look for triangular sections and discuss how they make the roof stronger. Bridges also use this triangular structure for support and it is often visible.
- Use the Internet to research how structures are designed and built.
- Using one of several Scotch® Tapes wrap a tube with tape in a spiral shape to find out what this does to the strength of the tube and any structures you might make with the tubes.

For more detailed directions, please see the Strong as Newspaper! Family Activity, and more activities found at: https://www.youngscientistlab.com/parents/family-activities.

We hope you continue learning together about the power of Science.