

5th Grade Engineering: Strong as Newspaper

Architecture is a practical application of design and engineering, which utilizes applied math and science principals. In this lesson, students make 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 can demonstrate their building skills to their parents and together they will construct more structures out of newspaper for a different purpose.

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.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K- 12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p><u>Asking Questions and Defining Problems</u> Asking questions and defining problems in 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships.</p> <ul style="list-style-type: none"> Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1-1) <p><u>Planning and Carrying Out Investigations</u> Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide</p>	<p><u>ETS1.A: Defining and Delimiting Engineering Problems</u></p> <ul style="list-style-type: none"> 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) <p><u>ETS1.B: Developing Possible Solutions</u></p> <ul style="list-style-type: none"> Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a 	<p><u>Influence of Science, Engineering, and Technology on Society and the Natural World</u></p> <ul style="list-style-type: none"> People’s needs and wants change over time, as do their demands for new and improved technologies. (3-5-ETS1-1) Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. (3-5-ETS1-2)

<p>evidence to support explanations or design solutions.</p> <ul style="list-style-type: none"> Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3) <p>Constructing Explanations and Designing Solutions</p> <p>Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.</p> <ul style="list-style-type: none"> Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. (3-5-ETS1-2) 	<p>range of likely conditions. (3-5-ETS1-2)</p> <ul style="list-style-type: none"> At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2) 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) <p>ETS1.C: Optimizing the Design Solution</p> <ul style="list-style-type: none"> 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) 	
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Docent Lab Guidelines:

- Schedule a date and time with your teacher. Allow at least 1 hour if not more of class time. Ideally 1 hour and 15 minutes minimum.
- Reserve the science room on the Science Lab Master Schedule. Please make sure you add 15 minutes of set up time and about 15 minutes of clean up time to the overall class time.
- Safety glasses and aprons are not required.

Docent Reference:

<https://www.youtube.com/watch?v=mGMEFgCP2j0>

Materials for each pair of students:

- at least six full sheets of newspaper
- small pieces of masking tape
- table or floor space
- plastic bag or small tub  string (50cm per group)
- weights (batteries, heavy washers, etc. Groups could share these if necessary.)

Engage

1. Ask students if anyone has ever been to the attic (or basement) of their house or seen parts of their apartment that help hold the building up. 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 and 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.

Activity

4. 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 younger hands that might have 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.)

5. 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. 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.
6. Next students should set their pyramid on a flat surface like the floor and 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 so it is 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

1. Students could try making the tubes with two sheets of newspaper instead of one. Does this modification make the pyramid stronger? Built this way, does it support twice as much weight as the original pyramid?
2. 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?
3. Build a cube from newspaper tubes. Will this cube be stronger, weaker, or the same in strength as the triangular pyramid?
4. 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
5. diagonal support beam, etc.)

Evaluate

1. How many line segments or tubes are needed to make a triangular pyramid?
2. What geometric shape is used in structures to make them light but strong?
3. Name two man-made structures that make use of triangles in their basic design.

Home Connections:

Parent Background Information

1. Building structures is a fun and inexpensive way to allow children to explore engineering. A little newspaper and some Scotch® Tape or 3M™ Masking Tape will allow an upper elementary grade child to invent and build for hours on a rainy day! How can newspaper be used as a building structure?
2. The newspaper tube can be made using a full sheet of newspaper and a small piece of Scotch® Tape or 3M™ Masking Tape. Lay the sheet on a flat surface and begin rolling it up from one corner towards the opposite corner. The tighter you roll the sheet, the stronger the tube will be. Secure the opposite corner with a piece of Scotch Tape™ so it doesn't unravel.

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 (2x4s), 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 your child made in school was a sheet of newspaper rolled into a tube*. The 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.