Bridges: Strong and Stable Structures Virtual

Grade 3

A FACILITATOR'S GUIDE

*Developed by **Sue McKee** for Let's Talk Science in Ottawa*

Thank you for volunteering for Let's Talk Science! The following manual will help guide you through the workshop. Please read this manual before visiting the group you are working with.

Let's Talk Science in Ottawa, University of Ottawa and Carleton University
Contact kits.letstalkscience@gmail.com

Important Notes

Introduction & Guidelines

- This manual is meant as a guide to help you prepare for your activity. The introduction includes questions that get at the curriculum link/science concept the workshop covers. You are not expected to memorize this manual. It is a guide and we want you to bring your own experiences and your style of teaching into it.
- As a general guideline, do not speak longer than the age of the students at one time.
- Most workshops fit well in a 1-hour time period but some like bridge building or some high school activities can take longer if you have more than 1 hour.
- Practice your introduction and test out the activities beforehand so you can anticipate sections that may take more time or may be difficult for students.
- If you are working with a partner, work out roles and responsibilities before the visit.

Safety

As a Let's Talk Science volunteer, safety must be foremost in our minds during all activities. As STEM role models, volunteers must always also model safe science practices.

Always keep in mind the following precautions:

- Emphasize and demonstrate appropriate safety procedures throughout the presentation.
- Be professional but have fun.
- Keep workspaces clean to avoid tripping hazards.
- Allergens should have been checked before reserving the kit (e.g. allergies to latex).
- **Activity Specific Safety:** na

WHMIS

An overview of Canada's Workplace Hazardous Materials Information System (WHMIS) is included in these materials at the end of this manual where needed. No WHMIS sheets are included with this activity.

Overview of the Workshop

Grade Level and Curriculum Learning

Grade 3: *a structure has both form and function; structures are affected by forces acting on them; structures need to be strong and stable to be useful; design and materials enable structures to perform their load-bearing function; concepts of structure, strength, and stability and the factors that affect them.*

Materials where we are dropping off materials at the school

Introduction

A small pieces of clay (enough to make 4 mini marshmallow sized balls) per student
4 toothpicks per student
2 ½ pieces of spaghetti per student

Activity: Bridge Building

Popsicle sticks (enough for 6 per student if dropping off a set of materials for the class to use) (if individual kits, give each student 6)
Tape (5-6 electrical tapes if dropping off a set of materials for the class to use) (a roll of scotch tape for each if individual kit)
Toothpicks (a pack if dropping off a set of materials for the class to use) (6-10 if individual kit)
String (1 partial roll or full roll if dropping off a set of materials for the class to use) (1 2-foot piece of string for individual kit)
Elastics(30 elastics if dropping off a set of materials for the class to use) (2-3 elastics per individual kit)
Straws (enough for 5 per student if dropping off a set of materials for the class to use) (5 per individual kit)
Pipe-cleaners (1 small pack of pipe cleaners if dropping off a set of materials for the class to use) (1-2 pipe cleaners each per individual kit)
Newspaper or newsprint (2 sheets per student if dropping off a set of materials for the class to use; 10-15 extra sheets for the store) (2 sheets per individual kit)
YouTube Video of the Tacoma Bridge – this one is just under 2 minutes long and shows the bridge before and after (https://www.youtube.com/watch?v=XggxeuFDaDU).

Materials where we are NOT dropping off materials at school

Introduction (this activity is optional and can be done as a demo)

A small piece of clay (enough to make 4 mini marshmallow sized balls) per student
4 toothpicks per student
2 ½ pieces of spaghetti per student

Activity: Bridge Building

(the main thing students need is some paper that can be taped, folded, etc. to span 45 cm; they could also use any of the materials below to enhance, strengthen, etc. their bridge and I would let them decide how many of each they want to use but still have them draw out what they will build and have them stick to their drawing to start. Then they can change it as they test their bridge if needed.

Popsicle sticks
Tape
Toothpicks

String
Elastics
Straws
Pipe-cleaners
Newspaper or printer or notebook paper
YouTube Video of the Tacoma Bridge – this one is just under 2 minutes long and shows the bridge before and after (https://www.youtube.com/watch?v=XggxeuFDaDU).

Timing of the Workshop

	Approx. Time (min)	**Description**
Introduction	5-7 minutes	Introduce yourself, find out what they already know, add in bits to fit with the curriculum learning
Clay and toothpick activity and video	5-7 minutes including video	Making a square and then strengthening it
Bridge Building	40 minutes	Designing, purchasing, building of their bridge
Wrap up	20 minutes (includes testing)	Testing their bridge and clean up

Activity

Note: *The* ***questions*** *you might ask are in* ***bolded blue font****. Some things you might say are in blue font and the possible answers are in square brackets in black font. Actions are in purple font.*

Set-Up

Have the teacher set up a place to set all the materials out so students can collect their materials after drawing their design. If they are using individual kits or at home the teacher doesn't have to do anything.

Introduction

Hi everyone! We are Let's Talk Science volunteers. We come to schools and do hands-on activities. I study [simple terms] ________ at the University of Ottawa/Carleton University. I decided to study _____ because [when I was your age I loved… I think it's important to… I'm curious about…].

We're/I'm here today to provide you with materials and information to a build a strong bridge. You'll work in groups and you can keep your bridges at the end. Before we build let's see what you already know about structures.

Ask the teacher if she/he can pick students to answer questions as you ask them. Also, you might not be able to hear the answers so the teacher might have to repeat the answers. If you cannot see the students because the camera doesn't extend to where they can see you on a screen, you'll have to rely on the teacher to know if the students are ready for the next step.

What is a structure? [one definition: "something that is built by putting parts together that has a function].

What are some examples of structures and their function that we see every day (or maybe have seen while we've been traveling)? [houses – keep us safe from the elements, malls – a place where multiple shops can be enclosed, CN tower – a tourist attraction, play structure – for exercise and play, bridges – so we can get from 1 side to another over water, etc., animal nests or beaver dams – protect animals, etc.].

Why is it important that structures are strong and stable? (strong/strength = the capacity to withstand forces; stability = capacity to stay fixed in 1 position and maintain balance) [so they don't fall over and hurt us; so when we walk on them or drive on them they don't break, etc.].

What types of materials do we build structures out of? [cement, wood, plastic, metal, etc.]. Some structures are strong because of the materials they are made out of and some because of the shapes used to make them and some both.

Does anyone know what shapes are strongest? [triangle, arch, and cylinder].

Optional: Let's do a little experiment to see if we can show that the triangle is a strong shape to use.

Ask the teacher to distribute the toothpicks, clay and spaghetti if you haven't already. OR if they didn't receive materials for this because they are at home, show this quickly as a demo OR if you don't have the materials to do it, just skip this part.

Can you build a square using the sticks and clay?

Let the students try this themselves, but you may have to help a few.

Can you hold up your square by the corners and test it to see if it is strong? [it's strong on the sides, but bendy and collapses easily]. **Can you make it stronger with a piece of spaghetti?** You can break the spaghetti piece into smaller pieces if you'd like.
(Some might reinforce the sides to make them stronger but others will put one or two triangles in the square).

Now is it stronger? Does it bend like the square did? [no]. The triangle is one of the strongest shapes and we see it in many structures.

Slides: Show some of the slides of bridges and ask the questions below.
Do you see the triangles? What other shapes do you see [arch, cylinders]. These are also very strong shape and used a lot in building bridges. You'll want to keep these shapes in mind when building today.

What are some natural forces that affect a structure? [wind, snow (weight), vibrations (e.g. from large trucks), tornados (violent winds that extend from a thunderstorm to the ground), hurricanes (huge storm with winds that spiral around and upward with a calm eye in the center; rain, very strong winds), earthquakes (shifting of the earth's surface causing shaking)].

We're going to watch a video that shows what happens when structures may be built with strong materials and shapes, but where the engineers didn't build the bridge to withstand the forces of nature.

Have the teacher put on the "Tacoma Bridge" video.

After the video.
Today you're going to build the strongest bridge you can. We're going to use the engineering process to do this. Your budget only allows you to use the materials on the table (the space the teacher has placed all the materials) [or in your kit or what you have at home]. You must draw out your bridge design before using any materials and you must use at least one piece of paper in your design. Once you decide on the materials to use and have them included in your drawing, you can start to build. You can only use the materials in your drawing to start. We'll test your bridge by placing books on it.

You'll be making a Beam Bridge which is a bridge where there is a flat surface across two points. Today those will be two chairs (get the teacher to show two chairs separated). When we put a beam across two points with a space in between there is the force of tension on the bridge. Tension is like each end is in a tug-of-war. When we test your bridge we don't want to see any compression – that's the force that causes a squeezing together or your bridge to sag in the middle.

Activity: Bridge Building

Slide 6
Go through the tasks below and Build the strongest bridge you can that spans 45 cm.

- Draw your design including whatever materials you want (you cannot use more than 6 sticks or 5 straws).
- You have to use at least on piece of paper in your design.
- Once you have your design drawn, you cannot change the design – you must build the bridge you designed [This means, you should spend time thinking about how the materials will make your bridge stronger, the shape of your bridge, etc. before starting]
- Build your bridge.
- Test it using books for weight
- If time, go back and change or add new materials to make it stronger

Wrap-Up

Ask the teacher for some books each student can use for testing their bridge for strength. Have as many students as possible test their bridge in front of the class telling why they chose the materials they did or the shapes.
Remind them their bridge has tension and then as it starts to collapse with weight, remind them that is called compression. Don't let them break their bridge. As soon as there is compression, they should stop adding books.

After testing ask, **What are some strong shapes bridges are made out of?** [triangles, arches, cylinders]. We hope you had fun being an engineer today and designing, building, and testing your bridges.

Does anybody have any questions?

Thank you for having us in your class today!

Additional Information

Background Information

Some types of bridges
Beam – bridges with just a flat surface across 2 points, like a log across a stream supported by the bank on either side; these bridges experience bending (or flexure) and shearing (or sliding) forces.
Truss – similar to beam bridges but, with triangular structures giving it more strength
Cantilever – The Quebec Bridge (spanning the St. Lawrence River) is the longest cantilever bridge. It failed the first 2 times it was built; once because the dead load of it was too much and it wasn't tested properly. Lives were lost, but it was finally built properly and tested.
Arch Bridge – the arch and the triangle are two of the strongest structures! The arch allows more load.
Suspension – these bridges are supported by cables on towers to give extra support
Cable-stayed bridges – These bridges are like the suspension bridges, but less cable is required and the towers are often taller.

Types of forces on bridges

***Tension** – the force of stretching out, like in a tug of war; Tension makes material become longer; there is tension in a beam that sits on 2 points.*
***Compression** – the force of squeezing together; Compression makes material become shorter (and is often the most noticeable in the middle of a bridge).*
***Bending** – if there is too much weight put on one part of a bridge, it can cause bending and eventually collapse.*
***Shear or Sliding** – a force that appears when the parts of the material itself slides over each other; Shear/Sliding happens when materials that are made up of sheets (like some metals) that could slide over each other.*
***Torsion or Twisting** – Like from the Tacoma Narrows Bridge video.*

Types of Loads
***Dead load** – the force of the bridge itself.*
***Live load** – is something other than the structure itself, that puts a load on the structure (e.g. like a car on the bridge).*
***Settlement load** – is when the soil beneath the bridge may settle unevenly.*
***Thermal load** – is caused by heat.*
***Earthquake load** – causes the bridge to jet back and forth.*
***Wind load** – pushes the bridge horizontally.*
***Dynamic loads** – caused by vibrations.*

WHMIS Sheets na