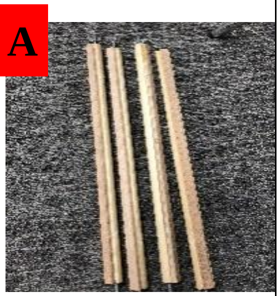
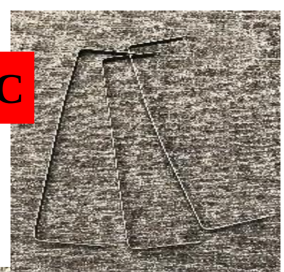
Wizards of Wright

Lesson: Bridges

Use WOW! Lesson Intro to begin.

Background Info for Wizards:	In this lesson, make sure to touch on shapes and stability. Compression and tension is important when working with 4th grade and up. Compression and tension doesn't need to be a big focus for K-3rd grade.
Materials:	<u>Kit will include:</u> 4 - wood dowels – *to be used as floor beams* (picture A) 22 - struts – angled irons (picture B) 3 - cross bars – *to be used across the top* (picture C) 4 – road bed connectors (picture D) 6 – strut and cross connectors (picture D) 3 - deck boards (picture E) 1 – ruler 1 Slinky Model bridge for visual aid. Pliers, in case things get put together too tight. (All bolts have Wingnuts.) **A**  **C**   **E** **B**   **D**
Lesson Time: 45-60 minutes	Introduction: 5-7 minutes Guided Lesson #1: 5-7 minutes Student Activity #1: 8-10 minutes Guided Lesson #2: 2 minutes Student Activity #2: 20-30 minutes Conclusion: 10 minutes

Learning Targets:	Students will learn why Bridges were first invented and how they have helped society progress. Students will learn about the three main types of Bridges, and the effects of compression and tension. Students will learn that the triangle is the strongest shape, and see how triangles are used in Bridge construction. Students will use teamwork to build a Bridge.
Introduction for Students: 5-7 minutes	Do you think life would be different without bridges? Are there places we couldn't get to, or are there places that are easier to get to because of bridges? People living during the 1850s were faced with this situation when heading west to explore the U.S. frontier. They walked and traveled with covered wagons pulled by horses or oxen. Often they would either have to cross streams or rivers or travel many miles out of the way to find a good place to cross. If a river was too high or dangerous, they were forced to wait – sometimes days or weeks. Traveling this way could be dangerous, and definitely slower. Throughout history bridges have served as links for survival and the success of a city. All bridges are unique. They pass over a different roadway, river, bay, valley, canyon or railroad track. All of these obstacles are different and therefore the bridges that cross them must be designed especially for them. Where a bridge is built and the kind of environment it is in must be considered during the design process. This includes how to anchor the foundation and minimize weathering from the climate. Let's talk about why bridges were built, and how. Some of the earliest bridges were just trees or logs that had fallen and were carried over to the water. Sometimes, cutting down a tree was the solution to crossing a gully. We call these natural bridges. They made it easier to cross over small rivers and ravines, so other communities could be reached or resources could be gathered. While natural bridges are inexpensive and effective for human travel, they were only good for very light loads. Later bridges were made by tying wooden boards together with strong rope. These bridges made it possible for more people to cross, and transporting materials could begin with the use of carts and wagons. These bridges were fairly weak and heavy loads were restricted. Think about how wind or rain might affect these rope bridges. Strong winds might cause the bridge to swing back and forth and heavy rain could wash away the ground that supports the bridge, or wash away the bridge itself.

	Ancient Romans had actually created stone arch bridges, known as some of the strongest and most durable bridges. Even today, many are still standing and being used. Other bridge designs suspended wire bridges that span large canyons and bodies of water. Today, the use of stronger materials like steel, concrete and cables allows the construction of even larger bridges capable of supporting many automobiles. There are almost 600,000 bridges in the US, with Ohio having the second highest in the country with almost 28,000. (Texas has the most with over 48,000….Rhode Island the least with 748.) Bridges are designed by civil and structural engineers. Teams of engineers decide what type of bridge is needed and what materials it should be built out of. They determine if the area/land is good, design the plans, and figure out the cost.
Guided Lesson #1: 5-7 minutes	There are three main types of bridges – beam, arch, and suspension bridges. Usually, the obstacle to be overcome — another roadway, a river, a valley, a canyon, or railroad tracks — is the main factor in determining which bridge type is best to use. Show pictures. Besides looking different, the main difference in these bridges is the distance each can safely cross. Typical span lengths are: beam = up to 200 feet (61 m) arch = 130-500 feet (40-152 m), and suspension = 2,000-7,000 feet (610-2,134 m) The main reason for the differences in span lengths is how each bridge type handles the two forces that act on a bridge - tension and compression. Compression is a force that compresses or shortens whatever it is acting on. Tension is a force that expands or lengthens what it is acting on. Think of a spring – like a slinky. If we push in on both ends of the spring, pushing the ends towards each other we are compressing the spring. The force of compression shortens the spring. If we pull both ends of the spring apart and away from each other we are stretching the spring. The force of tension lengthens the spring. Show pictures. Use Slinky to demonstrate.

	Compression and tension forces affect all bridges, and it is the job of engineers to design bridges capable of handling these forces.
Student Activity #1: 8-10 minutes	We want students to feel compression. Each student will need a partner, and they should stand face to face and gently press their palms together at about shoulder height (like a "high five"). Tell them to slowly lean into each other. Ask them to describe what they feel, where they feel it, and what they think is causing the feeling. Next, let's feel tension. While still standing and facing each other, have the pairs grab hands and gently lean away from each other. Ask them to describe what they feel, where they feel it, and what they think is causing the feeling.
Guided Lesson #2: 2 minutes	Explain to students that the shape of a structure and its individual parts is often as important as the material the structure is made of. - Shapes that have sides that are all straight lines are called Polygons. Polygons may have three, four, five, six, or more sides. - The triangle is the strongest shape. While all of the other polygons can be bent into many different forms, the triangle always keeps the same shape. It is the strongest polygon. Why is that? The reason is because in all of the other polygons, all of the angles can change. However in the triangle, the angles cannot change. The angles are fixed – three sides and three angles, and each one is fixed by the side opposite of it.
Student Activity #2: 20-30 minutes	The Bridge will be built on the floor, and then placed onto desks (or sturdy chairs) so student can crawl through it. Point out: the difference in a screw and a nut, and a wing-nut The material used is aluminum; strong but light weight. You can create groups of students to complete each step of assembly; 4-6 in a group. Steps – *Note: Always have angles and bolts on connectors pointing out.* 1. Place (4) dowels on the floor, flat side up. Remove wingnuts. 2. Discuss struts with the students. Both sides work together to give strength, stability, and rigidity. Explain an angle is rigid in two directions. (Use ruler example here. Bending one way gives flexibility,

but nothing will budge when you try to bend the other way.)

3. Attach 3 struts to each side to create a ladder. (6 struts total)
   (Note: The edges are facing in. Do not replace wingnuts yet.)

4. Attach 12 struts (6 on each side) to create **triangles**, 3 on each side. Be careful not to let strut "guillotine and pinch" fingers. (Edges facing out.)

5. Replace wingnuts on the bottom of the wooden dowels.

6. Attach 4 top struts (2 on each side) to complete two upside-down **triangles**.
   (edges facing out, flat edge on top)

7. Use (6) connectors. Use the bottom bolt and wingnut on the connector.

8. Attach (3) stringers/cross bars using the small bolts/wingnuts on the connectors from step 4. Discuss that these are used for more stability.

9. Explain washers to the students, they help with stability by supplying more surface area.

10. Assemble (3) deck boards. Make sure the holes will line up before the students begin building. Use (6) connectors and (4) carriage bolts and washer and wingnuts per connector. This is easier to build upside down. Bolts will be sticking up through the holes.

11. Flip deck over and insert from one end. Connectors/Bolts for deck should straddle the wood dowels to anchor the deck in place.
12. A few students can serve as Quality Control and make sure all of the wingnuts are tight.

13. Lift the bridge onto 4 chairs or a few desks.

14. Students can crawl across the bridge for great photo ops. The bridge shouldn't go anywhere, but it's always a good idea to have someone stationed on the ends, just in case.

Conclusion: 10 minutes	Review the reasons for bridges, kinds of bridges, compression and tensions, structural shapes and why triangles are strong. Have students help you take the Bridge apart.