PASTA BRIDGES (G3-6)

In this workshop, students will engineer a bridge made of pasta that holds as much weight as possible. They will then test it with increasing weight until it breaks. The Works Museum's educators will provide a limited set of materials to use during building and constraints for the bridge design. Educators will also instruct and monitor students for safe tool use. See p. 3 for standards this workshop supports.

SCIENCE CONCEPTS

Bridges use many different designs and materials depending on the job they need to perform. Bridge engineers use designs both ancient and modern to complete their task.

- Some basic shapes work better than others to bear weight under pressure. Shapes like arches and triangles do not collapse when weight is placed on top or when they are squeezed from the side.
- Materials that seem weak, such as a thin rod or a single strand of uncooked spaghetti, can become strong when bundled together.
- Joints, or areas where two things connect, can represent weak areas, or can be reinforced or joined in such a way that they become even stronger.
- Most engineers work under budget or constraints.

Destructive testing is an important concept in engineering. It means testing something to the point that it breaks, in order to learn about and understand the weak areas of a design. In this case, breaking is not considered failure, but an opportunity for learning. We are often encouraged to build items that don't break, but the truth is that everything breaks eventually. By intentionally straining items such as bridges beyond their limits, we learn what those limits are. Engineers often go through many rounds of destructive testing before they are satisfied with a product that breaks only under conditions they do not expect to see in the real world.

Educators will also stress the **Engineering Design Process** to students.

- Build with a plan! Students should be thinking about their goals while they work, and focus on how to make a strong bridge.
- Engineers often borrow elements from pre-existing projects. It's okay to share ideas with neighbors or with bridges students have seen in the real world.
- Engineers always test before they finish, and projects often break during testing. This is a normal part of the design process.

BEFORE YOU VISIT

What are different kinds of bridges students have seen? Be specific in describing these bridges.	Students might name bridges by their style (suspension bridges, covered bridges, trestle bridges), by their purpose (train bridges, pedestrian bridges, car bridges), or even by their material (wood, stone, metal). Encourage students to think about why bridges have certain shapes, styles, or appearances.
Why is it important to test things before we declare a project finished? What kinds of testing do engineers perform?	We have to test things so we know that they work, instead of guessing or hoping. Engineers use many different kinds of tests, and students might have fun thinking of different kinds: crash tests in cars or shake tests for earthquake testing. Any machine that goes into space must withstand the heat, volume, and vibration of being launched on a rocket. Encourage students to be creative.

AFTER YOU VISIT

Questions

- We used destructive testing to see how much weight each of the bridges could bear before breaking. What other kinds of destructive testing might we have tried? What other kinds of stresses do bridges endure? (Answer: Wind testing, earthquake testing, and flood testing are all common tests for bridges, but students might come up with others.)
- What were the most common failure points on the bridges? How could students make them stronger? (Answer: Usually the abutments, other joints, or the center. This is why it's very important to reinforce any place that different materials meet and join. The center is very tricky, and this is why bridges usually have supports every so often, either pillars from below or suspension from above.)

Activities

- Students could try to build an improved bridge, using what they learned from their first attempts. (Materials hint: Elmer's glue is even stronger than hot glue, though it is slower to dry.)
  1. Students could engineer bridges using different materials.
  2. Try making bridges out of toothpicks and mini-marshmallows.
  3. Students can also make bridges out of paper and tape.
  4. Materials hint: It's best to add limits, such as three sheets of paper and a foot of masking tape, or 30 toothpicks, but teachers can improvise or adjust these limits depending on the complexity and length of the activity.
  5. How do these materials behave differently than the pasta-and-glue bridges? How can they best hold weight?

CAREERS THAT USE ENGINEERING

Architect: Architects shepherd a project from beginning to end stages of building. They start with an initial design that might be hand-drawn or, more commonly these days, computer-aided. They must carefully consider the best materials for the job at the same time they design its shape and structure. They ensure it can survive real-world stresses and strain, and address and solve problems that may arise during building. Architects design houses, skyscrapers, bridges, and all kinds of structures.

Civil Engineer: Civil Engineers are responsible for large projects that are used by many people. This might mean bridges, damns, or tunnels. They might also plan how water moves by designing irrigation or sewer systems. Civil engineers think big, since their projects affect many people and communities. But they also must focus on small details of deciding which materials to use and how a project should be built.

Mechanical engineer: More highly technical than a carpenter, in many ways mechanical engineers use the same basic skills. Engineers spend their time figuring out how to design and build a machine or object to do a specific job. Mechanical engineers might design a new car motor or build a skycrane to drop a robot on Mars.

Learn about **more careers** that use engineering!

MINNESOTA ACADEMIC STANDARDS FOR SCIENCE K-12

3.1.1.1.1 Provide evidence to support claims, other than saying "Everyone knows that," or "I just know," and question such reasons when given by others.

3.1.1.2.1 Generate questions that can be answered when scientific knowledge is combined with knowledge gained from one's own observations or investigations.

3.1.1.2.4 Construct reasonable explanations based on evidence collected from observations or experiments.

3.1.3.2.2 Recognize that the practice of science and/or engineering involves many different kinds of work and engages men and women of all ages and backgrounds.

4.1.2.2.1 Identify and investigate a design solution and describe how it was used to solve an everyday problem.

4.1.2.2.2 Generate ideas and possible constraints for solving a problem through engineering design.

4.1.2.2.3 Test and evaluate solutions, considering advantages and disadvantages for the engineering solution, and communicate the results effectively.

5.1.1.2.1 Generate a scientific question and plan an appropriate scientific investigation, such as systematic observations, field studies, open-ended exploration or controlled experiments to answer the question.

6.1.2.1.1 Identify a common engineered system and evaluate its impact on the daily life of humans.

6.1.2.1.4 Explain the importance of learning from past failures, in order to inform future designs of similar products or systems.

6.1.2.2.1 Apply and document an engineering design process that includes identifying criteria and constraints, making representations, testing and evaluation, and refining the design as needed to construct a product or system to solve a problem.