Session 9: Bridge Building

Age Range:

- Nine years and older

Next Generation Science Standards

(Grade level: Middle school)

Performance Expectations:

- 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.
- MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constrains of the problem.

Science and Engineering Practices:

- Developing and using models. Planning and carrying out investigations.

Disciplinary Core Ideas:

- ETS1.A. Defining and delimiting engineering problems. ETS1.B. Developing possible solutions.

Crosscutting Concepts:

- Influence of engineering, technology, and science on society and the natural world.

Approximate Time Required for Session:

- 1.5 hours

Learning Objectives:

- Be able to work as a team to design, construct, and test a bridge that meets the requirements (i.e., spans a 38 cm [15 inch] gap and supports 4.5 kg [10 pounds]).
- Learn about different types of bridges.
- Understand important features of the engineering design process.

Overview of Activities:

Campers work together as a team to design a basic blueprint for the construction of a bridge. After the team has designed and sketched their bridge, they will use the materials and implements provided to physically build it. The bridge must span a gap of 38 cm (15 inches) and support a weight of 4.5 kg (10 pounds).

Background Information for Facilitator:

A bridge is a structure erected to span a physical obstacle such as a depression or a body of water. Often it serves as a pathway for pedestrians or vehicles. Bridge designs vary depending upon the function of the bridge and the nature of the terrain near its location. There are seven main types of bridges: truss, girder, beam, slab, arch, suspension, and floating. Other types include cantilever, swing, lift, bascule, and so forth. However, the aforementioned seven varieties are encountered most often (see examples in Figures 9-1 through 9-3).

1. The arch bridge has abutments at each end shaped as a curved arch. Arch bridges work by transferring the weight of the bridge and its loads partially into a horizontal thrust restrained by abutments at each end.
2. The truss bridge has a truss for a superstructure. The span rests on one support at each end. These supports may include abutments, piers, bents, towers, or any combination of these.
3. The suspension bridge has its floor system and its incidental parts suspended on cables supported at two or more locations on towers and anchored at their extreme ends.
4. The girder bridge has two or more girders supporting a separate floor system of slab and floor beams.
5. The beam bridge is the simplest bridge, consisting of one or more horizontal beams with a support on each end.
6. The slab bridge is composed of a reinforced concrete slab that is either singular or in a series of narrow, pre-cast slabs. This slab is parallel with the roadway alignment and spans the space between the supporting abutments or other substructure parts.
7. The floating bridge has substructure parts that provide buoyancy such as logs or timbers held in position under a plank deck.

Figure 9-1. Arch bridge

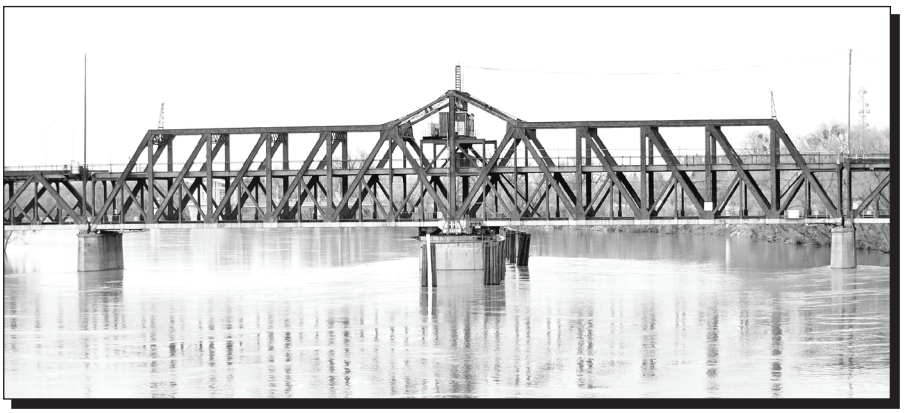


Figure 9-2. Truss bridge

Figure 9-3. Suspension bridge

Concepts and Vocabulary:

- Abutment: the supports at either end of a bridge.
- Deck: the roadway portion of the bridge.
- Span: the distance between abutments of a bridge.
- Superstructure: the upper structure or edifice built over the bridge to aid in its support.

Activity A: Bridge Building

Science Abilities:

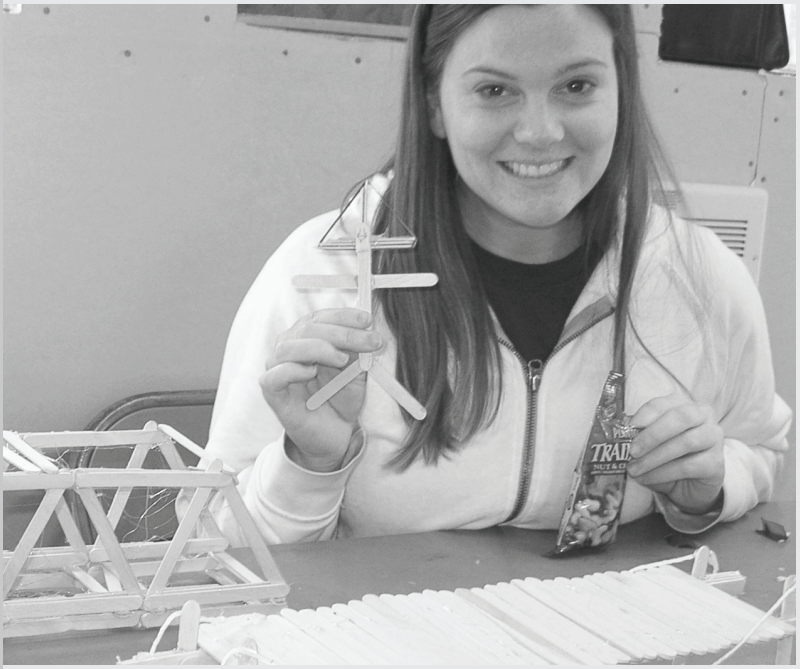
- Build/construct
- Collaborate
- Communicate
- Draw/design
- Measure

Approximate Time Required for Activity:

- 1.5 hours

Suggested Groupings:

- Large group of up to 20 to 25
- Smaller groups of three or four



Introduction:

Campers will design and build a working bridge that spans a 38 cm (15 inch) gap and supports a weight of 4.5 kg (10 pounds). They will work as a team to design and construct the bridge within the allotted time.

Materials Needed:

- Pencils
- Sheets/tablets of paper
- Rulers
- Craft (popsicle) sticks
- Glue sticks
- Glue guns
- String

- 0.9 to 2.3 kg (2 to 5 pounds) weights. Need at least 4.5 kg (10 pounds) total
- Belt (or small bungee cord)
- Bucket
- Black marker
- Flip chart paper, easel, and markers (optional)

Tips!

- Use low-temperature glue guns. The hot glue guns can be a safety hazard, particularly for younger campers.
- White glue can be used in lieu of glue guns. However, you must allow a considerable amount of time for it to dry.

Preparation:

1. Make sure you have adequately prepared for the activity. Read the background information and activity. Practice building a bridge that spans a 38 cm (15 inch) gap and supports 4.5 kg (10 pounds) of weight.
2. Determine the size and number of small groups. Have a plan for dividing the large group into smaller groups of three to four campers. Assign a trained facilitator to each small group, if possible.
3. Prepare a packet for each small group that consists of a pad of writing paper, pencil, string, a ruler, a glue gun, 10 glue sticks, and 100 craft sticks.
4. Create a 38 cm (15 inch) gap that must be spanned. This activity can be done outdoors over a natural setting. It can also be done indoors by using the ends of two tables of equal height or by placing two stacks of books of equal height on a table with a 38 cm (15 inch) gap between them.

Tips!

- There are different kinds of learners. While some people are auditory learners others are visual learners who learn information best by seeing it. It may be helpful for visual learners if the facilitator records responses from Introduction and Opening Questions on flip chart paper.
- Be sure to make it clear that the goal is to support a 4.5 kg (10 pound) weight!

Introduction and Opening Questions (10 minutes):

1. Gather campers. Explain that they will design and construct a working bridge that spans a 38 cm (15 inch) gap and supports 4.5 kg (10 pounds) of weight.
2. In large groups, facilitate a discussion with campers about the various types of bridges they have seen in their travels. Example prompts include:
   a. Discuss and evaluate the different sizes and shapes of bridges and how they are designed.
   b. Compare the different types of material you have seen used for bridge construction.
   c. Explore the purpose that different types of bridges serve. Discuss the various types of obstacles bridges span.
   d. Discuss what keeps a bridge from collapsing. Compare the various support systems of bridges.
3. Ask campers to discuss what they might need to consider if they were architects in charge of designing a bridge or engineers in charge of building it.

Tips!

- Remember to encourage lots of exploration. Avoid answering questions. Ask questions to help campers discover their own answers.
- In the design phase of the activity, give the teams only two craft sticks as reference. This requires them to sketch the plan on paper.

Experiencing I (10 minutes):

1. Show them the area you have established to be spanned.
2. Divide campers into teams of three to four participants.
3. Provide each team with a tablet of paper, pencils, a ruler, and two craft sticks.
4. Show campers all the materials they have to construct their bridge.
5. Have campers study the area to be spanned, and design the type of bridge they will build.
6. Ask them to prepare a sketch of the bridge. They will need to keep in mind the materials they have available to them for construction. They are not required to use all the materials, but cannot use more than what they have been provided.

Sharing, Processing, and Generalizing I (10 minutes):

Bring small groups together to form the larger group.

1. Ask the teams to share their experience in the design process:
   a. Share the sketch of your bridge, and explain why you designed it as you did.
   b. Is there any additional information you would like to share?
2. Give small groups an opportunity to change or adapt their design.

Tips!

- As campers begin the process of construction, they may realize that they will need to make corrections or adaptations to their original design. They may do so.
- The gap to be spanned is 38 cm (15 inches), so the bridge needs to be longer than 38 cm (15 inches).

Experiencing II (50 minutes):

1. Give each team 100 craft sticks, one glue gun, a 91 cm (36 inch) length of string, and 10 glue sticks.
2. Allow the participants approximately 30 minutes to construct their bridge.
3. When all teams have completed their structures, allow a few minutes for all groups to visually examine each other's creations.
4. Begin the process of placing a bridge, one at a time, over the area to be spanned. Place the belt around the bridge at its most central point. Fasten the belt through the handle with the bucket being suspended from the bridge. Place one 2.3 kg (five pound) weight in the bucket at a time.
5. Repeat until each bridge has been tested. Record the results on the bottom of your bridge or on the flip chart paper for the group to see.

Sharing, Processing, and Generalizing II (10 minutes):

Gather all the small groups together to form the larger group for the rest of the activity. Ask each small team to share their experience in the construction process:

1. What were the group dynamics like? How did you work as a team?
2. Did some bridges work when it looked as if they would not and some not work when it looked like they would? If so, explain why.
3. Share with us any surprises.
4. How would you describe the engineering design process that you just went through?

5. How were you acting like an engineer?
6. Explain how you can apply some of the things you did today to evaluate the next bridge you see.

Taking It One Step Further:

1. You can adapt this activity to see which bridge can support the heaviest load by increasing the weight to the breaking point of each structure and recording the results.
2. You can make this activity more challenging by doubling or tripling the size of the gap to be spanned. Be sure to increase the amount of material you provide to the design/building teams accordingly. Ask campers if and how they altered their design to accommodate the extra gap to be spanned. Explain your reasoning.

References

WGBH Educational Foundation. (2000–2001). *Building big: All about bridges*. Retrieved from http://www.pbs.org/wgbh/buildingbig/bridge/index.html.

Headquarters, Department of the Army. (2003). FM 5-34 *Engineer field data*. Retrieved from http://www.survivalschool.us/wp-content/uploads/fm-5-34-engineer-field-data.pdf