

Bridges of Paper

Estimated Time: 45-90 minutes

SUMMARY

We're used to seeing bridges of stone or metal but can you make a bridge out of something flimsy like paper? How much could that bridge actually hold? If you build it right, a paper bridge can hold quite a lot of weight! Students will explore the engineering design process as they find the most effective way to use paper in bridge-building.

WHAT YOU'LL LEARN

- Engineering design process.
- Material properties of paper.

Materials Used	
<ul style="list-style-type: none"> • Printer paper (or other type) • A ruler • Scissors • Masking tape 	<ul style="list-style-type: none"> • Pennies, washers, or other stackable weights • Four large books (for the "banks") • Index card or square of cardboard (optional)

WHAT TO DO

1. Ask the students what people build bridges with. Make note of all the different materials (stone, metal, brick, etc.) and then ask if they've seen a bridge made of paper. If you tried it, could you hold much with a paper bridge?
2. Start the hands-on portion by building the "banks" of your "river" which the bridge will span. Two large books, like a textbook, on either side will work, or you can push two tables or chairs together to create the gap (although a longer fall means a bigger mess when the bridge collapses). The distance between banks should be 7 inches.
3. Have the students attempt to make a bridge across the span using two sheets of paper and a length of masking tape (this should be the same for each bridge but can be anywhere from six inches to two feet depending on how generous you feel).
 - a. You and your student can decide on the rules for bridge-building but it's recommended that bridges *not* be able to touch the table (although an extension in Tips introduces this idea) and can't be taped to the "banks" of the gap.
 - b. Test out bridge designs with the stackable weights, keeping track of how many are held up by the bridge before it collapses. If you have index cards or cardboard, this can be placed in the middle of the bridge as a flat area for stacking.
 - c. Students will have a lot of failures in this stage and *that's a good thing*. Having the bridge collapse is expected and an event that can be fun. They'll also have plenty to share in the next step.
4. After a brief period of testing (about ten minutes) stop the students and ask what they've learned. What is working well in their design that other students might want to try? What is not working well and others should avoid?

5. Go back to testing to try out these new ideas. This is part of engineering design as new data and lessons are incorporated into later designs. You can continue this cycle of test, share, test, share as long as the group is motivated and focused.
6. Conclude the lesson by reviewing what you've learned about bridges. Return to the original question about bridge materials. Can paper make a good bridge? They might have said "yes" or "no" originally but now they have a qualified answer: it can if the design is right.

TIPS

- Depending on the students' interest in competition, you may find it motivating to track the "high score" for weights somewhere visible. As a student beats the old record for most weight supported, they get their new score on the board and other students can try to beat it.
- Students will find all sorts of excellent properties for paper but you can point them to a few key ones...
 - Paper is fairly weak when you press on its surface but strong when you press on the edge. This is why you get paper cuts and why folded paper like origami can be fairly strong (because the edges are multiplied). Laying paper flat won't hold up as much weight compared to paper rolled into tubes or folded into accordions.
 - Students can cut and tape their bridges but tape can be an easy failure point. Just as it's easier to pull apart pieces of paper taped together than it is to pull (not rip) a sheet of paper in two, the more that students cut and tape the more points of failure they are introducing to their design.
- This activity is amazingly scalable. After students are comfortable with this challenge, you can extend it by having them try a wider (10") gap. Introduce the idea of pillars underneath to get them to try that design or suspension designs for folded paper arcing over the bridge.
- A way to help students who are struggling or feeling defeated is to demonstrate something simple for them. Fold a paper accordion and toy with it as you talk to them about their design. They might notice and be inspired to try it themselves. If not, you can bring it up during a discussion break to let all the students see this new design idea.