LESSON 12: PAPER TOWERS

SUPPLIES

MAIN BIN
- Masking Tape (5)

HANDOUTS FOLDER
- Paper - (125)

PENCIL BOX
- Brass fasteners (60)

OBJECTIVES

- [x] Create a tower out of paper that can hold the weight of a the iSTEAM pencil box.
- [x] Understand tension, compression, and strong shapes.

HOOK

2-3 min

- Ask students to name towers they are familiar with. Ideas include: Eiffel tower, Space Needle, water towers, Leaning Tower of Pisa, Big Ben.
- Ask students to identify common features of towers. (Tall, narrow, etc.)

INTRODUCTION

3-5 min

Today, we're going to build towers made out of paper! Here's the catch--even though they are made of a flimsy material, our towers will be strong enough to hold the weight of the pencil box!

But before we start construction, let's talk about how real buildings stay strong and don't fall down. Engineers have to think about **compression**, **tension**, and **strong shapes** when they build tall buildings. **Compression** is when something is being pushed together. **Tension is** when something is being pulled. And triangles are a super **strong shape** because they don't change easily when they are pushed and pulled!

So as you build your paper tower, think like an engineer and use compression, tension, and triangles to make it as tall and strong as possible!

NOTE FOR TEACHERS

Many of these concepts are the same as Lesson 2, Building Bridges. If you have already taught that lesson, you can spend less time on the demonstration and discussion sections, or take the opportunity to cover more advanced material than you did before.

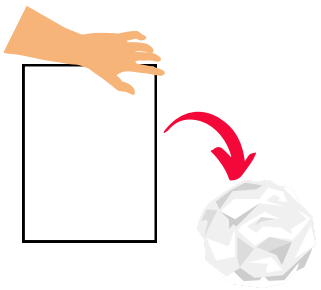
TIP:
Ask your students to explain tension and compression to you to see what you should revisit.

PAPER TOWERS

DEMONSTRATION

1-2 min

- Place a piece of paper standing straight up on a desk. Ask the kids to think about what would happen if you pressed straight down on it.
  - Demonstrate that if the paper could stand on the narrow edge, it would crumple and bend under the weight of your hand.
- Now, take a new piece of paper, and roll it into a tube (use tape if necessary). Ask them the same question: if you pressed straight down on the cylinder, would the paper crumple?
  - Press down on the tube slowly, and show them that is can support a lot more weight than the paper on its own (of course, if you apply a lot of pressure, it will eventually crumple).



DISCUSSION

5 min

There are many ways we can make our paper tower as stable as possible. Here are several design concepts that we should be aware of while building!

Compression (or being pushed on) is one way to stablize a structure. When a beam is compressed, or pushed, the particles of the material become closer together and they become stronger.

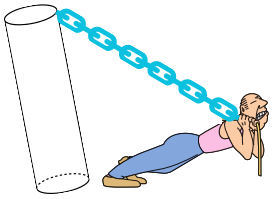
- This is exactly what happened with our paper cylinder. Pressing straight down on the cylinder made the tiny particles in the paper compress on top of one another and become stronger.

COMPRESSION

Now, imagine we placed an object, like the pencil box, on top of our cylinder. Ask the students what they think would happen. Maybe it could support the weight, but it would tip over easily. One way we could solve this problem is with tension.

Tension (or being pulled on) is another way to stabilize a structure.

- For example, we could use chains or ropes to hold our tower steady. Pulling on a rope makes it strong. Without tension applied with the rope being pulled tight, the tower remains loose and floppy.



TENSION

STRONG SHAPES

Strong Shapes are the last way we can build a stable structure. Strong shapes are created by combining beams (for example, connecting multiple paper cylinders with tape)

- When beams are combined into different shapes, they are stronger!
- Triangles are the strongest shape. That's why you see so many bridges, towers, and other structures made up of triangles. Triangles support top and side loads much better than a square or rectangle—all the weight can be supported from a single point on the top. Think about how you can use triangles when building your tower!

PAPER TOWERS

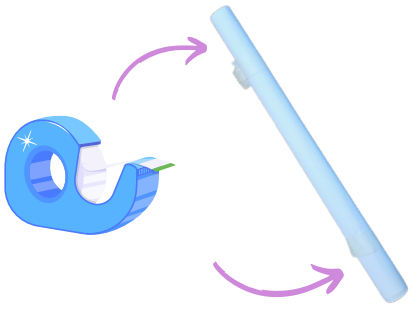
DESIGN & BUILD

25-30 min

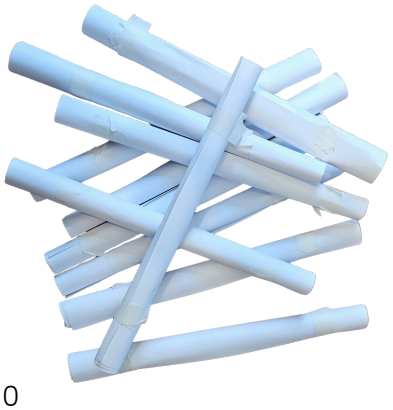
Now, students will use these three main concepts to design and build a tower. The tower must be able to support the weight of a pencil box for ten seconds. Remind the students to use what we've learned about compression, tension, and strong shapes.

1. Divide students into groups of three.

2. Pass out 30 pieces of paper, one roll of tape, and scissors to each group. You can also pass out pencils and a few extra sheets of paper for planning. Demonstarte how to roll a sheet of paper and tape at both ends so that it creates a tube. Let students know that they should plan to make lots of tubes!

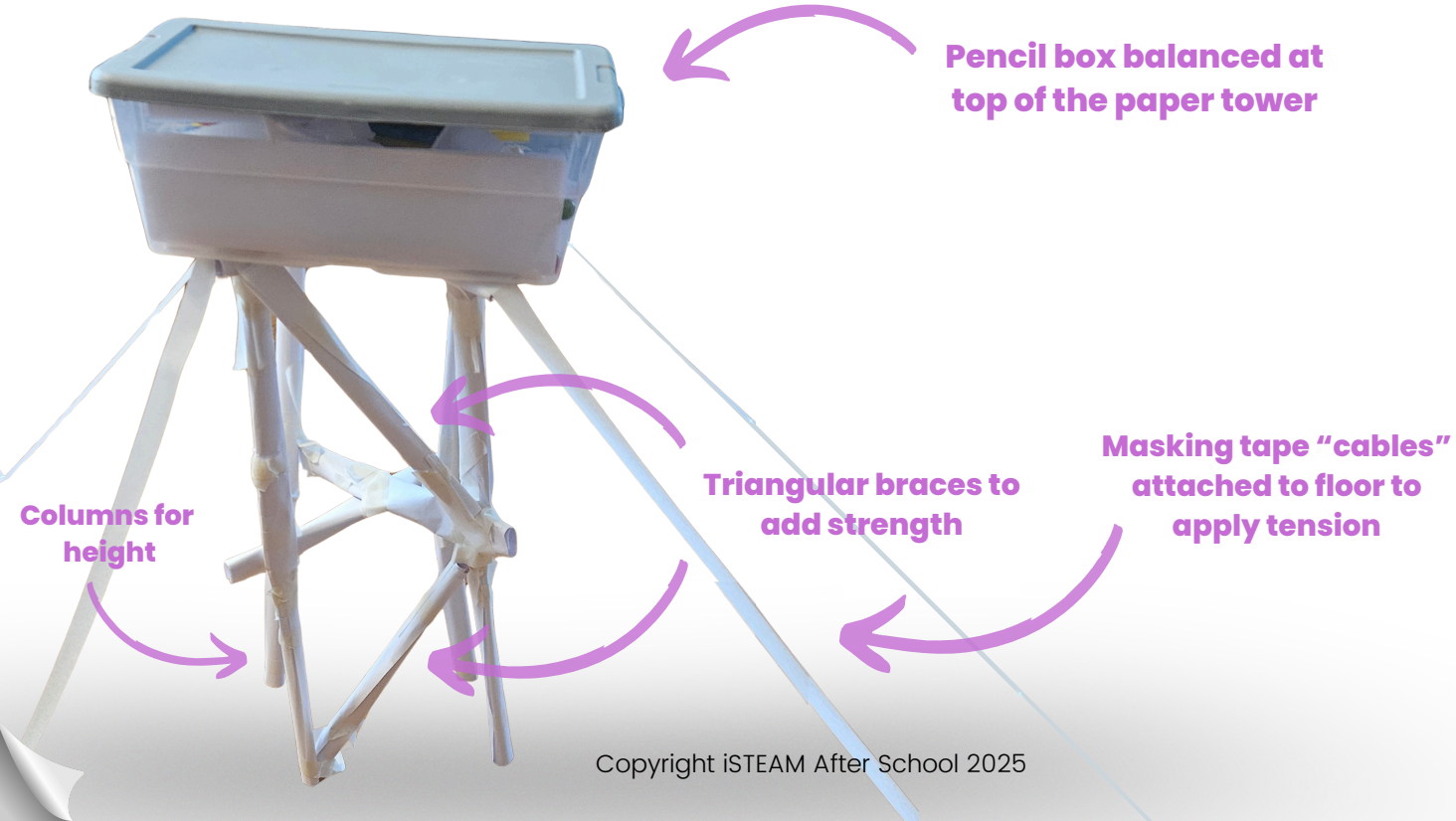


3. Give the students 15 minutes to design and build their structure, giving them regular reminders of the time. Allow students to use as much masking tape as they need, and encourage them to use masking tape to apply tension via "cables." See example.



4. At the end of the construction period, have all students place the pencil box on the top of their tower. Time it for 10 seconds. Any towers holding the box at the end of the 10 seconds have been successful!

5. Measure the towers to determine which tower was the tallest. Allow students 5-10 minutes to make their structure taller, then repeat the competition.



PAPER TOWERS

OBSERVE & EXPLAIN

5 min

As a class, discuss the following questions:

- What were key architecture elements that made the towers strong?
- Have students point to where their towers are under compression. Point to where it is in tension.
  - Have older students sketch their towers on scrap pieces of paper and label which parts are under tension and compression.
- Ask students if they needed to redesign their original builds. If so, why?

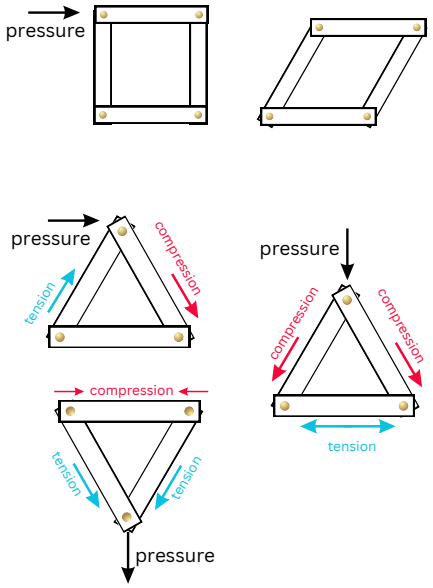
Explain to students that in order to stay standing and support the weight of the pencil box, the towers had to resist gravity. Some students may have created "trusses" that were in the shape of triangles, which helped distribute weight in the structure.

It was also important to create a strong base, giving the tower a center of gravity that was balanced. Additionally, if students overlapped rolls of rather than stacking them on top of each other in the same direction, the force was distributed more evenly and stability increased.

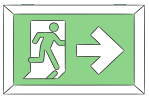
EXTENSION ACTIVITY

Using round brass fasteners and strips of paper, make two shapes: a square and a triangle.

When pressure is applied, see how the square gets bent out of shape, but the triangle stays the same. When pressure is applied to the triangle, compression and tension balance each other out.



Exit Ticket



Ask each student one of the following questions as they walk out the door.

- Q: What is the strongest shape?
  - A: Triangle
- Q: How are tension and compression used to make a tower?
  - A: Different materials become more stable under tension versus compression. Understanding the property of materials and placing it under the correct force strengthens the tower
- Q; Why was a strong base important?
  - A: To give the tower a strong center of gravity so that the weight of the pencil box didn't make the paper crumble!