

NEWSPAPER TOWERS

Lesson Type: Engineering / Construction/ Challenge

Target: Elementary or High School

Author: Robert Chen

Semester: Spring 2013

Updated: April 15, 2013



Challenge:

- Build the tallest self-standing tower out of newspaper.
- Can be taped to a surface at its base, but can not be supported along its sides or top.

Teaching Points

- Triangles are strong
- The 5-Step Design Process
- Trial and error construction
- Teamwork

Agenda

Introduction (10 min)

- Introduce what they'll be building.
- Discuss what shapes are the strongest.
- Demo with cardboard triangle, square, and square with crossbeam.
- Show pleated paper demo.
- Show examples of triangles.
- Discuss the 5 Step Engineering Design Process.
- Break into groups of 3-4.
- Give mentees paper to sketch out their ideas *before* giving them materials.

Build (40 min)

- Distribute materials to every group. Start with 1 foot of masking tape (make this the limiting component to force creativity) and 4-10 newspapers.
- Assist mentors with their construction. Focus on making sure that they know to constantly improve their structures based on the immediate feedback they get.
- Make sure

Recap (5 min)

- Compare the towers that were built between the various teams and point out things that made really good ones.
- Positively reinforce them if they use triangles.
- End with the point that triangles are strong.

Materials

Per group of students

- Paper and pen
- 1 foot of masking tape. Can increase to 3 feet if necessary
- 4-10 newspapers, your choice.

Only during DeCal, per site

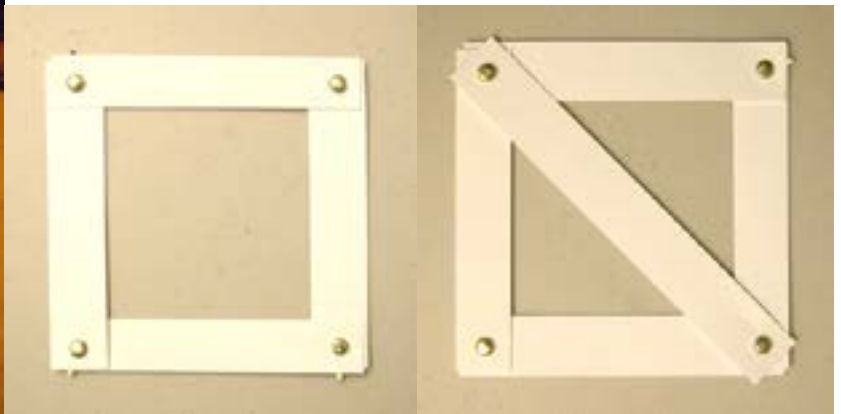
- 12 strips of cardboard, roughly 1"x8"
- 11 paper fasteners



Material to Teach

5-Step Design Process

- Ask what makes a good tower
- Imagine possible designs
- Plan your tower on paper.
- Create it out of newspaper.
- Improve it.
- Cyclical process, so never truly stops.



Cardboard Tringle Structures

- They are very strong, so try to include them in your design.
- In the DeCal, make the following three structures with strips of cardboards and paper fasteners.
- Give them to the mentees and have the mentees describe what they are: triangle, square, and square with brace. Emphasize that the square with brace is also two triangles.
- Have them try to distort the shapes (image below). They should find that of the three, only the square can be distorted.
- Ask them why the triangle can not be distorted while the square can.
 - A: Geometrically, the triangle's angles can't change without changing the lengths of the sides.



Pleated Paper

- Pleat paper (image below), and show that it can support a lot of weight because of how the weight gets distributed across all the triangles.



Examples of Triangles

- If you can print these out or have a laptop, show them to your students



Background for Mentors

Why Triangles are Strong

- Triangles have fewer degrees of freedom than many other shapes, so you have to account for fewer failure points
- Given sides of constant length, you can't change the angles of a triangle. A rectangle can be warped into a rhombus, but a triangle's joints need to break to alter the angle. Triangles are the only polygons with this property.
- When you put force on a triangle, the force goes into tensing or compressing **the material that makes up the sides** and the **strength of the pivot in the joints**. Those are easier to strengthen than the **angle of the joint**, which is the failure point of other shapes.

- For a (simple truss) structure to be stable, it must satisfy the equation:

$$K = 2J - R$$

M = number of members (beams)

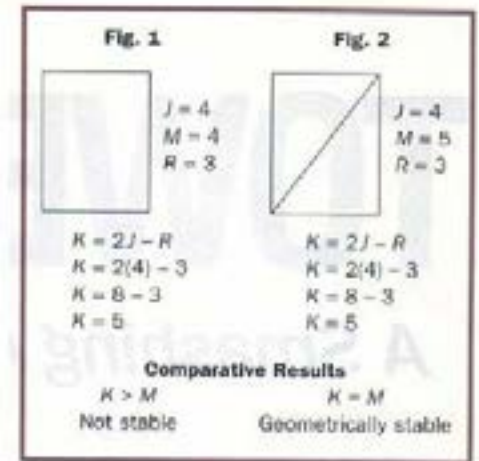
J = number of joints

R = 3, number of sides of triangle

If $K = M$, stable design

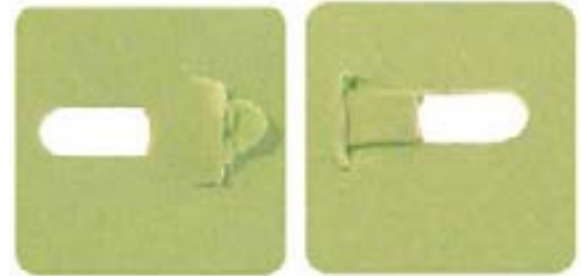
$K > M$, unstable design

$K < M$, indeterminate design



Hints/Tips for Building

- It is possible to build a tower without any tape (the one on the frontpage has none). Doing this requires making a “staple” by smart cutting of paper.
- First, cut a strip out. Then, Make a slot a little bit behind the strip. Feed the strip through the slot. It will look a little like a belt buckle.



Things to Try

- Build a tower to compete against your mentees.
- If your students are having trouble or find it too easy, you can adjust the amount of tape you give them.
- Build without any tape (see next page for an example)

References

- <http://www.mathsinthecity.com/sites/most-stable-shape-triangle>
- <http://www.rogersconnection.com/triangles>
- http://www.oocities.org/wvmsteched/TSAFiles/Events/engineering_structure_formulas.htm
- Similar lesson from Fall 2011: <https://docs.google.com/document/d/1WfUMmTtsld2c2jBUf1qxbufZUkiBIaJRyA321R4TVg/edit>

A tape-free example



Material	Amount Per Group	Expected \$\$	Vendor
Newspaper	Lots		
Masking tape	roll	\$20	ACE