

Marshmallow Toothpick Engineering Challenge

Essential Questions:

1. What is an engineer, and what do they do?
2. How do engineers build tall, freestanding structures that won't fall?

Essential Understandings:

1. An engineer is a person who designs and builds a machine or structure. To do that, they have to engage in the *design process*: they review information they already know, think of ideas and imagine solutions, plan something to try, build it and test it, and then think about ways to improve it.
2. Through planning and designing models, engineers test different building materials and types of structural forms to see which will best accomplish their goal.

Materials:

- 1-2 bags of mini marshmallows
- 1-2 boxes of toothpicks
- Paper and pencils
- Plastic sandwich bags (*optional*)

Note: This lesson calls for marshmallows and toothpicks, though you could substitute these building materials with other items (instead of marshmallows, use gumdrops or gummies, or packing peanuts, or possibly Play-Doh or clay; you could also use uncooked spaghetti noodles in lieu of toothpicks).

Before the Activity:

- Divide the class into groups of three to four students each.
- Parcel out 25 marshmallows and 30 toothpicks for each group. For convenience, it may be easiest to put these materials in plastic sandwich bags ahead of time so that you can quickly hand them out during the lesson.
- The remaining marshmallows and toothpicks will be used as practice building materials. You can lay these out on the student tables before or at the beginning of the lesson.
- It is recommended that you let the marshmallows you're going to use for this activity get a little stale, as allowing them to harden will make them a bit easier to build with. Do not let your students eat these! Instead, reserve some marshmallows as a "snack" to be enjoyed after the activity.

Activity Structure:

CHALLENGE: Build the tallest freestanding structure you can with 25 marshmallows and 30 toothpicks.

Step 1: Become familiar with the building materials.

- Have your students practice using the materials a little bit by building two-dimensional and then three-dimensional shapes. Not only will this help them become used to handling these materials, but it's a great way to reinforce their knowledge of basic geometric shapes and get a sense of which shapes will stand best on their own. They can even have a little fun before the challenge and make letters to write their names or build a little house.
- Once students have moved on to building three-dimensional shapes (e.g. tetrahedrons, cubes, triangular prisms, etc.), ask them which shapes they think will be the strongest or most stable when

they move on to build a tower. Have them test their theory by pressing down on the structures they've built.

Step 2: Think about what you know, and plan.

- Now that your students know some of the shapes they can make with the marshmallows and toothpicks, and now that they have an idea of how strong or stable some of those shapes are, have them begin planning their structures. In groups, have them sketch a plan on their sheet of paper. Before they begin planning, outline the following rules for them (you may want to write them on the board):
 - You have 25 marshmallows and 30 toothpicks to use. You do not need to use all of them, but if any materials are broken (or eaten!), they will not be replaced.
 - You may not use tape, glue, or anything else to assist in the support of your structure.
 - *(At the discretion of the educator, you may give a time limit to plan and/or build. A 5-10 limit for planning and then just as long for building should be sufficient. Be clear in communicating these limits, both at the beginning and throughout the build time.)*

Step 3: Build it!

- Allow your students to begin constructing their designs. As they build, walk around the classroom and prompt them to consider what is working and what is not. For example, is part of their structure collapsing on one side? What can they do to support it? They may find that certain shapes work well, while others do not.
 - *This is the design process – You plan and design it, you build and test it, and then you redesign it as needed.*

Step 4: Assess and reflect on your design.

- After all of the materials have been used (or after time is up), measure each group's structure vertically from the table to the tip.
- Once your class has determined (and celebrated!) the group that built the tallest freestanding tower, reflect and talk about what happened. Some possible discussion questions:
 - Which approaches worked and which did not, and why?
 - How was the winning group's structure different?
 - What strategies did each group use, and did you change strategies or your design during the building process?
 - How would you build your tower differently next time?

Activity Extensions:

- Have your students try the challenge again and see if they can beat the class record (or challenge another class to build a taller one!).
- Could your students' structures survive a high gust windstorm or hurricane? An earthquake? Simulate these real-life disasters by using a fan with adjustable speeds or by shaking the table. If they collapsed, how would they redesign their structures so that they could withstand these conditions?
- Using these same materials, could your students build a strong structure that could hold something (i.e. a deck of cards, or a book)? How would their design change for this purpose?

Resources:

- "Building Big: Skyscrapers" (PBS). <https://www.pbs.org/wgbh/buildingbig/skyscraper/index.html>. An online companion to the television series, with some great information and fun challenges!
- "Strong Structures with Triangles | Design Squad" (Design Squad Global). <https://www.youtube.com/watch?v=mBHJtWbsiaA>. Check out this video on why certain shapes are stronger than others when it comes to engineering!