**The Marshmallow Challenge (STEM Education)**

**Introduction**

The Marshmallow Challenge is an engineering challenge that can be used in any content area or situation. In this challenge students will work in groups of four to collaborate and build the tallest free standing tower out of 30 strands of uncooked spaghetti, a meter of string, arms length of tape, and a marshmallow that must be mounted on the top of the structure. Students have 20 minutes to finish this challenge. In this lesson students will use the Engineering Design Process to ask, imagine, plan, create, and improve their design. This lesson can be used as a get-to-know you activity, collaborative team building, engineering lesson, or lesson with Math connections. Students are assessed on how successfully they complete the challenge.

***Important Note: Please check allergies before doing this challenge.***

**Learning Outcomes**

* Students will collaborate in groups of 4 to complete an engineering challenge.
* Students will follow the steps in the Engineering Design Process so that they can identify constraints to the challenge, brainstorm ideas, and diagram their marshmallow tower.
* Students will, in writing, clearly articulate their plan and process results so that they can reflect on their group’s procedures in order to make improvements to their design.

**Curriculum Alignment**

1. RST. 6-8.3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
2. RST.6-8.7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g. In a flowchart, diagram, model, graph, or table)
3. WHST.6-8.1.c Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.
4. WHST.6-8.1.e Provide concluding statement or section that follows from and supports the argument presented.
5. WHST.6-8.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

**Classroom Time Required**

This lesson was designed for two 90 minute periods; however, it can be taught in smaller segments. The pace will be determined by how you divided parts 1 & 2. Suggested time limits are included in Day 1 and can be used again or modified for Day 2.

**Materials Needed**

* Classroom setup: Desks need to be arranged to accommodate groups of 4 students.
* Documents Needed:
  + Classroom set the North Carolina State University Elementary Engineering Design Process, (to be pasted/taped in their journals)
  + Glue/tape
  + Marshmallow Challenge Document,
  + Engineering (STEM) journal or another interactive journal,
  + A personal model of a finished STEM notebook to show the students. (at a minimum you should model on a piece of paper.)
* Document camera (recommended)
* Challenge Materials: (Remember this challenge will be done twice. Make sure you have double this amount.)
  + 20 pieces of spaghetti
  + 1 arm’s length of masking tape
  + 1 meter of string
  + 1 large marshmallow
* Marshmallow Challenge Rubric

**Technology Resources**

Technology use is highly recommend, but not necessary. If a teacher uses a class blog or www.edmodo.com it is recommend to have students share their finished challenge and reflections on one of these platforms. This can be accomplished by posting their pictures and/or writing their reflections on one of the above platforms.

**Pre-activities**

Introduce the challenge with a scenario: “A local engineering company has contacted me with a request. They want us to brainstorm the most efficient and effective way to build a tower. I told them this was a smart group and we could do whatever they asked. So, they hired us to complete their engineering challenge.”

Here are the directions they sent us. “You will have 20 minutes to build the tallest free-standing tower with a marshmallow on top. You may not touch the tower after 20 minutes, and it cannot be taped to the table or floor. The marshmallow can have pasta pieces stuck into it. So you will be given 20 pieces of spaghetti, arm’s length of masking tape, 1 meter of string, and 1 large marshmallow.”

*The test process*: The height of the tower will be measured in inches from the surface it is resting on to the highest point on the tower. If it falls, it will be measured to the highest point after falling.

**Activities**

**Day 1/Part 1**

1. Teacher will pass out the Engineering Design Process and the Marshmallow Challenge worksheet.
2. Teacher will explain the Engineering Design Process, its steps, and the possibility of repeating the steps more than once.
3. Teacher will ask students to write the title “Marshmallow Challenge” at the top of their journal. Use the document camera and model what this looks like in your own journal.
4. Teacher will have students write the first steps (ask, imagine, and plan) in their journal leaving significant space for data collection. Again, use the document camera and model what this looks like in your own journal.
5. Student will complete the above tasks. (5 minutes)

Assuming this is the first time teachers have used the Engineering Process/Journal you will give students time to address each of the steps in the process so that they understand the expectations.

1. Teacher will restate the test process. Use the Marshmallow Challenge worksheet as a reference.
2. Teacher will explain to the students the step “ASK.” Pose the question: “How does the test process affect your design? What makes this activity challenging. Explain to students that in their group of 4 they will come up with a list of problems or constraints to this challenge. Give them 5-7 minutes to make their list in their notebook.
3. In groups of 4, student will make a list of constraints or problems for the challenge.
4. Teacher will explain the next step “IMAGINE.” Ask the groups what ideas do you have for reaching your goal? Have students make a list of all the possible ideas they have for designing their tower. When they are done brainstorming have them choose the best one. (20 minutes)
5. In groups, student will brainstorm and list all the groups’ ideas under “IMAGINE” in their notebooks. Last they will circle or mark their best idea.
6. Teacher will explain “PLAN.” Here students will draw a diagram of their best idea, designate roles for each engineer, and decide on a tentative plan to finish on time. (10 minutes)

It is also important to show students the expectations for the diagram. Model the following steps in your own journal and show the class.

* Student goal is to make them accurate, large, and detailed
* Label all parts
* Add explanations of what your illustrations or diagrams are showing

*Note: teachers can provide graphic organizers initially with plans to move to student generated ones.*

1. Student will complete “PLAN” in their journals.
2. Teacher will pass out challenge materials reminding students not to start until you call time.
3. Student will begin building when teacher calls time.
4. Teacher will walk around the room and engage students in questions about their designs.
5. Teacher will call time at 20 minutes and be ready to walk around and measure all the towers. You can write the measurements on the board so everyone can see their heights. (15 minutes)
6. Teacher will tell students they need to reflect using their journals. Under “CREATE” they will write a paragraph that describes if things went as planned, was their design successful why or why not, and how tall was their tower. Encourage students to write as much detail about their process as possible.
7. Student will individually write a paragraph answering the above questions. (5 minutes)

**Day 2/Part 2**

A key to the Engineering Process is for students to learn the importance of improving. Part 2 of this lesson is giving groups a chance to redesign due to either a failed attempt or to improve the height of a successful tower.

1. Teacher will explain the importance of improving a design and explain that today they will be given an opportunity to improve their tower.
2. Teacher will prompt students to turn to a new page in their journal and continue with the heading “Marshmallow Challenge.” Next, have students write the subheadings “IMAGINE” and “CREATE”.
3. Teacher will explain to students that they will repeat “IMAGINE” and “PLAN” using the same format as previously used. This time the teacher can give students a combined 20 minutes to complete both sections. When they are done you will give them the same challenge to complete again.
4. In groups, student will complete “IMAGINE” and “PLAN” in their journals.
5. Teacher will pass out challenge materials reminding students not to start until you call time.
6. Student will begin building when teacher calls time.
7. Teacher will walk around the room and engage students in questions about their redesigns.
8. Teacher will call time at 20 minutes and be ready to walk around and measure all the towers. You can write the measurements on the board so everyone can see their heights.
9. Teacher will tell students they need to reflect using their journals. Under “CREATE” they will write a paragraph that describes if things went as planned, how their redesign was different, was their redesign successful why or why not, and how tall was their tower. Encourage students to write as much detail about their process as possible.
10. Student will individually write a paragraph answering the above questions.

*Possible Whole Group Discussion Questions:*

1. *Distinguish between the different bases used in each tower. What base allowed for the tallest structure?*
2. *If we used a bigger marshmallow or thinner spaghetti would the success rate change? How would the design have to change?*
3. *Take a few minutes with your group and discuss and develop a logical argument for using a square base or triangular base.*
4. *Web search “world’s tallest buildings” and investigate their base types.*

**Assessment**

* Use the Marshmallow Challenge Rubric

**Critical Vocabulary**

It is important that students understand the Engineering Process and its 5 steps:

1. Ask
   1. What is the problem?
   2. What are the constraints?
2. Imagine
   1. Brainstorm ideas
   2. Choose the best one
3. Plan
   1. Draw a diagram
   2. Gather needed materials
4. Create
   1. Follow the plan
   2. Test it out!
5. Improve
   1. Discuss what can work better
   2. Repeat steps 1-5 to make changes

**Websites**

* North Carolina State University Engineering Place: <http://www.engr.ncsu.edu/theengineeringplace/> NC State University’s K–20 education and resource headquarters for exploring engineering. Through hands-on summer camps, in-school mentoring, dynamic volunteer programs, topical workshops and much more, the Engineering Place builds excitement around engineering for students and teachers.
* The Marshmallow Challenge:<http://marshmallowchallenge.com/Welcome.html>

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**Marshmallow Challenge**

**Objective: To build the tallest tower possible out of uncooked spaghetti noodles that can hold a large marshmallow on top.**

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**Activity Details: You will have 20 minutes to build the tallest free-standing tower with a marshmallow on top. You may not touch the tower after 20 minutes, and it cannot be taped to the table or floor. The marshmallow can have pasta pieces stuck into it.**

**Test Process: The height of the tower will be measured in inches from the surface it is resting on to the highest point on the tower. If it falls, it will be measured to the highest point after falling.**

**ENGINEERING DESIGN CYCLE**

**ASK:** How does the test process affect your design? What makes this activity challenging?

**IMAGINE:** What ideas do you have for reaching your goal? What is your best idea?

**PLAN:** Draw a diagram of your design below. What are the roles of everyone in your group? What is your plan for finishing in the time allotted?

**CREATE:** Carry out your plan and test your design. Did everything go exactly as planned? Was your design successful? Why or why not? How tall was your tower?

**IMPROVE:** What was good about your design? What would you do differently if you did this activity again?