Teacher's Guide: Space Needle Renovation Activities

This lesson can be used before youth take a field trip to the Space Needle, and as a follow-up afterwards. During the hands-on activity, youth will act as structural engineers as they create a tower out of spaghetti that holds a predetermined amount of weight. They will be introduced to structural engineering, along with balanced and unbalanced forces. They'll also learn some fun facts about the Space Needle, and read the profile of an architect working on the project.

Grade Level	Grades 3 - 8
Activity Time	45 minutes before the field trip; 15-20 minutes afterwards
Preparation Time	10 minutes to collect materials and prepare the room (see Advance Preparation)

Objective

As a result of this activity, youth will be able to:

- Learn about the Space Needle and the renovation project
- Describe what structural engineers do
- Define balanced and unbalanced forces
- Work within a problem's criteria and constraints to design a solution.

Materials

Per Individual

- Space Needle Facts handout

Per Pair:

- 60 sticks of spaghetti, divided in half
- 2 two-foot long pieces of masking tape
- A marshmallow

Per Class:

- A yard stick or measuring tape
- A rope
- 3 feet of masking tape *(see Advance Preparation)* Advance Preparation

Advance Preparation

Gather the materials you will need for the activity. Make sure there is place in the classroom (or outside) for a game of tug-of-war, and place a piece of tape on the floor or ground to mark the line that teams will try to cross.

Connections to NGSS

This activity connects to the following *Next Generation Science Standards* performance expectations:

- ***3-5-ETS1-1***. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

- ***3-5-ETS1-2***. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- ***3-5-ETS1-3***. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
- ***3-PS2-1***. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.
- ***MS-ETS1-1.*** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- ***MS-ETS1-2***. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Before the Field Trip

Introduction (15 minutes)

1. **Talk about the Space Needle and discuss structural engineering.** Explain to youth that they will soon get to visit the Space Needle, which is undergoing a *renovation*—a design and construction process where parts of the building are changed and updated. Ask youth:
   - Have you ever been to the Space Needle?
   - What do you know about the Space Needle?

   Explain that some of the many people working on the Space Needle project are *structural engineers*. Ask:
   - Have you heard the term engineer before? If so, what do you think engineers do?
   - What do you think structural engineers might do?

   Possible answers: Engineers design, build and test materials, structures, and systems (like traffic systems). Structural engineers work on buildings, bridges, and other types of structures.

   Tell youth that during this activity, they will act as structural engineers. They will need to use their design and engineering skills to design, build, and test a tall structure.

2. **Have youth learn about balanced and unbalanced forces by playing tug of war**. Mark a line on the floor with a piece of tape. of six. Ask for six volunteers, divide them into two teams of three, and have them play tug of war with the rope until one side pulls the other side over the line. After they play, ask the group:
   - Which team was stronger? How do you know they were stronger?

   Possible answers: The team that won was stronger, because they were able to pull the other team over the line.

   - What do you think a force is? What forces were at work during the game?

   Explain to the group that a *force* is a push or a pull on an object. During the game, the forces at work were the pulling on the two sides on the rope.
   - Were the forces in the game *balanced* or *unbalanced*?

Possible answers: The forces were ultimately *unbalanced* because one side was stronger, exerted more force, and pulled the other side over the line (causing motion to occur).

- If the force were *balanced* (the same on both sides), who would win the game?

Possible answers: No team would win; if the force between both teams was balanced, both teams would be equally strong, and no motion would happen (both sides would stay on their own side of the line).

Tip: Stress to youth that when forces acting on an object are in balance, no movement occurs; if the forces acting on the object are unbalanced, movement occurs.

Hands-on Activity (25 minutes)

1. **Describe the challenge and give criteria and constraints**. Hold up the marshmallow. Tell youth to imagine the marshmallow as the top of the Space Needle. Explain that they will be *structural engineers* who must design and build the tallest tower that is *stable* enough (solid and not moving) to support the weight of the marshmallow.

   Explain that engineers often have to work with *criteria* and *constraints* when designing products. *Criteria* are design requirements, and *constraints* are design limits (like limits on cost or materials). For this challenge, they will work with the following criteria and constraints:

   Criteria:
   - The tower must be as tall as possible
   - The tower must hold the weight of the marshmallow without falling over

   Constraints:
   - Teams can only use 30 pieces of spaghetti and 2 feet of tape
   - Teams have to work within the time limits you set for design and building.
   - The marshmallow can't be attached to the tower (with tape or by spearing it on a piece of spaghetti)

2. **Brainstorm and sketch.** Divide the group into teams of two or three. Have each team spend five minutes brainstorming possible designs for their tower and then sketch the structure they'd like to build.

3. **Have teams build their towers.** Give each team 30 pieces of spaghetti and a two-foot piece of tape, and give them 10 minutes to build.

4. **Conduct tests.** Once the time is up, have each team test its structure by placing a marshmallow on top. Measure the towers that remain standing to determine which is the tallest. As teams are testing and presenting their towers, ask:
   - Are the forces balanced or unbalanced in this structure when the marshmallow is placed on it? How do you know?
   - Where are the weak points in the structure?
   - How can you redesign your structure to make it more stable (less likely to fall over)?

5. **Optional: Have teams redesign and build new towers.** If time permits, ask teams to apply lessons learned from the testing phase as they redesign and build a new tower. Give them a new set of materials. Set a time limit for building.

6. **Retest structures.** Bring the group together to test the redesigned structures.

Reflection and Discussion (5 minutes)

Discuss structure designs and the Space Needle. Ask the group:

- What design worked the best for making a tall tower and still holding up the marshmallow?
- How did having a time limit affect your end product?
- What design constraints do you think that people designing the Space Needle had to consider?

Distribute the **Space Needle Facts** handout appropriate for your grade, and have youth read it (either during another class session or as homework) before the trip to the Space Needle. Tell youth that during the field trip, they should look at the structure of the Space Needle and think about what makes the structure stable.

After the Field Trip

After returning from the field trip, discuss what youth have learned by asking questions such as:

- What did you learn about the Space Needle during the trip? What is your favorite fact?
- What did you learn about the Space Needle's structure?
- Where did you see balanced or unbalanced forces at work?
- What different careers do the people working on the Space Needle renovation project have?
- Which of these careers are you the most interested in for yourself? Why?