Lesson Plan Title
Shake-Proof Science: Engineering Earthquake-Safe Structures*

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Scientific Theme(s):
Concepts of Physical Science: (2) Develop an understanding that energy appears in different forms, can be transformed from one form to another, can be transferred or moved from one place or system to another, may be unavailable for use, and is ultimately conserved; (4) Develop an understanding of motions, forces, their characteristics and relationships, and natural forces and their effects
Concepts of Earth Science: (2) Develop an understanding of the origins, ongoing processes, and forces that shape the structure, composition, and physical history of the Earth

Physical Science
*Properties of Matter
*Energy Transfer and Transformations
*Interactions between Matter and Energy
*Motion and Forces

Life Science
*Changes in Life Forms over Time
*Natural History and Biodiversity
*Ecological Interactions

Earth Science
*Geochemical Cycles
*Forces that Shape the Earth
*Seasonal Cycles
*Solar System and the Universe

Grade Level(s):
Grade 2 and up (with modification)

Lesson Duration:
Three, 1 hour lessons needed.

Overview
1.) To introduce students to earthquakes, how they are formed and where they occur
2.) To connect earthquake hazards with building vulnerability in a real-world context
3.) To introduce students to the realities of engineering, where materials and resources will be limited
4.) To introduce students to the Richter earthquake magnitude scale

Objectives
Measurable student outcomes:
1.) Students will work together in groups of 3 – 4 to sketch a design for a noodle-bamboo skewer-marshmallow building
2.) Students will construct a noodle-bamboo skewer-marshmallow building using their original sketch as a starting point, changing their design over the building process
3.) Students will be able to identify which shapes maintain the most flexibility while withstanding the greatest amount of load and vibration
4.) Students will be able to identify ways in which they can improve their original design
5.) Students will be able to identify how earthquake-proof structures influence causalities and damage during a real earthquake

**Grade Level Expectations (GLEs) Addressed**

**Grade 3 GLEs addressed:**

1.) Science as Inquiry and Process  
   a. SA1.1 Asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating

2.) Concepts of Physical Science  
   a. SB4.2 Recognizing that objects can be moved without being touched (e.g., using magnets, falling objects, static electricity)

3.) Science and Technology  
   a. SE1.1 Identifying local problems and discussing solutions
   b. SE2.1 Identifying local tools and materials used in everyday life
   c. SE3.1 Listing the positive and negative effects of a single technological development in the local community

4.) History and Nature of Science  
   a. SG4.1 Asking questions about the natural world

**Required Background**

This unit assumes little to no student background knowledge in seismology or plate tectonics. The first lesson serves as an introduction to what earthquakes are, where they form, and how they cause the Earth's surface to move.

**Vocabulary**

Earthquake  
Plate tectonics  
Plates  
Magnitude

**Materials**

Lesson one materials:  
Tectonic Plates puzzle or large print-out of tectonic plates map with the individual plates cut out.  
Red yarn and blue yarn  
Slinky  
Song "Shake, Rattle, and Roll" by Bill Haley and the Bill Haley Comets

Lesson two materials:  
1 – 2 packages of dry spaghetti noodles  
1 large bag of mini marshmallows  
Large freezer bags, one for each group  
1 package of wooden bamboo skewers  
Classroom set of rulers  
1 piece of cardboard per group, at least 1 ft. x 1 ft. in size

Lesson three materials:  
Homemade shake box (see references)  
Classroom set of safety goggles  
Small piece of scrap paper for each student

**Activity Preparation and Procedure**

**Lesson One: What are earthquakes?**

The main goal for this lesson is to introduce (or review for older students) plate tectonics using a tectonic plates puzzle and red and blue yarn to illustrate where the volcanoes and earthquakes occur on the Earth's surface.
Lesson One Preparation: Prepare a tectonic plates map by printing out a large (poster-size if possible) image of a plate tectonics map (see references for a recommended version). The puzzle will work best if the pieces are slightly sturdier than paper so it is recommended that the image is backed onto cardboard or poster board. Cut out the individual tectonic plates in order to make the puzzle pieces.

Lesson One Procedure:
- Begin by laying the map out on the ground. The puzzle can either be left in pieces where the students have to put it together or, for younger students, the pieces can already be put together. Ask the students what they think this is a map of in order to assess prior knowledge of plate tectonics (5 minutes)
- Ask the students if they know of any states or countries where we have a lot of earthquakes and volcanoes. Some possible answers may include: Alaska, California, Washington state, Hawaii, Japan, New Zealand, Chile, Haiti, etc. (5 minutes)
- As a way of summarizing all of the class answers, place red yarn where the volcanoes are located and blue yarn where the earthquakes are located. Ask the class if they notice any particular patterns in where the volcanoes and earthquakes are located: they are mostly located along the boundaries of tectonic plates! (10 minutes)
- Explain that the tectonic plates are different than the continents: multiple continents can be on just one tectonic plate! Ask how many continents there are? Then ask how many tectonic plates there are. Break up the tectonic plates puzzle and first have the kids try and count the puzzle pieces to answer how many plates there are. Then have them try and put the puzzle together (this may be done best by having smaller groups try to do this as an extension activity if there is time). (15 minutes)
- Introduce the idea that tectonic plates move and it is their movement that causes both volcanic eruptions and earthquakes. How do tectonic plates move? Teach the students the plate tectonics dance, taking two hands and pushing them towards each other for convergent boundaries, pushing them apart for divergent boundaries, and sliding next to each other for transform boundaries. Two small pieces of cloth or towel can be used to demonstrate this as well. It is fun to do this dance to an appropriately themed song such as “Shake, Rattle, and Roll” (15 minutes)
- How does the motion of the tectonic plates affect how the ground moves during an earthquake? Ask for a student volunteer and have him/her hold one end of a slinky. Use the slinky to show that earthquakes form waves that move through the Earth’s surface, causing us to move up and down or side to side during an earthquake. Tell the students to think about how this movement would affect buildings. (10 minutes)

Lesson Two: Building an earthquake-proof structure
The main goal for this lesson is to have the students work in groups to design and construct an earthquake-proof structure using marshmallows, dry spaghetti noodles, and (optional) bamboo skewers.

Lesson Two Preparation: Prepare a bag for each student group containing the following materials:
- 50 mini-marshmallows
- 50 dry spaghetti noodles
  Also, provide each group with a 1 ft. x 1 ft. piece of cardboard and a ruler.

Lesson Two Procedure:
- Review how the surface of the Earth moves during an earthquake. Have students use their arms to show these different motions. Have two student volunteers show how the Earth moves using a slinky in front of the class. (10 minutes)
- Announce to the class that today they will be constructing their own earthquake-proof structures and that each group’s building will be tested using a shaker box (if possible, bring the shake box into class to show the students what it is). Give the students the rules for the assignment. (5 minutes)
  1. Each group must use all of the marshmallows and dry spaghetti noodles that were provided in their materials bag.
  2. The earthquake-proof structures can be as tall or as short as wanted but they must be smaller than 1 ft. wide (in order to fit into the shake box).
  3. Each group may decide to use bamboo skewers for their structures, but the cost of the bamboo skewers is 1 skewer for 10 of their marshmallows. The group must elect a representative to “purchase” the skewers and the majority of group members must agree with the “purchase”.
  4. Each group would only get 45 minutes (or whatever amount of time is left after the lesson introduction) to build their earthquake-proof structures.
- Let the students start building, recommend that they first start off by sketching a building design. Rotate around the classroom in case there are any issues but allow the students to take the lead on figuring out a good design. (45 minutes)
Lesson Three: Earthquake! Testing out the building designs

The purpose of this lesson is to test out the student-designed earthquake-proof buildings using a shake box. An additional goal of the lesson is to introduce the students to the Richter magnitude scale by testing how each building fares in a Magnitude 3, Magnitude 6, and Magnitude 9 earthquake.

- Lesson Three Preparation: Prepare a shake box by modifying the instructions found here: http://www.mysciencebox.org/book/export/html/596. Instead of using a plywood box, it is possible to use a large cardboard box with a poster board platform and large elastic bands to attach the platform to the box. The large elastic bands can be stapled onto the box and platform to make construction easier. It may be beneficial to construct the shake box earlier in order to show the students what will be used to test their buildings before they begin building.
- Lesson Three Procedure:
  o Introduce the class to the Richter scale of earthquake magnitudes by telling them that, as the magnitude number gets larger, the shaking is greater. Have the students stand up and shake to show the relative motion of a Magnitude 1, 2, 3, etc. earthquake up to a Magnitude 9 (make sure the students spread out an arm’s length so they don’t crash into each other). (10 minutes)
  o Inform the students that their buildings will be tested in a Magnitude 3, Magnitude 6, and Magnitude 9 earthquake. Show them the relative strength of these earthquakes by shaking the shake box. (5 minutes)
  o Give each student a pair of safety goggles, just in case pieces of the building go flying. If possible, use the shake box outside in order to minimize the small noodle pieces that will need to be picked up inside the classroom.
  o Give each student a scrap of paper to write down one aspect of their building that they believe will help it survive the earthquakes. Before their group's building is tested, have each student read what they wrote. (5 minutes)
  o Test each group's building, seeing whether the building can survive through a Magnitude 3, 6, or 9 earthquake. Before beginning, tell the students what "surviving" the earthquake means, i.e. where most of the building is still standing, if a certain number of noodles are still standing, etc. Have the students give the shake box a 5 ft. radius for safety purposes. (35 minutes)
  o Ask the students which shapes were the strongest in their buildings. How would they make a cube stronger? What were the benefits of using the bamboo skewers? What were the benefits of using the dry spaghetti noodles and marshmallows? (5 minutes)

Assessment

The main way that this lesson is assessed is by using post shake box questions (Ask the students which shapes were the strongest in their buildings. How would they make a cube stronger? What were the benefits of using the bamboo skewers? What were the benefits of using the dry spaghetti noodles and marshmallows?) If time allows, after testing each building, the students can be given a piece of paper to sketch how they would improve their building design if we were to have another earthquake. Ask students what they think the most hazardous part of an earthquake is (poor building design leading to structural collapse).

Complementary Activities and Extension Ideas

There are a number of great online resources to use for pre-construction research. Depending on time, students can use these resources to get ideas for how they should build their earthquake-proof structures.

http://www.exploratorium.edu/faultline/damage/building.html


http://www.ck12.org/earth-science/Earthquake-Safe-Structures/#all

In terms of the building construction assignment, older students can have a height minimum imposed on their building designs, as shorter buildings will often outlast taller buildings during an earthquake. For instance, each group may have to construct their building so that it is at least 1 foot tall. For students who are very inspired by the engineering-design process, the project can be extended so that the students have the opportunity to use various material types in their building construction. If students have an interest in the design process, they could have longer to sketch their building and design a safety poster for earthquake-proof building construction. Finally, in order to better connect real-world to the classroom, students can research or observe how earthquake safe their own school building is.

References


