Curriculum Guided Investigation
Middle School Science

Core Science Curriculum Framework
Content Standard 7.3

http://www.exploratorium.edu/faultline/activezone/photos.html

Shake, *Rattle* & Roll

A guided exploration of earth movement

Teacher Manual

Connecticut Science Center
Sandra M. Justin, Ph. D.

Teacher Materials

Introduction to "Shake, Rattle *and Roll"*

An Exploration of the Effect of Earthquakes on Structures

This is a learning unit about the movement of energy through the Earth's crust. Each year more than 3 million earthquakes occur; many are too small to notice. The ground may move as a result of an erupting volcano, the collapse of a cavern, the tumbling of an underwater ridge or the impact of a meteor. Because earthquakes are among the most destructive of disasters, it is important to understand how and where earthquakes occur in order to protect and prevent the loss of lives and property.

In this performance task, students will explore the effect of earthquakes on structures. By simulating the movement of energy through the earth, with the use of a shake table, students will be able to design, create and test structures that are resistant to motion.

Curriculum Embedded Inquiry Investigation: "Shake, Rattle and Roll" can relate conceptually to the following:

Energy in the Earth's Systems – How do external and internal sources of energy affect the Earth's systems?

Safety:

- Marbles that fall on the ground can be a sliding hazard. Use caution when walking around the room.
- Elastic bands when released against skin can be painful and cause irritation. Avoid dangerous use of elastic bands.

Content Standards

7.3 Landforms are the result of the interaction of constructive and destructive forces over time.

C.1 Describe how folded and faulted rock layers provide evidence of the gradual up and down motion of the Earth's crust.

C.2 Explain how the boundaries of tectonic plates can be inferred from the location of earthquakes and volcanoes.

8.4 In the design of structures there is a need to consider factors such as function, materials, safety, cost and appearance.

Unpacked Content Standards

- Earth's surface is constantly being shaped and reshaped by natural processes. Some of these processes like earthquakes and volcanic eruptions produce dramatic and rapid change. Others, like weathering and erosion, usually work less conspicuously over longer periods of time.

- Earth's surface features, such as mountains, volcanoes and continents, are the constantly changing result of dynamic processes and forces at work inside the earth.

- Most volcanoes and earthquakes are located at tectonic plate boundaries where plates come together or move apart from each other. A geographic plot of the location of volcanoes and the centers of earthquakes allows us to locate tectonic plate boundaries.

Underlying Science Concepts

- Most earthquakes occur as a result of the buildup of strain at plate boundaries.
- The energy released in an earthquake travels in waves.
- A seismograph is used to determine the magnitude (strength) of an earthquake and the location of its epicenter.
- The amount of damage an earthquake causes depends on where it occurs and its magnitude.
- Safe building practices can limit the loss of life and property.

Key inquiry Skills

- Identify questions that can be answered through scientific investigation.
- Design and conduct appropriate types of scientific investigations to answer different questions.
- Use appropriate tools and techniques to make observations and gather data.
- Draw conclusions and identify sources of error.
- Provide explanations to investigated problems or questions.
- Communicate about science in different formats, using relevant science vocabulary, supporting evidence and clear logic.

Objectives: Students will

1. Explore different materials, shapes and design options that affect the durability of a building.

2. Understand how to use models to perform controlled, scientific explorations.

"Shake, Rattle & Roll."

<u>Per classroom:</u>
Shake table (At least one is needed, but more can be made available.) Directions as follows:

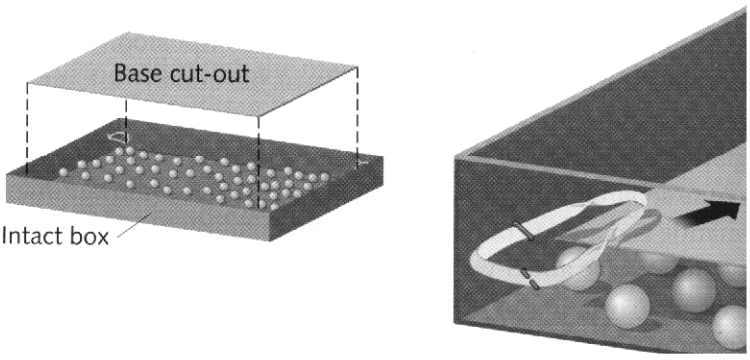
How to Build a Shake Table

Materials:
1 shallow box, about 10 cm tall and lid
4 elastic bands
10 -20 marbles
scissors, staples, string

1. Cut the lid so that it will fit into bottom of the box with a 2 cm clearance on all sides. This is the base of the Shake Table.

2. Staple an elastic band to each corner of the base.

3. Fill the box with marbles and place the base on the marbles.

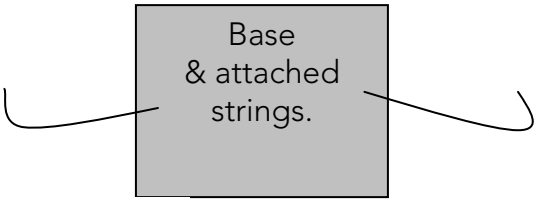


3. Cut small slits in the corners of the box at the height of the base.

4. Attach the free end of the elastic to a paper clip and slide it through the slits. Adjust the elastics for easy movement.

5. To simulate an earthquake, gently pull one side of the base and let go.

Optional: To simulate more rapid movement, attach strings to each side of the base at the middle, make small holes at the corresponding point in the sides of the box. To move the base, pull the strings through the holes and pull them back and forth.



For each lab group:
Building materials, such as straws, straight pins, sugar cubes, mini marshmallows, toothpicks, pipe cleaners and Popsicle sticks.
Cardboard or stock paper (for the making of roofs and for foundation support)
Modeling clay
Advance preparation for the teacher:
Make the shake table(s). Obtain construction materials.

ENGAGE

This is where you set the hook! Give the students something to observe or to think about, but no tools. Ask them to raise a question/make a statement about the object(s). Compare/contrast, use Venn diagrams and other graphic organizers. This is an anticipatory set to introduce them to the exercise and to set the context. This is an opportunity for a pretest. Listen carefully and note any misconceptions that might arise. Knowing the most common misconceptions, you might consider exposing the students to a demonstration to pique their interest and curiosity and most importantly, to get them to begin to confront their misconceptions

When you think of earthquakes, what comes to mind? What is an earthquake? Where and why do earthquakes occur? *Teacher notes: At this point you might expect to hear comments related to tsunamis, falling buildings, loss of life, fault lines, the movement of the earth, and other similar topics.*

Technology connections: There are some engaging simulations and videos on the Internet that would interest the students. These may be used at an introduction to the unit, as a way to present content or as an attention grabber.

Engage students with video clips from a website, such as the National Geographic website, listed below. Other appropriate web sites can be found at the end of the unit. The video clip information found at these sites are exciting and informative and would be a natural introduction to Shake, Rattle & Roll.
http://video.nationalgeographic.com/video/player/environment/environment-natural-disasters/earthquakes/earthquake-101.html

Student Misconceptions

Misconceptions and Facts about Formation of Landforms

Misconceptions	Facts
There are gaps between the tectonic plates.	The rigid outer layer of Earth is made up of plates that fit closely together. Each plate directly touches the plate next to it.
Mountains are created rapidly.	Plate movement is very slow; it can only be measured in centimeters per year. Mountain formation can occur as the plates slowly move.
Earthquakes occur only in certain places on the earth.	Earthquakes occur in many areas, although some areas are more susceptible.
Someday, during an earthquake, California will break off from the continent, fall into the ocean or become an island.	The plates that meet at the San Andreas Fault System exhibit horizontal motion. In effect, Los Angeles is moving north at a rate of 46 millimeters a year.
If an area has not has an earthquake for some time, it means that a large earthquake will soon happen.	An increase or decrease in activity does not predict an earthquake. There is natural variation in seismic activity and there is no way to know when an earthquake will happen.
The ground can open up during an earthquake.	During an earthquake, movement occurs along the plane of the fault. The edges of the fault slide up or down, they cannot spread apart.

EXPLORE

Teacher note: *To allow for a fair test, the teacher should determine the magnitude (strength) and length of time of the 'earthquake' on the shake table. This information should be shared with the students. For example, the teacher states that the earthquake will last 5 seconds and consist of 15 back and forth shakes of the table.*

Investigation #1 allows the students to start thinking about and working with building structures and the use of materials. As the students manipulate the sugar cubes, they will learn that the structures they create are fragile. You may or may not introduce the shake table at this time.

Investigation #1 - Guided exploration

Materials:

20 sugar cubes
Paper & cardboard
Scissors

You have the job of building a structure out of bricks. You may only use 20 bricks and your structure must have a roof. Use a cardboard base as a foundation.

- What would you structure look like?
- How big would it be?
- How sturdy is your structure?

1. Plan the shape of your structure.
2. Build your structure
3. Did you have any problems? How were they solved?
4. Would your structure survive an earthquake?
5. What do you notice or wonder about as you build your structure? Write your noticing and wonderings in your notebook.

Teacher note: *Investigation #2 is a challenge. The students have a choice of building materials. It is up to them to create the design to meet the challenge.*

Investigation #2 -Challenge

Materials:

Sugar cubes, toothpicks, stirrers, mini marshmallows,
plastic or paper straws, straight pins, pipe cleaners, Popsicle sticks,
clay to be used as a base, cardboard, construction paper, scissors, rulers,
tape *Students may also bring in pre approved materials from home.*

In this activity, you will **design, build and test** a structure for stability during an earthquake. Your structure must be at least 30 cm tall, have a roof and not collapse on the shake table. You may use any of the materials on the table to build your structure. All completed structures will be tested on the shake table under the same conditions.

Purpose: In small groups, you will **investigate variables** such as the shape and size of the building, stability, and building materials. Don't forget that buildings are designed to be attractive and functional. As you design your structure, keep an OWL chart.

Observations What you notice	Wonderings Questions or ideas you have	Learning What you have learned

Procedure:
1. Using paper and pencil, **design** a structure that is at least 30 cm tall.
2. **Check** the design with you teacher.
3. **Build** your model.
4. **Test** your model on the shake table. You may use tape to secure your base to the shake table.
5. **Observe** the designs of your classmates as they are tested. Which designs were more stable? **Draw** the designs and make notes about the designs in your notebook.
6. Did you make any **changes** to your original design? Why or why not?
7. Write **questions** that you would like to investigate based on your **observations** and **wonderings.**

Thinking tool: *Note for the teacher: A thinking tool is a demonstration, probing question, or comment that focuses student thinking.*
Cut a 30 cm piece of foil wrap from a roll. Lay it on the table. With your hands firmly placed on the edges, slowly bring your hands together. As the foil buckles, it models the folding of the earth as two plates slowly come together. Ask the students to identify mountains, valleys and other geologic features as they appear on the crumpled foil.

Teacher note: *Share with the class any additional materials that will be available for their use; this may add to the number and type of questions. Collect and post the student generated questions. You might read through the questions and post them according to content or concept area. When the questions are posted, you could discuss the questions with the students. Some questions might not be investigable at this time, others might need clarification and some might inspire new questions. The students are now ready for a 'gallery walk.'*

A gallery walk allows the students to walk by and read all the posted questions. You may chose to allow pre-formed groups to select a question. Students can also form groups based on interest. Once a student has selected a question, he/she can stand by the question and wait for others who are interested in the same question. This grouping technique discourages groups based on friendship alone.

Examples of student generated questions. *What type of foundation or base of the structure is more stable? What shape of building is more stable? How tall can we build a stable structure? How do bridges react to a shake table?*

ELABORATE & EXPLAIN

Taking your investigation further.

You have been exploring structures and building materials. You have tested your ideas and observed the plans and ideas of other students. You are now ready to explore and do research on your ideas. Feel free to investigate variables such as the shape of a building, construction materials, foundation support or the type of substrate a structure is built upon.

Take time to think about and to write what you have learned. Use your science notebook to write about your experiences and new learnings.

Teacher note: *This is a good place for students to engage in writing and research. The students now have some experience in manipulating building materials. This new knowledge should be written in their science notebooks. It can also be used as a writing prompt. Research, via the internet or text, into earthquakes and building construction can also happen at this point.*

Investigation #3 - Inquiry

In this investigation, you will choose a question to explore based on your interest. Feel free to use your imagination. Once you have decided upon a question and discussed it with your teacher, you will be ready to design your own investigation.

As you plan, keep these questions in mind.

- How will you build your structure? What materials will you use?
- How will you identify the variables? What is your control?
- How will you test your structure(s)? How will you judge success?
- How will you present your findings? Diagram? Chart? Graph? Demonstration?
- On what will you base your conclusion of a successful design?

1. Choose a **question for investigation.**
2. Using the materials at hand, **design** a structure that can withstand 'an earthquake.'
   Give reasons why you chose certain materials and how you decided upon the design. This should be part of your explanation to the teacher.
3. Show your design to the teacher before you start construction. You will be expected to **share your design, reasoning and results with the class.**
4. **Build** your structure.
5. **Test** your structure and complete your investigation.
6. **Plan** your presentation.
7. **Communicate** your findings.
   - What were your results?
   - What did you learn?
   - What would you do differently next time?

Teacher note: As you go from group to group, you should make a note of the science concepts that are discussed or demonstrated. This is when you might identify and correct misconceptions. During the presentations, encourage questioning and clarification from the students Add any new learnings

that are expressed to your list. While the students are present, you may chart the concepts and scientific content. This important next step is the ***synthesis****. The teacher summarizes the evidence presented and ties the concepts together. The student's work is validated and the learning is reinforced.*

Extensions or Variations

- Students might enjoy constructing their own shake table.
- Other materials can be used as a base, such as gelatin, pudding and foam.
- Some students might wish to build a bridge that is earthquake resistant.
- Interested students might explore the 'Ring of Fire,' the zone of volcanic activity that rings the Pacific Ocean.
- The study of plate tectonics can be a unit of study for motivated students.
- Earthquake tremors occur frequently in New England. A study of local earthquakes is an appropriate extension.
- Encourage the use of mathematics to present data - height, mass, elevation, etc.

EVALUATE

Performance Assessment

Teacher note: *This task may be used in a variety of ways. It can be a performance task, an end of unit assessment, or a research project.*

Your company has been hired by the City of San Francisco to build the new town hall on Alcatraz Island. Your job is to design an attractive structure that is earthquake resistant on Alcatraz Island. Use what you have learned about earthquakes, building materials and structures to prepare a presentation to the town council in support or rejection of your design.

Simulations, demonstrations and teacher information

There are numerous sites on the web that offer "up to the minute" earthquake information.

Lesson plans and tools for educators.
http://school.discoveryeducation.com/lessonplans/programs/earthquakes/

A well organized site offering video, audio and dramatic photos of earthquakes.
http://www.nationalgeographic.com/xpeditions/lessons/07/g912/fonquakes.html

U.S. Geological Survey Earthquake Survey Hazards program - Offers all types of information. There is a site for students and teachers. Shows recent earthquake information for New England.
http://earthquake.usgs.gov/

World Wide Earthquake Locator - offers up to the minute earthquake information.
http://tsunami.geo.ed.ac.uk/local-bin/quakes/mapscript/home.pl

A good, teacher friendly website with examples of activities and assessments.
http://quake.ualr.edu/schools/quakelsn.pdf

USGS site with activities and information for students
http://earthquake.usgs.gov/learning/kids/

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Write your thoughts in your science notebook.

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    11. What were your results?
    12. What did you learn?
    13. What would you do differently next time?

EVALUATE

Applying your findings: Expected Performance

Your company has been hired by the City of San Francisco to build the new town hall on Alcatraz Island. Your job is to find a location on Alcatraz Island suitable for a town hall and to design an appropriate building. Use what you have learned about earthquakes, building materials and structures to prepare a presentation to the town council in support of your location and design.