Whole Lot of Shakin' Goin' On

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Arkansas Frameworks:
http://arkedu.state.ar.us/curriculum/benchmarks.html#Science

Next Generation Science Standards: (insert after NGSS is released)

Essential Questions:
Is it possible to determine seismic risk of various locations on the earth?
Has increased population changed earthquake risk?
What measures can be taken to reduce earthquake risk?

Science/Engineering Practices:

1. Asking questions and defining problems
2. Developing and using models
4. Analyzing and interpreting data
6. Constructing explanations and designing solutions
7. Engaging in Argument from evidence
8. Obtaining, evaluating, and communicating information

Disciplinary Core Ideas:
ESS3.B, ETS1-A, ETS2-C, ETS2

Cross-cutting Concepts:

A. Patterns
B. Cause and effect. mechanism and explanation
D. Systems and system models
F. Structure and function
G. Stability and change

Grade Level End-point (From K-12 Framework):
Earth Science ESS3:B
By the end of Grade 5: *A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions, severe weather, floods, coastal erosion). Humans cannot eliminate natural hazards but they can take steps to reduce their impacts.*
By the end of Grade 8: *Some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions. Others, such as earthquakes, occur suddenly and with no notice, and thus they are not yet predictable. However, mapping the history of natural hazards in a region, combined with an understanding of related geological forces can help forecast the locations and likelihood of events.*

Objectives:

- Create a data table and analyze information related to specific earthquakes.
- Identify areas on the earth where earthquakes are most likely to occur?
- Design, construct and modify model buildings that can withstand a simulated earthquake.
- Establish design guidelines or "building codes" from observations of various designs of model buildings.

Class Time: 3-4 class periods
Day 1: Analyze news reports, locate earthquakes on maps. .
Day 2: Examine locations of earthquakes and discuss distribution. Complete building designs and submit.
Day 3: Construct and test buildings.
Day 4: Students prepare visual poster and present their assessment of their building design. The entire class can determine a building code that produces the safest building. (Limitations to height, size of base, shape of entire structure, shape of support structures in side walls etc.)

Key Vocabulary Terms: earthquake, epicenter, p-wave, s-wave, Richter Scale, qualitative and quantitative data, seismic zone, crustal plate boundary.

Materials: (For each group) 1 set of Seismic News Articles, data chart, wall map of the world, earthquake data distribution sheet, individual maps, group kits of various materials used for building construction, rulers, poster paper. One shake table for the class.

Teacher Preparation:

- Print the articles and data charts.
- Hang a large wall map of the world or locate one for the Smart Board.
- Construct a shake table from models and instructions online (references provided.)
- Collect materials for model buildings and prepare kits for teams. The teacher may choose to use one type of material, or give a variety that students select from. Suggested materials- thin spaghetti and mini-marshmallows for connectors, toothpicks and clay blobs for connectors, paper and tape that can be used to form construction tubes, or a variety of materials such as cardboard, tape, paper, straws, craft sticks, plastic drink cups, foam plates etc.

BACKGROUND INFORMATION

An earthquake begins when stress on large blocks of rock becomes greater than the strength of the rock. The rock fractures, releasing vast amounts of energy. This energy is carried outward in all directions by various seismic waves, some of which can reach the opposite side of the earth in about twenty minutes. The further the waves travel from the focus of the earthquake, the weaker they become.

Throughout history earthquakes have caused destruction in seismic risk zones, and even though technology has improved the structure of buildings in many areas, the unpredictability of earthquakes still presents problems. High risk areas have been identified through tracking of earthquakes and their locations on the earth (many along crustal plate boundaries).

As the population increases more people live near seismic risk areas and in many cases the buildings are not created to withstand earthquakes. When an earthquake occurs in a densely populated area with few (or no) building codes, the result is often injury and death to thousands (Haiti, 2011). In this lesson students investigate actual data related to earthquakes and speculate on why the injuries varied from one incident to the next. They then build a model building and test its ability to withstand a simulated earthquake. The lesson encourages student engineering and inventiveness, team cooperation to design and modify a structure, and analysis of their work.

LESSON PROCEDURE

Pre-Assessment Plan:

Students should have an understanding of earthquakes resulting from the release of energy from areas of stress within the earth. The energy is transferred through the rock and may cause violent motions of the crust. They should know that intensity can be measured using the Richter Scale and have some knowledge of the various types of earthquake waves, such as P-waves, and S-waves. The teacher should provide lessons related to these topics and assess the student understanding prior to doing the earthquake locations and building construction.

Introduction (Elicit) None will be used for this lesson.

Engage:

Show a short video of the damage done by an earthquake that has recently been in the news (i.e. Haiti). Comment on the widespread destruction and tell students they will be exploring the reasons for earthquake destruction and possible solutions.

Explore:

- Divide students into groups of 4-5 and pass out the Seismic News articles and the data table instructions.
- Tell the students to read their article silently and highlight data they find. Afterward they will each share what they read.
- The group will develop one data chart that will be shared with the entire class.
- They will describe the differences they see in the data and propose reasons.

Explain:

- If a SMART Board is available, display a blank data chart (or draw one on the board or chart paper). (A completed data table is included in the lesson resources.)
- Ask one group to share the kind of data categories they included.
- Determine if other groups agree or have other categories to include.
- Ask which categories are qualitative/quantitative.
- Let group members to come to the board and add their data.

Questions:

- Do you notice similarity in the data? Are there differences or inconsistencies in the data? (The Richter scale value is approximately the same for all quakes. There are differences in the number of deaths/injuries and the amount of damage observed. The earthquakes occurred during different time spans.)
- Can you describe something that seems unusual in the data? (Even though the earthquakes are about the same magnitude some resulted in no deaths.)
- What do you think might account for these differences? (Some earthquake locations weren't densely populated, the buildings were built to withstand earthquakes in some areas but not in others, or areas may have been farther from the epicenter.)
- What evidence do you have for your ideas? (Knowledge of the locations of the earthquakes, or students can refer to maps.)
- What other questions could you ask and research that might help you determine the reasons for these differences? (Knowing more about the buildings that were destroyed, what time of day the earthquake occurred to determine if people were asleep, at work, or outdoors, and knowing the population of the area.)
- What could account for the differences in the number of dead/injured and the amount of building damage? (If some areas had no building codes then many people may be killed as the poorly built structures collapse.)

Evaluate:

Assess student ability to construct the data table and their answers to questions.

Elaborate:

Ask students if they think there should be more precautions taken in some places on earth than others because more earthquakes happen in these locations. (Students may not realize it at this time, but some areas are more prone to earthquakes.)

Ask how they could determine if there were areas of higher seismic risk. (Discuss reviewing historical data on earthquakes and where they occur to look for patterns. Mapping this could show areas of greater risk if they exist.)

Procedure:

- Give each group the ***Earthquake Data Distribution Sheet*** and a map of the world. (Divide the data and give each group only part of the list to save time.)
- Tell them to locate each earthquake listed on the map of the world and label each

area with a dot and a number.

- When they finish, ask random members to place a sticky dot on the display map where the earthquakes are located.

Questions: (Post these questions and ask each group to discuss. Afterwards they can report their observations to the class.)

- Do you notice any patterns related to where earthquakes occur? (They may notice that the earthquakes occur more frequently in some areas.)
- What other information might be helpful in determining if there is a pattern? (Plotting more earthquakes) You may want to display another map showing many earthquakes or use the Google Earth files included in the technology links.
- Compare the master wall map showing the earthquake locations to the plate boundary map. What do you notice? (Many of the earthquakes are located on the plate boundaries.)
- How do you think scientists may have constructed the map of plate boundaries? (By mapping many locations of earthquakes and other events such as volcanic eruption over a long period of time.)
- How can this information help us in better protecting populations from the hazards of earthquakes? (Known seismic risk areas can monitor earthquakes closely, and create evacuation plans, and building codes that enable buildings to withstand the earthquakes.)

Extend:

Tell students they will design and create model buildings and then test them on a shake table that simulates various wave motions caused by an earthquake. You may wish to divide students into different (or smaller) groups for the building activity. They are to discuss the design and scale, and create a diagram of the proposed building design including the measurements. Tell them to justify measurements and design features in their plan where possible. Give them material kits, or allow them to make selections from available materials.

Use the sheet "Shake Table Testing" to allow self-evaluation of their designs.

After tests are complete the students will create a visual or poster that includes:

- The design drawing
- The test results
- Weaknesses/strengths in the design
- Suggestions about structure and design limitations that seem to create the stability or instability. (You might use an example of how car manufactures test cars to determine how much impact a car can withstand, and what design features can help eliminate damage and injury.)

When all groups have completed their presentations, students should evaluate the best design suggestions and develop specifications for earthquake resistant structures. If time allows, they may redesign their buildings for a second series of tests with the shake table.

Discuss with students the limitations of their designs to simulate the real world design specifications necessary to produce buildings.

Teaching Note: If the amount of material is limited and all groups have the same materials, then the design will determine the durability rather than the material itself. If students choose their own materials, and a price for each is included, they can also determine a cost to construct the building which can be compared to the durability. The method is left to the discretion of the teacher. You may also impose time limits on design and construction of the building itself.

Evaluate:

- Assess students on details of their design drawing, the stability of their building design, their ability to work as a team, how much thought they put into the original design and suggestions for improvement, how well they assess the limitations and features of their design.

Additional Extensions:

- Research earthquake preparedness or building codes in areas prone to earth quake in the region or state.
- View videos or photos of large shake tables used by industry to test buildings in the real world.
- Review the "ABC's of Building Codes" to connect the building to real-world concerns related to buildings.

ADDITIONAL RESOURCES and CROSS-CURRICULAR CONNECTIONS
Math: If materials used for the buildings are priced, then students can do a cost analysis of their building. Students will also measure using rulers.
Language Arts:
Social Studies: Historical accounts of earthquakes along the New Madrid Fault are available online.
Parental Involvement: Parents may be able to donate supplies to use in buildings.
Technology Connections: Locate earthquakes as related to plate boundaries with online maps and view earthquakes in real time. **Google Earth:** USGS KMZ/KML files on real time earthquakes displayed in Google Earth (free download): http://earthquake.usgs.gov/earthquakes/feed/ Real time maps of earthquakes. http://earthquake.usgs.gov/earthquakes/map/

Resources and Bibliography:
Online news articles from BBC, AP, New York Times and other sources.
Simple Shake Table: Raft Ideas http://www.raftbayarea.org/readpdf?isid=374
Built with binder covers and rubber balls.
Shake Table: This table is built with PVC and a piece of plywood and other materials for a cost of about $15. http://nees.org/resources/2938
Slinky Simulation: Simulate the way P and S waves propagate using a toy slinky.
http://www.exploratorium.edu/faultline/activezone/slinky.html
Earthquake Resistant Buildings: Explanations and structural details that make building more resistant to vibrations. http://www.ideers.bris.ac.uk/resistant/resist_home.html
Earthquake Towers Challenge: A competition in tower construction with soda straws.
http://www.mysciencebox.org/book/export/html/596
Design Evaluation Worksheet: Modified from Teach Engineering.
http://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_seismicw/cub_seismicw_lesson01_activity1.xml#intro
Library of Congress: 1812 Article on Charleston Earthquake.
http://memory.loc.gov/rbc/rbpe/rbpe04/rbpe049/04901600/001dr.jpg
Earthquake Prediction: Short videos on earthquake prediction and other topics.
http://www.teachersdomain.org/resource/ess05.sci.ess.earthsys.japan/

Notes:

The Seismic News - Key

Quantitative Data refers to numbers and comparable events. **Qualitative** refers to inferences made from data. Damage is qualitative in that it requires a deduction or subjective evaluation based on observations. The following data can be derived from the ***Seismic Times*** articles.

Location	Date	Magnitude	Deaths/Injury	Damage
New Zealand	**Sept. 10 2010**	**7.0**	**0**	**Significant**
San Francisco, California	**Oct. 17 1989**	**6.9**	**62 deaths**	**Unbelievable damage with extensive collapse of buildings and structures.**
Haiti	**Jan. 10 2010**	**7.0**	**100,000 deaths 3 million injuries**	**Unimaginable, complete.**
Japan	**Jan. 1 2012**	**7.0**	**0**	**Shaking of buildings with insignificant damage.**
Armenian	**Dec. 10, 1988**	**6.9**	**45,000 dead 500,000 injuries**	**Complete destruction of area cities.**
Chile	**Mar. 26 2012**	**7.1**	**3 injured**	**No major damage**

Whole Lot of Shakin' - Design Worksheet

Team members: _____

Design

Goal: Create and evaluate an earthquake resistant building with the materials provided. Discuss different designs with your design team before beginning. In the space below, draw the design for your building. Label all the materials used in your designs and include measurements.

** Remember—you are not required to use all the materials! **

Model Building/Structure Design

(Materials: _____)

Shake Table Testing

1. Which type(s) of seismic wave(s) does the shake table simulate?

   ❑ P-waves ❑ S-waves ❑ Crustal waves ❑ Rayleigh waves

   Explain these movements.

Earthquake Test

2. How long did your building last through the earthquake simulation?

3. Describe what happened to your building while it was going through the "earthquake."

4. Create a visual poster: Be prepared to present your findings to the class.
   Include: design drawing, weaknesses of your design, strengths of the design, suggested modifications.

5. Based on what you noticed and the information each group presented, which design features and strategies were most effective in withstanding the simulated earthquake?

6. With the whole class develop a list of "building codes and specifications" for the most earthquake proof design. List your suggestions below.