Assignment Discovery OnLine Curriculum

Lesson title:
Earthquakes: Getting Ready for the Big One

Grade level:
6-8, with adaptation for older students

Subject area:
Earth Science

Duration:
Three class periods

Objectives:
Students will:
1. Understand the different types of earthquake waves and the impact theey can have.
2. Understand why an earthquake can affect different parts of a city in different ways.
3. Understand the importance of taking substrate and construction design into consideration when preparing a city for an earthquake.

Materials:
The class, student, and teacher will need specific materials to complete the lesson on earthquakes. The class will need the following:

· Computers with Internet access (optional but very helpful)
· Reference books

Each student will need the following:
· Pens and paper
· One copy of Classroom Activity Sheet: Planning for an Earthquake
· One copy of Take Home Activity Sheet: Write a Letter

The teacher will need the following:
· Scenario Fact Sheet

This lesson plan can be enhanced by purchasing a copy of the documentary “Earthquakes: Seismic Sleuths” from our School Store. This documentary airs on the Discovery Channel on February 28, April 4, May 9, and June 13.

Procedures:

1. Discuss with students where earthquakes are mostly likely to occur. If they don't know, they can look at a map of earthquake hot spots or at the Java Earthquake Globe at http://www.crustal.ucsb.edu/ics/understanding/globe/globe.html. If students live near one of these areas, discuss life in "earthquake country."

2. Before proceeding with the activity, make sure that students have a basic understanding of plate tectonics and the relationship between plate movements and earthquakes. To guide the discussion, review the following questions:

   - What are tectonic plates?
   - What are faults?
   - What relationships do tectonic plates and faults have with earthquakes?
   - What is the Richter scale? What do the numbers on the Richter scale mean?
   - What is the difference between P waves and S waves?
   - What are Love and Rayleigh waves, and why are they more destructive than P and S waves?
   - What is the relationship between soil type and susceptibility to damage from an earthquake?

   If they need to review this subject, they can browse through available reference materials or the Web sites listed below.

   - Life Along the Faultline (link to "Why the Earth Shakes: Seismic Science): http://www.exploratorium.com/faultline
   - This Dynamic Earth: The Story of Plate Tectonics: http://pubs.usgs.gov/publications/text/dynamic.html
   - Earthquakes and Plate Tectonics: http://wwwneic.cr.usgs.gov/neis/plate_tectonics/rift_man.html
   - Plate Tectonics, the Cause of Earthquakes: http://www.seismo.unr.edu/ftp/pub/louie/class/100/plate-tectonics.html

3. Ask students if they remember hearing about any particular earthquakes. Where did these earthquakes occur? What were the consequences? What types of structural damage resulted? If any of your students have ever been in an earthquake, ask them to briefly share their experiences with the class. Help students understand that two major factors contribute to the level of earthquake damage: (a) construction design and quality and (b) the type and magnitude of the waves that an earthquake emits.

4. Divide the class into small groups of approximately four students each. Give each group the Classroom Activity Sheet: Planning for an Earthquake. Ask them to read and discuss the scenario and to carefully follow the directions to create proposals for the city government. Their proposals should include the following components:

- An introductory paragraph that explains why it's important to consider the different types of soil and construction in a city located near an earthquake fault
- An analysis of the impact of an earthquake on different neighborhoods of the city
- A map of the city with its neighborhoods numbered in order of priority. Include buildings at greatest risk.
- A discussion of the different types of waves that could hit the area and why some are more destructive than others
- A discussion of the types of buildings that face the greatest risk from earthquake damage
- A discussion of modern construction techniques that could help protect buildings and bridges from earthquake damage
- A closing paragraph that summarizes what the city should do to minimize its earthquake risk and to make each of its neighborhoods safer

5. Students should be able to find information in print resources and at the following Web sites:
   - Life Along the Faultline (link to "Why the Earth Shakes: Seismic Science" and "Building for the Big One"): http://www.exploratorium.com/faultline
   - Earthquakes! http://whyfiles.org/094quake/index.html
   - Earthquake Hazards and Preparedness: http://quake.wr.usgs.gov/hazprep/index.html
   - Soils and Earthquakes: http://mceer.buffalo.edu/education/exercises/soil.asp
   - Designing Structures To Perform Well During an Earthquake: http://mceer.buffalo.edu/education/exercises/struct.asp
   - Liquefaction Hazards: http://www.abag.ca.gov/bayarea/eqmaps/liquefac/liquefac.html

6. Have each group share its assessment with the class. Did the groups come up with similar proposals? What neighborhoods do they think are the most at risk and why? Do they all agree on the riskiest neighborhood? Would they like to be in the position to assess a real city's earthquake risks? Why or why not? Refer to the Scenario Fact Sheet for clues about what students might discover.
7. Assign the Take Home Activity Sheet: Write a Letter for homework. Ask students to choose one of the two highest-priority neighborhoods of their fictitious city and write a letter to its residents. The letter should inform residents of the reasons why their neighborhood is at risk, describe what might happen to their homes during the next earthquake, and provide some recommendations for minimizing their risk. This activity is a logical extension of the proposal that students completed and provides them with an opportunity to consolidate their thinking and practice persuasive writing techniques.

Adaptation for older students:

Have older students hypothesize some of the political complications that can arise when a city or region is planning to retrofit its structures in preparation for the next earthquake. Ask them to

find out about the progress that has been made since the Loma Prieta Earthquake of 1989 (near San Francisco) and to write a paragraph explaining the role of politics in the retrofitting process. Do they think, from a political perspective, that the situation has been handled appropriately or should policies have been made differently to make sure that the Bay Area is prepared for the next major earthquake?

Questions:

1. Discuss the reasons why an earthquake that measures 6.5 on the Richter scale can inflict very different levels of damage in different places near its epicenter.

2. Explain the reasons why it is important to know about the types of substrate on which a city's neighborhoods are built.

3. Imagine that an earthquake has hit your town, causing a downtown building to collapse. Describe the destruction process, starting with the initial tremor and its resulting waves and ending with the collapse of the building.

4. Discuss the ways in which people can work together to make sure that their neighborhood is as safe as possible in the event of an earthquake.

5. Hypothesize the reasons why the 1999 earthquakes in Turkey damaged so many structures and killed so many people.

6. Hypothesize the reasons why, despite modern technology and construction capabilities, many structures in the world's earthquake-risk zones have not been retrofitted.

Evaluation:

Use the following three-point rubric to evaluate students' work during this lesson. For this lesson to be successful, students must pay close attention to your directions and follow all the steps on the Classroom Worksheet. Inform students that you will be evaluating them on their ability to listen and follow directions as well as on their groups' final proposals.

> Three points: Students showed exemplary performance or effort in cooperating efficiently in their groups; completed all sections of the Classroom Worksheet; followed all directions to present proposals that reflect thorough research and a clear understanding of the differences between the neighborhoods and the potential impacts of an earthquake
>
> Two points: Students showed average performance or effort in cooperating in their groups; completed all sections of the Classroom Worksheet; followed most directions to present proposals that reflect some research and an adequate understanding of the differences between the neighborhoods and the potential impacts of an earthquake

One point: Students showed below-average performance or effort in cooperating in their groups; did not complete all sections of the Classroom Worksheet; followed few directions and did not present proposals that reflect thorough research or a clear understanding of the differences between the neighborhoods and the potential impacts of an earthquake

Extensions:

Learn from the Past, Prepare for the Future
Have each group research one major earthquake, such as the Loma Prieta or the Northridge quake, and focus on their impact on people's lives. Then have each student write a paragraph explaining what the public should know about earthquakes to prepare themselves for the next one. As a follow-up, ask students to find out how individuals and families can prepare for an earthquake.

Organizing a Public Education Campaign
Have each group develop a public education campaign alerting citizens to the potential danger of earthquakes. The campaigns could include posters, brochures, or a Power Point presentation. Make sure the groups identify the real or fictitious city they are educating and describe the potential risks facing the city and actions that can minimize damage. Have groups present their campaigns to the class.

Suggested Readings:

Why the Earth Quakes
Matthys Levy and Mario Salvadorim W.W. Norton & Co., 1995.
This book combines an engaging and authoritative text and over one hundred illustrations to explain why earthquakes happen, how we can predict their occurrence and behavior, and how we can prepare for them personally and as a society. The authors use several of history's most famous earthquakes to provide a close look at what happens when the ground we expect to be rock-solid begins to move.

Earthquake Games: Earthquakes and Volcanoes Explained by 32 Games and Experiments
Matthys Levy and Mario Salvadori, Margaret K. McElderry Books, 1997.
Being caught in an earthquake is certainly no game, but the authors have devised a series of games and experiments that demonstrate and explain the principles behind earthquakes and volcanoes. Other experiments show how earthquakes can be predicted and measured and how buildings can be designed to prevent earthquake damage.

Web Links:

National Earthquake Information Center, USGS (U.S. Geological Survey)
Extensive earthquake information.
http://neic.usgs.gov/

Earthquakes for Kids and Grownups, USGS Earthquake Hazards Program
An excellent site that includes "Earthquake ABCs," "Cool Facts," and "Stuff for Teachers."
http://earthquake.usgs.gov/4kids/

USGS Learning Web Teacher Lessons
Teacher lesson plans focusing on faults; appropriate for grades 7–12. Includes models of three faults.
http://www.usgs.gov/education/learnweb/ESLesson1.html

The World-Wide Earthquake Locator
Developed by the Department of Geography at the University of Edinburgh. Includes maps of earthquake locations, frequently asked questions, and general information about earthquakes.
http://www.geo.ed.ac.uk/quakes/schools.html

Vocabulary:

epicenter
Definition: The part of Earth's surface directly above the focus of an earthquake.
Context: Even though our house was 50 miles from the epicenter of the earthquake, all the bookshelves fell over.

fault
Definition: A fracture in Earth's crust at risk for displacement or rupture.
Context: The San Andreas fault in California is an area most likely to experience a large and potentially destructive earthquake.

plate tectonics

Definition: The theory stating that the Earth's outer shell is divided into about 30 tectonic plates that move slowly in relation to one another.
Context: The theory of plate tectonics suggests that Earth is like a giant jigsaw puzzle, with enormous pieces that are constantly moving. When the stress from all this motion becomes too much, the plates slip and slide, resulting in an earthquake.

retrofit
Definition: To furnish a man-made object with new parts or equipment for improved performance.
Context: Engineers must retrofit the Golden Gate Bridge in San Francisco to make it more stable in the event of another earthquake.

Richter scale
Definition: A logarithmic scale for expressing the magnitude of an earthquake.
Context: The Northridge Earthquake ranked 6.7 on the Richter scale, making it 10 times more powerful than an earthquake ranking 6.6.

seismic
Definition: Of or relating to an earthquake.
Context: The San Francisco Bay Area is a hot spot for seismic activity; the region has many faults and is at serious risk for a major earthquake in the near future.

substrate
Definition: An underlying support or foundation, as for a building.
Context: Houses can be built on different substrates, such as rock, sandy soil, or mud.

waves
Definition: The way the force of an earthquake moves outward from the epicenter. P-waves are fast, longitudinal waves; S-waves move more slowly but are more powerful; Rayleigh waves churn like ocean waves; and Love waves are the ones most responsible for making buildings collapse.
Context: Geologists have identified four different kinds of waves, or motions, that can occur during an earthquake. The waves most likely to destroy buildings are the slow moving but deadly Love waves.

Academic Standards:

Grade level:
6-8

Subject area:
Earth and Space Science
Standard:
Understands basic Earth processes
Benchmark:
Knows that the Earth's crust is divided into plates that move at extremely slow rates in response to movements in the mantle.

Grade level:
6-8
Subject area:
Geography
Standard:
Knows the physical processes that shape patterns on Earth's surface.
Benchmark:
Knows the major processes that shape patterns in the physical environment (e.g., the erosion agents, such as water and ice; earthquake zones and volcanic activity; the ocean circulation system).

Grade level:
6-8
Subject area:
Geography
Standard:
Understands how physical systems affect human systems.
Benchmark:
Knows the ways in which humans prepare for natural hazards (e.g., earthquake preparedness; constructing houses on stilts in flood-prone areas; designation of hurricane shelters and evacuation routes).

Credit:
Betsy Hedberg, freelance curriculum writer and teacher.

DiscoverySchool.com
http://www.discoveryschool.com

Name: _____

Planning for an Earthquake

Imagine that your group is a panel of scientists and engineers in a U.S. city that is located 20 miles from a major fault. The city government has appointed your group to write a proposal recommending how the city can best prepare itself for an earthquake. (The last major earthquake occurred 50 years ago.) Your group needs to figure out which parts of the city should be "priority areas" and what should be done to protect each section of the city from major damage.

1. Review the Research

Your research has already revealed the following information about this city:

• The earthquake that hit 50 years ago toppled most of the city's buildings. Seismologists suspect that Love waves hit the building foundations, and they worry that even stronger waves will hit next time. City planners feel strongly that a plan for retrofitting the city's major buildings be put into place as soon as possible, but no action has been taken.

• The downtown area has seven skyscrapers more than 20 stories high. Five were built in the 1960s, and two were built in the mid-1990s. All buildings constructed after 1990 were built with the latest earthquake-resistant construction. Despite discussion of retrofitting the older buildings, no plans have yet been implemented.

• The southeast portion of the city is a primarily residential area built into the hills. Each year when the winter rains fall, these hills experience landslides.

• A river runs through the northwest portion of the city, which includes a portion of the downtown, central business district. Some people who live close to the river complain about soggy soil in their backyards.

• The northeast section of the city is a mixed commercial and residential zone and rests on a plateau made of solid rock tens of millions of years old.

• The southwest portion of the city is the industrial segment and contains several major petroleum processing plants and chemical factories. It's located on loose alluvial sediments.

Continued

Name: _____

Planning for an Earthquake

2. Consider the Impact on Each Section

On a separate piece of paper, write a brief analysis for each section of this fictional city (downtown, northeast, northwest, southeast, southwest), answering the following questions:

- How might an earthquake affect this neighborhood?
- Why would this neighborhood be affected in this way?
- What can be done to reduce this neighborhood's risk in the event of an earthquake?

You will be asked to turn in this section in as part of your proposal to the city government.

3. Decide on Priority Areas

Using your analyses of each section, think about which neighborhoods should be priority areas and which can wait a little longer for earthquake prevention measures. Number the neighborhoods (below) from 1 to 5, with 1 being the highest priority and 5 being the lowest.

- Downtown
- Northeast
- Northwest
- Southeast
- Southwest

On a separate piece of paper, make a map of the city showing the locations of its neighborhoods and other features mentioned in the scenario. Then write the priority numbers next to the neighborhoods on the map.

Continued

Name: _____

Planning for an Earthquake

4. Prepare Your Proposal

Prepare a proposal that recommends to the city government protection measures each neighborhood should adopt to minimize major earthquake damage. Your group's proposal should include the following components:

• An introductory paragraph that explains why it's important to consider the different types of soil and construction in a city located near an earthquake fault.

• An analysis of the impact of an earthquake on different neighborhoods of the city (your response to question #2 above).

• Your map of the city, with its neighborhoods numbered in order of priority. Include buildings at greatest risk (answer to question #3 above).

• A discussion of the different types of waves that could hit and why some are more destructive than others.

• A discussion of the types of buildings that face the greatest risk from earthquake damage.

• A discussion of modern construction techniques that could help protect buildings and bridges from earthquake damage.

• A closing paragraph that summarizes what the city should do to minimize its earthquake risk and to make each of its neighborhoods safer.

Take-Home Activity Sheet:
Earthquakes: Getting Ready for the Big One

Name: _____

Write a Letter

Choose one of the two highest-priority neighborhoods of your fictitious city. Write a letter to residents of this neighborhood informing them of the reasons why their neighborhood is at risk, describing what might happen to their homes during the next earthquake and providing some recommendations about what they can do to minimize their risk.

For Teachers:
Earthquakes: Getting Ready for the Big One

Name: _____

Scenerio Fact Sheet

Groups will not necessarily agree on the order of priorities for this city, and no definitive right answers can be used for evaluation. However, students' assessments of their cities' neighborhoods should reveal the following factors:

1. Retrofitting the older downtown skyscrapers should be a priority because many people work downtown, and an earthquake could cause catastrophic damage to these structures.

2. The downtown area is also at risk because it lies near the river, where the substrate tends to be sandy soil, which is much more susceptible to earthquake movement than is rock.

3. The northwest neighborhood is also in danger because of its loose river soil. The people who live closest to the river should be placed on a priority list for public safety education campaigns.

4. The southwest portion of the city needs attention, although perhaps not as much as the heavily populated downtown and southeast areas. Loose alluvial sediments are susceptible to earthquake movement, threatening the industrial structures. If a petroleum or chemical plant suffers severe damage, it could lead to a catastrophic explosion or fire.

5. The southeast neighborhood may be in danger of earthquake-induced landslides. It may also face risks related to its location. Because the neighborhood is built into the hills, the houses may be less sturdy than those built on solid land, though this is not necessarily the case. Any houses built on stilts are at risk.

6. The northeast neighborhood is the safest because it is built into rock, which is the sturdiest substrate.