Spaghetti quakes

Why are big earthquakes so much more destructive than small ones?

The "strength" of an earthquake has traditionally been measured by the Richter Scale of Magnitude. It is based on the amount of up and down movement (the amplitude) of the surface waves, as recorded by a seismometer, 100 km from the source of the earthquake. Because there is a huge range of values, a logarithmic scale is used, meaning that for every one point increase on the Scale, the amplitude increases by ten times.

A more useful measure is of the equivalent release of energy, or the seismic moment, and this increases by about 30 times for every point on the scale. So, a quake of, say Magnitude 6 is 30 times more powerful than one of Magnitude 5.

The huge increase in energy for each point can be demonstrated by using dry spaghetti as follows:

- Take one piece of spaghetti to represent rocks being broken and creating an earthquake of, say Magnitude 5, and show how it may easily be bent and then snapped. (We are using spaghetti of about 1mm diameter).
- Take a bundle of 30 pieces of spaghetti to represent an earthquake of Magnitude 6 and show that it can still be bent (and snapped if you do not wish to use it again!), but that it requires a lot more energy to do so.
- Demonstrate an earthquake of Magnitude 7, with a bundle of 30 x 30 = 900 pieces of spaghetti, which is much more difficult to bend or snap.
- For a Magnitude 8 earthquake a bundle of 30 x 900 = 27,000 pieces of spaghetti would be needed. This may be shown by the use of a circular piece of card of about 16cm diameter, to represent the ends of the spaghetti strands if each one is 1mm diameter (see photo).
- For a Magnitude 9 earthquake, a bundle of 30 x 27,000 = 810,000 pieces would be needed – shown by a chalk circle about 2m across, drawn on a garage door.

A demonstration of "earthquake energy" using spaghetti, showing one strand (barely visible), 30 strands, 900 strands, a circle of card representing the ends of a bundle of 27,000 strands and part of a 2m diameter circle on a garage door, representing the ends of 810,000 strands. (Photo: *P. Kennett*)

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The back up

Title: Spaghetti quakes

Subtitle: Why are big earthquakes so much more destructive than small ones?

Topic: Using increasingly large bundles of dry spaghetti to demonstrate how each unit of logarithmic increase in earthquake magnitude is related to a 30-fold increase in energy release.

Age range of pupils: 14-18 years

Time needed to complete activity: 15 minutes, including use of video clip

Pupil learning outcomes: Pupils can understand that:

- most earthquakes are produced by the fracturing of rock masses;
- energy is released rapidly at the source of an earthquake when such fracture takes place;
- the scale of magnitude by which earthquakes are measured covers a wide range and so uses a logarithmic scale;
- every increase on the earthquake magnitude scale represents a massive increase in energy release, approximately 30 times for every one point on the magnitude scale.

Context: A demonstration of "earthquake energy" using spaghetti, to help students to appreciate the use of logarithmic scales when measuring quantities with huge ranges in values.

Following up the activity:

- Use the video clip listed below, either as an introduction to the topic, or as follow-up.
- Ask students to try snapping a stick or a piece of scrap wood, and to notice the shock wave travelling up their arms. This is akin to the outward travel of the shock wave from an earthquake. (Ensure that

eyes are protected and that care is taken to avoid splinters of wood grazing skin).
- Ask the question 'could there ever be a Magnitude 10 earthquake?' (Able pupils may suggest that the crust can only store a certain amount of stress before it ruptures. Given 30-35km continental crust (and its composition) it would have ruptured before reaching the threshold for a Magnitude 10 earthquake. A Magnitude 10 is possible only if an area of global proportions were to rupture all at once. The theoretical maximum magnitude for a normal earthquake on Earth is about 9.7. However, it has been estimated that the Chicxulub impact in Central America at the end of the Cretaceous Period could have been as high as 11).

Underlying principles:
- The "strength" of an earthquake has traditionally been measured by the Richter Scale of Magnitude. It is based on the amplitude of the surface waves, as recorded by a seismometer, 100 km from the source of the earthquake.
- Because there is a huge range of values, a logarithmic scale is used, meaning that for every one point increase on the Scale, the amplitude has increased by ten times.
- It is of more value to measure the equivalent release of energy, or the seismic moment, and this increases by about 30 times for every point on the scale.
- So, a quake of, say Magnitude 6 is 30 times more powerful than one of Magnitude 5.

Thinking skill development:
A pattern is established as each successive set of spaghetti bundles, or the equivalent, is exhibited.
Cognitive conflict may occur where students are familiar with linear increases in values but have little experience of logarithmic scales.
Relating the spaghetti modelling to real earthquake occurrences is a bridging skill.

Resource list:
- a 500 gram packet of uncooked spaghetti strands. (We are using spaghetti of about 1mm cross section). Take out one strand to represent an earthquake of Magnitude 5: Count out 30 strands for Magnitude 6 (this weighs about 9g); estimate about 900 strands for Magnitude 7 (about 270g). Secure the bundles with rubber bands.
- paper or card cut to size to represent the end sections of thick bundles of spaghetti – 16cm diameter for 27,000 strands (Magnitude 8) and about 2m diameter for 810,000 strands – or draw a chalk circle on a wall or garage door - (Magnitude 9). These may be coloured to represent the ends of the spaghetti.

Useful links:
Earthlearningidea activities**:** For simple activities related to this topic see**: '***Shaken but not stirred? - how earthquakes affect buildings'*
'Earthquake prediction - when will the earthquake strike? - modelling the build-up of stress and sudden release in the Earth that creates earthquakes'
'Earthquake through the window - what would you see, what would you feel? - asking pupils to picture for themselves what an earthquake through the window might look like'.
Earthlearningidea video:
https://www.earthlearningidea.com/Video/300_Spaghetti_quake.html

Source: From a video on the website of IRIS, - Incorporated Research Institutions for Seismology, in the USA. With permission ttps://www.iris.edu/hq/inclass/video/pasta_quake_modeling_magnitude_scale_using_spaghetti brought to the attention of Earthlearningidea by David Rowley, Wells Cathedral School.
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