TeachEngineering STEM curriculum for k-12
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MAKE YOUR OWN LANDSLIDE! (Grades 3-5)

QUICK LOOK

Grade Levels: 3-5

Time Required: 45 minutes

Full version: https://bit.ly/czoagi19

Subject Areas: earth science, geology, physics, critical zone science

Educational Standards: NGSS: Next Generation Science Standards - Science
More about Educational standards met:
https://bit.ly/czoagi19

ACTIVITY SUMMARY

Earth's inhabited surface, known as the critical zone, is shaped by processes like landslides. To understand landslides, students use a small-scale model to explore how Earth materials (i.e., sand, gravel, lava rock) and water on varying slopes result in landslides of different severity. Students consider how the impact of natural hazards spawned in the critical zone affect their communities.

LEARNING OBJECTIVES

After this activity, students should be able to:

- Explain how different Earth materials affect landslide dynamics.
- Describe how landslide dangers are affected by slopes and storms.
- Describe how studying landslides allows scientists to determine where and when there are risks to buildings and people from landslides.

THE CRITICAL ZONE AND LANDSLIDES

We live in Earth's critical zone, where rock is altered by water, biota, and even air. Sediment and soil in the critical zone can move in dramatic ways during storms. For instance, a record-setting storm in Colorado in September 2013 unleashed more than 1,000 landslides, damaging roads and property.

Question: Why did landslides occur in some locations but not others?

Fourmile Canyon Creek near Lee Hill Drive in NW Boulder destroyed the road, carrying a van downstream, which created a dam for timber and sediment (photo credit Frederick Blume).

MATERIALS LIST

Each group needs:
- 1 model house template (link other side) printed on 1 sheet of cardstock
- Transparent tape, scissors, markers, crayons or colored pencils
- 2 small paper cups
- Mini-Landslide worksheet, one per student (link other side)

To share with the entire class:
- 2 ft section of plastic downspout (~$5)
- 1 bag small bag of sand (~$20), pea gravel (~$4), and volcanic (lava) potting rock (~$6)
- 1 large, shallow, plastic waterproof tub (8-in x 14-in x 30-in, ~$10-$20)
- Duct tape, scissors, ruler
- Stack of books, stool or chair, to support downspout
- Plastic scoop or small paper cup

BACKGROUND FOR TEACHERS

The critical zone is Earth's outer surface, from treetops to groundwater, a distinct environment shaped by organisms and essential to life. Landslides are one of many critical zone processes that affect our communities and shape landscapes. Sediment and soil formed in the critical zone can mobilize during storms or earthquakes, producing devastating landslides. Landslides, or the rapid downslope movement of sediment under the influence of gravity, occur when the balance between the pull of gravity on material on a slope and the forces (friction and cohesion) acting to hold it in place is upset. Common triggers are either increased water content or rearrangement of the load on the slope, such as earthquakes. Since it is difficult to observe and measure real landslides, U.S. Geological Survey engineers and scientists constructed a model flume (310 ft long, 6.6 ft wide, and 4 ft deep) in Oregon to conduct controlled experiments. A variety of materials (soil, rocks, gravel) are placed behind a steel gate at the top, saturated with water and released. Sensors in the flume measure sliding and colliding forces in the flows. Side windows allow flows to be observed and photographed as they sweep past. Measurements from this experimental flume help engineers create computer models to forecast debris-flow behavior and develop technologies to mitigate the destructive effects of debris flow from landslides. (https://youtu.be/F5OK_xUimFs)

This activity uses a small-scale version of the experimental flume to allow students to conduct similar experiments.

PROCEDURE

Note: Mixing water with the sand, gravel and lava rocks, can get messy and slippery. Conduct outside if possible.

BEFORE THE ACTIVITY

• Print the model houses template on cardstock.
• Set up the mini-landslide model activity. First cut the downspout in half so you have two equal sections. Tip: Cut through the narrow sides of the downspout to create the widest chutes.
• Duct tape one end of the downspout section to the bottom of the plastic tub, in the middle, to create a shallow angle (see Figure 1) Secure the top end of the downspout by taping it to a stack of books, stool or chair.

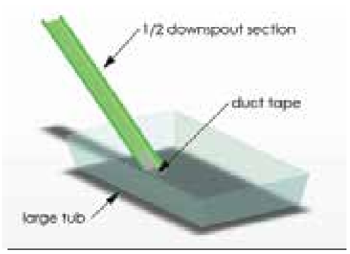

Figure 1. Pre-activity setup.

WITH THE STUDENTS

Note: It is best if the three materials and chute are damp when performing the trials. The materials react differently when wet. Damp materials produce greater uniformity in spreading.

1. Divide the class into three teams.
2. Have each team use the printed model house template to construct three houses per team. Label houses: 1, 2, 3 with the numbers on the rooftops.
3. Assign each team to one of the following materials: sand, gravel or lava rock. Note: Each group performs three trials with their material, assisted by the instructor, while the rest of the teams watch and record measurements on their worksheets.
4. For all trials: Clean off the runout zone (tub) and have students place their houses in three locations relative to the debris chute. Suggested locations: (a) 2” in front of and 2” to the side of the chute path, (b) 4” in front of and 2” to the other side of the chute path (c) 6” directly in front of the chute path (see Figure 2).


Figure 2. Placement of houses.

5. Ask the students to make predictions. Which of the model buildings will be "damaged" (moved from their original location, or worse) during each landslide trial? Have students record their prediction on their worksheets.
6. Note: For consistency throughout the experiment, make sure the sand, gravel or lava rock and the chute are already damp before the first trial begins.

7. TRIAL 1 EARTHQUAKE: Make sure the chute is at the shallowest angle allowed by the bin. Using a small paper cup, place one cup of damp sand at the top of the chute (see Figure 3). The material should not slide down the chute at this shallow angle.

8. Next, increase the angle of the slope until the material is on the verge of sliding. Then, simulate an earthquake, a common trigger for landslides, by gently shaking the chute. The material is not expected to go very far on this trial. It may not even make it out of the chute.


Figure 3. Placing material in the landslide chute.

9. Secure the chute at this angle by placing books (or a stool or chair, as necessary) under it and taping it in place. Prepare for the next trial with the same material.

10. TRIAL 2 SMALLER FLOOD: This time, place the material in the chute and pour a paper cup one-quarter full of water above the material. Observe what happens (see Figure 4). Have students record their observations on their worksheets.


Figure 4. Houses after trial using ¼ paper cup of water.

11. TRIAL 3 BIGGER FLOOD: The third trial is similar to the second, except with more water. Pour a paper cup half full of water into the chute and watch what happens. Have students record their observations on their worksheets.
12. Repeat the procedure with the other two teams for the other two materials.

13. CONCLUSION: Conclude with a class discussion comparing results. Have students share and compare their observations about which landslide scenario produced the largest runout and caused the most damage. How good were student predictions? Have students consider in turn the effects of steepness, of water additions, and of Earth materials on the landslide behavior. How can these observations be used to develop an analysis of where and under what conditions landslides might be expected, and whether some locations are safer than others? What factors would students use to create a landslide hazard map? As an extension, consider engaging students in thinking about how the sediment mobilized in landslides is generated by critical zone processes. How would students apply what they've learned to real-world landslide situations? Review students' worksheets to gauge their mastery of the subject.

LINKS:

This handout with extensions: https://bit.ly/czoagi19
Video: https://youtu.be/9oCWkElPK_4
Houses: https://bit.ly/czomodelh
Work Sheet: https://bit.ly/czosheet
Story: https://bit.ly/czonews13

MAKE YOUR OWN LANDSLIDE! EXTENSIONS (Grades 3-5)

ACTIVITY

• Have students re-design and place their own new buildings to survive a landslide. Give them some limited supplies and a building size constraint, perhaps about one cubic inch (2.5 cm^2).

• Each landslide material made a different pattern after it came down the chute. Have the students investigate more about the patterns made by the different materials. Then, have them create an informational flyer for an imaginary town that could be affected by a landslide from one of those materials.

• Scientist often use modeling to simulate natural disasters. They create different types of models for different purposes, such as mathematical models, computer models, conceptual models, and physical models. Have students investigate when and why different types of models are used.

• Have students work in groups of three or four to design, build and test strong mountains that can support houses through a rainstorm. Details are as follows:

1. Gather the following materials: topsoil, random objects (weed blocker, tulle, cotton balls, toothpicks, Popsicle® sticks), LEGO® pieces (3-4 pieces per group), plastic bins (1 per group), and a "rain-maker" (a plastic cup with holes punched in the bottom).
2. Have students brainstorm the things that make landslides happen.
- Natural causes: flooding and heavy erosion from wind or water, poor soil structure, vibrational force (earthquakes or volcanoes), groundwater pumping
- Human causes: deforestation (reducing root networks out of soil), construction

3. Have students design their mountains. Each should include their material in their designs, which include a plastic bin with a soil/sand/gravel mixture, some LEGO pieces to build a house, and a cup of random materials (the fewer, the better – recommend 2 cotton balls, 1 Popsicle stick, 2 toothpicks, 1 piece of mesh or tulle – scale the amount based on their ages).
4. Tell students that they have two chances to build a mountain out of these materials. Explain the challenge and requirements.
- Make your mountain as tall as possible. (This keeps groups from settling for small mounds that won't erode.)
- The mountain may not be anchored by the sides of the plastic bin: it must be free-standing.
- No unrealistic designs. For example, do not permit students to drape a cloth over an entire mountain. The additional materials should not be visible; in other words, all materials must be used to internally strengthen the mountain.

5. Before building, give students the materials they have to work with and the bins with soil mixture. Have them draw the mountain design with labels and details. Have them get their design approved before building.
6. Once approved, they can build, test, re-build, re-test. At the end, leave time for clean-up (there is lots!) and some time for them to each reflect (in writing) what worked and what they would do differently next time.

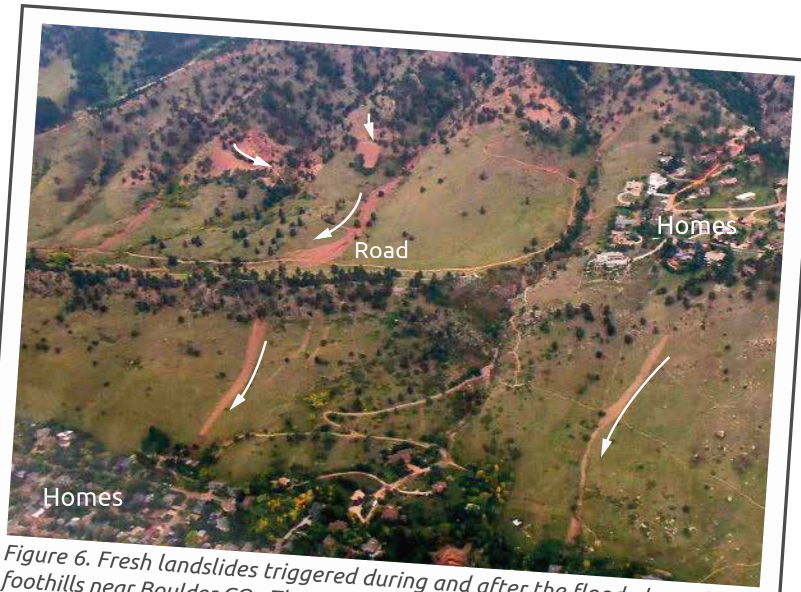

Figure 6. Fresh landslides triggered during and after the flood along the foothills near Boulder CO. These are believed to be translational landslides that evolved into debris flows (J. Godt, pers. comm.). (Photo credit Nate Rock, Oct. 3, 2013).

REFERENCES

Dictionary.com. Lexico Publishing Group, LLC. Accessed February 15, 2006. (Source of some vocabulary definitions, with some adaptation)
Lesson 5 – Landslides. Environmental Geology, Geology Education, Mansfield University, Mansfield, PA. Accessed February 15, 2006
Landslide Simulation. Environmental Geology, Geology Education, Mansfield University, Mansfield, PA. Accessed February 15, 2006. (Excellent video animation provides a realistic view of how landslide processes work and the damage that can be done by them; large, 2 MB file) http://www.geologyeducation.com/blackboard/lan/landsld.gif

EDUCATIONAL STANDARDS:

NGSS: Next Generation Science Standards - Science

Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved. (Grades 3 - 5).

Science & Engineering Practices

Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.

Disciplinary Core Ideas

Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.

A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts.

Crosscutting Concepts

NA

Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans. (Grade 4)

Science & Engineering Practices

Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.

Disciplinary Core Ideas

A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts.

Testing a solution involves investigating how well it performs under a range of likely conditions.

Crosscutting Concepts

Cause and effect relationships are routinely identified, tested, and used to explain change.

Engineers improve existing technologies or develop new ones to increase their benefits, to decrease known risks, and to meet societal demands.

WHAT IS THE CRITICAL ZONE?

The critical zone is a permeable layer from the tops of the trees to the bottom of the groundwater. It within this layer that rock, soil, water, air, and living organisms interact to shape the Earth's surface and create life. Water and atmospheric gases move through the porous Critical Zone, while living systems thrive in its surface and subsurface environments.

All of this activity transforms rock and biomass into the central component of the Critical Zone - soil. The Critical Zone is one of the most heterogeneous and complex regions on Earth.

VOCABULARY/DEFINITIONS:

Debris: The scattered remains of something broken or destroyed; rubble or wreckage.
Debris flow: A churning, water-saturated mass of rock, soil and debris that rushes down mountain slopes, typically originating as a landslide. (Source: USGS)
Friction: Force that resists the relative motion or tendency to such motion of two bodies in contact.
Gravity: The natural force of attraction exerted by the Earth, upon objects at or near its surface, tending to draw them toward the center of the Earth.
Landslide: The downward sliding mass of Earth, rock and/or other fill, under the influence of gravity.
Model: (noun) A small object, usually built to scale, that represents in detail another, often larger object. To make a observations about behavior (data, conditions, assumptions), for the purpose of predicting behavior at a larger scale.
Trigger: An event that initiates a landslide.
Unstable vs. stable: Whether or not a slope is prone to landslides.

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Prepared Spring 2019, by Eric Parrish