AVALANCHE! Investigating snowpack dynamics and snow safety

Overview

Duration: 20+ minutes
Location: Outdoor (possible inside)
About: Students use an avalanche tilt board with snow simulants (flour, sugar, etc.) to investigate how slope angle, terrain type, snow layering patterns, and human and natural triggers contribute to the likelihood of an avalanche occurrence.

Key understandings include:
● Avalanches occur most frequently on slope angles between 25 and 60 degrees.
● The order in which weak, icy, and/or strong, heavy snow layers are arranged in the snowpack influences snowpack stability.
● Weather events such as heavy snowfalls, melting and refreezing, rain on snow, large temperature changes, and strong wind events affect avalanche risk at a particular place and time.
● The surface underlying the snow also influences avalanche risk.
● Under conditions of high avalanche risk, a human (e.g. a snowmachiner or skier) or natural (e.g. heavy dump of snow or strong wind storm that re-deposits heavy snow layers) triggers an avalanche.
● There are many good resources available to learn more about avalanche risk and outdoor safety.

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Background/reference

Snow safety. 2021. Our Winter World website.
http://ourwinterworld.org/snow-and-people/snow-travel-and-recreation/snow-safety/
Avalanche Encyclopedia. American Avalanche Association and National Avalanche Center.
https://avalanche.org/avalanche-encyclopedia/#anchors

See especially: Avalanche (types of), Avalanche path, Anchors, Snow layer, Snow density, Stability, Weak layer, Depth hoar, Surface hoar, Rain crust, Sun crust, Trigger, Remote trigger, Loading, Wind loading, Terrain trap, Whumpf, Danger scale

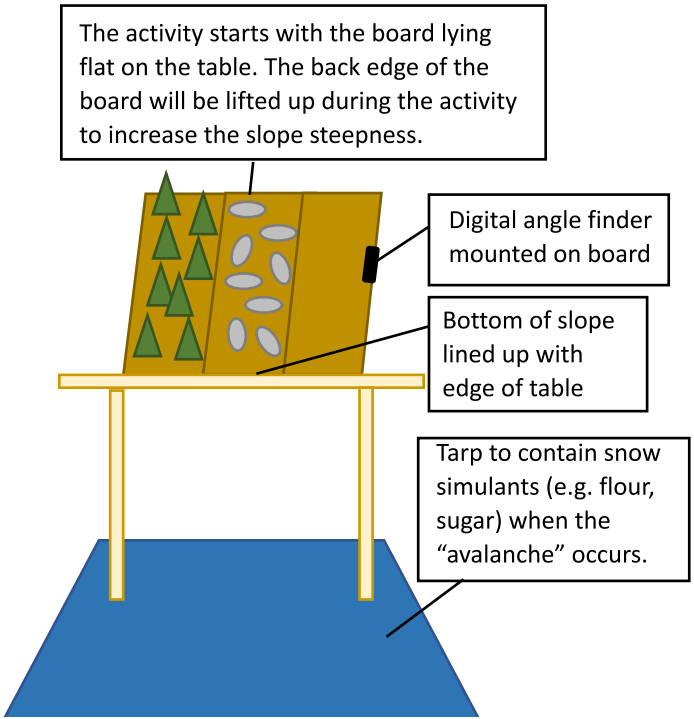
Materials

- ☐ Avalanche tilt board – wooden board divided into three terrain type sections
- ☐ Model trees (color-coded) to insert into terrain board
- ☐ Digital angle finder
- ☐ Tarp to lay out under activity area to collect flour, sugar, etc.
- ☐ Stuff sacks containing flour, sugar, and potato flakes
- ☐ Toy snowmachine

Procedures

1. Activity set up

This activity is messy in that it will result in several quarts to gallons of flour, sugar, and potato flakes sliding off of the avalanche board as the slope of the board increases. The kit includes a tarp to catch the materials. If your kit contains two boards and you plan to have students work in two groups, you can position one board at each end of the tarp.



One set up that has worked for us is to position the board at the end of a table or desk so that the bottom of the board (the end that will end up being the bottom of the slope) lines up with the edge of the desk or table. The board should be oriented so that as the back end is lifted, all three terrain types (trees, rocks, and smooth surface) are positioned on a slope.

Refer to the color coding on the bag to insert the small, medium, and large-sized

model trees into the appropriately sized holes in the avalanche board.

Remove the digital angle finder (clinometer) from the box and affix it to the Velcro on the board. If there is no Velcro on your board, attach the clinometer with duct tape along the side of the board, so that it will register the change in slope as the back of the board is raised up.

2. Avalanche demonstration orientation

Set up one or two activity stations (depending on whether your kit includes one avalanche board or two) as shown above. To start, leave the board lying flat on the table or desk.

Allow students to look at and feel the different snow simulant materials provided (flour, sugar, potato flakes). If you have already completed the snow pit study and examined different types of snow grains, ask the students for ideas as to what type of snow the different materials might best represent. Although the materials provided don't behave exactly like the different types of snow one might find in a typical snowpack, we suggest making the following comparisons:

- **Sugar** – Especially if it is coarse, sugar is crumbly and fairly large grained, so we can use it to represent ***depth hoar***, which are large, faceted crystals that tend to form at the bottom of cold snowpacks.
- **Flour** – Flour particles are much smaller than sugar grains, and flour tends to stick together more readily than sugar and form a denser layer than sugar. Flour will represent fairly ***stable, recent (but not fresh) snow*** that has had time to settle and pack together a bit.
- **Potato flakes** – (optional) Potato flakes are flat, large, and feathery, and they could represent ***fresh snow crystals*** that haven't started to break up and settle yet. Potato flakes could also represent ***surface hoar***, feathery crystals that form on the surface under some conditions and may then be covered up when it snows again.

Depending on their prior experience and any introductory information that you have presented, students might have a hypothesis about what layering sequence(s) would be more likely to result in stable snowpack conditions than others. It is okay if they don't however, as this activity is set up as an experiment and allows students to compare and contrast avalanche occurrence under different sets of snow conditions, slopes, and terrain types.

3. Avalanche activity procedures

A. Create your snowpack

1. With the avalanche board lying flat, affix the digital angle finder (insert batteries first), turn it on, and confirm that it reads 0 degrees slope.

2. Add the first layer of snow. Decide which type of "snow" you will use for the bottom layer of the snowpack. Use a scoop or (carefully) pour it from the bag to create an even layer across the entire board. If the amount of material that you have allows for it, the demonstration will be more effective if layers are approximately 1 cm or thicker. The layers may be different thicknesses.

Each time you add a layer, write down what type of "snow" you used or draw a diagram to help you remember the order of the different types of snow layers in your snowpack.

3. Add a second layer of a different type of snow. Allow different students to participate in each step.

Write down or add to your diagram the type of snow you used for layer 2.

4. Add a third layer of snow, so that your "snowpack" contains all three types of snow simulants.

5. If you have plenty of materials, you can continue to add one or more additional layers to your snowpack, recording the different types of snow layers from bottom to top as you go.

B. Increase the slope

6. One student will be in charge of slowly increasing the slope angle by raising the back of the board (the side farthest from the edge of the table). Another student will be responsible for watching the numbers on the digital angle finder as the slope changes. The other students are responsible for watching closely for signs of an avalanche starting as the slope increases.

Optional: Ask students to make predictions as to which part of the board (smooth surface, rocky surface, or forested area) will experience an avalanche first (at the lowest angle).

7. The student in charge of increasing the slope starts lifting the back of the board slowly and as smoothly as possible. When students notice any part of the snowpack starting to crack or slide, they should call out for the person lifting the board to stop for a moment so that the person watching the angle finder can note the slope angle. After everyone has observed what is happening, the person in charge of changing the slope can begin lifting the back of the board up again.

8. Repeat this process, stopping anytime a new part of the snowpack starts to crack or slide and noting the slope angle.

9. At any point during the process, especially if there is a portion of the snowpack that has remained after the other sections have slid, you might drop the toy snowmachine or skier onto the slope as an example of how the weight of a human on skis or a snowmachine can sometimes trigger avalanches. You might also place either the snowmachine or the skier at the bottom of the slope (on the table or desk just between the lower edge of the board and the table edge) to illustrate how human recreationists can get trapped in avalanches that start on slopes above them.

4. Discuss results and implications for safe winter recreation

Please refer to background/reference materials listed above. Our Winter World program staff are continuing to work on this section of the lesson plan.

Consider inviting community members who have experience with backcountry snow travel (e.g. by snowmachine for hunting, or on skis, snowshoes, or by dog sled). If they are willing, ask them to share any stories about their experiences traveling outdoors in the snow, ways that they evaluate whether snow conditions are safe, and connections between weather patterns and snow conditions that they might have observed.

A few examples of online resources related to avalanches and snow safety:

Avalanche Problems Explained (video, run time 4:47). 2016. National Avalanche Center. https://www.youtube.com/watch?v=DkbnT_9-cHU

Basic Avalanche Theory & Identifying Avalanche Terrain (video: run time 4:14). 2020. Altus Mountain Guides and EvoAcademy. https://www.youtube.com/watch?v=oKTUw78thcg

Avalanche Safety Tutorial (interactive online activity). American Avalanche Association. https://avalanche.org/avalanche-tutorial/

5. Optional extension – snow pit study connections

You might have already done a snow pit study with your class. Making observations and measurements and analyzing information collected from snow pits is an important way that scientists can learn about snow. But snow pits are also very important to avalanche professionals and people who spend time recreating in the backcountry. Because their focus is on assessing snowpack safety and likelihood of an avalanche occurring, people who dig snow pits for these purposes perform some different tests and measurements that are not typically part of a scientist's snow pit procedures.

Many videos and other resources explaining how snow pits are used to assess avalanche conditions are available online, including:

Snow Profiles (video, run time 12:44). 2021. American Avalanche Institute. https://www.americanavalancheinstitute.com/online-course/snow-profiles/

How to Dig a Snow Pit. 2018. Backcountry Skiing Canada and Summit Mountain Guides. https://www.youtube.com/watch?v=2tqLrCP4kAg

How to Perform a Compression Test. 2018. Backcountry Skiing Canada and Summit Mountain Guides. https://www.youtube.com/watch?v=UfeeWbQ2fAc

How to Perform an Extended Column Test. 2018. Backcountry Skiing Canada and Summit Mountain Guides. https://www.youtube.com/watch?v=WRaZZuTE1is

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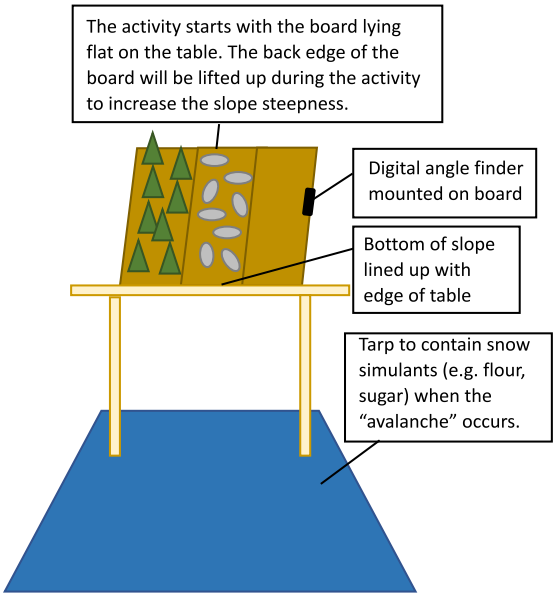
Introduction

When we see snow crystals falling from the sky, we usually call them *snowflakes*. Snowflakes can be individual snow crystals, or they can be clumps of snow crystals stuck together. Snow crystals can be different shapes and sizes, but they all have six sides or arms. (Sometimes when we find them they are broken, so we can't see all of the arms.)

Look at the snow crystal types chart. http://www.snowcrystals.com/guide/snowtypes4.jpg. Practice finding/counting 6 sides/6 arms of crystals depicted in the chart. Observe the symmetry of the shown snowflakes. Because snow crystals have six identical sides/arms and an individual crystal looks the same no matter which side or arm is "up," we say that snow crystals have *hexagonal symmetry.*

Procedures

1. Activity set up



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3. Add a second layer of a different type of snow. *Write down or add to your diagram the type of snow you used for layer 2.*

4. Add a third layer of snow, so that your "snowpack" contains all three types of snow simulants.

5. Continue as availability of materials allows

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Reflection Questions

1. What is the angle (or angles) that you estimated the avalanche to occur at?

2. What angle(s) did it actually occur at?

3. What is the order you think the avalanche will occur at with the smooth surface, rocky surface, and trees and why?

   First?

   Second?

   Third?

4. a.) What was the actual order in which they fell?

   First?

   Second?

   Third?

   b.) Did this surprise you? Why or why not?