Colorado Mountain Club
Youth Education Program
AVALANCHE SCIENCE
www.cmc.org/YEP

This avalanche awareness curriculum was produced to create a partnership between the Conservation Department of the Colorado Mountain Club's Backcountry Snowsports Initiative and Youth Education Program as well as the 10th Mountain Division Hut Association.

Activity 1: The Avalanche Triangle	
Time frame:	30 – 60 minutes
Materials needed:	White Board Three Envelopes(Snowpack, Terrain, Weather) with situations
Goal:	Students will: • Become aware of the decision making process within avalanche terrain
Objectives:	Students will be able to: • Assess each individual aspect of the avalanche triangle and determine how they are connected with each other
Introduction:	The real danger of traveling within avalanche terrain is making poor decisions. This activity will illustrate the human aspect of decision making in the field given a limited amount of information. In doing so, participants should be able to show an understanding of the interrelationship between the three aspects of the avalanche triangle: Weather, Terrain, and Snowpack. By seeing the complexities of the decision making process in the front-country, students should be better prepared to understand the weight of their decisions in the backcountry. In order for this activity to be successful, participants need to have a solid understanding of each aspect of the avalanche triangle and the interrelationships between them. • To ensure students are at the necessary competence level a brief description of the three sides of the triangle is provided. • A key is provided to ensure instructors understand the fabricated situations presented to the students. • If these resources are not needed, skip to the lesson lay out below the key.

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Outline:	1. Present or refresh the "avalanche triangle" to participants. If students needs are not fully grasping the core concepts of the avalanche triangle; weather, terrain, and snowpack be sure to review the components before moving on. 2. Split students into groups of 3 or 4 individuals 3. Each group will receive a single card from the respective envelopes "weather", "terrain", and "snowpack". 4. Within their groups students will discuss their ideas about traveling through the landscape described by the three cards they received. 5. Suggest students look at each side of the triangle individually and rank it with a level of risk metric, such as green, yellow, or red. 6. Once each side of the triangle has been ranked, the group needs to work on drawing the connections between the three sides to determine the likelihood that they would travel across the terrain. ** Really press them to make a yes or no decision; it will help highlight some of the differences of opinion within their group.* 7. Once all groups have completed the activity, have them read their statements to the larger group and explain their assessment of their statement for each side of the triangle. Finally, have them present their final decision. 8. **(optional)** Have the remaining students vote on whether they would follow the decision(s) made by the respective group(s) by having them move to opposite sides of the room*. Keep in mind disagreements are great conversation points, so if time permits work on getting the two sides to explain why they chose to follow or not follow the group's decision.*
Closure	It is well documented that the majority (1 study says 90%) of avalanche victims are caught in human triggered avalanches. Most avalanche victims make a decision to put themselves into avalanche terrain. It is up to each individual as to make the best educated decision when travelling in avalanche terrain.

For more avalanche education opportunities with youth, please check out the Colorado Mountain Club's Youth Education Program:
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Avalanche Triangle Information	Weather: **Precipitation**: Snow and rain add weight to the snow pack which can contribute to instability. *Rain*: Generally adds more weight and decreases the slope stability. *Snow*: Can go either way. Either fusing to the existing snowpack to increase stability or adding a large amount of mass. In general, the rate and weight of the precipitation is the most important aspect to consider. >mass and >rate = high slope instability; i.e. a rainy deluge, or mashed potato snow. **Wind**: Wind is an effective transporter of snow. It generally moves a lot of material and can round it resulting in a greater potential for slab creation. The most concerning aspect of wind is slope loading of a leeward (the opposite side of the slope to which the wind is blowing) slope. This process puts mass at the top of a slope which could be enough to trigger a slide. **Temperature**: Temperature changes affect snowpack in a number of complex ways. Some guidelines include: Warm weather results in more rapid changes and potential for cohesive slab formation. Cold weather results in little alteration of snowpack and presentence of weak layers. Terrain Avalanches are most likely to occur in areas that avalanches have occurred in the past. Identifying likely starting zones, paths, and areas of runoff is essential in determining the route to travel across a landscape. **Slope Angle**: Avalanches generally occur on slopes with slope angles that are greater that 25

degrees.
Slope angles of 30 to 45 degrees have the highest probability of producing a slab avalanche due to their ability to hold snowpack and the snow pack's ability to slide downward.

Slope aspect:
The slopes direction (north, south, etc.) affects the amount of sunlight it receives as well as the potential for wind loading. North slopes typically receive less sunlight are subsequently are typically colder.

Anchors/Slope Surface:
The roughness or texture of the surface beneath the snowpack greatly affects a slabs ability to move downward. The smoother the surface, the higher the potential for the movement of slabs. Trees and large rocks add to the resistance of a slope.

Slope shapes:
Avalanches can occur on any slope but are most likely in areas of higher strain, such as convex bulges.

Snowpack

Understanding the snowpack is very important in understanding the potential for slides. Understanding snowpack is a complex process and best done with field observations and mentorship. Three important aspects to understand this activity are base layers, weak layers, and slabs.

Base layer:
The point at which the snow contacts the ground. Commonly highly altered, may form weak layer due to snow metamorphism.

Weak layers:
These are areas of loosely consolidated snow or layers that form weak bonding surfaces. These are commonly the trigger point for slab avalanches.

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	Slabs: Consolidated snow layers that are likely to move as a continuous and cohesive unit.
Key	Weather It warmed up drastically over the last 24 hours – the temperature increased from 31 degrees to 50! - Lots of changes are occurring within the snow pack. If weak layers were present natural avalanches could be triggered due to surface layers reforming or a cornice collapse. It's been Steadily hovering around freezing with intermittent snowstorms over the past two weeks. - Due to cold temperatures, expect persistent weak layers. Due to storm activity, expect a complex snowpack with a high potential for wind loading. It has been extremely cold and windy for the last three days. - High potential for wind loading and persistence of snow stratigraphy It has been dumping snow for 24 hours! Two feet of powder already up in the high country. It's cold (about 20 degrees!), but the sun just came out. - A lot of weight has been added to the snowpack. The solar radiation increases the rate of change within that surface layer. It has been hovering around 34 degrees, but warming up very gradually over the last week. - Expect a consistent alteration of surface layer to a rather cohesive slab. Terrain The slope is 35 degrees, and south facing - This is within the danger zone for slope angle. The southern exposure may produce lots of reworking due to the higher temperatures. The Slope is 50 degrees, with lots of closely spaced trees. - A steep slope adds to avalanche potential. Trees disrupt the snowpack and create an area of high resistance. The slope has lots of big boulders, and is north-east facing. It has a slope of 18 degrees

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- Boulders alter the snowpack and create a lot of resistances to moving snow. Also the slope's low angle should prevent any large slab movement.

The slope is north facing with a few scattered trees. The slope angle is about 40 degrees.

- North facing slope has seen little warming via the sun so layers are persistent. The slope angle is ideal for avalanches. Slope surface offers little resistances.

The slope is windward facing and north facing with a slope of 40 degrees

- Expect loading for wind. Persistent layers. Ideal slope angle

The slope is 65 degrees – super steep!

- Expect very low retention rate of snow.

Snowpack

The snowpack consists of a think layer of well-consolidated snow with a thin layer of ice on top of it.

- This is a solid unit of snow; expect it to act as one. Ice may act as a poor connective surface if new snow were to fall.

The snowpack is one dense well-consolidated layer.

- This is a solid unit of snow expect it to act as one.

The snow pack has a dense wind packed layer on the bottom, with a stable, consolidated layer that has warmed gradually on top of it.

- Be wary of the connection between the two layers

The snow pack has a dense, wind loaded slab on top of a layer of unconsolidated loose powder.

- Danger; dense layer on top of a weak layer

The snowpack has many layers. In the middle of the pack there is a layer of sugar snow under a dense, six inch slab of very hard snow. The layers on top of that are mostly light powdery snow.

- Weak layer present with little to no consolidation on top.

The snow pack has a layer of depth hoar, or sugar snow, at the very bottom next to the ground.

- Be wary of triggering a deep slab due to the poor bottom layer.