THE HUMAN FACTOR - LESSONS FOR AVALANCHE EDUCATION

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ABSTRACT

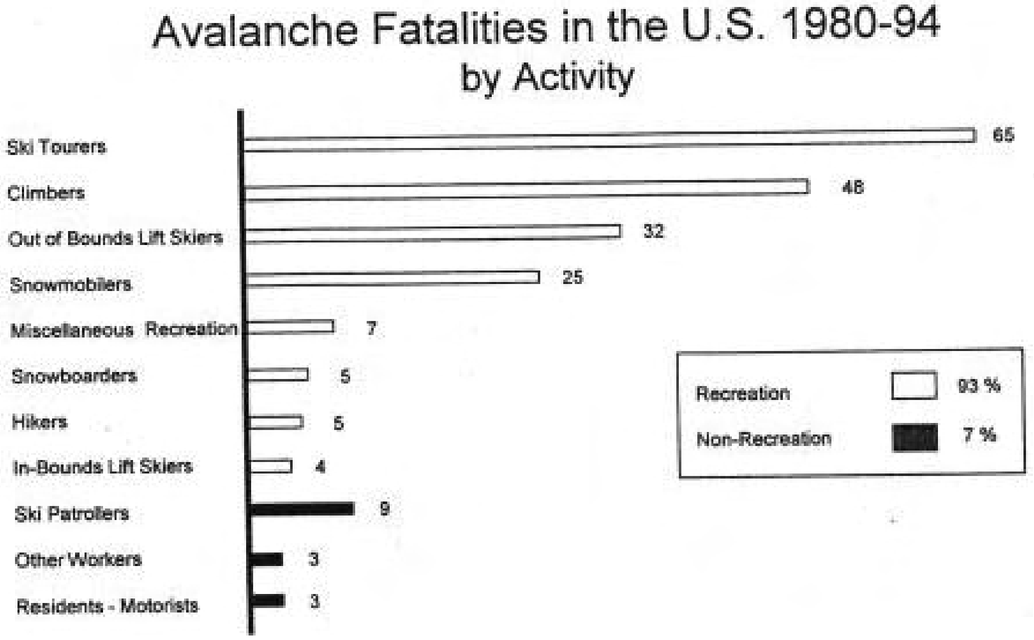
Avalanche accident statistics have long shown that the majority of avalanches catching people are triggered by people. While some accidents are the result of not recognizing potential hazard, most accidents occur because the victims either underestimate the hazard or overestimate their ability to deal with it. Victims tend to make critical decisions based on human desires and assumptions rather than upon the integration of key pieces of physical data. This paper addresses the importance of the "human factor" in contributing to accidents and distils some lessons and strategies for avalanche education.

INTRODUCTION

Most avalanche fatalities in North America result from slab releases triggered by either the victim or a member of the victim's party. Since 1980, recreationists have comprised 93 percent of avalanche fatalities in the United States with workers, residents or motorists accounting for the remaining 7 percent. Also, 94 percent of the fatalities occur in the backcountry, in other words, areas outside of ski area boundaries where no avalanche control is performed. Most of the deaths inside of ski area boundaries have occurred to ski patrollers doing avalanche control work. Only two percent of all fatalities since 1980 have occurred to motorists on highways or skiers inside of ski area boundaries while the runs were open.

While ignorance accounts for some accidents, this lack of avalanche awareness is relatively easy to cure. We worry most about the seemingly increasing number of avalanche accidents in which the victims have some level of avalanche training. By investigating avalanche accidents, we've learned that the human factor is a major contributor. The variables that repeatedly get travelers into trouble include: attitude, ego, incorrect assumptions, peer pressure, denial, tunnel vision, complacency, money considerations, poor planning, poor communication, the "sheep syndrome," (blindly following whoever is leading), the "horse syndrome," (a rush to get back to the barn) and the lion syndrome, (a rush for first tracks or summit fever).

The human factor is also a prime contributor to climbing accidents. Of 37 recent climbing accidents on snow and ice in Grand Teton National Park (Wyoming), 32 of them were attributed to "human error" (Schussman, 1990).



The question is why do avalanche victims sometimes look at clear evidence of danger but don't "see" it? And why do other victims sometimes see and understand the signs but ignore them anyway. The generally accepted theories on perception tell us that perception of a given situation depends strongly on our pre-existing beliefs, past experiences, emotions, and the context of the observation. There are a number of "perception traps" which can lead mountain travelers into making faulty assumptions, overestimating their abilities or ignoring important information.

The bottom line is that in order to prevent the greatest number of accidents, travelers must be taught to think like an avalanche and to make hazard evaluation and route selection decisions based upon data. This has been the emphasis of the Alaska Avalanche School which, during the past 17 years, has conducted over 350 intensive avalanche hazard evaluation and rescue techniques workshops (involving more than 15,000 participant days of training), investigated hundreds of avalanche accidents, and been involved in recovering the bodies of more than 20 victims. This paper will summarize what we have learned concerning the role of the human factor in *allowing* avalanche accidents to happen and discuss the design of effective avalanche education programs, including incorporating strategies for decision making into the curriculum.

HUMAN FACTORS

Incorrect Assumptions

A classic perception trap is that if we believe or assume that the snowpack is stable, then we are much more likely to see signs of stability than of instability. For instance, survivors of avalanche accidents often say that, "the avalanche advisory said that the hazard was 'moderate' so we didn't expect to get caught," or "there were tracks on the slope so we assumed that it was safe. n Many travelers get positive reinforcement because they are able to travel to a given area many times with no problems. They eventually assume that the area is safe, but if the terrain is capable of producing an avalanche, then sooner or later it will and they will get surprised.

Good science is built on removing subjectivity from the observation and often requires not only blind but double-blind tests to completely remove the tester's belief from the experiment. As avalanche instructors, we must teach students to identify their assumptions and check them out.

The Herding Instinct
Humans are clearly a very social creature. Safety in numbers has certainly served us well in the days where lions, tigers and bears were our major fears. But our herding instinct has just the opposite effect in avalanche terrain. More people standing in the same area means not only more triggers but more people to be buried with no one left to dig the others out.

Most people will admit that they are more bold in a group than when alone. Often the larger the group the more bold we become. Yet the instability remains the same. Although avalanche education has done a good job of telling students to always go one at a time or spread out, education often ignores teaching how group size affects our perception of safety. Since hazard does not exist until we add people to the equation, the more people we add, the greater the hazard, not only because of the increased numbers but because of the shift in perceived safety. In other words, as group size increases, hazard increases yet our perception of potential hazard decreases.

Attitude
Pride, ego, hubris--common traits in most anyone's weaker moments can easily produce unyielding behavior in the face of contrary evidence. We tend to filter information to suit our needs. People with high Ask-taking or "go for it" attitudes generally filter information about potential hazard and draw unrealistically optimistic conclusions which lead them to push the fine line even finer. People who are generally conservative by nature tend to use the same information to further justify their conservative approach. Attitude, ego and goal orientation are all tied together in a form of "tunnel vision" which allows the viewers to only see a small part of the big picture.

Testosterone
In Utah, even though females comprise over a third of the backcountry recreationists, since 1980, only one fatality out of 22 involved a female and she was a relative novice accompanying five other males at the time. This statistic repeats itself in most other regions of the country as well. Most male avalanche victims in the U.S. are between 16 and 35 years old. We can only suppose that testosterone is strongly correlated.

We can argue at length about which behaviors and perception shifts testosterone produces. But a more fruitful and less bigoted approach for avalanche instructors is to encourage students to retain the more useful testosterone-induced behaviors and save the less useful ones for less risky endeavors.

Weather and Perception
We know that most *natural* avalanches occur during or immediately after storms. But very few victims are killed by avalanches they do not trigger. More importantly, a disproportionate share of avalanche accidents occur during blue-sky days in between storms. It is true that more people are out during sunny days, but we feel that sunny days have a more important effect, namely, sunny days make us feel good. We get into trouble when the snowpack does not share our opinion. Most of our non-avalanche related experience teaches us that the danger is over when the storm is over. But avalanche hazard is notorious for lingering after storms especially with faceted snow and surface hoar as weak-layers. Once again, our perception of the hazard is out of synch with the actual hazard.

Travel during foul weather can also be just as dangerous but for the opposite reason. Being cold and wet makes us feel gloomy and we would rather be home by the fire. We tend to cut corners and rush decisions. Just when we need to pay attention the most, the weather pushes us to do the opposite. We often call this the "horse syndrome," a rush to get back to the barn.

City thinking versus mountain thinking
Another common perception trap is to bring our human culture into a non-human setting. In other words, city thinking and mountain thinking are very different things. The avalanche doesn't care if we have a meeting on Monday or that we paid $600 to fly in to a particular spot. The avalanche doesn't care if we are lost in conversation, tired, or hesitant to drop back 50 meters in elevation only to have to climb back up again. We have only one job in the mountains: to perceive the mountain on its own terms and adjust our behavior accordingly.

Avalanche Skills versus Travel Skills
We have noticed for years that most people getting caught in avalanches are very skilled at their sport. They may be excellent skiers, climbers, snowmobilers, or snowboarders. Newspaper accounts often report that they were very "experienced". But experienced at what? True, they have excellent travel skills but their travel skills almost invariably out pace their avalanche skills.

The greater the difference between travel skills and avalanche skills, the more likely they will eventually get caught in an avalanche because of their ability to access dangerous avalanche terrain. We have found that people highly skilled in their sport tend to consistently overestimate their avalanche skills, often they vastly overestimate them.

Communication
Poor communication is a common denominator in almost all mountaineering accidents. Poor communication typically takes several forms: 1) one or more people fail to speak up for fear of being the "nerd," 2) incomplete communication leads to incorrect assumptions or limited sharing of data, 3) misunderstanding of the plan or the potential hazard, and/or 4) there is no communication at all. Any mountaineering party can only accomplish what its weakest member is capable of. Often the weakest member doesn't speak up or the decision-makers fail to adequately consult everyone in the group. Members of the party may also have different levels of acceptable Ask, expectation, travel skills and avalanche skills and these are often not communicated.

LESSONS FOR AVALANCHE EDUCATION

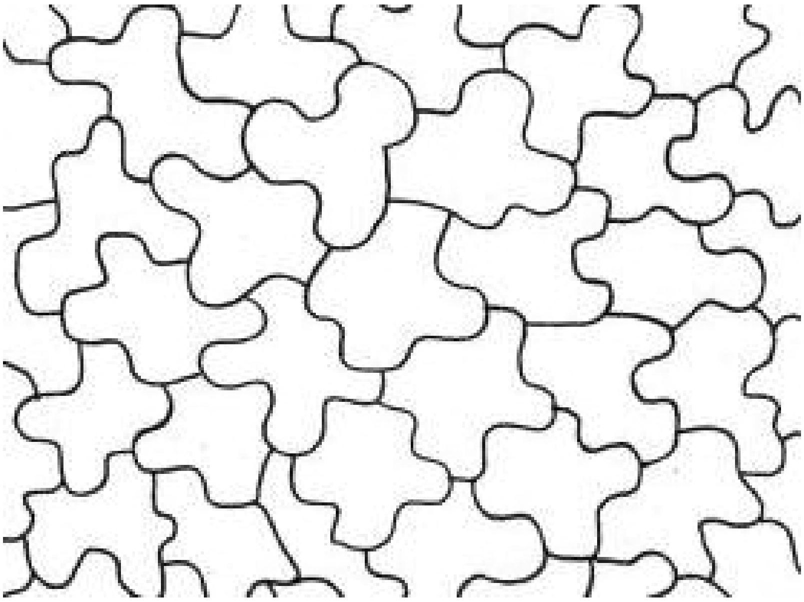
What we have learned is that we must teach mountain travelers to make decisions based upon the integration of hard data, for example, observations, measurements, and test results rather than upon assumptions or a single piece of data. They must learn to weigh their chances of success versus their chances of getting caught, buried, or killed. They must be made very aware of our tendency as humans to filter information so that it tells us what we want to hear. Travelers need to understand that while snow instability results from a combination of physical factors, the level of avalanche *hazard* to which we expose ourselves is our choice and is largely a result of our ability to evaluate snow stability and select safe routes. Most travelers could benefit from a decision-making framework that would help take the guesswork and subjectivity out of hazard evaluation and route selection decisions.

There's a famous story about a young, green, ambitious bank officer in awe of the achievements of the retiring bank president. Summoning his nerve one day, he knocks on the door of the president's spacious office to ask what the president feels has been the key to his successful career. The president answers him in two gruff words, "good decisions." Pondering this bit of wisdom at his own small desk, the junior officer still finds himself confused. He takes the elevator back upstairs and asks how the president knew how to make good decisions. The president barely looks up from his work this time, answering "experience." The young man mulls this information over for a few days but still can't understand how to get the experience to make good decisions. He finally takes this question back upstairs. This time, the president looks him straight in the eye and responds, "bad decisions."

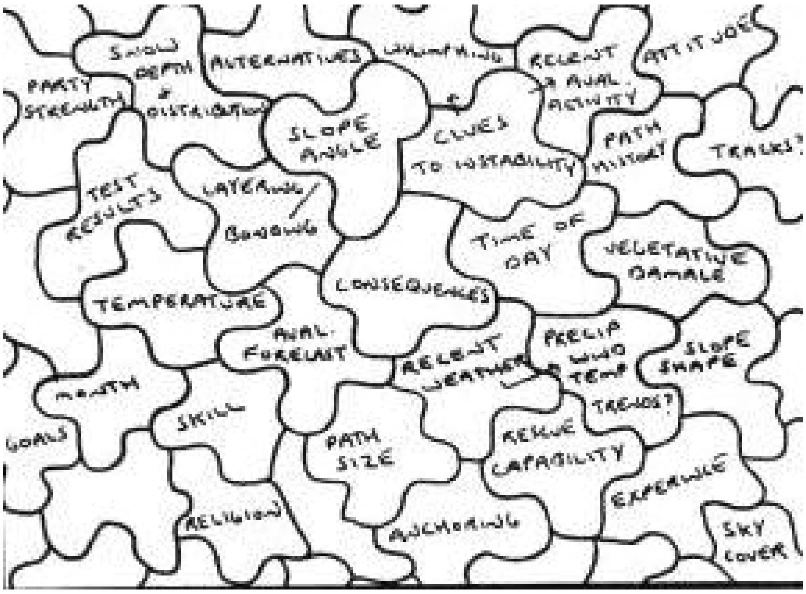
What we are trying to do with avalanche education is to speed up the learning curve, short circuiting the distance between bad and good decisions. While there is no substitute for experience, good avalanche training, can keep a person alive long enough to gain experience.

TEACHING THE DECISION-MAKING PROCESS

Seeking Information Using the Bull's-Eye Approach
When participants first come to an avalanche hazard evaluation workshop, we put them, figuratively at the edge of a steep, snow-covered slope and ask them what pieces of information they would like to have in order to evaluate if the slope is safe or unsafe. In other words, we ask them to fill in the pieces of the puzzle.

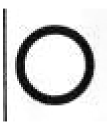


After a short time and numerous contributions, the puzzle looks something like this.

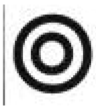


The essential problem the participants are faced with is one of uncertainty. Their heads are swimming with information and many find it difficult to organize their search for data or prioritize the information available to them. We stress that the key to eliminating or reducing this uncertainty is to gather meaningful information without getting bogged down by irrelevant data. (LaChapelle, 1979). This process is called the bull's eye approach.

THE BULL'S-EYE APPROACH



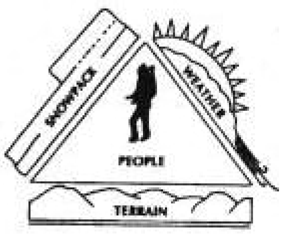
Within this circle exists all of the information available whether useful or meaningless. The marginal information does little or nothing to reduce uncertainty about the stability of a given slope. Examples: a) the air termperature is 32 DEGREES F (0 DEGREES C), b) the snow depth is 3.5 feet (1.1 meters), c) the slope is 800 feet high (244 meters), and d) the snow is white.



Within the smaller circle exists more *relevant* data which provides meaningful information but still leaves some uncertainty about the actual level of hazard. Examples: a) the air temperature was -4 degrees F (-20 degrees C) last night but is 32 degrees F (0 degrees C) this morning, b) 7 inches (18 centimeters) of new snow fell overnight, c) southeasterly winds gusting to 20 mph (10 meters/second) are transporting some snow, and d) the slope is leeward with a measured angle of 36 degrees.

Within the bull's eye exists the most useful or *meaningful* information with the highest degree of certainty in its message. Examples: a) recent avalanche activity on slopes with similar aspects and angles, b) the snow on small test slopes is fracturing when jumped on, c) very easy shear test results, and d) signs of significant wind-loading including hollow sounding snow with a rippled wind slab texture and/or shooting cracks. Best yet, perhaps the slope in question avalanches.

It is also generally helpful to point out that all the pieces of information can be classified into four categories. The interaction of three critical variables--the terrain, snowpack, and weather determines snow instability. To evaluate hazard, a fourth variable, people, must be considered.



Evaluating Hazard: Processing Critical Data

To reliably evaluate avalanche hazard, travelers need to be able to identify potential problems, collect and integrate bull's-eye data from a variety of sources, assess their alternatives and potential consequences, and make a decision. Most travelers want desperately to latch onto one piece of information, typically a snowpit, that will tell them the whole story. This is very similar to the blind man in India who concluded that an elephant was like a rope after feeling its tail. Or the other blind man who felt the leg and thought an elephant was like a great tree. ~.h one of them "looked" at important information, what they failed to do was interrelate the data. An incomplete examination of available data leads to faulty conclusions concerning the degree of hazard present. And the data in and of itself is not as important as the *interrelationship* of the data.

It must be understood that hazard evaluation is not an event, but an ongoing process. We encourage travelers to start the day by rating the stability of the snowpack on a scale from one to five. This seems to help them identify what they know and don't know about the snowpack, but then they must remain open to information that will either support or refute their opinion. They need to understand how quickly the stability of the snowpack can change, both over time and spatially.

Travelers also need to be aware that it's critical to foster good communication between members of their group. They need to feel free to exchange information and examine each other's assumptions. They need to get beyond the human factor problem of "being afraid to be a nerd. and be willing to say, "no, I don't think we should do this because...~ and lay out the data in an organized manner. Too often, group members discount their own judgements and rely on a more "experienced" partner without recognizing that most people's travelling skills (i.e., skiing, climbing, etc) far exceed their avalanche hazard evaluation skills. Equally important, they need to be willing to listen to a ~no. from a group member.

In examining avalanche accidents, it is striking how many times the victims picked up on several important clues but still got caught. Yes, the wind was transporting snow, they saw recent fractures, or heard the snow "whumph~ but "it was a blue-sky day and the skiing was terrific.. We developed an avalanche hazard evaluation checklist in an attempt to make it more difficult to filter information or rationalize the message and easier to communicate. We encourage participants to internalize this checklist, using it as a decision-making framework in the field. The checklist is centered around four bottom line questions:

* Is the terrain capable of producing an avalanche?
* Could the snow slide?
* Is the weather contributing to instability?
* What are your alternatives and their possible consequences?

AVALANCHE HAZARD EVALUATION CHECKLIST

Critical Data		Hazard Rating*		
PARAMETERS:	**KEY INFORMATION**	**G**	**Y**	**R**
TERRAIN: *Is the terrain capable of producing an avalanche?*				
-Slope Angle (steep enough to slide? prime time?)		[]	[]	[]
-Slope Aspect (leeward, shadowed, or extremely sunny?)		[]	[]	[]
-Slope Configuration (anchoring? shape?)		[]	[]	[]
Overall Terrain Rating:		[]	[]	[]
SNOWPACK: *Could the snow fail?*				
-Slab Configuration (slab? depth and distribution?)		[]	[]	[]
-Bonding Ability (weak layer? tender spots?)		[]	[]	[]
-Sensitivity (how much force to fail? shear tests? clues?)		[]	[]	[]
Overall Snowpack Rating:		[]	[]	[]
WEATHER: *Is the weather contributing to instability?*				
-Precipitation (type, amount, intensity? added weight?)		[]	[]	[]
-Wind (snow transport? amount and rate of deposition?)		[]	[]	[]
-Temperature (storm trends? effects on snowpack?)		[]	[]	[]
Overall Weather Rating:		[]	[]	[]
HUMAN: *What are your alternatives and their possible consequences?*				
-Attitude (toward life? risk? goals? assumptions?)		[]	[]	[]
-Technical Skill Level (travelling? evaluating aval. hazard?)		[]	[]	[]
-Strength/Equipment (strength? prepared for the worst?)		[]	[]	[]
Overall Human Rating:		[]	[]	[]
DECISION/ACTION:				
Overall Hazard Rating/Go or no go?	***GO [ ] or NO GO [ ]***			

* HAZARD LEVEL SYMBOLS: R = Red light (stop/dangerous), G = Green light (go/OK), Y= Yellow light (caution/potentially dangerous).

Analyzing Data Objectively

Assigning red lights, yellow lights, and green lights to the checklist's critical factors seems to help reduce the subjectivity of decision-making. Red lights mean danger, a hazardous situation exists. Green lights mean its OK, no hazard exists, and yellow lights say be cautious, potential hazard exists, there's too much uncertainty or conditions are deteriorating.

A 37 degree slope is a red light and in most cases, means that the overall terrain light is a red. Steep terrain travelers must be taught to understand that they can safely negotiate this terrain but it is a matter of timing. To do so, the snowpack and ideally, the weather must be green lights. Indications of a green light snowpack include *lack* of clues to instability, hard shears, and negative results when jumping, ski-cutting, or dropping cornices onto small test slopes. Let's look at various combinations of red, green, and yellow lights in terms of the bottom line "go" or "no go" decision we are teaching travelers to make.

DATA		TERRAIN	SNOWPACK	WEATHER	HUMAN	GO/NO GO
HAZARD RATING	1.	R	R	R	G	R
	2.	G	G	G	G	G
	3.	R	G	G	G	G
	4.	G	R	R	G	G
	5.	R	R	G	G	R
	6.	R	G	R	G	G/Y
	7.	R	Y	Y	G	Y/R

Key: **R = Red light, G= Green light, Y= Yellow light.**

Note that in each of the scenarios above, we've given the human factor the benefit of the doubt with a green light by assuming that the group is open-minded, strong, and competent. Scenario #1 is obvious: red terrain, red snowpack, and red weather is a "no go~ situation. Scenario #2 with all green lights is equally obvious. Scenario #3 with red light terrain but green light snowpack and weather is the situation we are teaching steep terrain travelers to look for if they want to ski a particularly gnarly chute or jump off cornices into avalanche terrain.

Scenario #4 is an option that many travelers don't realize they have on days when the snow is unstable but their attitude, for example, their strong desire to go skiing, may get them into trouble. A classic trap, which has been sprung repeatedly, is set during low snow winters. From a recreationist's point of view, low snowfall means poor skiing, snowmachining, snowboarding, etc. From an avalanche perspective, we know that thin snowcover often means a weak snowpack of faceted grains. When a storm finally arrives, recreationists want desperately to get outside. The snowpack is trying to adjust to the increased stress from the weight of new or windblown snow. Travelers must understand that if they go into an area where they have a choice of slope angles and find that the snowpack is a red light, they simply have to notch back the terrain from a red to a green. They can have a great day playing on slopes with angles in the low 20's where there is high instability but no hazard because these slopes, and the ones they are connected to, are not steep enough to slide. They just need to make sure that they do not stumble onto red light terrain.

When running through the various combinations with workshop participants, they are often surprised that the red terrain, red snowpack, and green weather situation in scenario #5 is quite obviously a "no go" and yet given more subjective decision-making, this is often the situation that snares people in the field. Note that scenario #6 is one of the few cases where party strength or ability could make a difference depending upon how quickly the red weather is changing the green snowpack. A strong party might be able to ~go quickly. while for weaker parties, it is a red light situation.

Initially, many travelers will have a lot of yellow lights. Teach them to determine whether these yellow lights are due to uncertainty or because conditions are deteriorating. If uncertainty is the problem, point them in directions where they can gather additional data to turn the yellow light into a more definite red or green. If conditions are changing, they need to monitor the rate of change and the trend. When in doubt or when conditions are changing rapidly, encourage them to leave a margin for error and be conservative in their hazard evaluation and route selection decisions.

STRATEGIES FOR EFFECTIVE AVALANCHE EDUCATION

Teaching travelers how to evaluate avalanche hazard objectively involves more than providing a framework for decision-making or grouping participants with an instructor who knows more than they do. Here are some thoughts concerning putting together an effective training program.

Goals/Desired Outcome: Begin by figuring out the desired outcome of the training. Who are the students? Skiers? Snowmachiners? Snowboarders? Linemen? Road operators? What's their experience level? What skills or knowledge will participants ideally leave with? The answers to these questions obviously affect the course design, including location and duration. If you are just trying to increase awareness of avalanches, a classroom format may be fine. If you are trying to teach actual skills, for example, snow stability evaluation or rescue techniques, a mixture of classroom and field training will likely be required.

Teaching approach: We think of those involved in workshops as participants rather than students and place an emphasis upon learning by doing, that is, hands-on, participatory, preferably field oriented training. Putting workshop participants in the hot seat, answering questions and making decisions, helps them think and acquire skills. Required pre-course work seems to help participants assimilate information more easily during the training.

Curriculum: We teach concepts rather than "rules of thumb" because exceptions can always be found to the latter while concepts will hold true. For example, rather than using the old guideline of "an inch of snow per hour leads to high instability, n we teach that the snowpack can only adjust to a certain amount of stress, at a certain rate of speed. How much stress it takes to tip the balance depends on the snowpack's initial stability.

So what? We put the information we teach to the "so what?" test. So what that many types of initial snow crystals fall out of the sky? Does this really help backcountry travelers evaluate avalanche hazard? Not really. Is it important for travelers to be able to read snow surface patterns to determine which way the wind was blowing? Absolutely. It is also helpful to put the "so what?" test to participants. So what that the slope angle is 38 degrees? They should not only know that this means that the terrain is capable, in fact, prime for producing avalanches but should also understand the underlying concept, that is, that as the slope angle increases so does the stress on the snowpack.

Quantifiable Measurements: In teaching travelers how to reduce their uncertainty about whether a slope is safe, focus on giving them the tools needed to identify, collect, integrate, and communicate bull's eye information. Emphasize being as specific as possible. For example, rather than just noting that a slope is steep, get them in the habit of measuring slope angles with an inclinometer. Puffing a number on the slope not only helps them reduce their uncertainty about slope capability but may also help them categorize the nature of the instability on a given day. Another example is rather than simply observing that recent avalanches occurred, encourage them to note details such as what angles and aspects slid, what the bed surface slope angles were, where the fractures broke, what they ran on, and how deep they were.

Terminology: While it may seem trite, the terminology commonly used in avalanche education can be very misleading. We would like to dissuade avalanche educators from using some specific terms because we have seen the confusion they can generate. One of these is the use of the term "settling" as a synonym for collapsing, "whumphing" or fracture propagation because it is very easily confused with the very different settlement process which strengthens the snowpack. Another is "sweet spots" instead of tender spots, stress concentration areas, trigger points, weak zones or, in light of the potential consequences, sour spots. We've seen sweet spots confused with sweet snow. The result is that some snowboarders, skiers, etc. think that sweet spots are good places to hit on their descent. In teaching avalanche rescue, we'd like to encourage use of the term "initial" or "scuff search," rather than "hasty search" as the latter seems to promote the common errors of doing an incomplete search, too quickly. Finally, we've found that the term "spot probing" better communicates the idea of checking out likely catchment areas in a systematic manner than "random probing. " The procedure is only random in that no particular grid pattern is used.

Teaching tools and methods: In trying to teach decision-making, it is more important than ever to use an interactive approach which involves workshop participants and the elements of discovery and anticipation. The more variety the better, both to keep participants interested and because people learn in different ways. We ask numerous non-rhetorical questions, encourage participants to ask questions (with the ground rule that any question is fair game), use humor and frequent review, and employ a variety of mediums such as slides, videos, and multi-colored wall posters depicting key concepts. We intersperse classroom and field sessions, limit classroom presentations to about 50 minutes, and split up the classroom topics among instructors so that we have a good mix of teaching styles. Here are a few teaching methods that have proved very effective.

Scenarios/Group Problem-Solving: Within the classroom, we have participants break up into small groups of 3-5, preferably joining with others they don't know. We then present them with a realistic scenario which is designed to put them "between a rock and a hard place." For example, in our "Mythical Pass~ scenario, the group has theoretically spent several days travelling to the base of a short but steep crux mountain pass. They have one day of food left and whatever gear they normally carry on a trip of this kind. The cars are just on the other side of the pass. If ~e group doesn't go over the pass, they will have to slog back out the way they came. It's storming. We want to know what are they going to do, how they are going to do it, and what data they are basing their decision upon. After a short time, we open the floor to questions, willing to be the eyes and ears for the group as long as they ask their questions in order of priority. "Is it safe?" is not a valid question but participants might ask if they've seen any clues to instability, what the recent weather has been, if there are alternative routes, etc. If they ask about layering and bonding of the snowpack, we'll ask them if they dug a snowpit and if so, where. Pre-drawn overhead mylars with pertinent information just happen to be available. If participants don't ask for a specific piece of information, we don't supply it.Scenarios are exercises in decision-making which generate a tremendous amount of heated discussion. It makes a big impression on participants to be subjected to the human factor and see how groups can use the same data to arrive at completely different conclusions. We wrap up a scenario by using the avalanche hazard evaluation checklist to look at the data with a set of color-coded "avalanche eyeballs." We also provide feedback concerning the consequences of decisions to "go" or "no go." Fortunately, those who "die" in the classroom get a chance to learn from the experience.

The same problem-solving approach can be used in the field. For example, on the third day of an avalanche hazard evaluation workshop, when we are trying to teach route selection and "putting it all together," each small group instructor picks a goal, for example, a spot high on a ridge, and then takes a back seat, creating a leadership vacuum. It is up to the participants to organize the group, communicate with each other, analyze their alternatives, choose a route, evaluate snow stability, and utilize safe travel procedures. All the instructors ask is that they make their decisions based upon data and be able to explain these decisions. If the group chooses to go to the right or decides that it is safe to descend a 40 degree slope, we want to know why. Sometimes a group will arrive with great satisfaction at a goal, thinking that they have picked the only safe route and we'll tell them that they can't return the way they came. Obviously, if it is unsafe, we will back off of this ultimatum at some point but it forces them to thoroughly examine their assumptions and alternatives. During one workshop with very unstable snow, a group was reasonably sure that the 37degree slope below them would avalanche if they tried to descend it. After some creative debate, they solved the problem, making their worst enemy into their best friend, by getting out their shovels and trundling snow onto the slope until it avalanched. Then they used the avalanche path to safely descend.

Note: To make field training effective and safe, the instructor: participant ratio should be as small as possible. We rarely allow ratios greater than 1:6. We do not split our groups. If one person has to return, the whole group returns. We divide groups according to travel ability and while the groups stay the same during the workshop, the instructors rotate between them.

Demonstrations: Creative graphics or models help to reinforce key concepts. For example, to show how terrain roughness affects the ability of a slope to produce avalanches, we use a plywood board with four different surfaces. One panel is varnished, one is unfinished with a few trees, one is covered with burlap, and the fourth has rocks glued onto it. We build a snowpack out of flour, sugar, and if there has been any recent volcanic activity, corn meal as ash. Slab formation is enhanced by simulated wind events, accompanied by sound effects. We ask participants what sequence they think the slopes will avalanche in and at what angles. With an inclinometer at the edge of the plywood and someone positioned to read the angles, we then incline the board. If all goes well, the smoothest surface (varathane) avalanches first at the lowest slope angle. The unvarnished plywood fails next and often, the fracture line runs between the stress concentration points, that is, from tree to tree. On the rocky slope, the initial fracture often occurs in snow layers above the buried anchors and then steps down to the deeper layer of sugar snow in the rocks. The burlap slope, which greatly resembles a rimed slope, is commonly the last to avalanche, convincing participants to only ski burlap. Another effective demonstration is to use "silly putty" to illustrate how snow can respond in viscous, elastic, or brittle modes depending upon a number of variables including temperature and the rate/amount of stress. We also use a gigantic rubber band as a special learning tool for those who are not grasping the concept of snow storing elastic energy.

By example: It does not work to teach one thing and do another. For example, we've learned that we can reduce the number of snowmachiner avalanche accidents by teaching snowmachiners that if they're going to play the risky game of "highmark", they should generally choose windward rather than leeward slopes and limit one rider at a time to the slope while all others are watching from a safe spot. During snowmachine field sessions, we reinforce this message by following this protocol. Another example is that many people have a conception that they have to be able to pick up a block of snow for it to be cohesive enough to be a slab. If you say that this is not necessarily true while showing a photograph of someone holding a block of snow, you are unwillingly reinforcing this misconception. People seem to remember visual images better than verbal qualifiers.

An interesting example of the "human factor" at work is that during an avalanche workshop, participants seem willing to unquestioningly follow the instructor. Sometimes, it is very instructive to set up a "no go" situation in which red lights are flashing. For example, during one avalanche workshop with very unstable snow, the instructor picked a goal that was unrealistic for the conditions and knew that the group would have to turn around when they reached a certain crux spot. The group reached this last safe spot, ate lunch, and talked in great detail about all the clues to instability and the high avalanche potential. Everyone then put their packs back on and the group continued uphill. The instructor let them file out ahead of him, knowing that they could move about 40 meters before they were in real danger. The last person in line turned around, saw the instructor standing in place, and asked if he was coming. The instructor answered "hell no" and the whole group scurried back. They were asked why they decided to go in the face of all the data and were amazed when they discovered that even in an avalanche workshop, where communication is encouraged, they had fallen victim to peer pressure and the "sheep syndrome". They learned far more from falling into this trap than if they had just been told to turn around by the instructor.

20/20 Hindsight: This is an invaluable tool because it allows us to work backwards from a known result. For example, we often play audio tapes of a victim talking about an accident and then have participants piece together the contributory terrain, snowpack, weather, and human factors, using the avalanche hazard evaluation checklist and assigning red, yellow, and green lights.

<u>Other:</u> There are many other factors that contribute to the success of an avalanche education program. These include attention to small details, logistics, and safety considerations, creating a good learning environment with a quiet classroom and easy access to avalanche terrain, having qualified instructors who not only are avalanche professionals but also know how to teach, making the limitations of the training clear, and steering participants to further resources for learning.

CONCLUSIONS

Probably the two groups at greatest risk are novices who do not even recognize potential avalanche problems and experienced travelers whose skill levels either lead them to take greater risks or who, at some point, become too complacent and get surprised. In teaching mountain travelers how to evaluate avalanche hazard, especially with the second group of experienced travelers, it is not enough to focus on the physical factors causing avalanches.

Human factors are a major influence in almost all avalanche accidents. A large number of accidents could be avoided if route selection and hazard evaluation decisions were based on critical data rather than upon assumptions and feelings. Teaching techniques to encourage this include learning by doing, with an emphasis on using a decision-making framework such as a checklist to help seek and assimilate important information.

Avalanche education will never prevent all accidents from occurring. More than once, someone has attended a good avalanche workshop and shortly thereafter, been caught or killed in an avalanche. This is tremendously disturbing to the instructors. Was something left out of the curriculum? Was false confidence instilled? At the completion of an avalanche workshop, participants should have many of the skills necessary to jump off the diving board, but they still need to make the leap, hit the water, and swim. Whether or not they drown depends largely on their attitude, judgement, and experience. It's very important to teach that avalanche education has its limitations and that the participants have the ultimate responsibility to use the information correctly. The biggest lesson is that the education process never stops.

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