ABSTRACT: Kids and snow – this obvious match can extend well beyond fun winter recreation, to be building blocks for intriguing and authentic units of study in school curriculum. By moving beyond the single day guest speaker, students can conduct authentic research in snow science. Since 1997 in Pinedale, Wyoming, high school students have been studying winter snow and wind in classes called “Field Science.” The results have spread beyond the classroom to students’ families and friends, and have stayed with students as lifetime learning.

The primary yearlong goal of Pinedale’s Field Science classes is to involve students in authentic science research projects, targeting local topics close to student interests. Winter projects in December through March in Wyoming, therefore, target snow and wind!

During Field Science 1, students focus on questions posed about snow and avalanches. Students work in “pit teams” with “pit kits” to dig numerous snowpits from December into March to compare snowpack characteristics over time and in various terrains. Weekly results are related to avalanche trends and recent occurrences, to build skills in personal safety and forecasting.

For second year students, the focus shifts to questions about wind, blowing snow, and control strategies. These students conduct field and lab trials to answer questions about wind and snow behavior around natural barriers and sets of differing snow fences. Results are applied to local landowners’ drifting problems, to further build skills in problem solving and communicating in real-life situations. The new challenge question begun in 2004 focuses on vortex generators and their potential for a drifting road to the White Pine Ski Area.

From 1997-2004, approximately 245 students have conducted snow science field research, and over 90 have continued through the second year. Both study units are evolving annually to incorporate new professional advisors, additional equipment, and new research questions. The program’s successes give a clear message that snow research is definitely a strong match for student science studies and lifetime learning benefits.

Keywords: outdoor education, avalanche education, snow studies, winter curriculum

1. INTRODUCTION

Kids and snow – this match is obvious for weekend and sports. However, the combination can extend well beyond recreation to become the building blocks for intriguing, challenging, and authentic units of study in school curriculum.

In Wyoming, often over half of the school year is during winter conditions, creating a superb opportunity for studying snow, ice, wind, avalanches, and winter habitats. Students can conduct authentic research studies in snow science by going outside, accessing real-time data on the Internet, and moving well beyond the single-day guest speaker.

Since 1997, high school students in Pinedale, Wyoming have been studying winter snow and wind in classes called “Field Science.” The primary year-long goals of Pinedale’s Field Science classes are to involve students in authentic science research projects, and to target topics that are related to student interests and where they live. Winter projects in Wyoming, therefore, target snow and wind! The positive results from these studies have spread beyond the classroom to students’ families and friends, and have stayed with students as lifetime learning.

During Field Science 1, students focus on questions posed about new snow, snow pack, and avalanches. The students are involved in various investigations: 1) In the field, students work in “pit teams” with “pit kits” to analyze numerous snowpits from December into March; snowpack characteristics are analyzed in diverse terrain and over several months. 2) Students use the Internet to access regional weather and avalanche forecast information to compare their own snowpack findings to that of the professionals. 3) Students also use the Internet to track avalanche incidents worldwide and regionally and compare to multi-year trends. Through these activities
students build knowledge and lifelong skills in snow science, winter safety and communication.

For second year students, the focus shifts to investigating questions about wind, blowing/drifting snow, and control strategies. These students participate in several investigations: 1) indoor experiments with small scale models to answer questions about wind behavior around various objects, 2) outdoor student-guided tours of wind and snow behavior around natural objects and driveways, 3) field trials at a field experiment site throughout the winter with full size snow fences to test variables of fence design, and 4) the Landowner Project, where students are challenged to be consultants to solve a blowing and drifting snow problem for a local landowner. The newest challenge project that started in 2003-04 focuses on vortex generators and their potential for a drifting road to the White Pine Ski Area.

Snow science offers potential for use of multiple core areas of education: science, history, sociology, math, art, reading and writing. Snow and wind are conditions many students live with for many months of each year. Teachers and snow professionals can build a partnership to incorporate winter research projects into the school curriculum, for the benefits of students' knowledge, active involvement in research, and lifelong personal safety.

2. HOW DOES THE PROGRAM FUNCTION?

Pinedale High School is in Pinedale, Wyoming, a small town at the base of the Wind River Mountains and at the edge of a sage/grass basin. The area typically has snow pack from mid-November into March, with plenty of wind. A school bus can drive from 7250' elevation at school to over 8000' near the White Pine Ski Area in just about 20 minutes. Most of the snowpit sites are within 5-15 minutes drive. The snow fence field experiment site is just 5 minutes from the school.

The school offers two years of "Field Science" as electives in our science offerings. Field Science 1 and 2 are outdoor-based research classes that target topics such as rivers, snow, wind, habitat, vegetation succession, fire ecology, local issues, etc. The goal is to use guided outdoor research projects from which students can develop concepts and skills about science topics from their locale and interest.

The Field Science classes meet Mondays and Wednesdays for 90 minutes per session, and 45 minutes on Fridays. This provides ample time for a 5-20 minute drive to a field site, with nearly an hour of fieldwork time, twice each week. Fridays work well for indoor activities. The winter projects run from December through March.

This type of class does require funding and access to land. The bus expenses are paid by the school's activity travel fund. The field equipment is purchased through the school budget, with frequent donations by local businesses as well. Private landowners have been very generous with allowing access to sites for research projects.

Teacher training has come through a variety of sources. Previous degrees in sciences were a starting point. The professional community both locally, regionally and on-line have been necessary for teachers to stay current in advancing knowledge and technologies in snow science. Teachers must be active in seeking out these professionals. Building a partnership between teachers and snow professionals is optimal for creating and maintaining a good program for students.

Students come into these classes with diverse backgrounds. Some students have lived in Wyoming their entire lives and already have extensive knowledge and experience with the outdoors, snow and wind. Other students are new to this environment and have to get their first pair of winter gloves for the class. Some students are taking every science class our school offers, and others are taking this to get their minimal requirements. The common thread is that they like to be outdoors, and they want to learn about something that affects them nearly every day (Figure 1).

Figure 1. Field Science students are diverse, but want to learn about their outdoor surroundings

3. FIELD SCIENCE 1 – WINTER SNOWPACK AND AVALANCHES

The objectives for Field Science 1’s Winter Snowpack and Avalanches span the activities during three months:
3.1 Students utilize “pit tools” to analyze snowpack (Figure 2):

- Shovel (dig pit and shear test)
- Brush (determine layers)
- Wooden/plastic sticks (delineate layers)
- Slope meter (slope angle)
- Wind gauge (wind speed)
- Meter stick (layer thicknesses)
- Stem thermometers (layer temperature)
- Fist (layer resistance)
- Magnifying loupe (crystal size & type)
- Crystal card (crystal size and identification)
- Snow scoop & spring scale (density of layers)
- Data sheet (recording pit profile)
- Camera (documentary)
- Followed by readings from numerous sources of professional literature

Figure 2. Part of a Snow "Pit Kit", a toolbox for studying snow pits

3.2 Students work in pit teams, doing a different job each day (Figure 3):

- Shoveller (slope, wind, dig pit, shear test)
- Layers Specialist (delineate layers, temperatures, resistance)
- Crystal Specialist (crystals, density)
- Recorder (record data, photograph)

Figure 3. Clockwise from upper left, students work in the tasks of the Shoveller, Layers Specialist, Crystal Specialist, and Data Recorder

3.3 Students analyze snow pits, focusing on the following topics and interaction (Figures 4 and 5):

The order in which these are presented is flexible in response to weather. For example, after a big snowstorm, the session would focus on effects of a large amount of new snow on the underlying layers, while after a night of wind, the session would focus on differences of scouring and deposition on windward and lee slopes. Each topic is eventually presented. Additionally, specific locations are chosen to exemplify each concept.

- Terrain
  - Slope angle, critical range
  - Aspect, north vs. south
  - Aspect, windward vs. lee slopes
  - Anchors, surface roughness
  - Elevation differences

- Weather
  - Precipitation
  - Temperature
  - Wind

- Snow Pack
  - New precipitation, types, amount
  - Metamorphosis
  - Layering
  - Temperature profiles
  - Resistance
  - Density
• Shear and Bonding
  • Relate to Avalanche Potential
    • Check online professional forecasts
    • Compare current snowpack
    • Propose a hazard rating to peers

Figure 4. Students climb sage-grass ridge for snow pits on both windward and lee slopes

Figure 5. Student teams work in pits in meadow site

3.4 Students study avalanche characteristics, statistics, and an introduction to rescue
  • Use video footage to visualize avalanches
  • Evaluate %’s of fatalities per activity, state, country, age group
  • Present incidents to peers
  • Focus on “what went right and what went wrong”
  • Design an active model of an avalanche so that changing the variables will change resultant avalanche (Figure 6)

Students complete this unit with two major projects. First, each student has an individual field test, where he/she analyzes a snowpit in an interview situation with the instructor, with no notes. The goal is for the student to use snow pit data to convince the instructor as to the safety of the snowpack in the terrain of that site. Additionally, students create and present a PowerPoint or poster presentation about some of their conclusions from the winter’s snowpit data, and their advice for avalanche safety. Students typically do very well with these, having worked in many snowpits during two months.

4. FIELD SCIENCE 2 – WINTER WIND AND BLOWING/DRIFTING SNOW ISSUES

The objectives for Field Science 2’s Winter Wind and Blowing/Drifting Snow Issues are related to the activities and achievements of the students over the course of three months. The research activities are overlapping during this project. The scheduling is flexible in response to weather, as drifting occurs only after the major snow/wind events. Activities include:

4.1 Model Experiments (Figure 7)

Students design small-scale indoor models to study the effects of various barriers on wind flow patterns. The results are then incorporated into recommendations for the Landowner Project. Past models have included:
  • Solid barriers of varying shapes such as buildings
  • Varying porosities
  • Vegetation types
  • Hairdryers for changing wind flow
  • Models of driveways and landscaping
  • Models of vortex generators
4.2 Field Trials at a Field Experiment Site

Students conduct a controlled experiment with full size snow fences throughout the winter, to test variables of fence design. Variables often include porosity, height and width, orientation to prevailing wind, and bottom gap height. The results from this controlled setting are then incorporated into recommendations for the Landowner Project. Each team of three students is responsible for one fence:

- Installation and maintenance (Figure 8)
- Collection of quantitative after several major wind events to analyze length, depth, and total volume of the snow collected with this type of fence (Figure 8)
- Reporting their fence results and implications for use (Figure 9)

4.3 Student-Guided Tours to Problem Drifting Sites

Each student locates and analyzes a place with a blowing and drifting situation, and then interprets the situation on-site for the rest of the group. The student-guide explains the wind, drifting, and presents a potential solution. The audience students respond with questions and propose additional solutions. The experience gained from this activity of communicating about multiple situations of drifting snow is also incorporated into recommendations for the Landowner Project.

4.4 The Landowner Project

This is the focus toward which the other activities are eventually directed. Early in the winter, a landowner with a drifting problem is chosen. Site visits are made (before the snow begins) to meet with the landowner, become familiar with the site and the owner’s goals and priorities (Figures 10 and 13). After literature research and some indoor wind flow model experiments, students propose snow fencing or other strategies to attempt to solve the landowners’ problem. Each team of 2-3 students is given a specific portion of the area to protect. Each team proposes their fence solution to the rest of the group for a final consensus overall plan.
The students install the fences (Figure 14). They collect drift data throughout the winter after major snow and wind events (Figures 11, 12, and 15). After observation of their results through the winter, and incorporation of results from other research (field trials, drifting tours, model experiments), each team makes a recommendation to the landowner for future strategies. The final presentation is attended by the students, landowner, and a local specialist in snow fence issues. Each student's explanation includes background, landowner's priorities, explanation of wind flow and fence design/function, analysis of that student's fence's intent and success, recommendation to the landowner for future, and responses to questions from landowner and snow specialist (Figure 16).

This Landowner Project has been in place for two winters. Landowners have been the Haffey family (Figures 10 - 12) and the McGuire family (Figures 13 – 16), both with new homes in challenging areas to keep free of blowing snow. These projects have proven to be the most intriguing aspect of our winter studies for Field Science 2 students. The task to “investigate, test, and recommend” draws on the students’ studies of field trials, models and literature. The Landowner Project combines all of the other projects into one consultant type, real-life project that connects the students and their work to community members and professional scientists.

Figure 10. Students make an early winter site visit to the Haffey Landowner Project to plan for fence strategies to keep snow off the yard and out of driveway

Figure 11. Students check on maintenance and snow catchment of fences mid-winter at Haffey's

Figure 12. Students evaluate success of snow fences in meeting goals and priorities to catch snow at Haffey's

Figure 13. Student team looks over drifting problem area at the McGuire Landowner Project during the planning process
Field Science 2 students investigate the use of vortex generators along his road.

During the first year, 2003-04, the students designed tabletop models of the vortex generators, which actually functioned in low to moderate winds (Figure 18). The goal is to establish a field investigation to test variables of the design. Also, to build full-size vortex generators to place along White Pine’s drifting road. This project puts students in a position to interact with business owners, Forest Service, other students, and scientists in a cooperative mission to address a big drifting situation.

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5. CONCLUSION

From 1997-2004, the Field Science program at Pinedale High School has continued to have the support of students, the school, and the community. Approximately 245 students have conducted snow science field research, and over 90 have continued through the second year. The program is evolving annually to incorporate new professional advisors, additional equipment, and new research questions. We now get calls from community members, telling us about a great spot
to study an unusual snow situation, or asking to be the next Landowner Project to help with their drifting problem. The program's successes give a clear message that snow research is definitely a strong match for student science studies and lifetime learning benefits.

The objective for presenting this educational program at the ISSW is to give an example of snow science in a public school. Snow professionals could use this example to encourage and mentor a teacher or two in their own communities to incorporate winter research projects into their curriculum. This would benefit students’ knowledge and personal safety, encourage students and teachers to do authentic scientific research, and provide teachers with support for an outdoor educational opportunity.

Snow science should be included in student research about their surroundings . . . and besides, it's really fun and energizing to do research in the snow and wind with students.

Yes, I still truly believe that after eight winters with kids and snow!