# SNOW SCIENCE IN A SECONDARY SCHOOL PHYSICS CURRICULUM

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ABSTRACT: As high school physics teachers, we want students to experience a strong applied curriculum, and snow science/avalanche education provides a unique opportunity to meet that goal. We included snow science as a unit in 12th-grade Physics at Nathan Hale High School in Seattle, Washington, combining classroom preparation with expert lectures on snowpack mechanics and snowpack analysis. Students assembled field kits that included tools, student-written instructions, and data tables. Two faculty took 60 students on an overnight field trip to Snoqualmie Pass, Washington, where we met with Washington State Department of Transportation avalanche controllers and analyzed snowpack at two very different sites. Students related classroom learning to field-based problems, increased their awareness and respect toward mountain environments, and learned some basics of snow avalanche forecasting and snowpack mechanics. Some students found connections to their participation in winter recreation, whereas others were in the mountains for the first time even though their homes are only 80 km away. Incorporating snow science/avalanche education in a standard secondary school curriculum prepares students to further their learning about snow science, causes them to connect classroom learning to real-life situations, and exposes students to careers and learning opportunities they may not have previously considered.

KEYWORDS: Education, physics, avalanche awareness, curriculum and instruction.

## 1. CONTEXT AND INTRODUCTION

Nathan Hale High School is a grade 9-12 secondary school in Seattle, Washington. It has an enrollment of approximately 1,100 and draws a student population roughly representative of the population of Seattle in terms of ethnicity ("Washington State Report Card," "Seattle-at-a-Glance"). Nathan Hale is one of Seattle's ten large, comprehensive high schools, but is the only one that has eliminated academic tracking as an intentional school reform ("CES Schools & Centers"). Physics classes are taught based on the Modeling Instruction Program, developed by Hestenes and others (Jackson). This curriculum is different from traditional lecture-first curricula in which labs reinforce the concepts taught by the teacher: in the Modeling curriculum, students are introduced to key physics concepts through labs, and lectures, homework and practice reinforce those concepts (Jackson). As such, this curriculum is a bit "stripped-down," and one of our goals as teachers was to add more applied physics to the class, whether they directly applied the concepts learned in the standard curriculum or provided supplementary content. In addition to snow physics/avalanche education, we created mini-units that deviated from our curriculum, including skits about "out there" physics topics such as relativity. In our view, a snow physics/avalanche education unit meets this goal of applied science in a way unlike other experiences our students have during high school.

## 2. INTRODUCING SNOW SCIENCE TO HIGH SCHOOL STUDENTS

We taught a unit covering some basic snow physics and avalanche topics with the express purpose of preparing the students for an overnight field trip, during which they would apply their knowledge and skills. In late January when the snow unit began, the students had built a significant knowledge of kinematics and dynamics, having studied linear motion, acceleration and forces; most students by this time understood and could draw force diagrams. We introduced the students to snow avalanches with a video, "Avalanche: The White Death," intended as a "hook"* to capture student interest. Students researched a variety of snow science topics in class using the Internet and presented posters about these topics to their colleagues; topics included snowpit tests, where avalanches can occur, what local forecast resources are available, what a transceiver is, etc. The instructors discussed selected relevant topics in greater detail in order to further understanding. Mark Moore of

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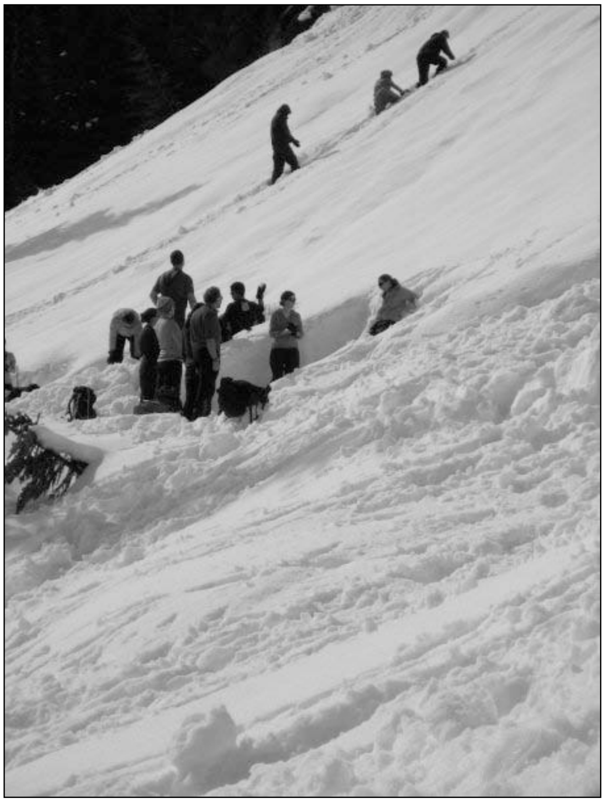

Figure 1: Students and instructors digging snowpits on a south-facing slope near Snoqualmie Pass, Washington. (Student photo)

the Northwest Weather and Avalanche Center gave a 50-minute presentation on the formation of avalanches, snow crystal types and specific snowpack analysis techniques that students would use in the field (Moore). Additionally, this unit had relevant timing as Interstate 90, Washington state's main east-west road, was shut down due to avalanche hazard for several days; Washington State Department of Transportation photographs posted to the Web were invaluable in showing students the physical environment in which avalanche professionals work, techniques for avalanche control and the consequences of major snow avalanches ("I-90 Avalanche Control"). Analysis of weather leading up to major snow avalanche events in the Cascade Mountains in 2008 led to some basic understanding of how snow avalanches form in the Cascades.

Students made final preparations for the field trip by authoring their own snowpack analysis handbooks. Most of these contained snow stratigraphy data tables for several sites as well as diagrams and instructions for digging snow pits and conducting strength tests.

## 3. FIELD STUDY

### *3.1 Physical setting*

Our overnight field trip took place on March 6-7, 2008. We stayed at the Washington Alpine Club's Guye Cabin, located 1 km west of Snoqualmie Pass, Washington, and dug snow pits at an open, south-facing site approximately 500 m northwest of the cabin at 900 m elevation and at a forested, north-facing site 1.5 km northeast of the cabin at 1100 m elevation. Conditions on the first day were relatively warm and sunny and on the second day slightly cooler and cloudy, but air temperatures remained above freezing during both days and dropped below freezing during the night. Students took advantage of the first day's sunny weather to not only dig snow pits and conduct stability tests, but also to use their snow pits as fortresses in an epic snowball battle.

### *3.2 Stability tests*

In groups of 3-6, students dug snow pits at both sites. Digging to the bottom of the snowpack was in itself a significant learning experience; most students, including those who participate in winter recreation, did not know how deep a Cascade snowpack can be. Students collected data on hardness using hand hardness tests, used Kool-Aid in spray bottles to identify layers, noted snow crystal types and sizes and snow temperature. Students conducted stability tests including shovel shear, shovel tap, stuff block and rutschblock. At the first site, students were in general agreement that snow avalanches were relatively unlikely, and at the second site students found that a colder snowpack had better preserved several weak layers.

### *3.3 Avalanche control demonstration*

In addition to field stability tests, avalanche controllers Aaron Horwitz and Lee Redden from the Washington State Department of Transportation gave a presentation on their work that included explanations of explosives and a demonstration of blasting caps. Students learned how snow is capable of dissipating energy by comparing the noise from a blasting cap detonated under the snow surface to that of one above the snow surface. (Horwitz and Redden)

### *3.4 Companion rescue practice*

In their field teams, students practiced a group transceiver search for two transmitting beacons. This lesson had the effect of demonstrating to the students what transceiver rescue consists of rather than developing skills,

Figure 2: Nathan Hale High School 12th-grade physics students, instructors and chaperones near Snoqualmie Pass, Washington. (Student photo)

and also gave students a rudimentary hands-on experience with electromagnetic fields.

*3.5 Other activities*

Also, students built igloos and snowcaves, which was not only a fun activity but also an effective hands-on lesson about some physical properties of snow.

## 4. STUDENT LEARNING AND REFLECTION

"Overall I'd say I learned why snow falls down hills."

(Nathan Hale Physics students)

*4.1 Reinforcing and applying physics concepts*

Why is teaching high school students, many of whom may not participate in winter recreation at all, important? Learning about snow physics and avalanches gave students an opportunity to apply some of the physics concepts they had learned in class to a real-world setting. According to student Cailen D. "there was the whole thing about the bonds between snow and how that affected the chance of an avalanche occurring. I would say that basically the avalanche pits and avalanches themselves were a way for us to really experience what we had talked about in class for the whole year. It made the physics concepts real not just something to memorize an equation for... I think the part that stuck with me the most was how the different layers formed and why and also how that contributed to the chance of an avalanche happening." (Nathan Hale Physics students)

According to student Kai R. "the snow avalanche trip unit fit into the physics curriculum because the whole reason an avalanche happens has to do with gravity, potential energy, and many other factors. It just so happens that physics deals a lot with gravity and energy!" (Nathan Hale Physics students). Students also saw how concepts of energy transfers apply during a demonstration of blasting caps. The cognitive value of applying concepts or transferring knowledge to new situations has been established by educational research (Bransford et al. 73-78).

*4.2 The value of unique educational opportunities*

Additionally, this unit was valuable because it gave the students a unique group learning experience. This increased students' affinities toward science and toward the outdoors. According to student Nick L. "The activities we did on the field trip were all new to me, which is why I found it such an amazing experience. I had never been much of an outdoors person, but this field trip was unique and enjoyable, not to mention educational." (Nathan Hale Physics students)

According to Patrick T. "I felt that this trip was definitely one of the highlights of my high school experience, that provided bonding time with my peers that was lacking in our school." (Nathan Hale Physics students)

Providing experiences that are not only educational but also enjoyable should be a goal for teachers in order to increase students' affinities toward science, and combining powerful conceptual applications with enjoyable experiences also makes for a good career exploration.

## 5. APPLICATION/CONCLUSION

In terms of snow avalanche education, this unit can be categorized as avalanche awareness, an introduction to avalanches, and a portion of a companion rescue field clinic. Educating people who would not otherwise come into contact with snow avalanches about this topic can be important in order to make other learning more relevant, to explore previously unconsidered careers, to develop affinities toward outdoor recreation, and to understand transportation policy in areas such as Washington state. Given an understanding of snow avalanches, it seems more likely that students would support funding for avalanche forecasting. Other secondary schools could integrate a snow physics/avalanche education curriculum into various courses; physics is especially appropriate, and interested students may be able to continue and deepen avalanche education with local organizations and receive academic credit for such studies.

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