EXEMPLARY SCIENCE

Exemplary Science for Resolving Societal Challenges

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Tahoma Outdoor Academy:

Learning About Science and the Environment Inside and Outside the Classroom

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Setting

We encounter scientific information and products of scientific inquiry in our everyday lives, thus science literacy is a necessity (AAAS 1993; NRC 1996). Learning standards emphasize preparing students to become responsible citizens who are able to actively participate in debates and problem solving by using science concepts and skills. As the number of environmental problems the world faces grows, it is important for students to understand the science concepts and social issues underlying these problems and to be able to develop effective solutions. A promising educational approach involves using the environment as an integrating context to help students develop understanding of science as well as a sense of responsibility and stewardship toward the planet. Helping students develop another type of literacy—environmental literacy—is crucial for the 21st century (Hungerford 2010; NAAEE 2004).

Introduction

Science is often regarded as the most appropriate subject with which to integrate environmental education because scientific concepts form the foundation of environmental education (Ham, Rellergert-Taylor, and Krumpe 1988; Simmons 1989). The essential features of scientific inquiry, such as posing questions, organizing evidence to make a claim, and communicating results

(Martin-Hansen 2002) allow students to apply the "processes of science" (NRC 1996, p. 105) to complex environmental issues and interactions. Environmental education can provide novel and interesting learning contexts, activities, and perspectives. It also can make the science curriculum more appropriate and accessible for a wider range of students. Much of typical science education focuses on knowledge acquisition and learning concepts that are outside the experience of many students and therefore lacks relevance in their lives. In contrast, environmental education focuses on the local environment and community issues, making these alien science concepts more interesting and likely to be remembered (Dillon and Scott 2002; Gough 2002). It also can make science more culturally and socially relevant and help students develop novel and useful social and cognitive skills.

Although science is considered as the best fit for environmental education, proponents of infusion and interdisciplinary models recommend incorporating environmental education into a wide range of school subjects, including science, social studies, mathematics, language arts, and art. For instance, Rosenthal (2003, p. 154) advocates an arts-based approach; through this approach teachers can "cultivate systemic thinking, interdisciplinary problem solving, collaboration, and social and environmental responsibility" which is beneficial to all students entering "a world that demands creative and far-reaching responses to the damage we have wrought upon human and non-human systems."

Taking students outside of the classroom is recognized as a valid and important pedagogical practice; however, teachers at all levels feel challenged when faced with integrating informal, outdoor, and community settings with subject-specific curricula and mandated learning outcomes (Falk and Balling 2001; Michie 1998; Price and Hein 1991; Simmons 1998; Smith and Williams 1999). There is a need for models of integration that also address engaging students in field investigations and civic participation.

In this chapter we describe a high school program that uses the environment as an integrating context for science, language arts, health and fitness, and service-learning. We explore how the program influences students' understanding of science, environmental concepts, and inquiry skills.

Program Description: High School Outdoor Academy

The Tahoma Outdoor Academy is a program implemented in a high school in a suburban community of 17,800, 30 minutes outside Seattle, Washington. Over the years, teachers and staff have worked closely with the Pacific Education Institute (PEI)[1] to design interesting and innovative programs with inquiry, critical thinking, and environmental education as threads that unite different grade levels and subject areas. Aided by these coordinated efforts, the district has become one of the 10 highest performing districts in the state, with students scoring in the top 10% on the state standardized tests in mathematics, language arts, and science.

1. The Pacific Education Institute (*www.pacificeducationinstitute.org*) is a consortium of stakeholders interested in advancing student learning through curriculum designed around using the environment as an integrating context. It includes representatives from the business community, nonprofit educational and environmental organizations, state agencies, national environmental education programs, residential environmental learning centers, school districts, and individual schools.

Thematically organized instruction helps to integrate the normally disconnected course offerings found in comprehensive high schools and creates learning communities of teachers and students (NRC and Institute of Medicine 2004). The Tahoma Outdoor Academy Program is a yearlong, Grade 10 outdoor and environmental course that connects the study of science to other school subjects (including language arts, health, and fitness) as suggested by NSES Program Standard B (NRC 1996). The goals of the program are (1) to improve student learning; (2) to teach students to become environmentally literate citizens and lifelong learners; (3) to create a link between learning in school and the world beyond school; and (4) to explore local areas and the impact of humans on the environment. A service-learning component engages students outside the classroom in county nature parks and is consistent with NSES Program Standard D: "Good science programs require access to the world beyond the classroom" (NRC 1996, p. 218). Students conduct field investigations. Exploring the park environments, they "formulate questions and devise ways to answer them, they collect data and decide how to represent it, they organize data to generate knowledge" (NRC 1996, p. 33).

The program is taught by three teachers who integrate their subject areas with topics of environmental education, outdoor education, and stewardship. It enrolls approximately 90 students annually and includes students at all levels of achievement.

Students meet every other day (the school has a rotating schedule) and participate in the outdoor academy for an entire school day. A typical day starts with a whole-group session in which teachers and students discuss environmental issues using presentations, newspaper articles, books, and guest lectures given by community environmental advocates and wildlife biologists. Students then have time to discuss the issues with their peers and write reflections in their science journals. After the whole-group session, the class is divided into three groups of 30 students, one group per teacher. The groups rotate among the teachers for the rest of the day, and all students participate in one science, one language arts, and one health and fitness class. Lessons are often built around a common topic and use integrated assessments that require application of science, language arts, and fitness skills and concepts.

Outdoor Academy Curriculum

The Outdoor Academy curriculum includes themes of stewardship, environmental sustainability, and responsibility. It was designed by the three teachers, who tailored existing resources on outdoor and environmental education and ecology to the needs of their students (see Table 7.1, pp. 96–97).

The year begins with a water unit (September to December). Students explore their connections with the natural world through literature, scientific investigations, and such recreational activities as fishing and hiking. In the language arts class students read books about rivers and oceans and their roles in human lives (*A River Runs Through It* and *The Old Man and the Sea*). In science class they study aquatic ecosystems, visit a local river, and complete a field investigation research project exploring one aspect of the river's health. In health and fitness class students learn fly fishing skills, fish identification and classification, and discuss how to act responsibly in the outdoor environment.

In the second unit (January to March), students explore human behavior in the natural world. They discuss topics of risk taking, self-control, and perseverance. They read books about

Table 7.1. Outdoor Academy Program: Curriculum Topics (italics) and Activities (bullet

	Language Arts	Health and Fitness	
September – December			
Topic: Humans and Nature. Exploring humankinds' relationship with the natural world. Personification of nature. Integrated Assignment: Research project on water/river issues	*Old Man and the Sea* • Characterization; metaphor; symbolism; allegory; allusion; theme/motif *River Runs Through It* • Personification (reinforced with Emmons and Green River trips) • Foreshadowing • Expository essay *River Packet* • Supplements the two novels • Reinforces learning targets above • Stewardship *Research component (river project)* • Working with secondary sources	*Fishing skills and activities* • Fishing equipment • Casting, fly tying, knots • Casting competition • Personification of rod, cast *Stewardship* • "Leave No Trace" *Reading water* *Life cycle of aquatic invertebrates* *Fish identification* *River practice*	
January – March			
Topic: World of life. Risk. Perseverance. Integrated Assignment: writing assignment	*Lord of the Flies* • Theme/Motif • Symbolism • Allegory • Diction *Thematic unit (perseverance, ambition, dual nature, addiction to risk)* • Into Thin Air • Touching the Void • Shackleton • other	*Orienteering* • LOTF exercise • GPS *Rock Climbing* • Terminology and equipment; techniques; rescue; safety; communication; movement principles; climbing activities *Fitness Testing* • Personal Fitness Plan *Touching the Void* • Large discussion	
April			
Topic: Biking and poetry	*Literature Circles* • Readings about nature and environment *Poetry* • WASL practice	*Biking* • Safety; maintenance; skills; field experience *Fitness Testing* • Personal Fitness Plan	
May – June			
Topic: Field investigations Integrated Assignment: "I went to the Woods" - culminating project with stewardship focus	*Into the Wild* • Discussion skills; diction; irony *Walden* • Stewardship • Text-to-text connections • Self-reliance and nature *"I went to the Woods"* • Personal narrative	*Stewardship* *River restoration* *Conservancy exploration*	

	Science	Service-Learning	Other Field Experiences
	Aquatic Invertebrates • Life cycles • Classification • Water quality (including chemistry, biology, environmental impact) *Experimental design (research project)* *Communities and Ecosystems* *Managing Human Affected Ecosystems* *Symbolism* • Spotted Owl; Salmon *River Culminating Project*	*Aquatic Invertebrate Survey* *Stewardship* • Identifying concerns/issues • Begin reconciling *Habitat Restoration* • Invasive species removal *Trail Building* *Links to curriculum* • Personification work • Theme work • Symbolism work • Reflective writing • Casting practice	*Hikes* • Green River • Mid Fork of Snoqualmie • Emmons/Glasier Basin • Holder/Carey Creek hike *Habits of Mind* • Gathering data through the senses • Responding with wonderment and awe • Thinking and communicating with clarity and precision • Listening with understanding and empathy
	Organisms and Systems • Interrelationships • Limiting factors • Human/ Environment interaction • Continuity of life *Stream/River Dynamics* *Cartography/Mapping* • Soil investigations *DNA* *Research project*	*Data collection* • Erosion evaluation • Soil data collection • Mapping the area *Habitat Restoration* • Invasive species removal; planting of native species *Trail building* *Links to curriculum* • Orienteering • Rescue training	*Hike, Snowshoeing, etc.* • Vertical World • White River hike • Taylor Mt. Geocache hike *Amazing race* *Habits of mind* • Persistence • Taking responsible risks • Managing impulsivity *Other skills* • GIS training • Arcview training
	Human Body Systems	*Habitat Restoration* • Trail building *Links to curriculum* • Outdoor poetry	*Biking* *Habits of Mind* • Thinking flexibly • Responding with wonderment and awe
	Ecology *Identification of plants and animals* • Field guides • Systems • STELLA *Ethnobotany*	*Habitat Restoration* *Trail building* *Links to curriculum* • Filed survey/guide development • Outdoor reading/writing	*Hike* • Mailbox Peak • Overnight base camp

human behavior in extreme natural environments (*Touching the Void*), and learn rock climbing, mapping, GPS, and orienteering skills.

The third unit (April) focuses on poetry and recreation activities such as biking. Students explore local trails and read poems about the natural world.

The fourth, culminating unit (May to June) is designed around ecology concepts. Students read about and discuss ideas of survival in the wilderness, self-reliance, and self-actualization. In science they learn about local plants and native peoples' uses of them. The year ends with an overnight camping trip and a challenging hike on a local mountain, Mailbox Peak.

Environmental Education and Stewardship

Environmental education and stewardship are important components of the Outdoor Academy program. The curriculum uses these topics as a basis for integrating assignments and discussions. Environmental topics are included in discussions and presentations during the common hour in the morning. The following comment by a teacher illustrates the nature of program learning experiences.

> In large groups we usually talk about different issues. We talk about problems, current issues that appear in the newspapers; we talk about stewardship. So if something [is] going on, we usually use it as a focus for a discussion. We talk.

In addition, a number of field investigations, such as water quality and soil testing, are conducted throughout the year. In the first semester students do a group research project in which they investigate an issue related to a stream at one of the service-learning sites. Each student also completes a secondary research project in which he or she selects an environmental issue or a stewardship topic. Students are taught how to search for and work with information sources and how to write a report. One student explained the process:

> We wrote 30 or 40 different topics on the board and everybody took one they liked and we wrote tons of questions on it. We started off with global warming and then things that were affected by global warming and then we broadened it to this environmental stuff... you know, trees, fishing, life in oceans... things to do with the environment. Then we started to research them, and make note cards and write outlines. And now we are at the point when we are writing a paper right now. It's kind of the whole research process.

Finally, environmental and stewardship education is part of outdoor activities where students participate in service-learning projects. Again, emphasizing the importance of discussing environmental issues, the teacher explained, "It's something that we also do when we go outside. When we go on the field trips, we discuss how to be respectful and, you know, leave no trace. We talk about stuff like that a lot."

Service-Learning

Service-learning is a teaching and learning strategy that "integrates community service with academic study to enrich learning, teach civic responsibility, and strengthen communities"

(National Commission on Service-Learning 2002, p. 3). Some consider it to be one of the elements of a successful environmental education program (Athman and Monroe 2004). It allows educators to design programs that integrate academic learning with meaningful service that meets the needs of the community and includes personal development and stewardship. Teachers of the Outdoor Academy name "connecting" and "giving back to the community" as important goals of the program. As a result, two service-learning projects are designed and incorporated into the program. From September to June students work with county representatives on restoring the Log Cabin Reach natural area, removing invasive species and planting native plants. As one student described,

> We planted trees at Log Cabin Reach, we planted a lot, and then we removed blackberry bushes, because they are invasive and then we put this black mat over the trees that we just planted, so the blackberry bushes cannot grow back and kill the trees.

Another service-learning project involved trail building and maintenance in a neighboring nature park. A student shared, "We went to Taylor Mountain and we cleaned all the trails, we clean all the roots and stuff and the leaves, and that was interesting." Students visit the sites every two weeks for the whole day. In addition to the service-learning components, the sites are also used to teach classroom concepts and topics; for example, students conduct water and soil tests, practice fly fishing skills, write journal entries, and discuss "leave no trace" practices.

Curriculum Models: Field Investigations and Civic Participation

The Outdoor Academy program is guided by two curriculum models—one for field investigations and one for civic participation. As "science is not a fixed body of knowledge but an evolving attempt by humans to create a coherent description of the physical universe" (White 2003, p. 174), students learn how to conduct descriptive, comparative, and correlative field investigations to explore natural and scientific phenomena (Figure 7.1, p. 100). Three types of field investigations are explored. *Descriptive* field investigations involve describing or quantifying parts of a natural system. In *comparative* field investigations, data are collected on different populations of organisms, or under different conditions (e.g., times of year, locations), to make comparisons. *Correlative* field investigations involve measuring or observing two variables and searching for a pattern (Ryken et al. 2007; Windschitl et al. 2007).

The students' field investigations involve essential features of scientific inquiry (NSES Content Standard A), such as asking "a question about objects, organisms, and events in the environment," planning a systematic approach to data collection, and developing "descriptions, explanations, predictions, and models using evidence" (NRC 1996, pp. 122, 145). In addition, the investigations help students develop skills such as mapping and perspective-taking to study community sites (CEE 2002). Students talk vividly about their field investigations. One student said,

> We learned a lot about the experimental design and collecting data and .... procedures to find levels of DO [Dissolved oxygen] and that kind of stuff... We had to make a hypothesis

Figure 7.1. Sample Student Field Investigation Research Questions

Essential Question How does housing development in the community affect fish in the nearby stream?	
Field Investigation Type	**Investigative Questions**
Descriptive studies Choose measurable or observable variables.	What areas of the stream are more populated with fish? What do fish eat?
Comparative studies Choose one focus variable to be measured and observed in at least two different locations, times, or populations.	How does the level of dissolved oxygen needed by fish vary by season? Is there a difference in numbers of fish upstream and downstream from the housing development?
Correlation studies Choose two continuous variables to be measured together and tested for a relationship.	Do the numbers of fish decrease with more houses being built along the river? Is there a relationship between fish population decreases and human population increases?

about the water, like the plants, how they grow and we had to make a whole science experiment, and then we had to do it and collect all the data, and that was fun.

Students are able to talk at length about their investigations and connect them to the research of other scientists, as this student explained,

> We've done a lot with rivers and bugs in the rivers. First we wrote questions about the river and what would look like good scientific investigation questions. So I did some kind of bug study, how logs in the river affect bugs. So we had to go to the river and go to different sites and collect data and go into the river and get bugs... It went pretty good. ... [I found] pretty much what I expected. I mean I thought that there would be more bugs downstream than it would be upstream from the logs ... and it was pretty much what I thought. I did a lot of research in class before we went there, so I kind of based my study on that research. And it was right... I think because the water runs past the logs, and there is material, organic stuff that comes off of it which bugs eat, so there are more bugs downstream because all that stuff is washed off the log and they eat it... so downstream there is more food, so there are more bugs.

Consistent with the NSES Science and Technology Content Standard E and Science in Personal and Social Perspectives Content Standard F (NRC 1996), the Outdoor Academy uses benchmarks for civic participation (Figure 7.2) to emphasize that the scientific process involves engagement with stakeholders within the community (Ferguson et al. 2004). Students identify an issue that involves interplay between human and natural systems, consider the perspectives of multiple stakeholders, create a plan of action, and implement and evaluate the plan. One student reported,

We're doing a project right now; we chose something that we have to think about. I chose waste and I found out what they do to our environment. And everybody does his own topic. The teachers teach us about it and we are still finding out facts and then we'll have to write a paper about it. I'm writing about how we can recycle, and that we need to reduce the waste because if affects our environment. What we do now will affect future generations.

Figure 7.2. Civic Participation Integrated Benchmarks

Step 1: Work with peers and community members to identify and describe a local, regional, or international issue that involves interplay between human and natural systems.

- Identify and describe the natural system, human political and economic systems, and human cultures.

Step 2: Identify the major players and stakeholders (e.g., government agencies, diverse cultural groups, producers, consumers, organizations, and individuals), their perspectives, interests, and resulting positions.

- Determine and describe why the stakeholders hold their given values and beliefs.

Step 3: Explore ways to address the issue by creating and/or considering alternative solutions related to the issue.

- Consider the feasibility, responsiveness, and likely effectiveness of different action plans.

Step 4: Collaborate in the development of a plan of action in response to the issue.

- Include objectives, timelines, tasks, products, division of labor, and evaluation methods.

Step 5: Prepare a rationale for the plan.

- Consider the impact on the major stakeholders, response of stakeholders, potential consequences (e.g., environmental, human health, public policy, and economic) of implementation.

Step 6: Implement the plan.

- Collect evidence of civic behaviors (e.g., communication with stakeholders, videotapes, surveys or evaluations, photographs, products, and action logs).

Step 7: Evaluate the effectiveness of the plan.

- Evaluate effectiveness based on initial criteria and describe the unintended consequences of implementation.

Assessment Strategies

To evaluate student learning, teachers use a variety of assessments that range from traditional quizzes and short reflections to large, integrated research and writing projects. For example, students design and carry out an investigation related to a water issue (science) during their outdoor classes and write a report summarizing their findings (science and language arts). They also write papers on environmental issues in which they have to demonstrate both understanding of the concepts related to the topic (science) and their ability to use and reference various sources of information (language arts). Another integrated assignment asks students to write a fictional mystery story: students are provided with the beginning of the story and the facts from a "crime scene" in the mountains. They create a story (language arts) that solves the mystery using knowledge of DNA concepts (science) and skills and knowledge of rock climbing (learned during their health and fitness classes). Finally, at the end of the year, students reflect on their experiences in the program through the "I went to the woods" writing project in which they explore their relationship with the natural world and their understanding of stewardship values.

Evidence of Student Learning

The Outdoor Academy program provides a model of how the environment can serve as an integrating context for learning the combined content of science, language arts, and health and fitness at the high school level. Inquiry tasks are used to document student learning, and students' reflections are used to understand their experiences in the program.

Inquiry Performance Tasks

Two scenario-based inquiry tasks developed by the Pacific Education Institute are used to assess student knowledge of science topics as well as their ability to design a field investigation. The tasks are administered at the beginning and the end of the year. At the beginning of the year, students complete a soil percolation task which asks them to design an experiment on how different locations affect water percolation time. At the end of the year, students complete a hot spot task that requires them to design an investigation to determine how different locations affect the surface temperature of the ground. Students identify and include the responding (or dependent), manipulated (or independent), and controlled variables. They also describe steps of the procedure that could be used to repeat the investigation successfully. Student work is evaluated using a rubric (Figure 7.3).

Analysis of inquiry performance tasks demonstrates that students develop better understanding of the field investigation process over time. Most students (75%) were able to design more elaborate and complex investigations to answer the proposed research questions. On the pre-program task, some students struggled with identifying manipulated (independent) and controlled variables; in contrast, on the post-program task the majority of the procedures included all three variables. At the end of the year, students also developed better tables for recording the measurements and more detailed step-by-step descriptions of the investigations.

Figure 7.4, page 104, illustrates a representative inquiry performance task response, in which the student makes a prediction ("the higher up the more it rains") and then gives a reason for her thinking ("because the higher up one goes the higher the humidity/moisture

Figure 7.3. Inquiry Performance Task Rubric

Prediction/Hypothesis	Student predicts how manipulated variable (e.g., time, location, organism, population) affects the responding variable. Students provide a reason for their prediction/ hypothesis.
Materials	Student lists materials and tools needed to perform the investigation.
Controlled Variable (kept the same)	Student states or implies at least two ways that measuring variables and/or sampling are kept the same.
Manipulated Variable (changed)	Student states what is changed (e.g., location, substrate, habitat, time, organism, or population).
Responding Variable (measured)	Student states how data is observed, measured, and recorded.
Logical Steps With Trials Repeated	The steps of the procedure are detailed enough to repeat the procedure effectively. Student indicates that data will be recorded or creates a data table that includes date, time and weather conditions. Student notes that data will be measured more than once at each location.

is found in the air"). In addition, the student states three ways that sampling and measuring are kept the same (e.g., collect rain for three minutes, select sites that are open, and collect in the same rainy weather), notes three different elevations for study (manipulated variable), and includes multiple trials at each elevation.

Student Reflections

To explore the types of learning experienced as a result of the outdoor academy program, interviews were conducted with a subset of students at the beginning and the end of the year. The interviews demonstrated that students learned about environmental science concepts, interactions among humans and the environment, and social skills.

Understanding of Science Concepts

The interviews revealed that students developed understanding of science concepts and began to make connections between areas of science as well as connections between science and other subject areas. Students developed inquiry skills, learned how to conduct field investigations, and commented that learning became more engaging, relevant, and personal. The curriculum included physics, chemistry, and biology as well as environmental science topics, which assisted the Outdoor Academy students to develop an understanding of relational concepts such as populations, cycles, and carrying capacity. Many of these topics and issues were explored through hands-on investigations and group work. Students were encouraged to pose questions, search for information, and explore multiple perspectives and points of view. One student said,

> We asked some questions, and we had our own questions... we had to get some information for it. It could focus on water quality; it could ask how the soil affects the water quality, and then how the native plants in the area affect the water level. Then we had

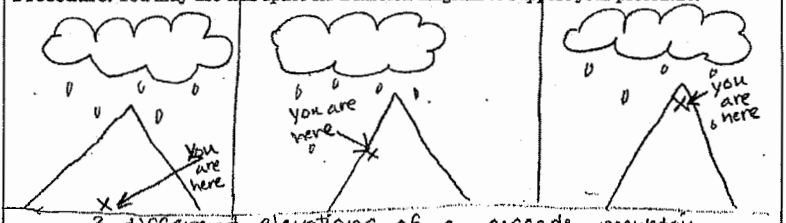
Figure 7.4. Inquiry Performance Task: Student Response

Question: How does change in elevation up the west side of a Cascade mountain affect the amount of rain?

Hypothesis (prediction): If the change in elevation affects the amount of rain then the higher up the more rain you'll get because the higher up the more amount of humidity/moisture is in the air

Materials:
- elevation counter on a watch
- measuring cup
- stop watch
- cascade mountain

Procedure: You may use this space for a labeled diagram to support your procedure.



3 different elevations of a cascade mountain

Procedure (continued):
1. Record date, time and cascade mountain
2. Describe rain weather(sprinkles, hard rain, freezing rain, ect.)
3. Pick 3 different elevations on the mountain, where you will test rain fall amounts.
4. Record elevations (ex. 5ft, 500ft, 100 ft.)
5. Go to each elevation, and pick a spot that is open and not crowded by trees.
6. Hold a measuring cup out and time for 3 minutes.
7. Record the amount of rain collected during the 3 minutes in mL.
8. Repeat steps 5-7 for the other two elevations.
9. Repeat the entire investigation 3 more times, using the same elevations and almost the same rainy weather.

> a whole bunch of different kits we could use to go and find additional information. My question was [about] the difference between native and invasive species and the water quality. I found there were more native species where the water quality was better. Where there are more invasive species like raspberries, no blueberries that were not supposed to be there, the water quality was poor.

Field investigations were part of the program's curriculum, and students were required to design and conduct an experiment that dealt with a water issue. However, unlike many of their peers who explored similar topics by reading a textbook, Outdoor Academy students used their service-learning sites as areas for data collection. This made the process of learning more real, memorable, and interesting.

Because the Outdoor Academy program integrates several subjects, students were able to develop connections between subject areas as they explored environmental topics through the lenses of difference disciplines. They recalled studying creative and technical writing, symbolism, metaphors, allegories, and motifs in English, and learning games, fitness, and recreational skills in physical education. Students reflected that integration of the three subject areas made learning a more integrated experience. One said,

> In English we are learning to cite works and stuff like that, which is also connected to a project in our science class. It's helping... we were working on fly fishing and we study lots of fish in science, and then we work on the actual fly fishing in PE, and then we read a book about fly fishing in English. It's always like mixed all together. They are integrated.

This student's comments demonstrate that meaningful assignments increase student commitment to learning:

> Mr. V. had us write, which incorporated genetics and rock climbing and story writing, all in one assignment. That was pretty cool. It was a murder mystery, and you had to explain what happened, who did it [committed murder], how the detective found out who did it and why that person did it. It was actually pretty fun to write. I ended up with 5-6 pages more than what was required. He asked for 12 and I ended up with 19. So, I really liked doing it.

Learning About Environmental Issues

Over the course of the year, students conducted a number of research projects that focused on various environmental issues. Topics identified through group discussions included global warming, climate change, pollution, acid rain, and deforestation. NSES Content Standard F emphasizes the importance of students exploring how humans use natural resources and how human activities impact natural systems (NRC 1996). Student awareness of environmental issues increased, as one student noted,

> We picked an environmental issue that we liked, I picked deforestation and learned how it's affecting the world in general and what the problems are because of it right now... really important issues that we are learning about and we are more aware about.

Students learned how to search for and evaluate information, compare stakeholders' perspectives on environmental issues, and consider possible solutions, and reflect on how the topic each student selected was related to individual lifestyles and choices.

Learning About Interdependence Between Humans and the Natural World

Through discussions and readings, Outdoor Academy students developed an understanding of the interdependence of human and natural systems and explored various cultural perspectives on these issues. Students saw humans as an integral part of the environment and came to understand how human activities and choices affect the delicate balance of natural systems. For example, students learned that humans are a part of the environment and human actions have indirect impacts on the state of the environment in other parts of the world. A student commented,

> The environment it is not like way back in the woods where there are no humans, and everything that we do. That is what I've learned this year so far, that everything that we do affects things that we never even see. And down the road, there are a lot of things that we don't see, but we have to take them into consideration, even if we are not directly affected by something else.

Participation in the Outdoor Academy program encourages students to rethink their personal lifestyles and choices so they can consider how they might act responsibly toward the planet. Students reported making changes in their everyday actions, noting that their sense of responsibility had grown from experiential learning aspects that gave them numerous opportunities to enjoy the "great outdoors." The program changed students' behaviours and empowered them to take environmental actions, viewing environmental stewardship not as an obligation, but as a way to solve problems, as one student remarked,

> The care for the environment is not just, "take care because you have to," it's really, you want to do it. It's really trying to understand it, to learn about the environment, and stuff like that. Do not just think about it as an obligation, but to think of it as... people think about it as they need to do it. But you should think about it as what it is expected from everybody because of people you love. We talk about what it should look like. And when we go there, on field trips, before we went we got to learn what it is like properly act out there. We learn... to leave no trace, when we leave none of our garbage behind. We don't break stuff, we leave the environment as it was before we came and when we began it was just a role, but they don't need to tell us any more, we just do it, because we understand what the problem is. And what we can do about it.

Lifelong Learning Skills

Students in the Outdoor Academy collaborated and learned to engage in scientific conversations as recommended in the NSES Teaching Standards. Through group projects (inside and outside the

classroom) and discussions and reflections on readings and experiences, students developed better understanding of themselves and their classmates. They developed communication and public speaking skills, and learned how to work independently and in groups. Through the various activities they gained insight on their life choices and personal goals. As one student's comments below demonstrate, they learned about their own beliefs and also the beliefs of others,

> I think I learned more about myself, what I want do, where I want go... being more outgoing, more comfortable with speaking in front of people, presenting, being myself. I learned about my perspective on a lot of different issues, politics and things like that. I learned a lot about what my beliefs are, how to handle myself in situations, how to push myself, to try harder and motivate myself. I learned a lot of things in science, basic science, but fun I guess. Language arts and English, I actually I learned more in that class probably than in the others, because all of the writing tests that we did were kind of like what would you change about yourself... questions you have to think a lot about, make you question things and just make you think a lot, and I learned a lot about myself, and how I feel about things. Then we read some of them aloud and kind of learned what other people's perspectives on all things that we've talked about. I learned how to be open minded to other people's ideas.

Students developed better group skills and learned how to work with peers, how to help each other, to be open-minded with other peoples' ideas, and to value others' opinions and perspectives. As this student said,

> I learned a lot of maturing things... how to be a part of a group, how to respect other peoples things, and ... the way the people are. I learned to function well with other people who might not necessarily be the same as [me]. And then, I learned respect overall for everything, learning to be... instead of being loud and being in everybody's face all the time, to sit back and listen to what other people are saying and ... I guess just be more receptive to other people.

The program provides many physical, mental, and intellectual challenges for students. The large, integrated research projects require that students apply knowledge and skills from all three subject areas, and go beyond the regular high school curriculum. In addition to curriculum challenges, the program includes a lot of intense physical activities, such as tree planting, removal of invasive plants, hikes, mountain biking, and rock climbing. For many students, especially those without prior outdoor or recreational experience, the level of difficulty was challenging. Students however, emphasized that the program taught them perseverance and how to face these challenges, as one said,

> They [the teachers] don't tell you how to make it up to the top... you can just sit down and wait for them to come back down when they are on the hike. The challenge is to keep going like, no, I am making it to the top. Because they gave the option of not doing it or doing it. And you want to show them you can. I am not in this class just because I thought it was easy, I am in this class because I am going do what we are going to do. So challenges really

> ... because they are not there to push you anymore, you have to push yourself. And the challenge is keep on pushing yourself to make it better. And that's one of the hardest things.

Students particularly enjoy the social aspects of the program, the hands-on learning, the encouragement from teachers who created fun and interesting lessons, and the fact that the program activities often had real-life applications (such as collecting research data for county officials regarding water and soil quality). These activities kept students motivated, as one noted,

> Personally for me school, especially at this time of the year, during the last couple of months, It's hard to stay focused a lot of the times. And stay motivated ... and this class helps you... It's almost easier to stay focused. It's easier to just get your work done and do a lot of stuff because all these things, you enjoy them I guess.

Conclusion

The Outdoor Academy program illustrates how using the environment as an integrating context for learning at the high school level can help students develop an understanding of science concepts; engage them in debates about local, regional, and global issues; and involve students in community projects. The interdisciplinary nature of the Tahoma Outdoor Academy program helps students make connections among topics and phenomena in science, technology, the environment, and society, and makes school learning relevant and engaging. Intellectually challenging discussions about society and the environment, reflections on the program experiences, whole-day activities outside the classroom, and active engagement with community groups, provide students firsthand experiences to engage in community life and become active and responsible citizens.

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