SCIENCE SERVICE LEARNING: LEARNING IN DEED

by

Lelia "Dale" Soutter Glass

A professional paper submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

July 2013

STATEMENT OF PERMISSION TO USE

In presenting this professional paper in partial fulfillment of the requirements for a master's degree at Montana State University, I agree that the MSSE Program shall make it available to borrowers under rules of the program.

Lelia "Dale" Soutter Glass

July 2013

ACKNOWLEDGEMENTS

Thanks to all my colleagues at National Presbyterian School who have generously supported me with their time, great ideas, and inspirational teaching, especially my partners on the Service Learning Committee Laura Krentel and Chaplin Rev. Jen Dunfee. I appreciate the school administration and Board of Trustees for providing a vision and funding for professional development.

I would like to thank Bruce Moravchik and Peg Steffen of NOAA's National Ocean Service for their support and leadership of the Climate Stewards Education Program which has supported this work. Hilarie B. Davis, EdD provided assistance developing assessments in her role as an external evaluator for NOAA's CSEP Program.

Most of all, I would like to thank my family for their patience, proofreading, problem-solving, love and encouragement. Carter, Lelia, and Emma – you're the best!

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Many schools require community service, yet students work at a food bank or stream clean-up without understanding causes or solutions for the issues they encounter. Since students learn best when they make connections between scientific concepts and real-world issues that interest them, integrated science service learning is an effective and engaging way to teach. My fifth grade students at National Presbyterian School in Washington, DC learned about climate change through a service learning project to help the environment on campus.

My class of 28 fifth-graders investigated environmental variables affecting our campus. They brainstormed ways they could help the environment and decided to focus on reducing idling in the school carpool lane. Students researched the relationship between automobile exhaust and climate change, acid rain, and health. Students crafted a tally sheet to record the number of cars and their idling times. Over an average week with pleasant weather, 35 of 165 cars (22%) which arrived early for carpool idled for a total of 509 minutes. This put out 75 kg of the greenhouse gas, CO_2, and cost $34.00 in fuel. Students used this research to develop an anti-idling campaign, which they presented to the whole student body and posted on the school website and e-newsletter.

Students showed improvement on climate science knowledge and realized typical or better marks on benchmark assessments. They also became more confident in their knowledge, moving from an average 3 before the project to an average 8.5 afterwards on a 10-point Likert scale. Students also demonstrated a change in their view of science. Before the project they drew chemists with bubbling test tubes but after the project they drew themselves as a variety of different scientists helping to solve problems in the world.

This project attests that science service learning can make science more concrete and relatable, teaching students not only about the concepts and techniques of science, but its role as a tool for the public good.

INTRODUCTION AND BACKGROUND

This study examined the impact of a science service learning project on student achievement and attitudes during the fifth grade environmental science unit at National Presbyterian School (NPS) in Washington, DC. NPS is a traditional, co-educational elementary school dedicated to educational excellence in an ecumenical Christian environment. A loving and inclusive community, NPS strives to help children develop intellectual, spiritual, and personal foundations that will serve them throughout their lives. NPS has 265 students in grades nursery to 6th, and 1 student in 3 receives financial assistance (J.T. Neill, personal communication April 23, 2012). Most students come from the nearby neighborhood and have supportive parents. Generally, students are engaged and enthusiastic about the school's science program.

The primary goal of science instruction at NPS is to help students work towards science literacy, defined as the desire and ability to pursue life-long learning in science. NPS believes that the best way to meet this goal is to employ a hands-on/minds-on approach to science instruction to enrich students' natural curiosity about the world around them. This curiosity is enhanced by exposing students to the fundamental concepts, themes, skills and attitudes of science. Students in kindergarten through sixth grade use FOSS (Full Option Science System), an inquiry-based curriculum developed at the University of California, Berkeley, and study Earth, physical, and life science topics each year. Students in third through sixth grades spend formal time in the science lab as a "specials" class with me as their teacher. Fifth grade has science four times every six-day rotation, meeting for 45 minutes each class. There are 28 students in the grade, 14 boys and 14 girls, and although they are evenly divided in to two classes, they are treated as a whole class for this study.

An innovative service learning program transformed school culture with integrated, student-led service in every grade (Glass & Krentel, 2011). Based in the homerooms, students see the relationship between their studies and the real world, are invested in the process, and feel that they can make a difference in their community. As one of the students said, “Some people think little kids can’t do anything to help, but I think we can do a lot!” Seeing the success of the program in the homerooms made me want to implement it in science class too.

CONCEPTUAL FRAMEWORK

Service learning applies active learning to solve real-world problems (Jensen & Burr, 2006). Even young students can use their academic skills and knowledge to make an impact. For example, within the science curriculum, kindergarteners can sprout acorns then plant the oak seedlings to help reforest an area as they learn about seasons of the year and life-cycles of plants. Upper elementary students can develop an education campaign to boost school-wide recycling, applying science concepts of renewable and non-renewable resources, energy flow, the carbon cycle, data collection and analysis, and measuring matter. During service learning, students use their academic skills and knowledge to meet school or community needs (Wade, 2011).

Exemplary service learning includes student voice and choice in all phases of the project. Steps include selecting and developing the project, just-in-time learning as students meet curricular goals while researching the project, implementing the service activity itself, reflection, communication, and celebration (Kaye, 2007; Billing, Root & Jesse, 2005). Teachers can help steer the students towards a manageable project, which is relevant to the curriculum. Students can develop hypotheses about the impact of their project and collect data to test them, learn about the nature of science and meet curricular benchmarks as they determine the effectiveness of their work. Lab reports, narrative essays, or artistic interpretations can serve as reflective work, examining the academic and civic learning experience. Once the project is completed, community partners and schoolmates can share what they have learned and celebrate the outcome. Assemblies, articles in the school newspaper, and simple rewards such as extra recess or a special snack are ways to celebrate accomplishments (Dymond & Neeper, 2012).

Service learning consistently shows positive outcomes on a variety of measures including student confidence, engagement, attitudes, and academic achievement (Dayton-Wolf, 2011). As an example, over the past 13 years, Brandeis University evaluated Earth Force's environmental service-learning programs' effectiveness (Earth Force, 2012). Earth Force reaches over 18,000 students each year and has demonstrated positive, statistically significant outcomes for its participants. Students were engaged as environmental citizens, with 85% reporting a better understanding of environmental issues and 54% reporting they learned more. Additionally, 59% of the students said they paid more attention to Earth Force classes; this response is supported by the fact that 84% of educators noticed an increase in their student's interest in and enthusiasm for learning. Further, 86% of students felt their project made a difference, creating lasting change in their communities. This Earth Force example showcases the various impacts service learning can have on students' achievement and engagement.

Not only does service-learning integrate meaningful community service with instruction and reflection to enrich the learning experience, it teaches civic responsibility and strengthens communities (Kielsmeier, Neal & Crossley, 2006). For example, nursery students may learn about caring for pets, make a career connection through a visit with a veterinarian, and then engage the whole school community in a drive to collect old towels for pet bedding at an animal shelter. Community relations between schools and neighborhoods, student-teacher relationships, and peer-to-peer cooperation all improve with excellent service-learning programs (Kaye, 2007).

Engaging students' hearts, hands, and minds through service learning results in improved confidence and on-task behavior and has demonstrated benefits to students' attitudes toward school (Dayton-Wolf, 2011). Science service learning can improve academic achievement, student engagement, and student perceptions of the value of science (Sevier, Chyung, Schrader & Callahan, 2010).

Science service learning is an ideal way to connect science with other curricular areas, and to provide opportunities for students to explore the outside world. These science practices and skills are recommended in the National Science Education Standards (NRC, 2012). As a simple example, my third graders study flower bulbs' structure and plant tulips to beautify the campus. They track the bulbs' emergence and blooming in the spring through "Journey North," a citizen-science project, engaging with students and their tulips around the world documenting the arrival of spring. Service learning can answer the eternal student question, "When are we ever going to use this?" (Shapiro, 2009).

METHODOLOGY

The purpose of this study was to evaluate the effectiveness of doing a service learning project during fifth grade students' study of environmental science, their spring-term life science unit. Not only was academic achievement assessed, but students' attitudes and ideas about the value of science were measured. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained.

The 28 fifth grade students at National Presbyterian School began the environmental science unit with the standard curriculum: an inquiry-based 5E investigation about biotic and abiotic factors in an isopod environment (FOSS, 2005). This set of investigations took place in science class during the month of March. Students began work on independent biome reports, a standard topic, and continued on and off as time allowed throughout the quarter (Appendix A). Next, instead of following the standard FOSS curriculum, students developed a science service learning project related to the environmental factors on the school campus. This project was the subject of the action research. The National Oceanic and Atmospheric Administration (NOAA) Climate Stewards Education Program (CSEP) funded the stewardship project with a mini-grant (Appendix B). To provide an overall structure to the entire unit, a "Discover, Connect, Take Action" plan was laid out (Table 1). The service learning project included science class work to learn about the environmental impacts of several factors, collecting data, and designing and implementing an action plan. Aspects of the service learning project that were not part of the standard FOSS curriculum are considered treatment. This treatment took place over six weeks, the remainder of the school year.

Table 1

Discover, Connect, Take Action Plan and Its Relationship to Standard or Treatment Instruction

Goal	Details	Instruction Method
Discover	Learn about environmental factors & preferences	Both
	- Isopods	Standard
	- Fish	Standard
	- Guinea pigs	Treatment
	Learn about the impact of some environmental factors	Both
	- Radish seeds don't grow well with soapy water	Treatment
	- Fish, plants, CO_2, and acidity	Standard
Connect	Research biomes	Standard
	Look at environmental factors at school	Treatment
	- Brainstormed inputs/outputs - Concept maps of NPS environmental factors - Decided on carpool idling project	
	Learn about the carbon cycle	Treatment
	Research impact of idling (small group projects)	Treatment
	- Greenhouse gas and temperature - Acid Rain - Air pollution and health - Gasoline as a fossil fuel	
	Data Collection	Treatment
	- Brainstorm data collection activities - Collect data - Analyze data	
Take Action	Present Anti-Idling Campaign	Treatment
	- Chapel Powerpoint	
	- NPS website	
	- Carpool line outreach	
	Follow-up	Treatment
	- Post campaign data collection and analysis	
	- Report results	
	Communicate	Treatment
	- "Celebration of Service" Chapel	
	- NOAA CSEP Video Contest	

Students created concept maps of environmental factors on campus to begin the science service learning project (Appendix C). They decided that air pollution from idling cars was an interesting problem to tackle. As part of their research, students learned about automobile exhaust, carbon dioxide (CO_2) as a green house gas, particulate air pollution, and acid rain. In the classroom, students plunged Vernier temperature probes into ice water and set up plants inside plastic tents with CO_2 probes to learn to use the equipment and graphing software. Clipboards and data sheets in hand, students headed outside to tally the cars waiting and idling in the carpool line (Appendix D). After collecting data for five days, students calculated the average weekly CO_2 output and cost of gasoline (Appendix E). They documented events with photos and video. Students combined their research, data, and analysis into an anti-idling campaign which they presented to the students in chapel and to the parents via the school website and weekly e-newsletter (Appendix F). The following week, students collected data to document the effect of their project. After the project, students reflected on the service and their learning. They shared and celebrated their work in an all-school assembly and in a video.

Several assessments were given before and after the standard and treatment units. The FOSS Environments Unit Survey and Post-Test was given to the students as a baseline survey and then after the entire unit as a summative assessment (Appendix G). This was graded using the standard FOSS rubric. Appropriate benchmark assessments were given at the end of each of the investigations, standard or treatment (Table 2).

Table 2
Unit Assessment Flow Chart

Topic	Instruction Method	Benchmark Assessment
Entire Environments Unit		FOSS Pre-Test Survey; NOAA CSEP Elementary Climate Survey
Investigation 1: Environmental Factors	Standard: 5E Learning Cycle	FOSS I-Check 1-2
Investigation 2: Environmental Impacts and Preferences	Treatment: Service Learning Project	Biome Reports
Investigation 3: Carbon Cycle	Treatment: Service Learning Project	FOSS Student Response Sheet 3
Entire Environments Unit		NOAA CSEP Elementary Climate Survey

The FOSS I-Check 1-2 (Appendix H) and FOSS Student Response Sheet 3 (Appendix I) are the standard evaluations provided with the FOSS Environments curriculum and were scored using the FOSS rubric (FOSS, 2005). Students' biome reports were scored with a standard rubric and the results compared to previous year's students. Focus group interviews and a Knowledge and Attitude Survey provided an opportunity for students to report their own feelings about the effectiveness of the service learning project and their attitudes about science (Appendices J & K). NOAA's Elementary Climate Survey provided further information about student knowledge (Appendix L). These instruments asked students to reflect on their understanding before and after the project, demonstrating change (if any) more clearly than asking the same questions pre and post activity.

Student science notebooks provided data as well. They were graded for completion and quality on a three-point scale (0 = incomplete, poor quality; 1 = complete, poor quality or incomplete, good quality; 2 = complete, good quality). Quotes from the science notebooks revealed student misconceptions, questions, and understanding.

Students began the unit with a modified Draw A Scientist Test (DAST) (Appendix M). They drew a picture of a scientist, showing what he/she was doing, what kind of expression was on the face, and what tools they were using. Students were asked to draw after the service learning project, with the modification that students were asked to draw *themselves* as a scientist. This alteration was made to reduce the temptation to draw a "stereotypical" scientist. These second drawings were evaluated to measure students' perception of scientists as regular people enjoying using science to answer questions, solve problems, or help people.

A reflective teacher journal containing my observations and reports of student comments, behavior, and scientific accomplishments helped provide the answers to questions about student interest and attitudes. Photographs documented the project and illustrated student engagement. These data sources provided qualitative input to the research.

I assessed the impact of the service learning project in several ways, as shown in the triangulation matrix (Table 3). To assess academic achievement and answer the main focus question, I compared results on assessments for the service learning topics of environmental preferences and the carbon cycle with assessments on the standard environmental factors topics. Student science notebooks and interviews provided additional quantitative academic achievement data.

Table 3
Triangulation Matrix

Focus Questions	Data Source 1	Data Source 2	Data Source 3
Primary Questions:			
1. Does adding a science service learning project increase students' science achievement?	Student benchmark assessments	NOAA CSEP Survey	Student interviews
2. Does adding a science service learning project increase students' interest in science?	Instructor observations and journaling	DAST	Student interviews
Secondary Questions:			
3. In what ways does participating in a service learning project impact achievement and interest in science learning?	Student science notebooks	Field notes and photographs	Student interviews
4. In what ways does participating in a science service learning project change students' attitudes about science?	DAST	Student attitude surveys	Student interviews

The other three focus questions for the action research project looked at how, why, and in what ways a service learning project impacts student attitudes. Qualitative data from a variety of sources helped address these questions. My reflective teaching journal containing daily observations and reports of student comments, behavior, and scientific accomplishments helped provide the answers to the questions about student interest and attitudes. Individual interviews and focus group discussions allowed students to provide direct input. Students' view of themselves as scientists, shown in the DAST, illuminated their attitudes about science.

DATA AND ANALYSIS

To address the first focus question, academic achievement was assessed throughout the project. The results of the NOAA CSEP Elementary Audience Knowledge Survey indicated that most students correctly understood that weather often changes from year to year (67%) and that "climate" means the average weather conditions in a region (81%) (N=27). However, most of the students also thought that climate often changed from year to year (78%) and that "weather" means the average climate conditions in a region (67%). These incorrect answers demonstrated that students conflate the terms, with 93% stating that weather and climate mean pretty much the same thing.

Almost all the fifth graders understood that coal (96%) and oil (85%) are fossil fuels. Natural gas was not as well categorized, with only 41% identifying it as a fossil fuel. Most students knew that wood (59%), hydrogen (63%), and solar energy (78%) are not fossil fuels. A large majority of students (85%) knew that CO_2 is produced by burning fossil fuels.

Several questions assessed understanding of the flow of heat across the planet. Only 27% knew that the ocean carries heat from the equator to the north and south poles and most thought that the atmosphere carries heat from the north and south poles towards the equator (81%). All the students knew that glaciers are melting, but only one-third realized that *most are melting*; the rest selected *some are melting*.

Students felt that they learned a lot about climate during the service learning project, with all their self-reported scores on a 4-point scale moving from an overall average of *a little* before the project, to an overall average of *a lot*, after the project (Figure 1). Specifically, their average understanding of weather as what is happening today where I live went from *a little* (2.4) before to *a lot* (3.7) after. Additionally, their understanding of climate as weather over a long time improved from *a little* (2.0) to *a lot* (3.7) after the project. Students felt that they knew some more about the climate of the Earth getting warmer, moving from an average *a little* (2.0) before and *some* (3.4) after the project. They had similar perceived improvement in their knowledge about the connection between a warming planet and our weather, increasing from *a little* (1.7) to *some* (3.2). In the final self-assessment question, students felt that they learned that we can slow down the warming by changing some things we do, improving from *a little* (2.4) to *a lot* (3.8).

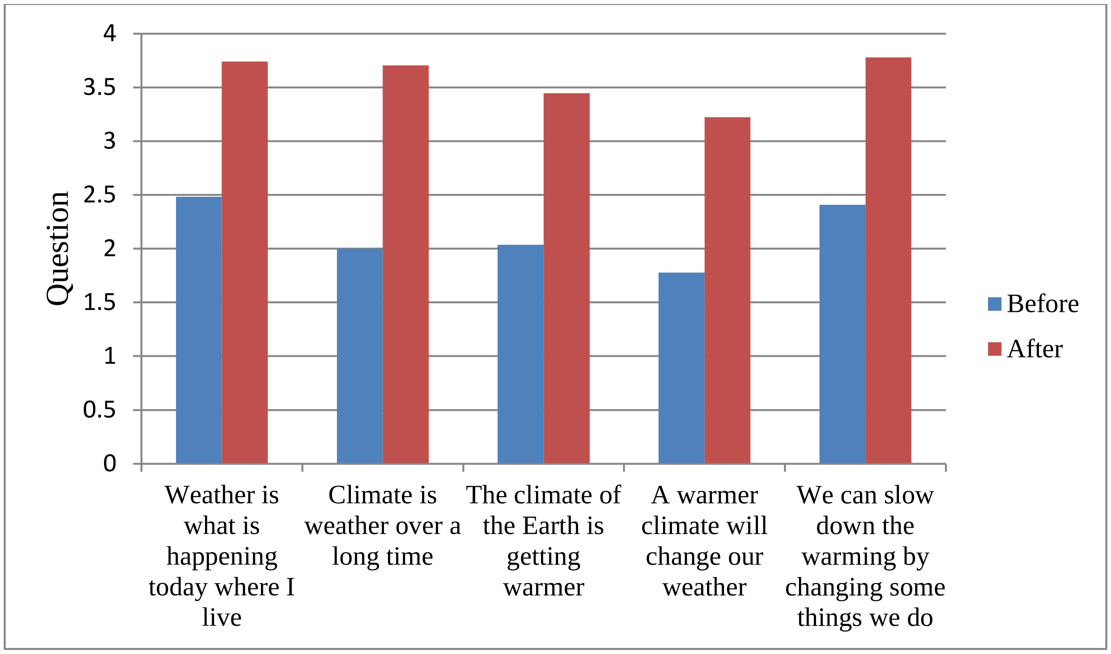


Figure 1. NOAA CSEP Knowledge Survey Questions 2-3, student self-reported knowledge. How much did you know before this project about the Earth compared with how much you know now? 1=Nothing, 2=A little, 3=Some, 4=A lot, (*N* = 27).

When asked to explain something they learned about how to take care of the Earth, 93% of the students wrote something about automobile idling, the subject of their service learning project. Forty-one percent of them mentioned carbon dioxide, gas, or air pollution as problems from idling. Almost half (48%) of the students included ideas about idling hurting the Earth, people, plants, or animals.

The Knowledge and Attitude Survey showed that students felt their awareness of the costs - in fossil fuel use, pollution output, and cash - of idling improved because of the project (Figure 2). Further, their attitudes about idling led them to be *very likely* (7 on a 1-10 scale) to remind drivers not to idle, to explain why that is important, and to watch their own idling time when they learn to drive (*N* = 28).

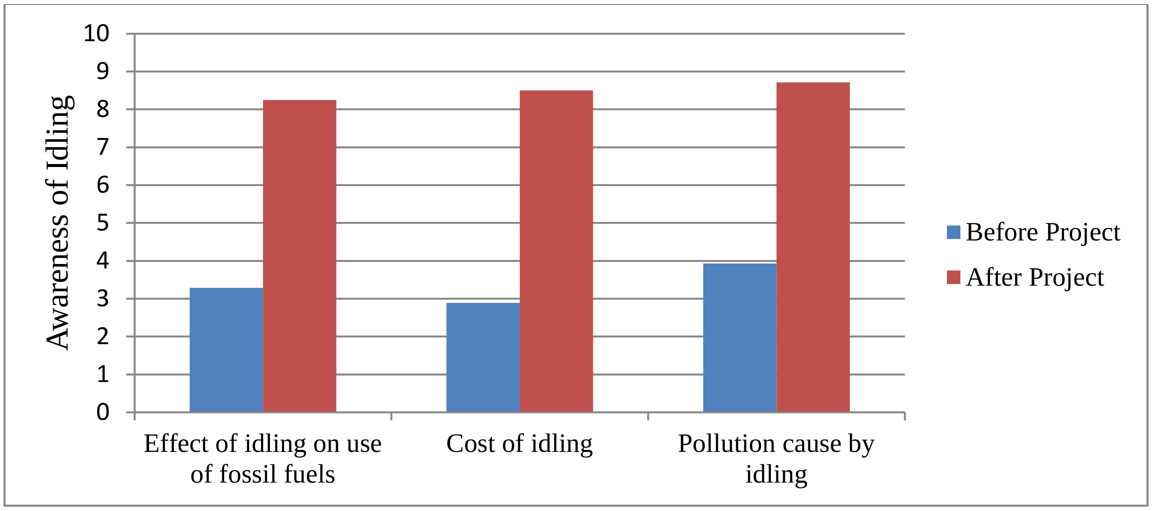


Figure 2. Knowledge and attitude survey, student awareness of idling, Likert Scale: 1 = Not at all aware – 10 = Extremely aware, (N = 28).

Throughout the unit, standard benchmark assessments were used as quizzes. Grades on the benchmark assessments were comparable to the two prior years' students, with a B+ average for all years on the FOSS I-Check 1-2 and the Student Response Sheet 3. Students also did reports on a particular habitat, examining the environmental factors present and the adaptations that plants and animals have to help them survive in that area. These reports earned an average score of 92% during the service learning project compared to the prior year's 87%.

During the interviews, students mentioned what they enjoyed about the service learning project and how it helped them to learn. They liked the group work, dividing the work among themselves and then teaching and learning from each other. Students particularly enjoyed the animal inquiry activities and the new technology for measuring temperature and CO_2. But these activities could happen without service. Mainly, the students liked seeing the connection between science class work and the real world and knowing that they could do something to help. One student said, "Global warming can be reduced by doing little things in your life like stopping idling." Another said, "I liked learning to help the environment; it was cool. Now I want to help the environment."

At the end of the service learning project students completed a modified Draw a Scientist Test. None depicted the wild hair, sinister expressions, or exploding chemicals which were features of the pre-project DAST ($N = 28$) (Figure 3).

Figure 3. Pre-project draw a scientist test example: "I am trying to create something but it all goes wrong."

Post-project, ten of the students (35%) clothed their scientific selves in lab coats. Smiling scientists were the most common (64%), with seven (25%) neutral expressions and the remainder undeterminable (Figure 4). The drawings showed a wide variety of scientific disciplines, with a fairly even distribution between Earth (29%), physical (25%), and life science (39%) occupations. Twelve students depicted collecting data such as gathering moon samples or measuring plant growth (Figure 5). Almost half of the scientists (12/28) were aiding someone, for example tending an animal or plant, searching for a cure, or solving a world problem (Figure 5). This demonstrates that students see scientists as beneficent.

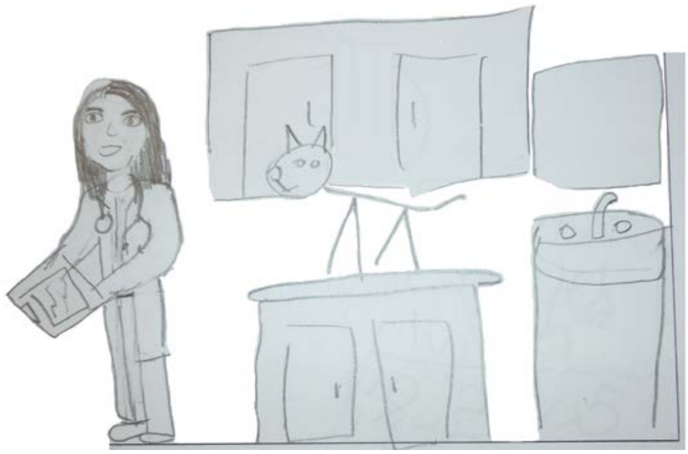


Figure 4. Draw a scientist Example 1 ""I am a veterian [*sic*] and I am checking up a cat. I work at a small building in the corner of a street. I am wearing brown pants, a pink sweater, and a lab coat. I am not that old, just 30, so I'm not that wrinkly."

Figure 5. Draw a scientist Example 2 "I am watering my special plants in different environments."

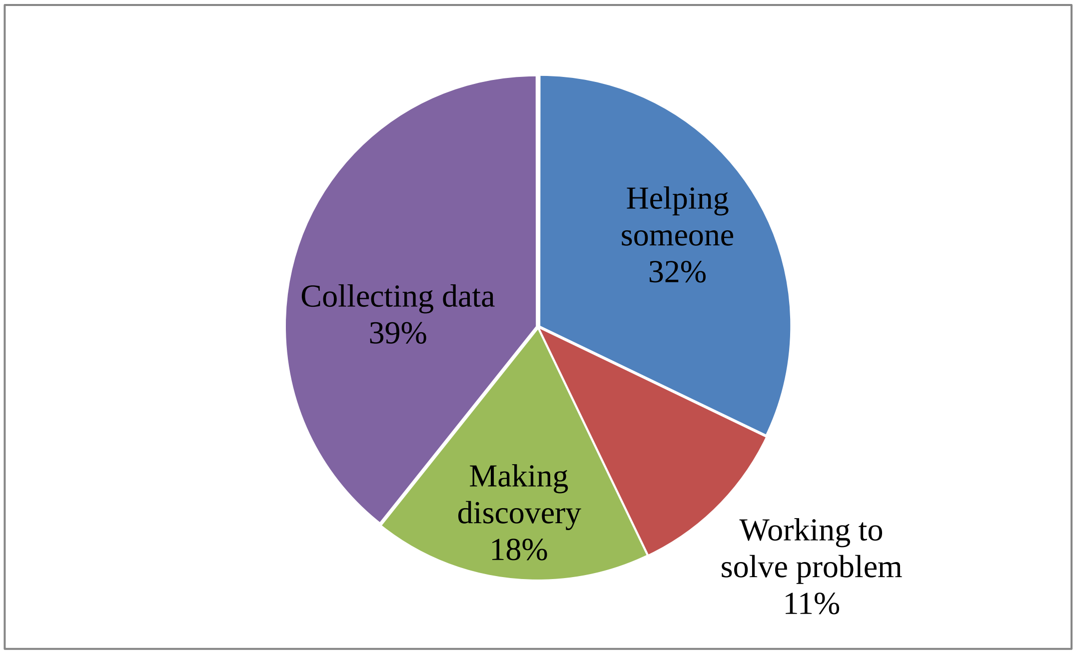


Figure 6. Draw A scientist test, reason for scientist's activity, (*N*=28).

During interviews, one fifth-grade student said, "Working on the science service learning project has changed how I think about it because if we work together we can make the world a better place." Another stated, "When we found the data for our service learning project it was easier for people to take us seriously."

INTERPRETATION AND CONCLUSION

The benchmark science content assessments (FOSS I-Check 1-2 and FOSS Student Response Sheet 3) reveal that participating in a science service learning project has little effect on academic achievement. Students earned similar scores on their quizzes, whether related to the standard or treatment instruction and these scores were consistent with the two prior years' standard instruction. Although the type of hands-on activities was different for the treatment and standard instruction, in both cases, students actively participated in learning, creating investigations, gathering evidence, and making connections between the underlying science content and the in-class experiments, so it is not surprising that they have similar results on benchmark assessments.

The NOAA Climate Survey, given as a pre- and post-summative assessment, showed that students had a better understanding of many environmental issues after the entire unit. However, it is not clear how much of that improvement was due to the service learning treatment and how much was due to standard instruction. Students did comment on enjoying the group work aspect of the service learning project. Each lab table of four students researched a particular aspect of the impact of auto emissions, becoming experts about a climate science topic. Further, they shared their findings with their classmates; this peer-to-peer interaction may have been more effective than teacher-directed instruction.

Fifth graders did do a slightly better job on their habitat reports this year compared to the prior year. In particular, students better expressed adaptations which made organisms survive in the specific environment (Figure 7). I attribute that improvement to the work we did as part of the service learning project when students designed experiments to determine the Guinea pigs' preferences for type of food or shelter. In comparison to the standard treatment of studying environmental preferences of isopods and beetles, students were better able to connect this work with an adorable mammal and its preferences to describing environmental adaptations and preferences of similar organisms in different habitats.

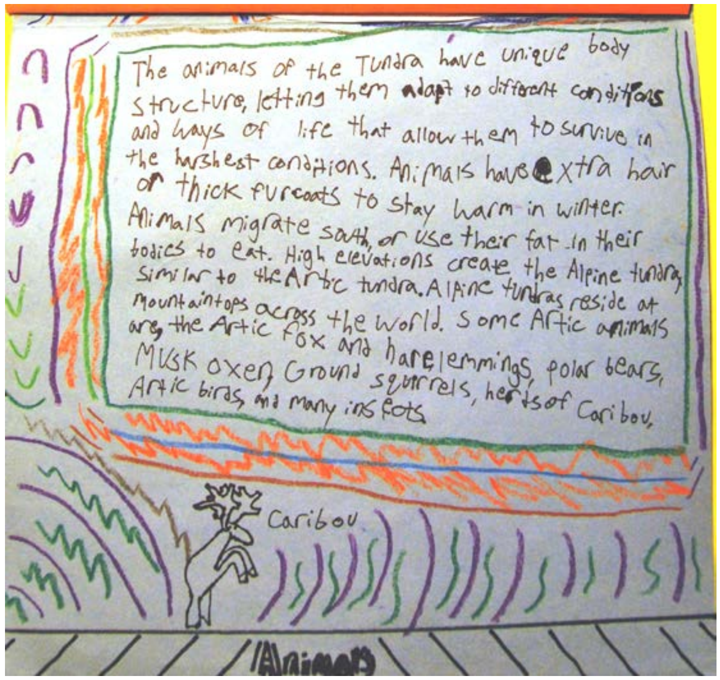


Figure 7. Sample student biome report page. "The animals of the tundra have unique body structures, letting them adapt to different conditions and ways of life that allow them to survive in the harshest conditions. Animals have extra hair or thick fur coats to stay warm in winter. Animals migrate south or use their fat in their bodies to eat."

Benchmark quizzes, habitat reports, and the NOAA Climate survey all documented student learning, whether related to the service learning project or standard instruction. However, the habitat reports, done throughout the service learning project, were more detailed and contained specific examples. These results answer to the first focus question, showing that participating in a science service learning project caused slight improvement in science content understanding. Examining why students had greater achievement and interest in science learning, the secondary focus question, shows two reasons. Students were thrilled to explore the new technology (Vernier temperature and CO_2 probes connected to laptops equipped with LabQuest software) and felt empowered to use "real science equipment" to collect "real data." The expert status expected of each group in preparing a report on an idling impact factor and their enjoyment of this group work challenged the students to have ownership of their learning. Fifth graders are naturally chatty and focusing this talkativeness into a collaborative group tapped into their innate strengths. Further, using charming Guinea pigs in some of the experiments also captivated the students, keeping their interest in science learning high.

The second focus question and related secondary question relate to the students' attitudes and interest in science. Three themes came up: connections with the world outside school, feeling that they were doing real work, and helping solve a problem. Together, these ideas changed students' views of themselves as scientists and their perceptions of the value of science.

Students were amazed to see the connections between their school work and the real world. This was noted throughout the project, from the first brainstorming session looking at the environmental factors affecting the school campus, to the classmate's pets used as experimental subjects, to the data collection, and the campaign to drivers. Another aspect of the service learning project was seeing careers which use science. The DAST results showed scientists working with animals, plants, rocks, and people, collecting data and making new discoveries. The word cloud summarizes the students' reports of their DAST activities (Figure 8). Students saw science not only in the classroom, but on their campus, in their homes, and in their community.

Figure 8. Word cloud of students' DAST descriptions, (*N*=28).

Instead of the usual plastic cups and Popsicle sticks we often use as lab equipment, students were able to use electronic devices and special computer programs. They felt that using the scientific equipment helped "people take us seriously." During the data collection, when lab equipment was evident and students were walking up and down the carpool line with their clipboards, adults stopped and asked the students what they were doing, validating their work. Further, since the new equipment was funded by a grant from NOAA, students realized that what they were doing was recognized as important by adults in a federal agency. Several of the DAST drawings showed the students as child-scientists themselves. Even though they were only ten years old, these students felt that their science activities were bona fide work.

The most meaningful aspect of the service learning project seemed to be the application of science to solve a real problem. Instead of just learning about some concepts, or worse, simply learning about the scientific aspect of some problems with serious consequences, students were able to take their understanding and to do something to help. Their aid went beyond personal changes they could make right now (riding their bikes to school) or in the future (not idling their cars once they are old enough to drive), but educating adults, causing real behavior change. This concept extended to the activities shown in the DAST where most of the scientists were shown helping.

Although real-world connections are incorporated to some extent in the standard instruction, the direct application of science to research, describe, and mitigate a problem done during the science service-learning project had a positive impact on students' attitudes and interest in science. In sum, this project demonstrated that doing a science service-learning project has slight positive impact on academic results and significant positive impact on students' view of science.

VALUE

This service-learning project had value for all the stake-holders. The students learned a lot of science content and were able to see its application to mitigate real-world problems. The community benefited from the anti-idling education campaign and the resultant behavior modification. I learned techniques and strategies that helped me to be a more effective teacher. Although the project was a lot of work to develop, I am pleased with the results.

Students learned environmental science concepts, applied technology, collected data, calculated results, communicated their findings, and helped solve a problem about idling in the carpool line. Their work was recognized on the school website and in the weekly newsletter. The project didn't stop there, however. Their findings were included in a report to the Washington DC Zoning Commission as part of an application for the school's expansion. Further, in response to the students' focus on auto exhaust and its impact on the environment, the school administration took several actions. "No Idling" signs were posted on campus. Two carpool incentive programs were established, giving front-of-line priority to carpooling families and preferred parking spaces for carpooling faculty. A public-transit incentive now provides metro fare cards for faculty who do not drive to school. Finally, the video documenting their project won first place in a NOAA CSEP contest, earning a $1,000 prize for the science department and nation-wide recognition. The students truly feel that their work on the science service-learning project was valuable.

The anti-idling campaign had value for the environment as well. Students calculated that the average weekly CO_2 load from idling cars was 75 kg. Reducing that by half through the student campaign and the school administration actions means that 1,500 fewer kg of CO_2 are added to the atmosphere in during the 40-week school year. This reduces greenhouse gases and is better for the planet. Less pollutants also means fewer health issues for sensitive people. The financial benefit to non-idling families could be $60.00 per year. More follow-up is necessary to determine the true climate, economic, and health value of the students' work.

The science service-learning project was valuable to me as well. Developing the project prompted me to research environmental science content benchmarks beyond the FOSS curriculum, resulting in a stronger science program for the students. With the student-led nature of the project, I had to quickly adapt the schedule to reflect the students' choices and keep them tightly tied in to scientific endeavors related to the benchmarks. This caused me to be more reflective and responsive with my teaching. Writing the NOAA grant application required me to resurrect my grant-writing skills, clarify my goals, and communicate them to others. Plus, the school received funding and recognition for the project. Doing this project as my MSSE Capstone paper necessitated more documentation and analysis of student formative assessments; this was illuminating and allowed me to adapt my teaching to suit the needs of the students more quickly than usual. I presented this work during a poster session at the American Geophysical Union's Fall Meeting, further honing my presentation skills.

Although doing the project was a lot of work, the benefits were significant. Homeroom teachers report that their subsequent years doing service learning projects incorporate improvements, refinements, additions, and result in even better projects which run more smoothly. I plan to continue to implement a science service-learning project with my elementary students in the future.

REFERENCES CITED

Billing, S., Root, S., & Jesse, D. (2005). The Impact of Participation in Service-learning on High School Students' Civic Engagement. *Circle Working Paper 33 RMC Research Corporation*. Retrieved February 12, 2012, from http://www.civicyouth.org/PopUps/WorkingPapers/WP33Billig.pdf

Dayton-Wolf, J. (2011). *The Impact of Service Learning on "At Risk" High School Biology Students.* Unpublished professional paper, Montana State University-Bozeman.

Dymond, S.K., & Neeper, L.S. (2012). "Green team to the rescue: how service-learning projects enhanced our environmental education program." *Science and Children* Mar. 2012: 41-45.

Earth Force Impact Statement. (2012). Retrieved April 5, 2013, from http://www.earthforce.org/index.php?PID=23

FOSS Environments. (2005). Berkeley: University of California Board of Regents.

Glass, D., & Krentel, L. (2010). *Learning In Deed – Transforming a School's Culture of Service*. Washington, DC: National Presbyterian School.

Jensen, S. & Burr, K. (2006). Participation and Learning Relationships: A Service-Learning Case Study. *Journal of Industrial Teacher Education 43(3)*, 6-28.

Kaye, C.B. (2007). *The Complete Guide to Service Learning*. Minneapolis, MN: Free Spirit Publishing, Inc.

Kielsmeier, J.C., Neal, M., & Crossley, A. (2006). *Growing to greatness 2006: The state of service-learning project*. National Youth Leadership Council. St. Paul, MN. Retrieved from http://www.nylc.org/sites/nylc.org/files/files/301G2G2006.pdf

National Research Council (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

Sevier, C., Chyung, S., Schrader,C., & Callahan, J. (2010). Effects of Service Learning Implemented in an Introductory Engineering Course on Student Attitudes and Abilities in the Context of ABET Outcomes. *Proceedings of the 2010 American*

Society for Engineering Education Annual Conference & Expo, Louisville, KY.

Shapiro, D. (2009). Blending Science and Service Learning. *NSTA Reports*, 9/4/2009. National Science Teachers Association, Arlington, VA. Retrieved March 20, 2013, from http://www.nsta.org/publications/news/story.aspx?id=56458&print=true

Wade, K. (1996). EE teacher in-service education: The need for new perspectives. *The Journal of Environmental Education, 27*:2, 11–17.

APPENDICES

APPENDIX A

BIOME REPORT GUIDELINES AND GRADING RUBRIC

Biome Report: Prepare a paragraph on each topic.

1. **Location:** Include specific countries, general world location (eg equatorial regions), surprising locales, proportion of world, and so on. Make it interesting and informative. Include a map.

2. **Climate:** Include temperature range, rainfall, seasons. If you traveled to this region, what clothes would you need to pack? Include pictures.

3. **Plants:** Discuss the types of plants and their location (eg layers in rainforest). Pick one example plant and explain how it is specially adapted to survive in this region (leaves, size, root system). Include pictures.

4. **Animals:** Discuss the types of animals. Pick one example animal and explain how it is specially adapted to survive in this region (coloration, time of day, cold/warm blooded, size). Include pictures.

5. **Example Food Web:** Show how matter and energy flow from producers (plants) to 1st level consumers (plant-eaters) to higher level consumers (predators) back to the soil and atmosphere (decomposers). Include pictures.

6. **Your Choice:** Pick something interesting about this biome, make a suitable heading, and explain all about it. For example, the Arctic Tundra has permafrost, so it would be interesting to discuss the soil and its freezing/thawing cycle. Or,

discuss conservation issues related to this biome. For example, the government of Brazil has recently approved building a hydroelectric power-generating dam across the Xingu River which will flood 6,500 km^2 (2,509 square miles) of the rain forest. Include pictures.

Grading Guidelines: Each topic can earn up to 4 points for containing the required content. An additional 6 points can be earned for the overall quality of writing, and depth of information. Total = 30 points.

APPENDIX B

NOAA CSEP MINI-GRANT APPLICATION

NOAA CSEP Stewardship Action Plan

1. The Climate Science Issue – *Describe the issue, the need, and the context for stewardship. Place the issue in the larger context in climate science to establish it as an authentic issue that others are working on.*

Most of the 265 students at the National Presbyterian School are driven to and from school daily. During the afternoon pick-up carpool time, cars line up, often idling, as they wait for the students to come out and the car ahead of them to move forward. Some cars arrive 20 minutes early. This unnecessary gasoline usage is wasteful (one hour of idling uses 0.25 – 1.00 gal of fuel)[1], pollutes, and impacts the amount of fossil fuels used. Carbon dioxide, from fossil fuel use in transportation, increased tropospheric ozone from the release of gases such as carbon monoxide, and aerosols from burning fossil fuels all contribute to increases in greenhouse gases[2]. 5th grade students will study the problem, collect "before" data, implement an action plan to educate their peer student and parents, and measure the results.

2. The Hypothesis to Test/Measurable Objective – State the hypothesis and design for testing it. What will be the effect? On what or whom? For how long? Under what circumstances? For example, "***If*** *students analyze the impact of the waste their families generate,* ***then*** *they will reduce it and encourage others to do so."*

If students educate drivers and student passengers about the environmental impact of idling in the carpool line, then the number of cars wastefully idling will decrease. This will reduce the amount of pollution and heat generated and will reduce the amount of

[1] http://www.consumerenergycenter.org/myths/idling.html
[2] http://oceanservice.noaa.gov/education/pd/climate/factsheets/howhuman.pdf

gasoline used. Students will tally the idling behavior, measure temperature changes during carpool time, and, using automobile idling data[3], determine the environmental impact before and after the education campaign. The expected effect is a reduction in idling in the NPS carpool line which will continue throughout the school year. A new crop of students and parents next September will necessitate a renewed education campaign. As always, information coming from the students will have the most impact, especially when backed up with authentic data.

3. Stewardship Process and Activities – *Describe the activities. Provide a timeline. Discuss how the process went according to plan, or did not, how things emerged or evolved, and any unintended events if they occurred.*

Timeline:

January & February 2012 – 5th grade students are introduced to project (this is a follow-up for some other environmental work they have been doing all year) and to the equipment (Vernier probes). Students will design the project, including developing a hypothesis, procedure, data collection methods, data analysis plans, and action plans. They will take test measurements to revise the protocol if necessary. Time-lapse videography of the carpool line will aid in car tallies and may provide interesting data. This work will happen during science class, interspersed with the regular physical science curriculum.

March 2012 – Students will collect data for several days during one week. Students will analyze the data and develop an action plan, using the data to back up their education

[3] http://www.epa.gov/oms/consumer/f98014.pdf

campaign.

April 2012 – Environments unit begins in science class. Action plan implementation – assembly presentation, Thursday newsletter, school newspaper, posters, etc. Additional data collection will occur immediately following the education campaign.

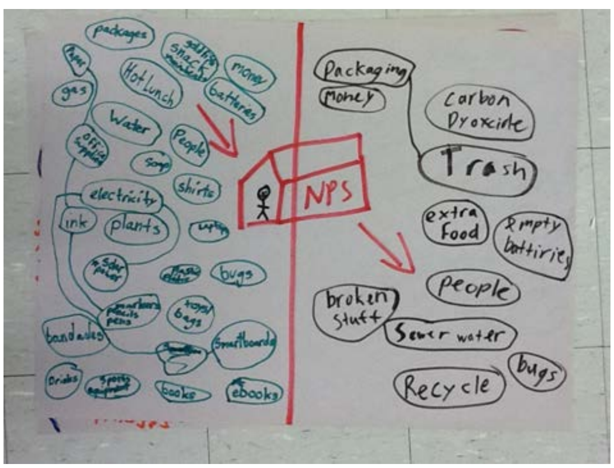
May 2012 – Follow-up report showing effect of action plan and encouraging continuation of improved no idling behavior.

***4. Stewardship Actions** – Describe the environmental stewardship actions. Including things like you as a Climate Stewards educating yourself and others, as well as working within your community to reduce the carbon footprint or develop plans to "go green." You involve others in an environmental stewardship project (short term <2 days, or long term >2 days). You make environmental stewardship part of your ongoing work and the work of an institution (your own or others). You are able to document the measurable effects of the environmental stewardship actions, such as showing how much you reduced the carbon footprint as a result of the project.*

5th grade students evaluated the ecological footprint of the school, and determined areas for improvement as part of their science education, tied in with service learning. Students have identified automobile idling as the focus of their 2012 project. During the spring, when the 5th grade life science curriculum is Environments, students will research, design and implement a project to improve the environment of the school by running a no idling campaign. They will explain the project to 265 fellow students in an assembly and/or class meetings and communicate to parents through the school website and newspaper, the Nebraska Avenue Times. They will engage the community and follow up with reporting several times throughout the spring term. Students will continue an environmental project each year, selecting different ways to improve the school's ecological impact. In addition to this work in science class, students on the Student Council's Safety and Environment Committee work to make the school more ecologically friendly, implementing service and awareness projects throughout the year. NPS uses a structured, student-led approach to service learning, with an award-winning, five-step approach[4]. This procedure and examples of student-led work is shown in the table below.

<table>
<tr><th>Service Learning Plan</th><th>Example of student-led work</th></tr>
<tr><td>Identify an area of need

Image: Concept map generated by 5th grade students showing inputs and outputs to the school.


</td><td>Students brainstorm inputs and outputs to the school, looking at ways to reduce the school's environmental impact. One topic is selected for further study, in this case, idling in the carpool line.</td></tr>
<tr><td>Learn more about the issue and identify ways to help</td><td>As part of the regular environmental science curriculum, students investigate ranges of tolerance for different</td></tr>
</table>

[4] http://www.csee.org/products/255#nps

<table>
<tr>
<td>

Image: 5th grade bioassay to evaluate the effects of dish soap on radish seedlings.

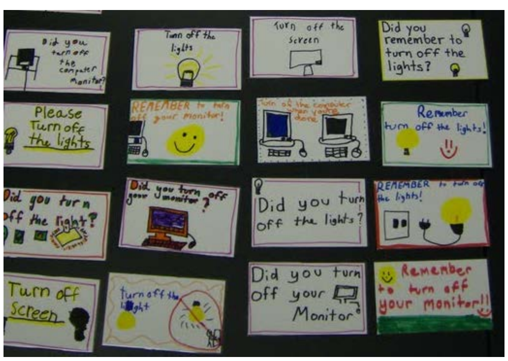
</td>
<td>

organisms to some biotic and abiotic factors. They research the impact the chosen topic has on the local environment and identify a way to help.

</td>
</tr>
<tr>
<td>

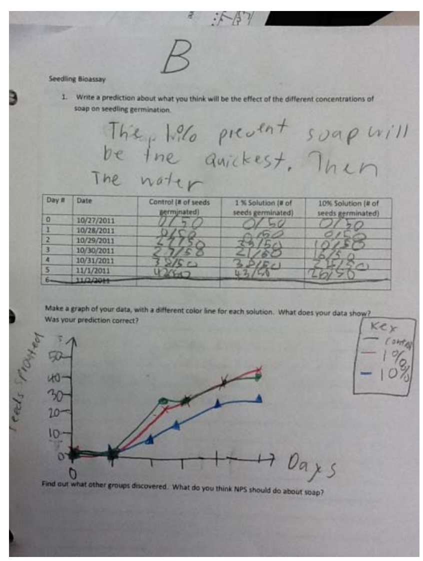
Implement an action plan

Image: Students made "Remember to turn off the lights" signs to encourage classmates and teachers to conserve energy.



</td>
<td>

Students develop a research-based plan to improve our school's environmental footprint in regards to the chosen topic. This project, done as a science experiment, involves developing a hypothesis, determining measureable data, and analyzing results.



</td>
</tr>
</table>

Reflect on the experience *Image: Students developed a skit, Recycle Idol, reflecting their learning about recycling school materials.* 	By reflecting on the experience, students will see how their actions have impacted others and improved the planet. They may develop ideas for future projects, envision themselves in careers as science professionals, and will identify themselves as scientific problem-solvers, empowered to effect change in the world.
Communicate and celebrate *Image: "Acorns" made from Hershey kisses, chocolate icing, and mini shortbread cookies.* 	An important part of the project will be to communicate the results of the action plan, celebrating the students' work and the environmental improvement their project caused. This may take the form of a newspaper article, assembly presentation, or web-based photo essay. Celebratory picnic food would be appropriate.

5. Use of NOAA and other Climate Resources *– List the NOAA and NOAA Partner resources that will be used to inform the project. Describe how each one is used.*

Resources found on CLEANET[5] that will be investigated include:

[5] http://cleanet.org/resources

Global Warming: It's All About Carbon *A sequence of five short animated videos that explain the properties of carbon in relationship to global warming, narrated by Robert Krulwich from NPR.* These videos can be used to introduce the project.

Air: Fuel for Thought *This lesson plan engages students in a real-life exploration of climate change as it is affected by greenhouse emissions from vehicles. The aim of this activity is for students to realize the impact of vehicle use in their family and to give students the opportunity to brainstorm viable alternatives to this use.* This lesson plan ties in beautifully with the project; using data to support changes in behavior allows students to improve their vehicle's impact without buying a new car.

Using a Very, Very Simple Climate Model in the Classroom *This is a teaching activity in which students learn about the connection between CO2 emission, CO2 concentration, and average global temperatures. Through a simple online model, students learn about the relationship between these and learn about climate modeling while predicting temperature change over the 21st century.* This model may be useful to tie together the information from the Global Warming intro lessons and the Fuel for Thought, in an age-appropriate way.

The Lifestyle Project *This multi-week project begins with a measurement of baseline consumptive behavior followed by three weeks of working to reduce the use of water, energy, high-impact foods, and other materials. The assignment uses an Excel spreadsheet that calculates direct energy and water use as well as indirect CO2 and water use associated with food consumption. After completing the project, students understand that they do indeed play a role in the big picture. They also learn that making small changes to their lifestyles is not difficult and they can easily reduce their personal* *impact on the environment.* The Lifestyle project can be a great home-school connection for families to join the conversation. Further, the excel spreadsheet use ties in well with the 5th grade technology curriculum.

There is an “anti-idling” toolkit which provides templates for an effective campaign. Fellow NOAA Climate Steward Brenna Holzhauer developed this useful resource which includes research, toolkits and curriculum: http://www.earthday.org/noidling.

The NOAA Climate Steward Audience Knowledge Survey for elementary students will be given: http://cselemaudience.questionpro.com/.

6. Career focus *– How will students learn about STEM careers such as backgrounds of resource people and roles they play in the Stewardship Project?*

In keeping with the tenants of Responsive Classroom, students are welcomed to class every day with a message such as, “Greetings, 5th Grade Earth Scientists!” and then, during the lesson, the significance of the welcoming message is explained. As students research the issues of stewardship, they will meet scientists, technologists, engineers, and mathematicians who work on the issues the students are examining. As a NOAA Climate Steward for the past year I frequently tell the students about the different kinds of things I’ve been learning and the various professionals who work on NOAA activities.

Throughout their project, students will **be** scientists: they will be meteorologists who collect and analyze weather data, they will be chemists who analyze gases, they will be scientific illustrators who use diagrams to clearly explain models and processes, they will be statisticians who analyze and interpret data, they will be policy-makers who use evidence to inform political decisions, they will be researchers who pose thoughtful questions, and they will be engineers who develop technical solutions to real-world problems. The students will be challenged, excited, engaged, and encouraged as they use science, technology, engineering, and mathematics to make a positive change in the world.

7. Data Collection, Analysis and Results *– Describe the data that will be collected or used to understand the problem, take action and effect change. Describe how the data will be collected and/or analyzed to inform the action and test the hypothesis.*

Students will measure the temperature of the driveway before, during, and after the carpool line-up time, 2:45 – 3:30, using Vernier temperature probes located at several positions along the roadway, and, for a control, elsewhere on campus to account for temperature changes due to weather, allowing us to determine the change in ambient temperature due to the cars. Further, students will tally the number of cars waiting in line, both idling and with engines off, and will record the model of the cars (or solicit that information via a web survey), and look up the fuel ratings. Time-lapse photography will aid in this tally process. This information will allow an estimate of the carbon load to be made. The same data will be collected after the education campaign, and differences will be measured.

8. Evaluation *– Describe how the effects of the project are evaluated. What are the effects on the Stewardship Project participant or stakeholder knowledge, behavior and/or attitudes? The environment? Policy? How did you expect them to be affected? How can you show they were affected? (you may use the project evaluator as a resource for this).*

You collect data from multiple sources. You analyze the results in the context of your goals, and similar projects by others.

The project will be evaluated in three ways. First, data will be collected to see the impact of the education campaign on the temperature and CO2. Secondly, students will be assessed on their science understanding, including the environmental impact of automobiles. The NOAA Climate Steward Audience Knowledge Survey for elementary students will be given online, before and after the project http://cselemaudience.questionpro.com/. Formative assessment of student learning will occur throughout the process, with a formal, summative assessment at the end of the unit. The third measure of effectiveness will be an assessment of attitudes and behavior changes due to the project as students complete a questionnaire before and after the activity; see Appendix 1.

9. Conclusions - *What evidence-based conclusions can you draw about the process and outcomes of the stewardship project? Was the hypothesis confirmed? What are the takeaways for others wishing to replicate your efforts? What lessons did you learn? What were the barriers, unintended consequences and/or benefits? Which of the direct and indirect outcomes in the logic model can you show evidence for in your project? What are the limitations to your conclusions? What contrary or incomplete evidence diminish the strength of your conclusions or limit when they would apply?*

[Conclusions will be determined after the project.]

***10. Presentations** – Who needs to know about this project before, during and after its implementation? What do they need to know? What format is best for communication?*

Students will write a proposal to the Upper School Director outlining their action project, requesting permission to communicate with parents and students. This communication will include a presentation in an all-school assembly, visits by student teams to homerooms during morning meeting time, an article in the school newspaper, the Nebraska Avenue Times, a paragraph in the parent e-newsletter, and sandwich-board style signs displayed in the carpool lane. Once the project is well underway, permanent "no idling" signs will be mounted along the carpool line to officially formalize the campaign.

***11. Tentative Budget* -**

Vernier Go Temp! teacher pack (8 USB temperature probes) $299

Time-lapse video camera $149.00

Poster Board (for student-made signs) $10.00

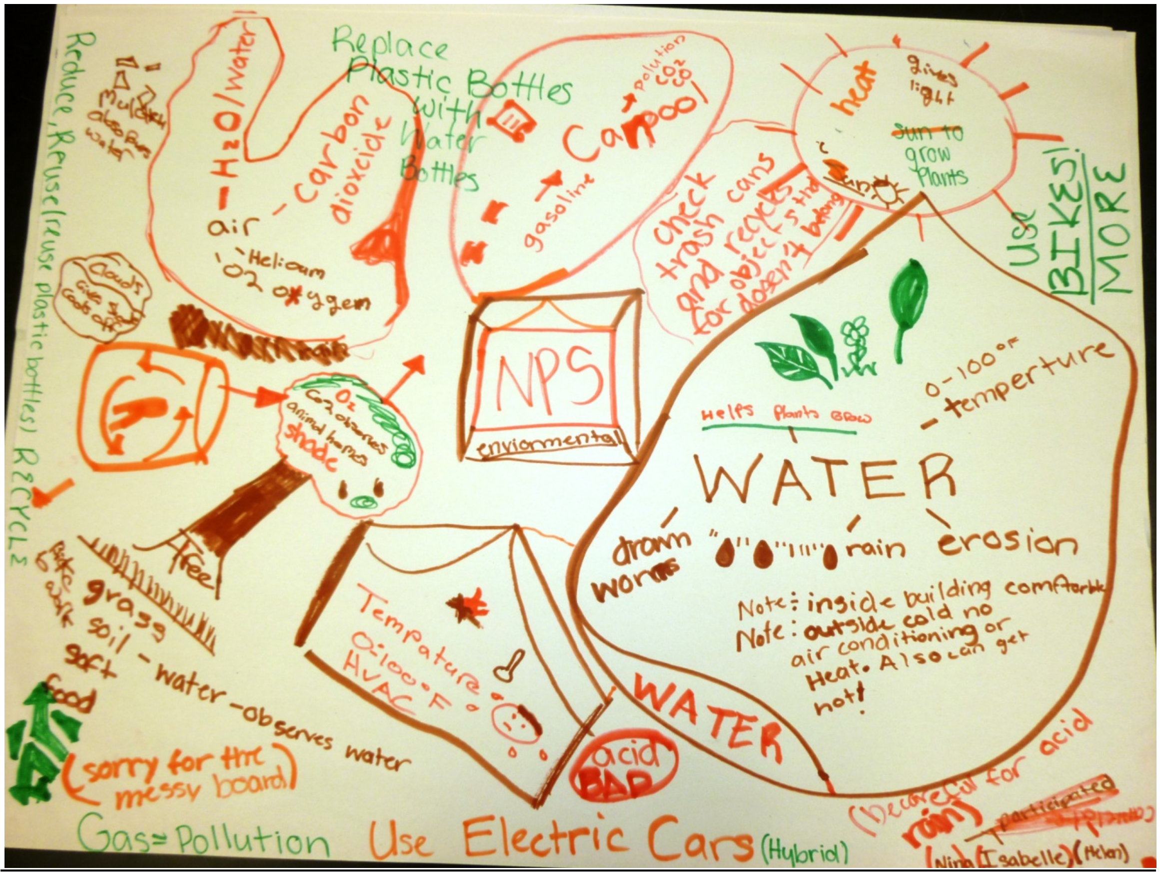
"No Idling" traffic signs 3@ $18.75 = $56.26

TOTAL Requested $**514.26**

APPENDIX C

CAMPUS ENVIRONMENTAL FACTORS EXAMPLE CONCEPT MAP

Example of student work: Concept Map of environmental factors affecting NPS.



APPENDIX D

CARPOOL IDLING TALLY SHEET

Data Collection Carpool Lane

Date: ________________________ Names: __________________

Start Time: ____________________ Ending Time: _____________

Weather: _____________________ Temperature: ______________

	Time arrived	Vehicle Brand	Idling? Y/N	Sedan, Wagon	Small SUV	Large SUV
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						

	Time arrived	Vehicle Brand	Idling? Y/N	Sedan, Wagon	Small SUV	Large SUV
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						
40						
41						
42						
43						
44						
45						
46						
47						
48						
49						
50						

(Multiple sheets were provided as necessary)

APPENDIX E

IDLING IMPACT CALCULATIONS

Idling Calculations

Look at the cars that were idling and the time that the carpool lane started moving. Figure out how many minutes each car idled. Using the information provided, calculate the CO2, VOC, CO, NoX and financial cost of each car's idling. Your table group should work out these calculations for each idling car that day.

Date: ____________________

Car # _______ Large or small? ______________

Idle end time (when carpool started moving) ___________________ - _____________ (idle start time) = _____ minutes idling.

Multiply the number of minutes by the g/min info above and complete the table.

Unit	CO2 (g)	VOC	CO	NOx	Cost (gas = $ 4.047/gal
Minute of Idling (1/60 gal)	148.97 g/min	0.269 g/min small car 0.401 g/min large car	3.82 g/min small car 5.65 g/min large car	0.079 g/min small car 0.095 g/min large car	$0.06745
X ___ min =					

(Multiple sheets were provided as necessary to account for each automobile)

APPENDIX F

STUDENT CHAPEL PRESENTATION

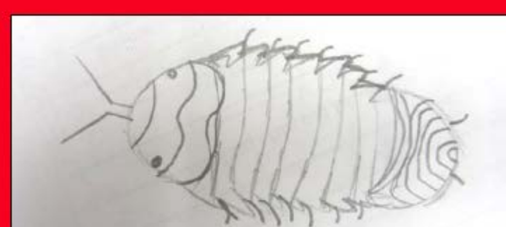
5th Grade Science Service Learning

Classroom Learning

- We learned about ENVIRONMENTS and how things like weather, water, plants and animals interact.

We studied the effect of CO_2 (carbon dioxide) in aquatic environments. Animals, including fish, breathe out CO_2 and plants use it to grow.

We designed experiments to find out whether roly-poly bugs prefer wet, moist, or dry dirt.



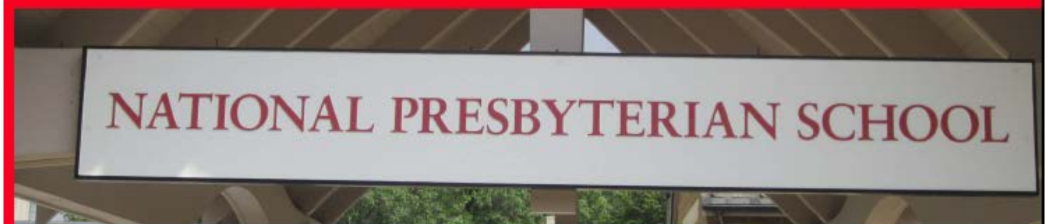
We designed experiments to find out what food and shelter Guinea Pigs like best.

Concept Maps

We looked at environmental factors affecting the school campus.

Our Environment

We talked about what we could do to make the school's environment better.

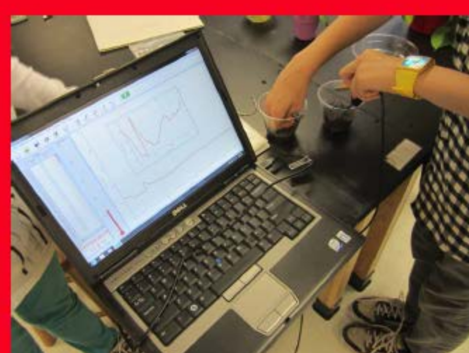


One environmental factor is auto exhaust

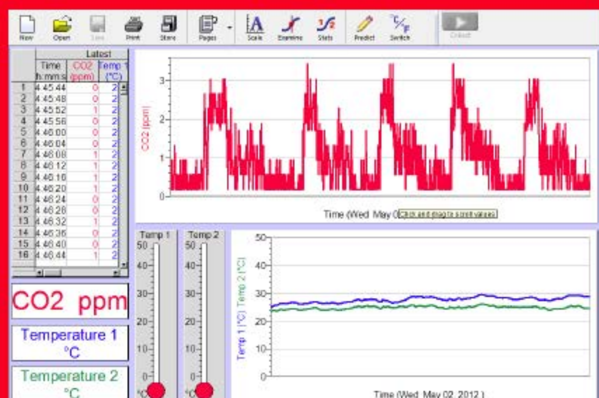
Some drivers leave their car engines running while they wait for carpool to start. This idling is not necessary.

- We brainstormed ideas about how we could study the problem and what we could do to solve it.

We explored new measuring equipment to use in our experiment. These probes connect to the computer.

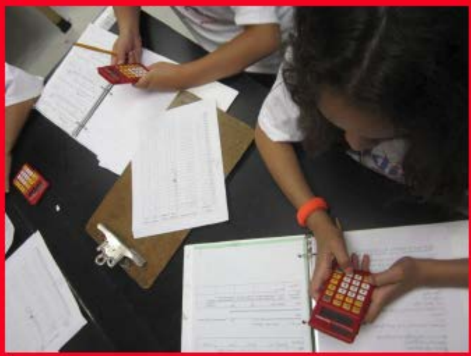


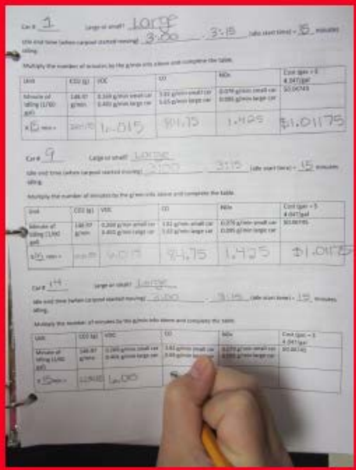
This is the computer screen showing the carbon dioxide (in red) and two temperatures (blue & green)



We collected data during afternoon carpool

We analyzed the data to calculate greenhouse gases, pollution, and cost.





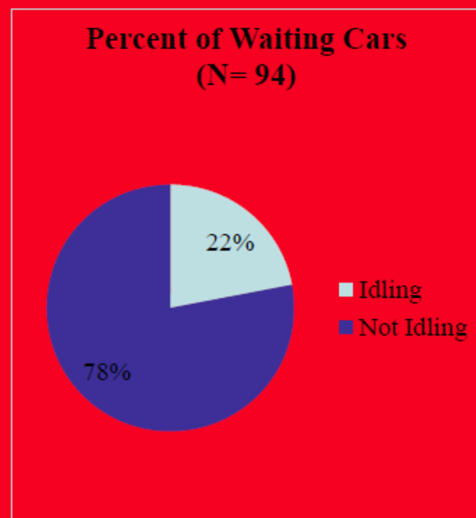
Sample data for one day

On this day,7 of the 30 waiting cars were idling, some for as long as 23 minutes!

Small/ Large Car	Minutes idling	CO2 (grams)	VOC (grams)	CO (grams)	NoX (grams)	Cost (Dollars)
Large	23	3,426.31	9.223	129.95	2.185	$ 1.55
Large	23	3,426.31	9.223	129.95	2.185	$ 1.55
Small	8	1,191.76	2.152	30.56	0.632	$ 0.53
Small	7	1,547.79	1.883	26.74	0.553	$ 0.47
Small	6	893.82	1.614	26.74	0.553	$ 0.40
Small	4	595.88	1.076	15.28	0.316	$ 0.27
Small	4	595.88	1.076	15.28	0.316	$ 0.27
7 cars	75	11,677.75	26.247	374.5	6.74	$ 5.06

Data

On average, about 22% of people idle in the NPS carpool lane.

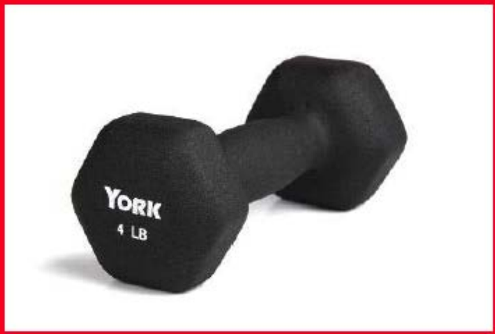


Weekly Average

- So during an average week, 35 cars idle for 509 minutes – that's 8 hours and 29 minutes.

During one week…

- We put out 2,737 grams of pollution. That's about 4 pounds.



During one week…

- Idling cars put out 75 kg of the greenhouse gas, carbon dioxide
- This is how much Mr. Sumner weighs

During one week…

- **Idling cars waste $34.00!**
- You could buy 1 share of Facebook stock

- Or 17 “tall” coffees at Starbucks
- Or a Mario Kart 7 game

Air Pollution

- Idling cars release gases and dust particles into the air.
- When this happens it affects Elliot’s eyes, nose, and throat. This makes Elliot unable to go to the park, and he loves the park.

Kit’s cousin, Elliot

Acid Rain

- Chemicals from air pollution mix with water vapor to create acid rain.

Acid Rain: What Happens?

- It eats away at statues and buildings.
- Acid rain damages animals and plants.
- Coral and shells cannot grow well if the ocean becomes acidic.

Earth's atmosphere

- Our atmosphere helps control the Earth's temperature.
- Sunlight reaching earth's surface changes to heat.

Greenhouse Gas

- Greenhouse gases trap some heat given off the earth's surface. This helps keep planet Earth warm. Some heat escapes into space.

Idling puts out CO_2 (carbon dioxide), a greenhouse gas

- Too many greenhouse gases in the atmosphere contribute to global warming.

Summary

- 5th Graders researched cars idling – sitting with their engines running – while waiting for carpool to begin.
  - Idling hurts the environment and puts out pollution.
  - It's bad for little children.
  - It causes global warming which warms the earth.
  - It wastes money.

What can you do?

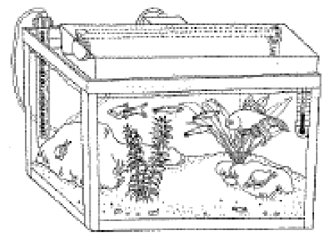
- Please ask your parents, grandparents, nanny, and babysitter to **turn off the car** when it is not being driven.

Science + Service + Learning = A Better World

APPENDIX G

FOSS ENVIRONMENTS SURVEY & POST-TEST
WITH GRADING RUBRIC

FOSS Environments Survey/Posttest Answers



1. Look at the picture of the freshwater aquarium and answer these questions. Here are some of the environmental factors that make up this aquatic environment.

☐ air	☐ heat (temperature)	☐ rocks
☑ fish	☐ light	☑ snails
☑ *Elodea*	☐ plastic plants	☐ water

   a. Mark an L in the box next to the living environmental factors above.

   b. Name two of the nonliving factors and describe how each might affect the organisms in this aquarium environment.

      i. *Sample answers*:

      Light: *Elodea* needs light to grow.

      Air: The fish need air (dissolved in the water) to stay alive.

      Water: The fish need water to swim (or to breathe).

      Heat: The temperature cannot be too hot or too cold for the organisms to survive (that is, it needs to be within the range of tolerance).

	Code	If the student…
1a	2	Marks the three living environmental factors (fish, *Elodea*, and snails).
	1	Provides any other answer.
	0	Makes no attempt.
1b	3	Describes how two nonliving factors could affect the organisms.
	2	Describes how one nonliving factor could affect the organisms.
	1	Provides any other answer.
	0	Makes no attempt.

2. What is the relationship between an organism's *range of tolerance* and its *optimum condition?*

   The optimum condition is within the range of tolerance.

	Code	If the student…
2	3	Indicates that the optimum condition is within the range of tolerance.
	2	There is no level 2 for this item.
	1	Provides any other answer.
	0	Makes no attempt.

3. Andrew wanted to find the optimum conditions for his chickens to lay eggs. He divided his 20 chickens into two groups, X and Y, and recorded their daily care and egg production for 2 weeks.

		Daily Care		Results after 2 weeks
	Number of Chickens	Chicken Feed for group	Calcium for group	Number of eggs laid by group
Group X	10	1000 grams	5 grams	82
Group Y	10	1300 grams	10 grams	104

a. Did Andrew do a good job of controlling the variables in his experiment? no

Explain why or why not.

Andrew changed two variables at the same time (amount of chicken feed and amount of calcium), so he can't tell the difference.

b. Which of the following could Andrew do to improve his experiment to find the optimum conditions?

(Circle the one best answer.)

A. Observe the chickens over a longer period of time.

B. ✓Test a great number of values for one condition (variable).

C. Record data for each chicken individually.

D. Repeat the experiment at least two times.

	Code	If the student…
3a	4	Writes "no"; indicates that Andrew changed more than one variable or did not control the variables
	3	Writes "no"; indicates that Andrew changed both the amount of food and the amount of calcium; does not include "variable" or "control."
	2	Writes "no"; gives vague or incomplete explanation
	1	Provides any other answer, including "no" with a wrong explanation.
	0	Makes no attempt.
3b	3	Chooses B.
	2	There is no level 2 for this item.
	1	Circles A, C, D or more than one answer.
	0	Makes no attempt.

4. Name four of the five basic needs of plants

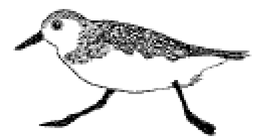
<u>(sun)light</u> <u>air (carbon dioxide)</u> <u>nutrients</u>

<u>space (support)</u> <u>water</u>

	Code	If the student…
4	3	Lists four of the five basic needs. *Note: "nutrients" cannot be replaced by "food." Plants make their own food from nutrients, carbon dioxide, sunlight, and water.*

	2	Lists soil in place of support, plus three other of the five basic needs.
	1	Provides any other answer.
	0	Makes no attempt.

5. Sanderlings are small, plump sandpipers which are a variety of shore birds. They are found on sandy beaches, mudflats, lagoons, and rocky shores. Michelle decided to study the sanderlings and determine their preferred environment. She spent 15 minutes each day observing each environment and recorded her sighting in her science notebook.



Sanderling Sightings (15 minutes/ day				
	Sandy Beach	Mudflat	Lagoon	Rocky Shore
Monday	24	12	7	4
Tuesday	26	8	5	0
Wednesday	18	15	5	3
Thursday	21	6	4	7
Friday	25	9	11	0

What is the preferred environment for the sanderlings?

(Circle the one best answer.)

A. ✓Sandy beach

B. Mudflat

C. Lagoon

D. Rocky shore

	Code	If the student…
5	2	Chooses A.
	1	Circles B, C, D or more than one answer.
	0	Makes no attempt.

6. The mangrove is a tree found only in saltwater environments. What would happen if you moved a mangrove tree to a freshwater environment? Explain your answer.

The mangrove tree would probably die (or would not grow well) because it needs a salt water environment. Water without salt is outside the mangrove tree's range of tolerance.

	Code	If the student…
6	3	Indicates that the tree would die or not grow well because fresh water is outside its range of tolerance.
	2	Indicates that the tree would die or not grow well; does not mention range of tolerance; may mention that the mangrove tree needs salt or salt water to live.
	1	Provides any other answer.

	0	Makes no attempt.

7. All of the things listed below are important when designing an experiment.

Which one is the most important?

(Circle the one best answer.)

a. Assigning tasks to group members

b. ✓ a plan to control variables

c. A list of materials

d. Deciding how to record data

	Code	If the student…
7	2	Chooses B.
	1	Chooses A, C, D or more than one answer.
	0	Makes no attempt.

8. Jimmy heard that small amounts of magnesium sulfate dissolved in water helps seeds to germinate. He decided to experiment to find the optimum amount of magnesium sulfate for the germination of sunflower seeds, but he didn't know how to set up his experiment.

Design an investigation for Jimmy to determine the optimum amount of magnesium sulfate for the germination of sunflower seeds.

<u>Student's design should control all variables (amount of water, soil, amount of</u>

light, number of seeds, etc) except the amount of magnesium sulfate. A criterion for determing the optimum amount should be included. *Sample answer:* Set up six pots. Each pot should be the same size, contain the same amount of the same soil, the same number of sunflower seeds, etc. Make magnesium sulfate solutions of 1, 2, 3, 4, and 5 grams, each in a liter of water. Water one pot with plain water and the others with the solutions. Use the same amount for each pot. Observe the pots daily and record observations. The pot being watered with the optimum amount of magnesium sulfate will have the most sprouted seeds.

	Code	If the student…
8	4	Designs an experiment that varies the amount of magnesium sulfate and controls other variables; includes criterion for determining optimum amount of magnesium sulfate.
	3	Designs an experiment that varies the amount of magnesium sulfate; does not keep all other values constant *or* does include criterion for determining optimum amount of magnesium sulfate.
	2	Indicates that the amount of magnesium sulfate needs to vary; does not include any other relevant information.
	1	Provides any other answer, including variations in light other than number of hours of sunlight.
	0	Makes no attempt.

9. Gina wanted to study goldfish so she set up two bowls with one fish in each. She feeds one Feisty Fish Food and the other Chum Fish Food and keeps everything else the same. She weighs the goldfish every other week and compares the weights.

What question is being tested?

(Circle the one best answer.)

a. Which type of fish food do goldfish prefer?

b. How much fish food do goldfish eat?

c. What is the range of tolerance of goldfish food?

d. ✓What type of food makes goldfish grow the most?

	Code	If the student…
9	2	Chooses D.
	1	Chooses A, B, C or more than one answer.
	0	Makes no attempt.

10. Which of the following is most likely to make aquarium water more acidic?

(Circle the one best answer.)

a. The fish food

b. ✓Fish breathing out

c. Chemicals from the air

d. Too many aquatic plants

	Code	If the student…
10	2	Chooses B.
	1	Chooses A, C, D or more than one answer.
	0	Makes no attempt.

APPENDIX H

FOSS ENVIRONMENTS I-CHECK 1-2
WITH GRADING RUBRIC

FOSS Environments I-Check 1-2 Answers

11. Moisture is an example of

(Circle the one best answer.)

a. ✓ An environmental factor

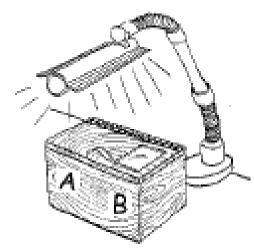
b. A preferred environment

c. An organism

d. An environment

	Code	If the student…
11	2	Chooses A
	1	Chooses B, C, D or more than one answer.
	0	Makes no attempt.

12. Look at the lid of the box under the desk lamp. Side A is solid wood. Side B has a window. The sides are connected; both sides get air, and insects can move between them.



Earwigs and waxworm moths are insects. Six earwigs and six waxworm moths were put into the box. The light was turned on. Fifteen minutes later, the waxworm moths were all found on the B side. The earwigs were all found on the A side.

What does this tell you about the insects' preference for light?

Earwigs prefer to be in the dark.

Waxworm moths prefer to be in the light.

	Code	If the student…
12	2	States that earwigs prefer the dark (Side A) and waxworm moths prefer the light (Side B).
	1	Provides any other answer.
	0	Makes no attempt.

13.

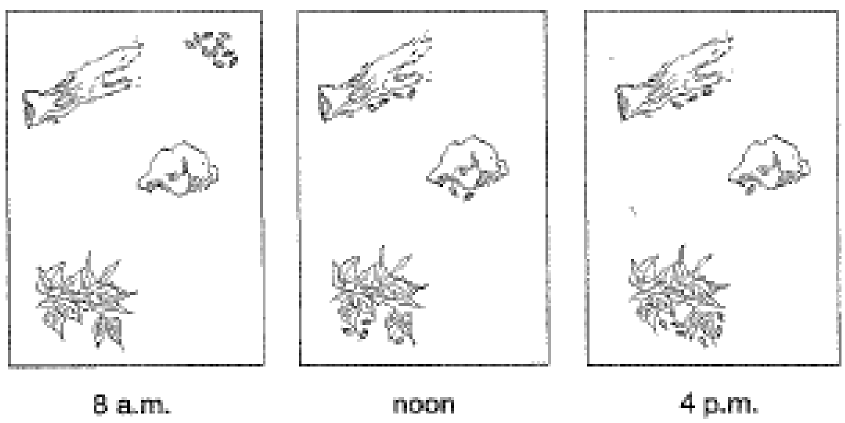
a. Name a natural environmental factor that could affect a cactus living in the desert. *Sample answers*: water, (sun)light, heat, cold, wind, birds.

b. Name a human-made environmental factor that could affect a cactus living in the desert. *Sample answers*: off-road vehicles, buildings, garbage, air pollution.

	Code	If the student…
13a	2	Names one appropriate natural environmental factor.
	1	Provides any other answer.
	0	Makes no attempt.
13b	2	Names one appropriate human-made environmental factor. (Water is only correct if it is clearly caused by humans, eg,

		"water from sprinklers.")
	1	Provides any other answer.
	0	Makes no attempt.

14. Some students observed the behavior of isopods (also called pill bugs, sow bugs, or roly-poly bugs). They made an isopod habitat by placing a rotting log, a rock, and some leaves inside a box. They put the isopods in a corner of the box as shown at 8:00 am, and drew pictures of what they saw during the day.



a. Look carefully at the pictures. Where do the isopods prefer to live?

<u>Isopods prefer to live near the leaves (and the rotting log).</u>

b. Explain how you know that is the isopod's preferred environment.

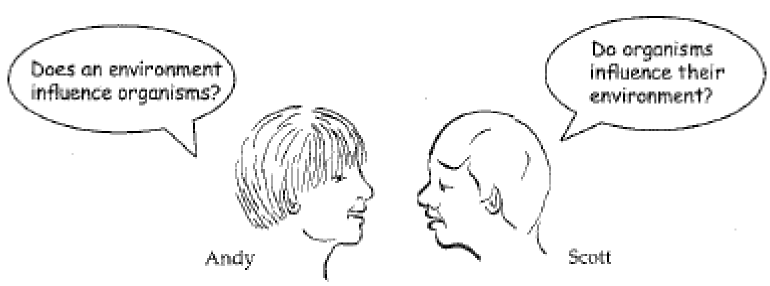
<u>The isopods moved to the leaves (and the rotting log) when they had a choice of environments.</u>

c. What does isopods' preferred environment provide for their survival?

<u>The leaves (and the rotting log) provide food (and possibly moisture and shelter).</u>

	Code	If the student…
14a	2	Identifies the leaves as the isopods' preferred environment. May also identify the rotting log, but leaves must be included..
	1	Provides any other answer.
	0	Makes no attempt.
14b	2	Explains that the evidence was that most of the isopods moved to the leaves when they had a choice.
	1	Provides any other answer.
	0	Makes no attempt.
14c	2	Describes at least one thing the preferred environment provides for the isopods' survival.
	1	Provides any other answer.
	0	Makes no attempt.

15. Two students have questions about the relationship between the environment and the organisms that live there.



a. Give Andy an example of a change in a natural environment and describe how it can influence an organism

Sample answers: If there were a drought, an organism might die due to lack of water. Colder weather may cause an organism to hibernate (animal) or go dormant (plant). Other examples include fire, flood, and landslides.

b. Give Scott and example of an organism and how it can influence its environment.

Sample answers: Earthworms tunnel through the ground, aerating the soil. Snails eat plants, possibly killing them. People build dams, interfering with salmon swimming upstream to lay eggs.

	Code	If the student…
15a	3	Provides an appropriate example of how a change in the environment can influence and organism.
	2	Provides a relevant example; doesn't clearly describe the effect on the organism.
	1	Provides any other answer.
	0	Makes no attempt.
15b	3	Provides an appropriate example of how an organism can influence its environment.
	2	Provides a relevant example; doesn't clearly describe the effect on the environment.
	1	Provides any other answer.
	0	Makes no attempt.

16. Mark an X next to each living environmental factor.

___	temperature	___	light
_X_	earthworms	_X_	grass
___	rocks	___	river

	Code	If the student…
16	2	Marks only earthworms and grass.
	1	Provides any other answer.
	0	Makes no attempt.

17. Mark an X next to each basic need of humans.

_X_	water	_X_	air
___	shoes	___	cell phones
_X_	food	___	television

	Code	If the student…
17	2	Marks only food, water, and air.
	1	Provides any other answer.
	0	Makes no attempt.

18. Which of the following is important when performing an investigation on animal behavior? *(Circle the one best answer.)*

a. Variables are controlled

b. One factor is observed at a time

c. The animal is not harmed

d. ✓All of the above.

	Code	If the student…
18	2	Chooses D.
	1	Chooses A, B, C or more than one answer.
	0	Makes no attempt.

e.

19. Which of the following environmental factors in a bear's environment is nonliving? *(Circle the one best answer.)*

a. Berries

b. Salmon

c. ✓Snow

d. Trees

	Code	If the student…
19	2	Chooses C.
	1	Chooses A, B, D or more than one answer.
	0	Makes no attempt.

APPENDIX I

FOSS STUDENT RESPONSE SHEET 3
WITH GRADING RUBRIC

Student Response Sheet – Aquatic Environments

Charlotte wrote in her science journal,

Today we put a few drops of BTB in a cup of water. Then we put a fish in the water. After 20 minutes I noticed that the water had turned from blue to yellow. We think if we put a tadpole or crayfish in the water containing BTB it would turn yellow in 20 minutes too.

Do you agree or disagree? Explain your thinking.

Score	If the student…
4	Agrees with Charlotte; and (1) states that BTB is an indicator for acid; (2) mentions that all aquatic animals produce carbon dioxide; and (3) describes the relationship of the more carbon dioxide in the water the greater the acidity.
3	Agrees with Charlotte and includes two of the three points described above
2	Agrees with Charlotte and includes one of the three points described above or disagrees with Charlotte and includes two of the points described above.
1	Disagrees with Charlotte, and includes no other information.
0	Does not complete task, or gives information that has nothing to do with what was asked.

APPENDIX J

FOCUS GROUP INTERVIEW QUESTIONS

FOCUS GROUP INTERVIEW QUESTIONS

1. What have you learned about environments as a result of participating in the science service learning project compared to what you learned during the regular lessons and investigations?
2. After participating in the science service learning project, do you feel you have a better, same, or worse understanding about environments than you have had from the regular lessons? (Choices on Scale: Much worse, A bit worse, About the same, A bit better, Much better) Why?
3. Has participating in the science service learning project changed the way you feel about your ability as a science student (your confidence)? How?
4. Has participating in the science service learning project changed the way you feel about science class? How?
5. Has participating in the science service learning project changed the way you feel about your relationships with classmates? If yes, what is different?
6. How was working with your partners during the science service learning project compared to working with your partners during regular science class? Explain.
7. Has participating in the science service learning project changed your view of the value of science? If yes, how has it changed the way you feel about the importance of science?
8. What activities during the science service learning project have been most helpful for you?
9. What else would you like me to know?

APPENDIX K

STUDENT KNOWLEDGE AND ATTITUDE SURVEY

Knowledge and Attitude Survey

1. How aware were you before this science service learning project, compared with how aware you are now? *Make two marks on each scale: mark "B" for your level of awareness before the project and "N" for your level of awareness now.*

a. Effect of idling on environments

1 (not at all) → 2 → 3 → 4 → 5 → 6 → 7 → 8 → 9 → 10 (extremely aware)

b. Human impact on the environment

1 (not at all) → 2 → 3 → 4 → 5 → 6 → 7 → 8 → 9 → 10 (extremely aware)

2. How likely are you to do each of the following?

a. Turn off the car instead of idling once I learn to drive

1 (not at all) likely → 2 → 3 → 4 → 5 → 6 → 7 → 8 → 9 → 10 (definitely will)

b. Explain to others why it is important to not idle

1 (not at all) likely → 2 → 3 → 4 → 5 → 6 → 7 → 8 → 9 → 10 (definitely will)

c. Volunteer to explain to others about the problems of idling

1 (not at all) likely → 2 → 3 → 4 → 5 → 6 → 7 → 8 → 9 → 10 (definitely will)

3. How likely are you to

a. Reduce idling by my family drivers

1 (not at all) likely → 2 → 3 → 4 → 5 → 6 → 7 → 8 → 9 → 10 (definitely will)

b. Be aware of idling in my community

1 (not at all) likely → 2 → 3 → 4 → 5 → 6 → 7 → 8 → 9 → 10 (definitely will)

c. Share with others how to reduce idling

1 (not at all) likely → 2 → 3 → 4 → 5 → 6 → 7 → 8 → 9 → 10 (definitely will)

4. What would you say to explain to a friend about what you learned about environments during this project?

APPENDIX L

NOAA CSEP ELEMENTARY CLIMATE SURVEY

Climate Stewards Education Program Elementary Audience Knowledge Survey - KEY

http://CSelemaudience.questionpro.com

What is the name of this event or activity or class ______________________

What is the name of your teacher or the leader of this event or activity ________________

What is your age? (so we can compare your responses with a national sample) ______

What is your zip code ____________

1. What is something you learned today about how to take care of the Earth?
   ____
   ____

2 and 3. How much did you know before today about the Earth compared with how much you know now?

1=Nothing 2=A little 3=Some 4=A lot DK= I don't know

2. Before		3. After
	Weather is what is happening today where I live	
	Climate is the weather over a long time	
	The climate of the Earth is getting warmer	
	A warmer climate will change our weather	
	We can slow down the warming by changing some things we do	

4. True or False
   T Weather often changes from year to year.

   T Climate means the average weather conditions in a region.

   F Climate often changes from year to year.

   T Ocean currents carry heat from the equator toward the north and south poles.

F Weather means the average climate conditions in a region.

F Climate and weather mean pretty much the same thing.

F The atmosphere carries heat from the north and south poles toward the equator.

5. How much does each of the following contribute to global warming?
   1=Not at all 2=A little 3=Some 4=A lot DK=Don't know

   All others minor or insignificant contributors

4	Cars and trucks	_	Nuclear power plants
4	Burning fossil fuels for heat and electricity	_	Volcanic eruptions
4	Deforestation	_	The sun
_	The hole in the ozone layer	_	Acid rain
_	Toxic wastes	_	The space program
_	Aerosol spray cans	4	Cows

Optional Questions

1. Which of the following are "fossil fuels"? - Check all the items below that you think are fossil fuels.

   Fossil fuels: Coal, Oil, Natural Gas

   NOT fossil fuels: Wood, Hydrogen, Solar Energy

2. What gas is produced by the burning of fossil fuels? Carbon Dioxide

   a. Oxygen
   b. Hydrogen
   c. Helium
   d. <u>Carbon Dioxide</u>
   e. Don't Know

3. Which of the following statements is true? Most glaciers are melting away.

   a. All of the glaciers on Earth are melting away.
   b. <u>Most of the glaciers on Earth are melting away.</u>
   c. Some of the glaciers on Earth are melting away.
   d. None of the glaciers on Earth are melting away.
   e. Don't Know

APPENDIX M

DRAW A SCIENTIST TEST

"Draw A Scientist Test" Directions: In your mind, picture yourself as a scientist. What are you doing? Where are you working? What tools are you using? What clothes are you wearing? What does your face look like? Now, draw this scientist. Stick figures are okay. You may add words or labels if you like. Underneath the drawing, please explain your picture.

Scoring Rubric

DAST Rubric

1. Age of scientist
    a. Child (student age)
    b. Young adult
    c. Old adult
    d. Can't tell
2. Clothing
    a. Lab coat
    b. Work-specific clothes (space suit etc)
    c. Casual clothes (jeans, t-shirt)
    d. Dressy professional clothes (suit)
    e. Can't tell
3. Facial expression
    a. Smiling
    b. Sinister/Angry
    c. Neutral
    d. Can't tell
4. Hair
    a. Kempt
    b. Wild
    c. Can't tell
5. Colleagues
    a. Working alone
    b. Working with others
    c. Can't tell
6. Work environment
    a. Indoor "science lab"
    b. Indoor office
    c. Outdoors
    d. Can't tell
7. Tools
    a. Computer
    b. Reference books
    c. Communication equipment (phone, chalkboard)
    d. Topic-specific equipment
    e. None
    f. Other:
    g. Can't tell
8. Type of scientist
    a. Chemist
    b. Physicist
    c. Earth scientist
    d. Biology – plants
    e. Biology – animals
    f. Engineer
    g. Other:
    h. Can't tell
9. Reason
    a. Working to solve problem
    b. Making discovery
    c. Helping someone
    d. Collecting data
    e. Excitement
    f. Other:
    g. Can't tell