Beyond Eco-Footprints: Using the STEM Process

Getting K-12 students involved in all stages of the greening process in their schools

Photographs: Cary Institute of Ecosystem Studies

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WHY DO environmentally-themed lessons often come with a full serving of guilt? One way in which this happens is through the use of an "Ecological Footprint" quiz that demonstrates to students how big their environmental impact is by asking a series of questions that indicate how many resources he/she uses. The student is presented with a score at the end, usually represented in the "number of earths" that it would take if everyone in the world lived the way he/she does.

What do students take away from doing an activity like this? Even if you take the quiz as an environmental "angel", you'll find that it is impossible to reduce your footprint to much less than two "earths". As acknowledged on many of the sites that offer footprint quizzes, a portion of your footprint is due to the fact that, if you live in countries like the United States, we have infrastructure and an economy that is based primarily on fossil fuels. Consequently, students are often left frustrated and unsure of what to do, since the situation feels somewhat hopeless.

In order to avoid the tendency towards what David Sobel termed "ecophobia", where students feel overwhelmed with bad environmental news and subsequently distance themselves even more from the natural world, we decided to take the ecological footprint idea local, and teach students techniques for collecting their own "footprint" about their local ecosystem. In this article, we describe how taking a place-based approach to the ecological footprint not only improved students' content knowledge but also provided new models of collaboration between grades and the ability for students to feel empowered to make a measurable difference in their community.

Using an Ecosystem Approach

We began our work in upstate NY with a school district of teachers and school leaders who were interested in making their schools more environmentally friendly. However, choosing an action to take was challenging, especially in light of the many different ways that any sustainability effort could be used in the classroom. There were ideas in the district ranging from improving recycling to installing solar panels to building a garden. While any of these actions are potentially powerful ways to engage a school community in positive environmental change, it was difficult to know which type of project

would have the biggest impact. So, we decided to take a step back and use science to help the school district determine which solutions to pursue. This began the "Eco-Initiative", a three-year program that builds environmental literacy through all grades of a local school district by mapping the ecological footprint of the elementary, middle, and high schools.

Our guiding principle was to use ecosystem thinking, which reminds us that every place is an ecosystem, and ecosystems have boundaries with inputs and outputs that can be measured and balanced. Our schools are ecosystems, and if you put an imaginary "box" around any school building, you can start to imagine the inputs – food, water, materials (pencils, paper, books) – and the outputs – wastewater, trash, heat. Students knew that they used raw materials every day, and they can see how those inputs are transformed to waste. But the students were less aware of where the food, water, and energy came from and where their waste goes, as well as what lives in and around the grounds of their schools. Our goal was to have students collect data about the school's ecosystem – focusing on the themes of food, water, waste, energy, and biodiversity – and use that information to guide future sustainability decisions. We wanted to model how to use science to make informed decisions, instead of just choosing a greening project and asking students to help us complete it.

We began the project through a series of meetings and workshops with district teachers, identifying appropriate topics (based on the themes mentioned above) for each grade level or class and developing age-appropriate investigations that would allow the students to gather data and to understand their theme. Since this was a small district, with one elementary, middle, and high school, we were able to have professional development sessions throughout the school year and summer for teachers to have time to meet and plan across grade levels. This vertical planning encouraged collaboration which led to unique projects across grades along with support between teachers who previously worked on environmental lessons on their own.

Collecting Data for the Scorecard

If we want students to use data to make decisions and assess the effectiveness of our decisions, we need to allow them to engage in genuine science as part of this process. This observation-based learning might be a departure from the traditional "scientific method" that is taught in many elementary schools, but it provides students with a more authentic understanding of one of the ways scientists gather data about the world around them – through observations which can lead to a robust database of information. Encouraging students to gather data about their school as an ecosystem means that students have more ownership over the process and the project. We also noticed some positive trends in student knowledge as a result of participating in this project.

At the end of each year, we published an Environmental Scorecard for the Eco-Initiative, which includes all of the collected student data and work. Below, we describe some of the classroom activities conducted in three of the project's four strands, which were part of the data collection for the Scorecard.

Water

This theme fit most appropriately into the curriculum of the first and second graders, who split up the ways in which to investigate water. In first grade, students focused on how living things use water, and where water exists in their school. Students tallied the number of sinks, toilets, water fountains, and other water appliances by doing a school-wide survey, and making a large pictograph of their results. First graders also explored the properties of water and took a field trip to the Hudson River to learn about the source of their drinking water. Consequently, the students' ability to identify the source of their drinking water jumped from 10% in 2010 to 75% in 2011.

In second grade, students conducted a simplified version of a schoolyard water budget, learned about permeability of different surfaces, and investigated the ways in which plants fit into the water cycle. Students compared their estimates of school water use to the amount that is shown on the school's water bill, and drew pictures illustrating how much water the school uses each year. They also designed and painted several rain barrels which were raffled off to families at our Eco-Initiative Open House. To find out how to investigate permeability and complete a water budget in your schoolyard, see the Resources section.

Waste

As a whole school, we evaluated the amount of waste created in the lunchroom over the course of several days. With the help of the school's environmental clubs, we sorted trash into major groups and weighed the results. This information provided a baseline for teachers who wanted to do more in their individual classrooms, and for school clubs who wanted to implement changes, such as the Middle School environmental club who began organizing Garbage Free lunches every Friday.

Third grade teachers took on the challenge of waste, and incorporated a daily waste weighing activity into their classroom routine. Students were taught how to sort garbage into recyclables, compost, and trash, and kept track of the results on a classroom data sheet. After spending several months weighing their trash, one third grade classroom made a big poster showing how much waste was created in their school and decided to make reusable napkins for use in the lunchroom. They then sponsored a "waste-free" lunch day for the entire grade. As a result, non-recyclable waste went down by 50%.

One of the eighth grade English teachers decided to make waste a research topic, and her students formed groups to learn about the different pathways of the waste types that were discovered by the third graders. The students were charged with presenting their results to the third grade via games, videos, or songs. For example, one group chose to investigate plastics, and developed a game modeled on "Twister" where each move is preceded by a question related to the creation, use, or disposal of plastic. Several eighth grade students spent an afternoon with the third graders, playing their games and talking with them about waste.

Biodiversity

We began by training all interested teachers in collection protocols to survey biodiversity, which included pit fall

traps, sweep netting, beat sampling, track plates, and direct observation and identification. Several teachers have since applied for a local grant to fund the purchase of remote controlled cameras to monitor larger animals on the property. The driving question behind our work was to document the biodiversity of the schoolyard, and to monitor any changes over the years. All of the protocols we used can be found in the Resources section.

Students in fifth grade, seventh grade, and in high school biology classes conducted schoolyard "Eco-Blitzes," where they cataloged all the living things they found outside. The younger students excelled at finding and identifying insects, while the older students worked with their statistics teacher to analyze their data. In the second year of the project, one fifth grade classroom became experts at identifying their schoolyard's living creatures, and brought the fourth graders outside for a day of exploration. This kind of near-peer teaching is a demonstrated strategy for improving student learning, as the student "teachers" become experts in their content as they work with other students.

Students used their data to begin a variety of conversations in their classrooms about biodiversity. In the fifth grade, students decided to set up bird feeders outside their classroom windows and monitor the birds that used the feeders, while seventh graders calculated the biotic index of the aquatic ecosystem they sampled. At the high school level, native shrubs were planted to enhance the schoolyard, and students began removing invasive plants. Because the Eco-Initiative is a multi-year program, we are continually developing a database of organisms that live in the Rhinebeck schools' lawns, playgrounds, and athletic fields, which will allow us to start thinking about ways to enhance biodiversity and support ecosystem function.

Using Data for Greening

As classes and teachers begin to make changes to their daily habits at school, we hope to see a response in our data. An easier path might have been to ask for the energy and water bills and call it a day, or to plant a few trees and declare our "greening" mission complete. But we wanted the students, teachers, and administrators to take ownership of the process, to figure out what their impact was, and to decide what kind of sustainability initiatives made sense for their schools. By modeling an iterative process, we are showing students how science can inform their actions and lead to lasting change. We are also helping them think through some of the really difficult questions that relate to any greening initiative, such as whether it really is more "green" to purchase compostable lunch trays made from corn if we're unable to compost them on site, or whether we should install energy-efficient lightbulbs when most of the energy in the school is being used for heating and cooling.

Engaging in this process is complex, but we believe such engagement develops students that are thoughtfully dedicated to understanding their local environment, and who can engage in making evidence-based decisions. We are thrilled that we have been able to undertake this long-term project with the Rhinebeck School System, and we hope that this data-based approach to a local environmental footprint inspires others to do the same!

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You can see Scorecards from two years of the project by visiting the Rhinebeck School District website, www.rhinebeckcsd.org , and we have included one part of the Scorecard from 2011 (Fig. 2). We want to thank the Rhinebeck Science Foundation for funding this project, and all of the teachers, students, parents, and administrators in the Rhinebeck School District for all their support and hard work over the last three years.

Resources

You can find the materials related to the protocols used for the biodiversity and water parts of this project on our searchable curriculum website, www.caryinstitute.org/educators/teaching-materials. For more information about the Rhinebeck Eco-Initiative, visit www.rhinebeckcsd.org/resources.cfm?subpage=1060162. This includes student work, the Scorecard, and data forms that might be helpful if you are hoping to replicate this type of project.