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NATIONAL EARTH SCIENCE TEACHERS ASSOCIATION

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Cleaning up your local shoreline or even just your neighborhood can help prevent trash from becoming marine debris and can help to create a healthy ocean that we can all enjoy. Pictured here is debris cleaned up by the NOAA Marine Debris team from the shores of Midway Atoll cleaning the waters of Papahānaumokuākea Marine National Monument.

Photo Credit: CREP/NOAA

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NESTA'S MISSION

To facilitate and advance excellence in Earth and Space Science education.

From the President

Engaging in Science

This edition of *The Earth Scientist* showcases projects supported by NOAA and the Planet Stewards Program. While I have not participated actively with Planet Stewards in the last few years, I was honored to be in the first cohort as a high school teacher and then a few years later I was lucky enough to receive support to engage students in science through "Citizen Science" with the Sea Urchins for Reefs Future (SURF) Project. This project, highlighted environmental stewardship, as well as place-based, experiential learning. It provided five K-5 classrooms with a saltwater fish tank, several dozen baby "collector sea urchins and limu, seaweed species and a wide variety of marine algae for food.

The students' task was to raise the urchins provided by the Hawaii Department Natural Resources Sand Island Urchin Hatchery. Each semester we started with 125 baby urchins, roughly 5 mm in diameter with the plan to grow them to 35 mm size for release on reefs that had been cleaned of invasive algae. Let's just say that raising urchins in an elementary classroom has challenges that were unexpected, but these challenges led to some amazing problem-solving on the part of the participating teachers and students. Yes, we had about 90% mortality in our first attempt, but with the help of the school principal, the custodial staff, and teachers who lived close to the school, we were able to decrease our mortality to 50% in the second attempt and by the third and fourth iterations we were hovering around 35% mortality. We were able to place 70 to 80 urchins out on the reef at Waikiki in December and June giving the students, their teachers, and their school the opportunity to help the ensure the future of the reefs off Oahu.

Putting 70 to 80 urchins on a reef is not a lot in the grand scheme of things but the parent project, now in its tenth year, aims to put 60,000 urchins out on 227 acres of reef in Kaneohe Bay and in the reef adjacent to the Waikiki Aquarium in the Waikiki Marine Life Conservation District each year. While the contribution to the overall project might have been minimal, the experience for these elementary students and their teachers provided maximum opportunity to "Engage in Science", help to control invasive algae, and to learn that they have the ability to truly be Planet Stewards.

Richard Jones, President 2020-2022
richard.jones@hawaii.edu

NESTA Address:
PO Box 271654
Fort Collins, CO 80527

Visit the NESTA website at
http://www.nestanet.org

Guest Editor's Corner

Celebrating Over a Decade of Stewardship

A bit more than ten years ago when Peg Steffen and I created NOAA Planet Stewards (https:/oceanservice.noaa.gov/education/planet-stewards/) I couldn't have imagined what the program would become. We started out with a dozen or so educators sitting around a conference room table, discussing how to engage students in solving real world environmental problems through hands-on stewardship. Since then, Planet Stewards has supported over 200 stewardship projects across the country, engaging thousands of students, educators, family members and volunteers, in tens of thousands of hours of educational and hands-on stewardship activities. Through our workshops, book club discussions and especially our bimonthly newsletter, *The Watch*, the program now reaches over 22,000 educators across the country and the world! Be sure to sign up to receive our newsletter to get the latest information about educator and student opportunities, new classroom resources, professional development workshops, grants, articles on science, stewardship and education, and more! https://public.govdelivery.com/accounts/USNOAANOS/subscriber/new?topic_id=USNOAANOS_139

Over the years, we have sponsored many informative webinars on environmental science and science pedagogy. You can find a selection of some of our best at: https://oceanservice.noaa.gov/education/planet-stewards/webinars.html.

While NOAA Planet Stewards Program activities have evolved over the years, the program's goals have always remained the same; to build science literacy among educators and students so they can:

- *understand* concepts in ocean, climate & Earth science,
- *assess* the scientific credibility of information,
- make *informed* and *responsible* decisions,
- *initiate actions* in their communities.

NOAA Planet Stewards recognizes that every community, school, and classroom is unique although they may face similar challenges. That is why we keep our focus broad in the types of stewardship projects we support. We want to provide opportunities for success that best suit the needs of every educator's community that applies. In this issue of *The Earth Scientist* you'll read stories about educators and students tackling tough environmental issues from carbon footprint and marine debris reduction, to watershed flood modeling and coral habitat restoration.

I hope you'll read this issue and be inspired to expand your students' or communities' awareness and knowledge of ocean, climate and Earth science, but also to take action, and empower your students and community to make a difference effecting real change in their world here and now.

Bruce Moravchik
NOAA National Ocean Service Education Coordinator

NOAA Planet Stewards Book Club Meeting Dates and Selections

(8:00-9:00 p.m. Eastern Time)

Monday, September 13, 2021: Hoot

Monday, October 18, 2021: How to Avoid a Climate Disaster

Monday, November 15, 2021: Under a White Sky

Monday, December 13, 2021: The Omnivore's Dilemma

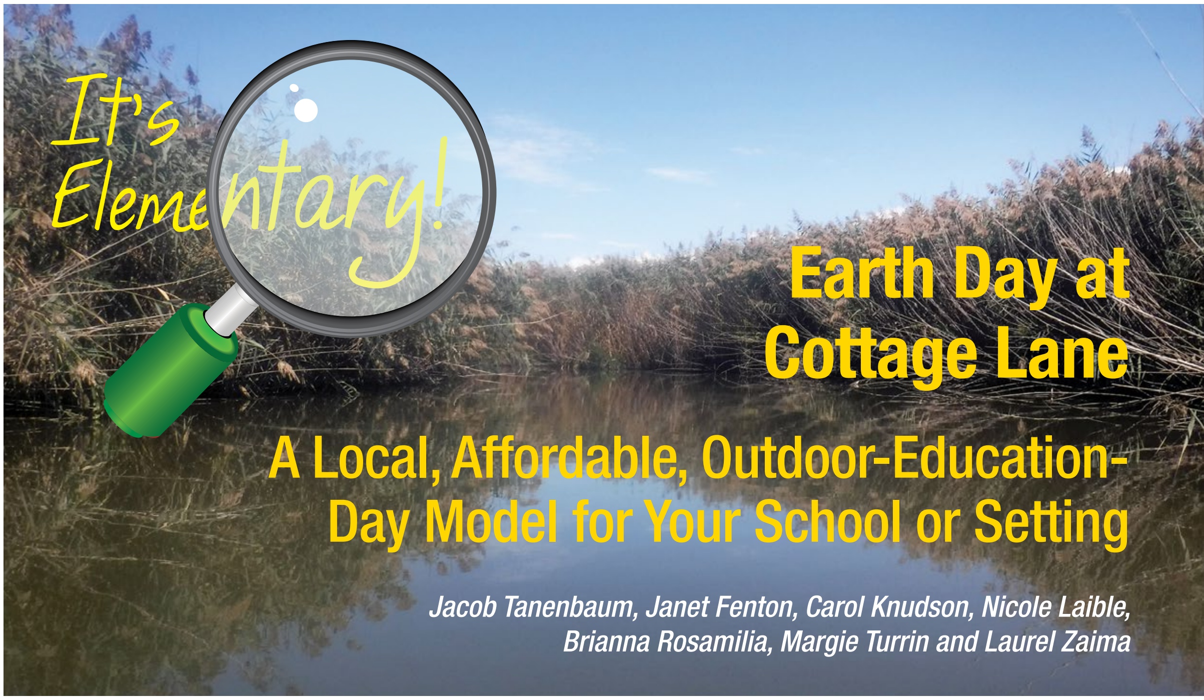
Monday, January 10, 2022: Sustainable

Monday, February 7, 2022: Our Changing Menu

Monday, March 7, 2022: Girl Warriors

Monday, April 11, 2022: The Soul of an Octopus

Monday, May 16, 2022: Cod



Earth Day at Cottage Lane

A Local, Affordable, Outdoor-Education-Day Model for Your School or Setting

Jacob Tanenbaum, Janet Fenton, Carol Knudson, Nicole Laible, Brianna Rosamilia, Margie Turrin and Laurel Zaima

Abstract

In his book "Last Child Left in the Woods," Richard Louv coined the term "Nature Deficit Disorder," which he thinks of as "... not a formal diagnosis, but a way to describe the psychological, physical and cognitive costs of human alienation from nature, particularly for children in their vulnerable developing years."(Louv, 2008) In the years that followed the publication of Louv's first book, schools began to think more deeply about how to give children authentic outdoor learning experiences. In 2010, our 3rd through 5th grade school, Cottage Lane Elementary in Blauvelt, New York, began an outdoor education event where we take our entire school to a local state park for a day. Once there, each class rotates from learning center to learning center to work with scientists, outdoor educators, local environmental groups and other volunteers to learn more about and experience the environment around them. What follows is a brief summary of what we have learned in the 10 years that we have been doing this work. We hope that it may serve as a model which other schools could replicate in their own way. Please visit this site http://jacobtanenbaum.com/outdoored.html for learning center activities that can be replicated if you want to try your hand at implementing a day of your own.

Where We Go

Tallman Mountain State Park in Sparkill, New York offers much that one should look for when selecting a location for an outdoor education event. To put it simply, there is a lot to talk about, do and study. A variety of habitats are present in the park. It is located along the western shore of the Hudson River estuary near the widest section of the River. Deciduous forest makes up much of the 700-acre park. The forest includes several freshwater ponds and streams that flow into the Hudson just below the park. The Piermont Marsh is a 1017-acre wetland that forms the eastern park boundary. (www.dec.ny.gov/lands/92365.html) It is one of the five remaining brackish tidal marshes in the Hudson River estuary (New York, 2018). The Piermont Marsh is part of the Hudson River National Estuarine Research Reserve and so it has been well studied over the years. The park provides a home to a variety of animals, birds and plants as well as aquatic life. Bald eagle and osprey are frequently seen in the area. We make use of the several miles of roads and hiking trails as well as restrooms and picnic areas in the park. The roads and trails roughly parallel one another allowing us to have some flexibility when we have individuals in our community with mobility issues.

The park also has some interesting geology. It is located along the Palisades cliffs. These basalt cliffs formed in the late Triassic when an intrusion of magma into an earlier layer of sandstone solidified below the ground, forming a sill. Erosion of the softer layers around the cliffs caused them to be exposed and they are a defining part of the Hudson river landscape in this region. (https://njpalisades.org/nature.html) Ice sheets scraped along the exposed rock during the ice ages, leaving striation marks which can still be seen today in some places.

When searching for a location to work outdoors with children, having access to a park which offers so much gives us the flexibility to have a wider range of learning centers placed strategically around the area so that children can directly interact with the subject that is being taught.

Finally, the park is just a 10-minute drive from our school. Less time on the bus means the students spend more time in the park. It also means the buses can make two trips each, cutting the largest expense of the day in half.

Volunteers and Centers

Examples of learning centers include: Forest Ecology, Mud Core Sampling, Bee Keeping, Plankton, Salt Marsh Ecology, Geology, Art in Nature, Hiking, Recycling, Macro-invertebrates, Local Turtle Protection, American Eels, Native plants vs. Invasive plants, Composting, Plankton Study, Meditation in Nature, Yoga in Nature, Geocaching and many more.

Figure 1. The Piermont Marsh with Tallman Mountain in the Background
Photo credit: Jacob Tanenbaum

Outside volunteers or school staff with unique expertise run all of the learning centers. Volunteers have included different local environmental groups, local scientists, environmental educators, our local water and electric companies and several community members; for example, a local bee-keeper created a center for us. Over the ten years we have been running this program, the group of volunteers has increased dramatically. Many come through my work with NOAA's Planet Stewards program, NOAA's Teacher on the Estuary program as well as through networks of outdoor educators around the community. We are fortunate to have many universities and scientific institutions in our area. Lamont Doherty Earth Observatory, a research arm of Columbia University is just minutes from the park, and the participation of many of their scientists and staff has been invaluable. Local environmental groups, such as Keep Rockland Beautiful

The Earth Scientist

EDITOR
Peg Steffen

PUBLICATIONS COMMITTEE
Peg Steffen
Carla McAuliffe
Howard Dimmick
Tom Ervin
Billy Goodman
Dr. Rick Jones, E-News Editor

CONTRIBUTING AUTHORS
Spencer Cody
Janet Fenton
Derek Hagen
Holly Hereau
Carol Knudson
Nicole Laible
Letitia Manning
Liz Martinez
Shannon Othus-Gault
Brianna Rosamilia
Matt Strand, Ph.D.
Beth Szijarto
Jacob Tanenbaum
Margie Turrin
Laurel Zaima

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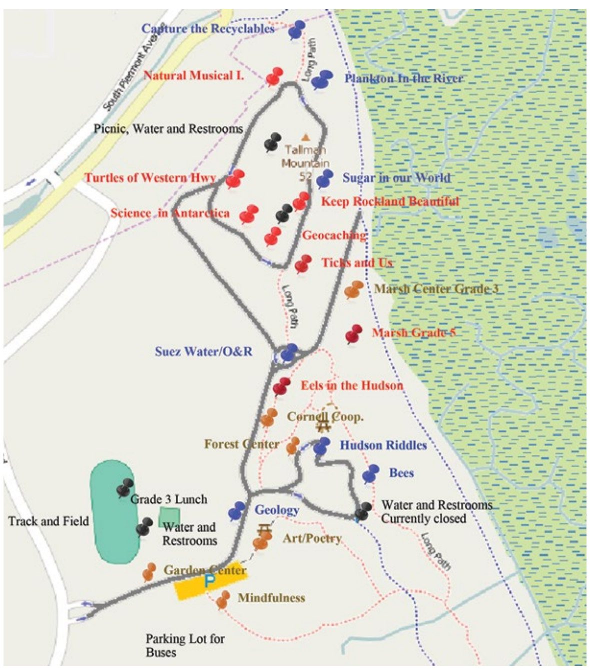
Figure 2. Earth Day 2019 – Creating Plankton Nets

Photo credit: Courtesy of South Orangetown Central School District



have also donated time as has the Rockland County Soil and Water Conservation District.

Each year we work closely with new center providers to create an activity that is age appropriate, hands on and that will fit in to the time constraints. This is critical, since many of our volunteers are not accustomed to working with third through fifth graders. Once developed, activities can be refined and repeated from year to year. Those new to outdoor education may need help with some of its unique features. One of the most important aspects of working with a group of volunteers is giving lots of advanced notice. We typically begin reaching out to volunteers in January for an event that takes place in June.

Examples of centers that you can use are found at http://jacobtanenbaum.com/outdoored.html and include:

- Composting by Janet Fenton
- Eel Game by Brianna Rosamilia and Nicole Laible
- Piermont Marsh by Margie Turrin and Laurel Zaima
- Plankton Nets by Carol Knudson

Logistics

An important part of keeping a program like this going is having well-thought-out simple logistics. Each classroom teacher and each center provider are given a map of the park with the centers clearly indicated. The map includes roads and trails as well as the location of picnic areas for lunch, water and restrooms. One of the critical parts of creating the map is paying attention to the amount of time it takes students and staff to walk between centers. We kept travel times to 10 minutes by clustering grades around the park. Centers are geared for one grade only. This way they can be repeated from year to year with no chance that students visited the center in previous years.

The day is divided into five 35-minute periods. We allow 20 minutes for center activities, 5 minutes for questions and 10 minutes for transition. Each group of students visits four centers and eats lunch during one of the five 35-minute periods. (See schedule below)

Addressing Teacher Concerns

For most teachers, their responsibilities for the day consist of guiding the students from center to center. Some teachers create learning centers

Grade 3 Schedule	***9:20***	***10:00***	***10:35***	***11:10***	***11:45***	***12:20***	***12:55***
Class 1	BUS	Art and Poetry	Walking Center	Lunch	Garden Center	Grade 3 Marsh Center	Return to Bus - Depart 1:10
Class 2	BUS	Garden Center	Grade 3 Marsh Center	Lunch	Mindfullness	Forest Center	Return to Bus - Depart 1:10
Class 3	BUS	Cornell	Garden Center	Lunch	Forest Center	Mindfulness	Return to Bus - Depart 1:10
Class 4	BUS	Mindfullness	Art and Poetry	Garden Center	Grade 3 Marsh	Lunch	Return to Bus - Depart 1:10
Class 5	BUS	Grade 3 Marsh	Forest Center	Art and Poetry	Cornell	Lunch	Return to Bus - Depart 1:10
Class 6		BUS	Mindfulness	Forest Center	Art and Poetry	Lunch	Cornell
Class 7		BUS	Cornell	Mindfullness	Lunch	Garden Center	Forest Center
Class 8		BUS	Walking Center	Cornell	Lunch	Art and Poetry	Garden Center
Class 9		BUS	Walking Center	Grade 3 Marsh Center	Lunch	Cornell	Mindfulness

and staff them for the day. Although we initially had to address many concerns, this event is now a favorite tradition for many teachers.

Teaching in the outdoors is often more reactive than proactive. This is hard for teachers trained in traditional techniques who like a more predictable set of circumstances. We try to show staff how to take joy in what is unpredictable. Many traditionally trained teachers are uncomfortable with questions they do not know the answer to. Naturalists and outdoor educators are accustomed to using guide books and apps because they often see things they can't identify right away. We try to model taking joy in not knowing as well as the process of using dichotomous keys and other tools to identify something we have not seen before.

Teachers may struggle with a lack of experience on trails. The first year we did this, we got together with a group of staff members on a Saturday before the event and we hiked around the park to help alleviate some of their concerns.

Students or staff may have mobility or medical issues that impact their experience and comfort levels. Having the choice to walk on roads as well as trails alleviates some concerns since the roads may be easier to manage than a rough trail. Staff may have fears about animals, ticks, weather or poison ivy. Each year we send out a guide to help staff recognize poison ivy in its many forms and remind students and staff how to dress appropriately for the forest to minimize issues from weather, ticks and insects. Concerns regarding those issues have faded over time.

Figure 3. Learning along the Hudson River

Photo credit: Jacob Tanenbaum

Hands on nature-based activities can often be tailored to address specific Next Generation Science Standards (NGSS) Disciplinary Core Ideas (DCI) applicable to a particular grade. For example, the unique geology of our area is well suited for teaching the DCI's in the fourth grade related to earth systems, which talk about patterns in rock formations that help us recognize changes over time.

Days like this are also an opportunity to go into some depth on NGSS Crosscutting Concepts related to patterns, scale, proportion, and quantity, structure and function as well as stability and change. All of those important goals are naturally addressed in a high-interest setting that cannot be duplicated in the classroom. The same is true of NGSS Scientific Practices such as asking questions, defining problems, analyzing and interpreting data, constructing explanations, engaging in argument from evidence and obtaining, evaluating and communicating information.

That said, it is important to note that we are committed to doing hands-on nature-based activities even if they do not connect directly to the standards, simply because they are worth doing.

Costs to the District

Keeping costs down is essential in public education. For this activity, all centers are staffed by volunteers. There are some minor material costs. The district also pays for an extra nurse to be on duty in the park for the day. We ask the local ambulance corps to keep their rigs in the park when they are not in use. They kindly do this at no cost to us. The major expense is busing the children. We minimize this by busing half the school to the park and then having the buses return for the second group of classes. This cuts the cost in half. All in all, this is one of the least expensive field trip activities that we run during the year.

A Note on 2020

During the COVID-19 pandemic, we created a virtual Earth Day event in June of 2020. We did this by scheduling a volunteer to meet with each class via video-conference for 20 minutes with time at the end for questions. There are some outdoor educational activities that lend themselves well to video conferencing. For example, we had a local bee-keeper connect using a cell phone and show the children the bee-hives close at hand. In general, though, we are all happy to return to hands-on outdoor education for 2021, though it will be in our schoolyard, since we cannot travel by bus to the park. Nature-based hands-on activities cannot be duplicated on a screen.

Conclusions

Outdoor education does not need to be expensive and often does not require long-distance travel. For 10 years running we have managed to bring 650 children to the outdoors for a day of learning from experts – though we were forced to do this virtually in 2020 due to the pandemic. For many students, it is their first time in Tallman Mountain Park even though it is just a few minutes from their homes. In the last few years, we have introduced more diverse and eclectic activities, such as yoga, meditation, poetry and art. Those have gone well and will be continued and expanded in the years to come. Future plans include adding a center devoted to the music of the natural world around them. After all, how can we teach about the Hudson River without singing a little Pete Seeger?

References

Louv, Richard (2008). *Last Child in the Woods*. Algonquin Books, Old Chapel Hill.

New York - New Jersey Trail Conference (2018). "Tallman Mountain State Park", www.nynjtc.org/park/tallman-mountain-state-park

About the Authors

Jacob Tanenbaum teaches science and computer technology in the South Orangetown schools located in Rockland County, just north of New York City. Mr. Tanenbaum has been an educator for over 30 years. In addition to schools in the New York area, Mr. Tanenbaum has taught in Tucson, Arizona; Buffalo, New York; Alabama; Georgia, Guatemala City; Guayaquil, Ecuador and Bogotá, Colombia. More information, as well as a list of his awards, grants, talks and publications appears on his website, www.jacobtanenbaum.com

Janet Fenton is a Master Gardener Volunteer through Cornell Cooperative Extension: Rockland, New York since 2010. She has conducted several presentations on gardening, especially composting and vermicomposting to children and adults. Additionally, she oversees the management of the Garden of Faith at Marydell Faith and Life Center which has produced thousands of pounds of fresh produce which is distributed through the St. Ann's Food Cupboard. She also serves as a volunteer garden educator at the Children's Garden at Marydell during the summer. She retired in 2014 after teaching for over 27 years.

Carol Knudson is a Research Assistant at the Lamont-Doherty Earth Observatory of Columbia University. Since 2008 she has been working on the Hudson River Water Quality Project with

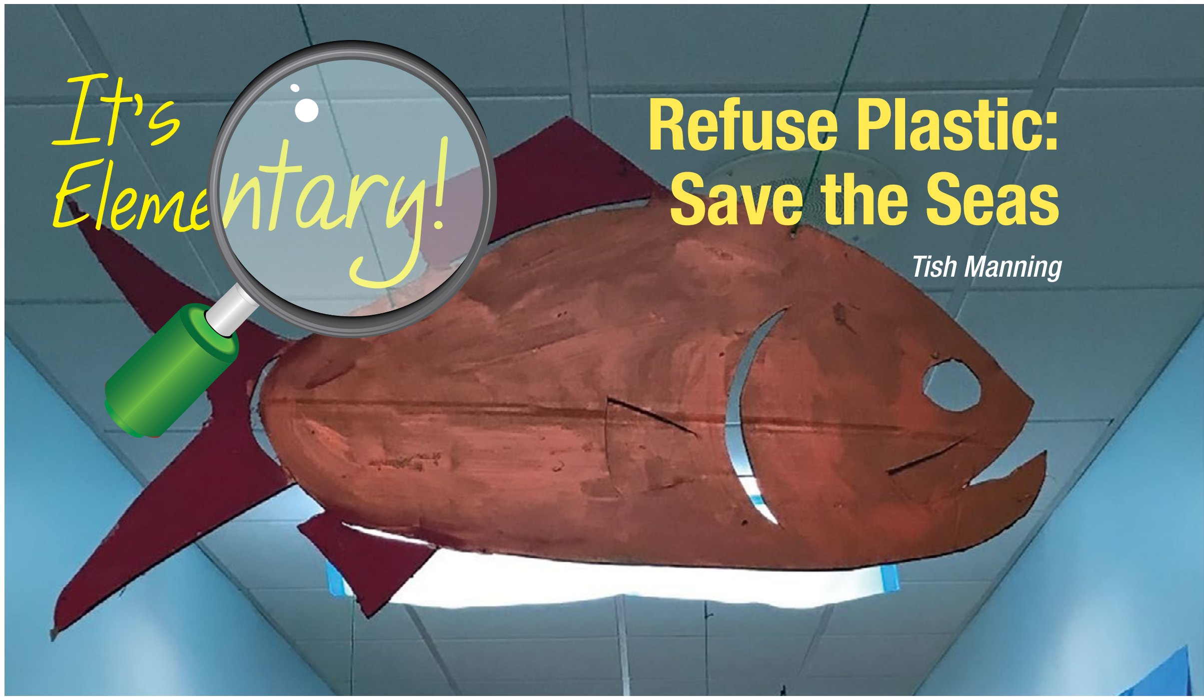
Riverkeeper. She is an alumna of Tappan Zee High School (class of 1981) and through her children, has been involved in South Orangetown Central School District activities since 2005.

Nicole V. Laible currently works as the Environmental Programs Manager for the Rockland County Division of Environmental Resources in New York. As Environmental Programs Manager, she leads four environmental boards and manages several professional water resources research projects. She also works with colleagues to host Conservation Field Day's and other environmental education programming for K-adult audiences. Nicole is on the leadership team for the Minisceongo Creek Watershed Alliance and Rockland Environmental Educators Working Group. She received the "Environmental Educator" award from Keep Rockland Beautiful in 2017 and the "Next Generation Leadership Award" from Strawtown Studio in 2018. She also serves as a board member on the Hudson River Watershed Alliance, working on the Finance and Governance committees. Nicole has a Master's in Public Administration and Policy from American University and a B.Sc. from SUNY Stony Brook University where she double majored in Marine Sciences and Coastal Environmental Studies.

Brianna Rosamilia is the Conservation District Technician at the Rockland County Soil and Water Conservation District in New York. In her current role she leads education programs focused on water quality and trains volunteers to collect scientific data for community science programs. She earned a bachelor's of science in environmental science from Marist College and a master's of science in environmental interpretation from the SUNY College of Environmental Science and Forestry. She started working in the environmental education field as a seasonal environmental educator with the Student Conservation Association. Since then, she has educated thousands of youth and adults in nonformal education settings on topics relating the Hudson River Estuary, its tributaries, and the Hudson Valley. In her free time, she likes to paint, look for birds, and take long walks.

Margie Turrin is Director of Educational Field Programs at Lamont-Doherty Earth Observatory of Columbia University where she has researched, developed, implemented and published on field-based educational work for students, teachers and faculty for over 20 years. She has been part of bringing thousands of students and educators to the Hudson to collect and analyze their own data, using the estuary as a classroom. She is an advocate of using data to pose and answer questions, focusing on incorporating authentic data into stories and activities that provide key insights about the environment. Her work spans from local to global with projects in both the Arctic and Antarctic that focus on climate change and sea level impacts.

Laurel Zaima is the Education and Outreach Coordinator at Lamont-Doherty Earth Observatory of Columbia University. Laurel has substantial experience working with youth, teaching students through informal education about the natural environment through hands-on experiences since 2015. At Lamont, she works on education initiatives that communicate science research to the general public, K-12 and undergraduate school groups, and New York and New Jersey teachers. Her primary educational focus is on connecting people to the Hudson River and their local waterways by using a place-based instructional approach with an emphasis on field explorations. She also teaches about sustainability, climate change, and sea level rise with a strong emphasis on the changes occurring in the polar regions.



Refuse Plastic: Save the Seas

Tish Manning

Abstract

The coast of Maine provides our students with views of rocky beaches, sea birds and the beautiful ocean, but not many students get to see the fish, sea turtles and whales which live in the Gulf of Maine. Even fewer understand that their actions on land can have an impact on the animals in the Atlantic Ocean. BRRRR (Belfast Refuse Reduce Reuse Recycle) is a group of dedicated third, fourth and fifth graders who volunteer their time to reduce waste in the school to protect the ocean. With funding from the NOAA Planet Stewards Project, our group focused on reducing waste by raising awareness about, and access to, reusables in school and home lunches. Students gathered data about cafeteria waste, learned about the impacts of plastic on the ocean and experienced positive choices students can make to reduce waste. Finally, they educated their school community and held a Zero Waste Lunch Campaign. Refuse Plastic- Save the Seas was designed to encourage a love of the ocean and an understanding of how simple choices can help our ocean friends. We can all be ocean heroes!

Introduction

A healthy ocean is important to the tourism and fishing industries and the enjoyment of all Mainers. On my daily walks I see plastic of all types on the roads, along sidewalks, even on our school grounds and our city park. Much of this waste ends up in the ocean, where it degrades into smaller and smaller particles, posing a threat to all marine wildlife (Le Guern, 2019). The garbage that makes it to the Belfast City, Maine, transfer station is sent to an incinerator. When plastic is incinerated it releases CO^2 (Center for International Environmental Law [CIEL], 2019), contributing to climate change and ocean acidification. Incineration also creates a toxic ash, which must be landfilled (Connett, 2013). Clearly, our students could make a big impact on the health of our community and the ocean by using less plastic. Learning to use less plastic is a valuable habit which can be practiced over a lifetime and is an action even young children can take. Research shows that environmental education boosts academic skills, knowledge gains, community engagement and leadership. Furthermore, environmental education increases environmentally-friendly behavior in students (Ardoin, 2018). Educating a small group of students about environmental issues had a big outcome for our entire school.

The Process

BRRRR students meet weekly during lunch to learn about the issue of waste and how to help the ocean. Our school projects for this year included encouraging students to reduce cafeteria waste by bringing zero waste lunches to school and hosting an ocean celebration for the entire school to promote stewardship.

After learning about the effects of plastic on the ocean and ways to reduce waste, BRRRR students set out to raise awareness and educate their peers about how to tackle this problem. Students collected, measured and recorded the cafeteria lunch waste. Students used the data as a baseline and analyzed the data after each zero-waste lunch (ZWL). With the help of NOAA Planet Stewards funding, stainless steel water bottles were purchased for K-1 students to ensure our youngest students could choose reusable bottles. BRRRR students made videos, posters, announcements and presentations to the entire school to promote ZWLs. Student volunteers helped to coordinate the ZWLs and actively took part in the cafeteria. Although this project was done at the elementary level, it could be adapted for any grade.

Desired Outcome(s) / Specific Effects of Project

- Created a Sustainability Committee involving a variety of staff and faculty.
- Reduced the cafeteria use of plastic dressing cups and lids by 100%.
- Switched from single-serve one-use breakfast cereals to bulk cereals served in reusable bowls.
- Raised awareness about problems of plastic through posters and announcements.
- Measured trash from one lunch to get baseline data. Had 5 Zero Waste Lunch days to try for no waste.
- Instituted school-wide marker recycling program.
- Created a website about our campaign to reduce single-use plastic in our school.
- Held World Oceans Day Celebration.

Learn-Create-Educate-Make a Difference

The model developed for the BRRRR group uses lunchtimes to provide a time for interested students to meet. Most of the teaching was done in a very short time, but true student understanding comes from discussions and from working on their projects with feedback from teachers and peers.

Learn

In order to understand the issue, students explored the effects of plastic pollution, lunch waste and each of the four Rs, with an emphasis on *refusing* single-use items, as it is the action most beneficial to the environment. Plastic pollution resources for every grade are readily available online. The sources used for this project were the Washed Ashore Integrated Arts Curriculum (NOAA, 2017) and the Marine Debris Monitoring Toolkit for Educators (NOAA, 2017). Students learned the harmful impacts of marine debris, and the benefits to ocean life if we reduce the debris.

Figure 1. Ms. Demers checks in with student helpers.

Photo Credit: Tish Manning

Figure 2. Third grader separating food from trash at the baseline waste audit.

Photo Credit: Tish Manning

Create – Educate

The next step is to connect the issue to the students. Students looked at their own school and noticed factors contributing to the use of plastic. Students were encouraged to design their own response to these local factors.

Students also watched inspiring videos. They saw other young people making a difference for the ocean or people taking a creative approach to raising awareness about plastic pollution. These videos motivated the students to get involved and to think creatively about the problem.

Students work on projects during recess or club time, at home or during our few weekend work sessions. Student work is reviewed to include 3 components: 1) a statement of the issue; 2) information, examples or effects of the issue; 3) an action which kids can take. BRRRR students work to communicate positive and empowering messages of change, connecting science and data with local action.

Figure 3. Students were excited to use reusable napkins.

Photo Credit: Tish Manning

Make a Difference – Zero Waste Lunch Project

Presenting to the entire school, BRRRR students explained what Zero Waste Lunches were and why they mattered. Fourth grade teacher, Dana Bierwas, created flyers to explain the project to families, the purpose of the water bottles and how to pack a ZWL. BRRRR student videos and messages were shared with the school via emails to teachers, and announcements on the school Facebook page before each ZWL. Bierwas created a BRRRR website which all families could access to learn about the group's mission and campaigns. A local news station featured the campaign on the evening news.

Gathering Data – Determining Next Steps

Partnering with Malia Demers, our Food Corps service representative, we planned and coordinated our data collection process. To establish a baseline, Demers worked with all third graders to collect waste from one lunch day in the cafeteria. After sorting the waste into categories, each type of waste was then measured and recorded. BRRRR students analyzed the results, and focused on two waste streams to target: trash and food waste.

After learning about the effects of plastic and food waste, and gathering data about the waste generated at our own lunch, students were ready to lead the way. They created a variety of educational materials including:

- posters showing what kids can do to help the ocean
- jingles to encourage reusables
- videos demonstrating why and how to pack a ZWL
- why to skip using straws
- the meaning of the 4 Rs
- negative effects of food waste on the climate

Cafeteria Set Up

A cloth napkin drive in the community secured a cloth napkin for each student and most were handmade. On ZWL days all students were given a cloth napkin. Bins of clean napkins replaced the paper napkin dispenser. Students separated waste into the following categories: 1.) dirty napkins, 2.) liquid milk, 3.) milk cartons, 4.) food waste, 5.) paper products, 6.) recyclables, 7.) recyclable plastic, 8.) nonrecyclable drink containers, 9.) waste. Two 4th grade boys were taught how to wash, dry, and then fold the napkins for the next lunch. Students assisted with waste separation, and measured and recorded it after each lunch. Many students outside of BRRRR were eager to participate in the data collection and to volunteer to assist with ZWLs.

Table 1. CASS Zero Waste Lunch Data
Total Waste For Each Category

Date	Compost (lbs)	Trash (lbs)	Milk Cartons Recycled (lbs)	Juice Pouches (count)
1/3/19	10.38	10.26	N/A	N/A
1/31/19	21.36	11.46	N/A	N/A
2/28/19	27.72	9.96	N/A	8
4/30/19	25	14	N/A	11
6/4/19	24	1.24	6.2	8
6/5/19	23.32	.78	6.8	12

Results

After each ZWL, students studied the results, and brainstormed ways to improve the outcome for the next one. Early on, single-use plastic drink containers became a target for waste reduction. One strategy the students came up with was to count and publish the exact number of juice boxes after each lunch to bring the number down. Another was to create a giant bar graph composed of the actual containers collected. We did not meet our goal for containers, but we did see that when we had ZWLs for 2 days in a row, the older students remembered to bring their reusable bottles to lunch. This indicates that regular reinforcement is necessary to establish the habit of waste reduction behaviors. The students speculated that it might be harder for K-3 students to pack their own lunches.

Another waste reduction target was to reduce trash from school lunches by 50%. By recycling the paper waste we reduced the amount of trash by at least 90%. It was a clear illustration of the power of recycling to reduce waste.

Additionally, single-serve breakfast cereals were eliminated and replaced with bulk cereal served in reusable bowls, and the cafeteria use of plastic condiment cups was reduced 100%, by simply placing any desired condiments directly on student lunches. These changes affect all lunches and breakfasts, and are a huge benefit to our environment.

There are two relevant Next Generation Science Standards performance expectations (NGSS, 2013) for this project.

5-ESS3-1.	Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.
4-ESS3-1.	Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

Students were able to investigate solutions to a problem caused by human activities that have had major effects on the ocean. They learned that individuals and communities can do things to help protect Earth's resources and environments. Students also learned about energy and fossil fuel resources and how their use affects the environment in many ways. This project allowed students to investigate ways to reduce the waste coming from the school and to see positive behavior change.

Figure 4. After pausing to consider how our waste causes problems for animals in the ocean, students and staff pass through garlands of waste, then enter a hallway lined with trash dumped on school property, eventually finding the "clean" ocean with art, information and activities.

Photo Credit: Malia Demers

Figure 5. Students used visuals to raise awareness about our lunch waste.

Photo Credit: Tish Manning

Figure 7. Fifth graders handing out Maine seaweed samples to celebrate the ocean.

Photo Credit: Tish Manning

Figure 6. The entire school collected used markers for recycling – diverting 82 pounds of plastic from the incinerator.

Photo Credit: Tish Manning

Celebrate

BRRRR students helped plan and run our World Oceans Day celebration. Packaging and container waste from our school population was carefully collected and cleaned and then strung to create garlands hanging across the entryway into the “ocean” hallway.

Trash cleaned up off the school grounds, including bottles, an old hose and a broken shovel, was strewn around the hallway entrance. Students wrote a script to introduce each class into the hallway showing the impacts of marine debris on the ocean, and asking them to imagine how it feels to have to live in marine debris. After passing through the “dirty ocean” classes emerged into a clean ocean, decked with ocean-themed artwork and lights, where they could touch and taste seaweed, learn about ways to help the ocean and finally, make a pledge to help it. At the World Oceans Day event many students waited in line to be able to make an ocean pledge, and first and second graders began asking if they could join BRRRR.

Go Team!

A big part of the success of the project was building a team of stakeholders. A Sustainability Committee, including the principal, was created and met regularly. Kitchen and custodial staff support were critical, and their input influenced all decisions. Our art teacher guided all students to create meaningful ocean-themed artwork, and our school librarians curated ocean books and transformed the library for our Oceans Day. Community and parent volunteers mentored students to create artwork from discarded cardboard to decorate the halls.

Conclusion

This project was unique in that these young students volunteered their time to learn and make a difference in their community. The students raised awareness about plastic pollution and zero waste lunches, and became advocates for change. The following year Zero Waste Lunches continued weekly until the pandemic. Students learned they can create an ocean of change.

Supporting Documents

Student Project Suggestions and Guidelines https://docs.google.com/document/d/1BeVCu7snoGElqytIeKU3hH0vju-qFNAYuCBWU8_kIuc/edit?usp=sharing

Plastic Waste Survey and Follow-Up https://docs.google.com/document/d/1106V3scXX672ECIk0Zz02WuHtq6fv_Hrni0G-Xr_PJE/edit?usp=sharing

References

Nicole M. Ardoin, Alison W. Bowers, Noelle Wyman Roth & Nicole Hothuis (2018). Environmental education and K-12 student outcomes: A review and analysis of research, The Journal of Environmental Education, 49:1, 1-17, DOI: 10.1080/00958964.2017.1366155

Also see https://naaee.org/eepro/research/eeworks/student-outcomes

CIEL (2019). *Executive Summary Plastic and Climate.* Center for International Environmental Law. Retrieved February 14, 2021, from https://www.ciel.org/plasticandclimate/

Connett, P. (2013). *The Zero Waste Solution.* Green Press Initiative. (pp. 67-72).

Le Guern, C. (2019). *When the Mermaids Cry: The Great Plastic Tide*. Coastal Care. Retrieved February 14, 2021, from https://plastic-pollution.org/

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press. http://www.nextgenscience.org/

NOAA. (2017). *Marine Debris Monitoring Toolkit for Educators*. NOAA Marine Debris Program. Retrieved February 13, 2021, from https://marinedebris.noaa.gov/sites/default/files/publications-files/MarineDebrisMonitoringToolkitForEducators.pdf

NOAA. (2017). *Washed Ashore Integrated Arts Curriculum*. NOAA Marine Debris Program. https://marinedebris.noaa.gov/curricula/washed-ashore-integrated-arts-marine-debris-curriculum.

About the Author

Tish Manning has been teaching for 25 years at the elementary and middle school level. She has taught in Puerto Rico and Hawaii, but has spent most of her teaching years in Maine. She led a group of middle and high school students, parents and teachers to the Amazon rainforest to study rainforest ecology in the late 1990's. She has dedicated the last 5 years to helping students learn how to protect the ocean. Her work earned the New England Aquarium's School Group award for Ocean Stewardship in 2019. She has received two NOAA Planet Stewards Project awards. She can be reached at tgmanning31@gmail.com.

oceanservice.noaa.gov/education/planet-stewards/

Runaway Carbon Cycle: Reducing Carbon Emissions through Understanding and Action

Spencer Cody

Abstract

Students in rural schools can produce substantial gains in environmental literacy through engaging activities on the carbon cycle and stewardship activities. The following article describes a NOAA Planet Stewards project that was intended to be one year in duration but is on-going into its second year due to the pandemic. Survey results document that substantial attitudinal and behavioral changes can be gained in areas of the country not normally served by curbside recycling programs through stewardship activities focused on recycling, reducing, and reusing materials in relation to saving atmospheric carbon. While the pandemic initially disrupted and delayed the project, it also forced the project to explore new ways to recycle materials that provided interesting insights into future approaches concerning environmental stewardship.

Introduction

It can be a challenge to relate something as complex as the carbon cycle to climate change, and it can be an even bigger challenge to relate a tenuous understanding of the carbon cycle to environmental stewardship that retains a meaningful, long-lasting impact on a student to motivate attitudinal and behavior change. While it may be easier to relate carbon cycle issues to students in a community that is well served by recycling and conservation programs, the potential gains in places that are lacking such programs provide remarkable opportunities to substantially shift opinion. If one really wanted to move the needle toward climate literacy, perhaps, there is no place better than rural South Dakota with its limited availability of drop-off recycling, nearly non-existent curbside pickup of recyclables, and, not surprisingly, low rates of recycling. Now, more populated regions of the country may wonder why this is the case. Think of all the times there was a bin for a certain type of recyclable conveniently placed there for you or neatly arranged curbside bins for sorting recyclables or various drops-offs located nearby for your convenience. Now imagine taking all of that away. You may think you would still recycle, and you would probably be wrong. The reality is that if you did not have these programs and convenience, recycling would be just as alien to you as it is to most of my students. I, myself, and my family used to burn our trash along with all of my burnable recyclables since I lived in a farmhouse during my early years of teaching and did not have trash pickup services like many rural residences. Because of these limitations, the tradition of a burn pit or burn barrel is engrained in many parts of rural America. When we moved to town and burning was no longer an option, we decided to save recyclables and drop them off in the nearest recycling center 85 miles away in Aberdeen, South Dakota. Recyclables were dropped off before the beginning of shopping trips in town making our trip carbon neutral many times over. This is a cumbersome means of recycling but is the only available option to many rural South Dakotans. Replicating this strategy among students was a key aim of the stewardship component of this project made possible by funding from NOAA Planet Stewards.

Table 1. Earth and Human Activity

Performance Expectation

MS ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

Dimensions	Classroom Connections
Science and Engineering Practices	
Asking Questions and Defining Problems • Asking questions and defining problems in grades 6–8 builds on grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models.	• Students collect and analyze materials to determine the amount of carbon dioxide produced in the production of various items and how much carbon dioxide from the atmosphere will be saved if it is recycled.
Disciplinary Core Idea	
SS3.D: Global Climate Change • Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming).	• Students identified an act of reducing and reusing in their daily life, document it, and calculate its impact over the course of a month and project that impact into a full year in terms of atmospheric carbon dioxide saved.
Cross-Cutting Concepts	
Cause and Effect • Cause and effect relationships are routinely identified, tested, and used to explain change.	• Students investigated the relationships of carbon dioxide emissions and climate change.

The Three Rs

The stewardship activity was coupled with an education component tied to our textbook's unit on ecology and environmental science to relate carbon emissions to climate change for 7th grade Life Science students and 10th grade Biology students; however, components of the stewardship project were implemented in all grades in 6-12.

This education component was paired with stewardship activities that focused on how students could individually decrease their carbon footprint through the three Rs of reduce, reuse, and recycle. While the concept of the three Rs in conservation may seem a bit worn out, in reality for those students who are at the beginning of their environmental stewardship, this is actually an ideal place to start. The concepts of reduce, reuse, and recycle are not tired phrases for students who are not actively engaged in environmental stewardship. In fact, one will find that students unfamiliar with stewardship often get these concepts confused. That is why each student that participated in the project had to identify at least 10 items that could be recycled at home. These items would need to be brought into school, approved for local recycling drop off in Aberdeen, and weighed to determine the environmental impact of its production and its recycling.

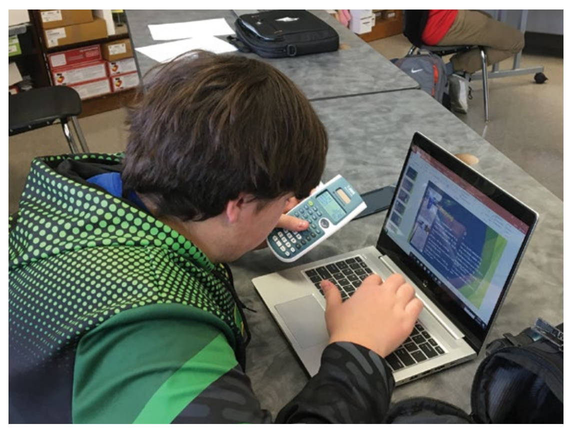


Figure 3. A sophomore biology student calculates the amount of carbon dioxide produced for the production of each of his recyclable items and how much atmospheric carbon dioxide would be conserved if these same items were recycled.

Photo credit: Spencer Cody

Having students bring in their recyclables for documentation allows the teacher to verify what is being recycled and allows students to apply specific calculations to determine the amount of carbon dioxide produced in the production of various items and how much carbon dioxide from the atmosphere will be saved if it is recycled. It has been my experience in working with middle and high school students that there is little awareness of what is thrown out in their homes and even more confusion over what is and is not locally recyclable. Frequently, when students bring in items to be vetted and measured, they bring in items such as single-use plastics or plastics that

Figure 4. Sophomore Biology students weigh their recyclable items in order to calculate the environmental impact production and recycling of each item.

Photo credit: Spencer Cody

have resins that are only recyclable in a few circumstances beyond our local means. These do not count toward their ten items.

The goal of the project is not to fix the issue of all of our non-recyclables or de facto non-recyclables but to get recycling items that are relatively easy to recycle such as cardboard, paperboard, paper, newspaper, magazines, resins #1 and #2 plastics, aluminum, and steel/tin cans. This alone should reduce trash by roughly half in most cases. The trick is to get students to recognize what they throw away, what could be recycled, what the environmental impact is, and get them in the practice of recycling.

Discovering Reducing and Reusing

Additionally, students were required to identify an act of reducing and reusing in their daily life, document it, and calculate its impact over the course of a month and project that impact into a full year in terms of atmospheric carbon dioxide saved. Again, documentation and verification by the teacher was important. Frequently, students demonstrated their perception of reality about what could be reduced and it was not realistic. For example, a student trying to explain how much carbon dioxide they are going to save by using a cold-water cycle to wash a load of towels versus a warm-water cycle can yield almost comedic level responses from a student who obviously has never washed clothes. It is important to cut through this perception gap since, unlike most adults who have had to stretch resources for financial means at some point through reducing or reusing, these thoughts do not come naturally to many students. It can be a difficult process for them to brainstorm ideas for reducing and reusing, but when they start to realize the many different possibilities and what could be saved environmentally and financially, it becomes valuable information to them.

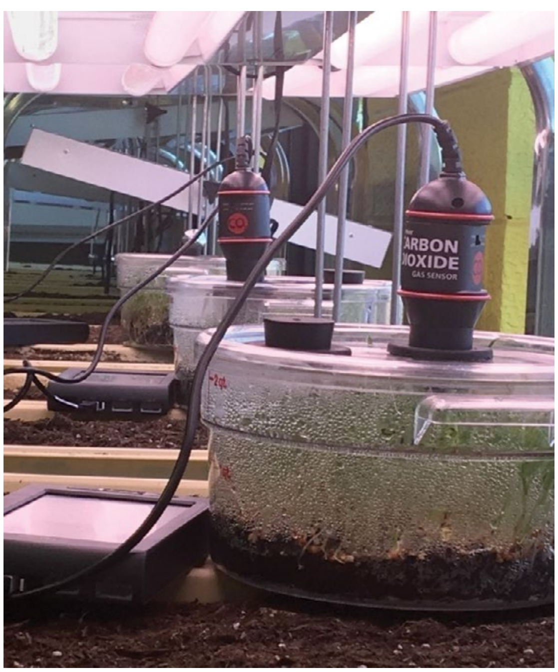


Figure 5. Students experiment with sealed environments by monitoring carbon dioxide levels over a three-week period to document levels as seeds germinate using cellular respiration and then begin to utilize photosynthesis.

Photo credit: Spencer Cody

Contained Environments and Biosphere 2

Our Planet Stewards project started without a hitch in October of 2019 with the initial administration of pre-surveys to capture pre-knowledge of climate literacy (Climate, 2009) and levels of environmental stewardship. As the pre-surveys cycled through the classes, there were many misconceptions concerning the carbon cycle and climate change. The surveys were based on similar surveys administered in a prior NOAA Planet Stewards project by the same investigator but now with an expanded set of questions on the carbon cycle, reducing, and reusing. Additionally, recycling was sporadic to nearly non-existent depending on what was being recycled. Practices of reducing and reusing were limited. Since there were a lot of misconceptions and questions surrounding the carbon cycle and sources of greenhouse gases, students began projects relating research into Biosphere 2 and developing their own contained environment while monitoring carbon dioxide levels. Students were given a 2-liter Vernier gas chamber and allowed to fill the chamber with potting soil and a variety of seeds then watered the chamber before placing the sealed lid back on. A Vernier carbon dioxide probe was attached to the sealed environment allowing for students to monitor levels within the container without opening it.

As one would expect, the container initially registered carbon dioxide levels comparable to what would be found in a classroom, about 400-1,000 ppm, depending on how long and how many students had been in the classroom. The sealed environments and carbon dioxide probes were placed under grow lights that were left on for 24 hours a day. Within a day the carbon dioxide levels would usually spike due to microbial activity in the soil. Then within two to three days when cellular respiration from the germinating seeds began, a massive increase carbon dioxide levels would be detected. Bird seed often works well for cheap and quick germinating plants for many investigations, including this one. Once germination is fully underway, it is not unusual to have some containers peak beyond 20,000 ppm, levels that would cause serious health problems in humans. The carbon dioxide levels do not begin to level off until photosynthesis overtakes the cellular respiration rate. Usually, this happens about one to two weeks into the experiment. The level then declines to an elevated level of a few 1,000 ppm. These results usually shock students into realizing how delicate and complex the carbon cycle really is and why carbon is always at the forefront of environmental issues. The project then related these results to the Biosphere 2 and the human experiments on contained scientists from the early 1990s. To heighten the interest level of students in the results of the Biosphere 2 experiments (Zimmer, 2019), 13 students were selected among applicants in grades 6-12 to visit Biosphere 2 in March of 2020 to work with scientists on site and tour the facility to learn about current and past research relating to climate issues. These selected students became the motivational core around our stewardship and research efforts. Of course, March of 2020 had other plans.

Pandemic of Possibilities

Sealed environments, Biosphere 2 research, and carbon dioxide levels would pave the way toward the stewardship aspect of the project. As has been described before, students would need to document recyclable items, apply that recycling to a 30-day time period, and project the carbon dioxide savings out over a year. The same would need to be true with their documented acts of reducing and reusing. Stewardship activities began in December of 2019 and went well until March 13, 2020. It was a Friday, of course, when it was announced that schools throughout the state would be closed indefinitely. This canceled our field trip to Biosphere 2, which was to be the next week during our spring break. This also halted our recycling efforts since all drop off sites were closed to the public. Even aluminum cans were temporarily no longer recyclable. While we were able to continue with most of our efforts of reducing and reusing, our recycling stewardship ground to a halt. All the recyclables that we had collected were held in storage until later that fall once drop off sites started to open. What were we to do in the meantime to meet our recycling goals? In looking at our options, I noticed that a scrap metal recycling facility in Aberdeen was still accepting scrap metals with no aluminum cans. With this information I discussed scrap metals with

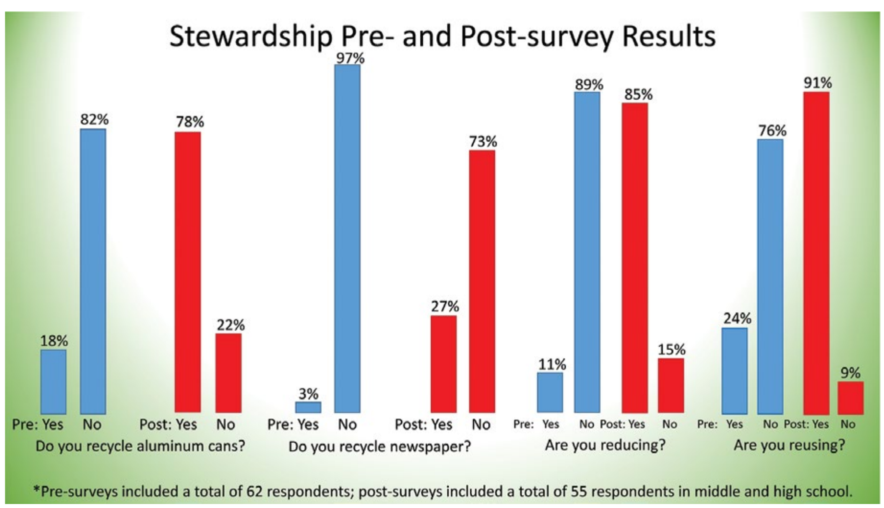


Figure 2. A sampling of the data collected from the pre- and post-surveys from the project indicate a significant shift in reducing, reusing, and recycling behavior. While data on a wide range of recyclables was collected, aluminum cans and newspapers represented the two extremes in what was already and what was not recycled. Similar shifts were experienced in all other areas of recyclables.

Photo credit: Spencer Cody

those students still trying to meet recycling goals. With a little socially-distanced coordination, we were able to easily exceed our recycling conservation goals by recycling scrap aluminum from junked ramps, platforms, rails, posts, siding, gutters, and downspouts. In fact, students were very interested in the idea of taking in scrap for money. The idea of finding shelterbelts (linear plantings of multiple rows of trees or shrubs) filled with junk, a typical place for rural families to discard old equipment, having profit potential and a major impact on conserving carbon really got their attention and may be a key area to explore for stewardship activities in the future. Without our participation in NOAA Planet Stewards, we would never have organized such an effort and would not have discovered such useful insights into recycling scrap through students' stewardship.

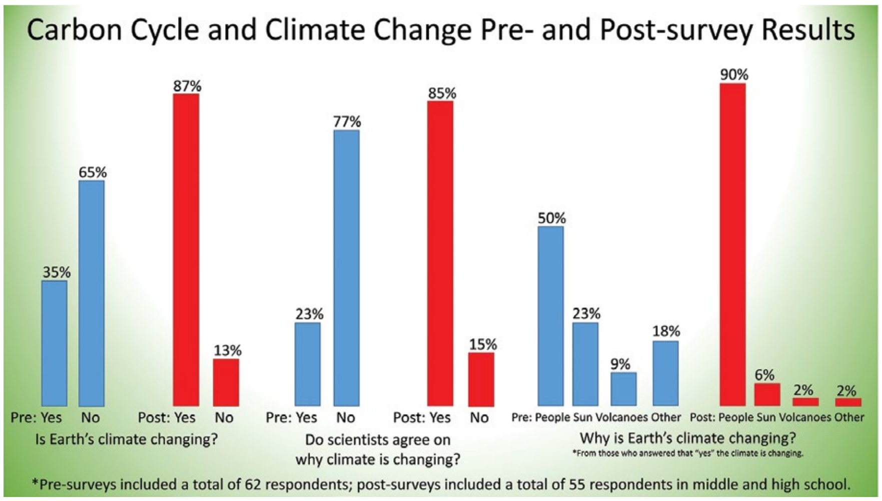


Figure 1. A sampling of the data collected from the pre- and post-surveys from the project indicate a significant shift in understanding the carbon cycle and climate change.

Photo credit: Spencer Cody.

Conclusion

Our goals of conserving at least 466 kg of carbon dioxide from the atmosphere through acts of reducing, reusing, and recycling were met. While the stewardship component has been restarted and will run until our rescheduled Biosphere 2 field trip in June, we have successfully conserved 952 kg of atmospheric carbon through documented acts of reducing, 556 kg through reusing, and 7,125 kg through recycling. Additionally, short-term shifts in attitudes concerning climate change and stewardship were documented. Some key documented gains included a more than doubling of students indicating that the Earth's climate is changing, a nearly quadrupling of those indicating that climate change is caused by human activity, and a 65% increase in students indicating that carbon dioxide is a greenhouse gas.

References

Climate Literacy: The Essential Principles of Climate Science. (2009) United States Global Change Research Program. https://downloads.globalchange.gov/Literacy/climate_literacy_lowres_english.pdf

Zimmer, Carl. (2019) The Lost History of One of the World's Strangest Science Experiments. New York Times. March 29, 2019. https://www.nytimes.com/2019/03/29/sunday-review/biosphere-2-climate-change.html

About the Author

Spencer Cody teaches 7-12 Science at Edmunds Central Middle and High School in the Edmunds Central School District in Roscoe, South Dakota. He holds a BA degree in Middle School and Secondary Biology Education from Concordia College in Moorhead, Minnesota, and an MS degree in Chemistry Education from South Dakota State University in Brookings, South Dakota. He has taught for 15 years in the middle and secondary sciences and is the recipient of numerous awards for his teaching including the 2018 Sanford Inspire Teacher of the Year for South Dakota, 2020 North Central Section Outstanding Earth Science Teacher, 2020 EPA Presidential Award for Environmental Education, and 2021 Region Four Teacher of the Year for South Dakota. Spencer can be reached at Spencer.Cody@k12.sd.us.

Leveraging Student Interest and Community Partnerships to Drive Learning in Meaningful Watershed Educational Experiences

Holly Hereau

Abstract

This high school project, supported by NOAA Planet Stewards, developed a learning community with shared goals of explaining a phenomenon and finding a solution to a local watershed problem. Students completed community environmental inventories, identified strengths and weaknesses in their community, selected an issue in need of a solution, and then researched and planned a stewardship action project to address the issues identified. Questions that students needed to answer were recorded and investigations were planned to help them design a solution to the problem they identified. We sought out community partnerships to provide learning experiences that helped answer those questions and the deeper questions that also emerged. We sought out cross-curricular and cross-grade partnerships within our school and district to draw the attention and interest of a wider range of students. Students presented their work within the district by creating videos for the morning announcements, presenting at school board meetings, and hosting groups of 5th grade classrooms for a field trip. Additionally, students reached beyond our district by presenting their work at conferences, submitting grant proposals, and entering journalism competitions.

Introduction

Professional learning: In the summer of 2017 I attended several transformative professional learning experiences. The first was the B-WET funded 3-day Great Lakes Watershed Field course where I was introduced to the Earth Force framework to authentically engage students in stewardship action. I also attended the week-long "Learn While Teaching" workshop at Northwestern University where I gained understanding about creating units of instruction that are coherent from the students' point of view while also thinking deeply about how to make my classes more equitable by creating lessons where ALL students are part of the knowledge building. (National Research Council, 2012) and (Berland et al, 2015). Lastly, I attended another NOAA B-WET Program – "Promoting Healthy Watersheds and Communities by Integrating Ecosystem Science, Transportation Networks, and Stewardship," hosted by Michigan Natural Features Inventory with support from River Raisin Institute. This heightened my awareness of many invasive species impacting our watershed and how they spread; this workshop also introduced

Figure 1. The Earth Force Framework (https://earthforce.org/caps/)

me to the Vernal Pool Patrol (https://vernal-pool-patrol-mnfi.hub.arcgis.com/). These combined experiences gave me the content knowledge and pedagogical confidence to apply for funding from NOAA Planet Stewards and to facilitate this authentic, student-led stewardship action project. The Earth Force framework gave clear guidance for how to help students work through this process and come to a consensus on the action project to undertake. The first two steps served as an extended anchoring phenomenon routine (https://www.nextgenstorylines.org/) and ensured the experience met the qualities of a good anchor (Penuel & Bell, 2016).

School: Lee M. Thurston High School is in Redford, MI which is a suburb that borders Detroit. Most students that attend this school live in Redford, and many students live in Detroit and other surrounding areas as well. The socioeconomic makeup of our school is such that 62% of students received free or reduced lunch during the 2018-19 school year.

Student Learning: The Earth Force framework makes space for students to practice thinking about what they need to consider when undergoing any large design project; defining a problem, research existing solutions, working within criteria and constraints, and identifying and reaching out to stakeholders. I used ideas I learned from NGSS Storyline design to ensure students were using the science and engineering practices to uncover important science ideas necessary and developing and using the Cross Cutting Concepts to construct detailed explanations of the phenomena underlying the issues they identified to design an effective solution. Typically, when designing a unit, first choose the performance expectations you want to build toward, then unpack the DCIs (disciplinary core ideas) to understand the ideas that students will need to figure out. Then, think about candidate phenomena that may get students to figure out these ideas (Reiser, 2014 and Reiser et al. 2015). If students are in charge of choosing the phenomenon/problem the instructor needs to be purposeful in determining a way to facilitate learning that provides three dimensional experiences that help students dig deeper and discover new connected ideas. Instead of unpacking the DCIs first, the teacher needs to work backwards from the phenomenon to the ideas necessary to explain the phenomenon or solve a related problem. These ideas inform the performance expectations that are selected to build toward for the unit.

Figure 2. Students attempt to enter the patch of *Phragmites* before realizing it is too thick to get through. As some students are measuring some of the physical characteristics of the area, other students record the data they are reporting.

Photo Credit: Holly Hereau

Community Environmental Inventory and Issue Selection to Identify the Problem

The purpose of the anchoring phenomenon routine in the storyline process is to ensure all students have a way to directly engage with the phenomenon or problem, voice their initial ideas publicly, think about related problems or phenomena, and finally record questions they have that will drive their learning throughout the unit. This process brings the class together as a learning community with shared goals of explaining a phenomenon and/or finding a solution to a problem. (Reiser et al., 2017)

Students completed the community environmental inventory by walking around outside the school, on the roof, through the hallways, in classrooms, and in the cafeteria. While there wasn't yet a specific problem that would lead to our project development, these inventories helped students begin to explore all the phenomena related to human activity and connect these to their own lives. They valued this experience more than I anticipated. Several students made comments such as "I've learned more in the first two weeks of this class than I have ever learned in any class for the whole year", which I attribute to the fact that these activities made students feel personally connected to this learning.

There were several problems that students identified as they discussed the data they collected from their inventories: Food waste in our cafeteria, electricity/energy waste throughout the building, lack of convenient recycling opportunities for both plastic and paper, several areas on campus where water pooled, lots of impervious surfaces that ran directly into the sewer, a human-made pond that was in disrepair and covered in duckweed and algae, and a retention pond/drainage ditch that was overrun by invasive *Phragmites*. Students presented information about potential solutions, the impact of the solution, and logistics involved with project implementation. Once all solutions were presented, the class discussed the options and came to a consensus on the project they would adopt.

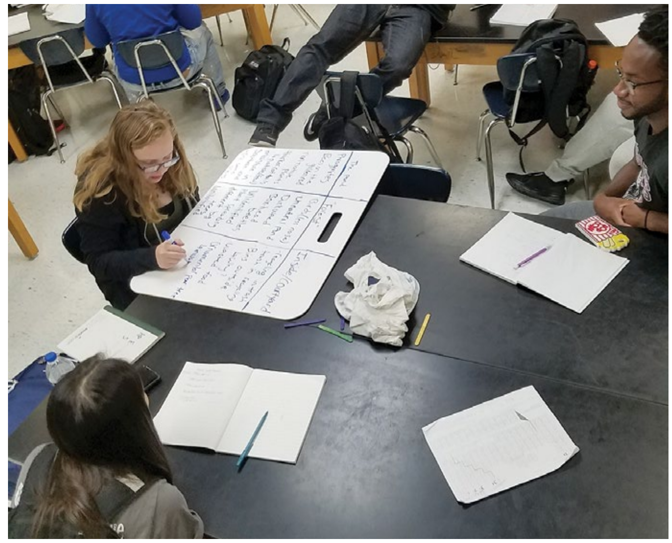


Figure 3. Small groups worked together to do preliminary research on one of the identified issues to present to the class.

Photo Credit: Holly Hereau

Students split into groups to research these issues and possible solutions so they could present their findings to the whole class. The class worked together to formulate a list of criteria and constraints that could help them decide which project to choose and each group agreed to consider and address each of these criteria and constraints when presenting their group proposals:

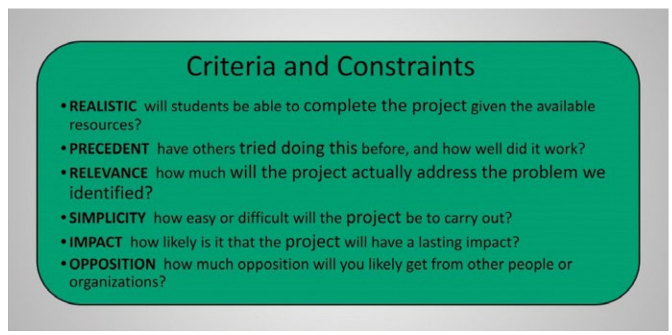


Table 1. Criteria and constraints that the class considered to inform project selection.

Each group presented their ideas to their classmates, and the class came to a consensus on finding a solution for the *Phragmites*-infested retention pond. They noticed it had low biodiversity which did not support pollinators, there were reports that the dense reeds were providing habitat for undesirable mammals (namely rats), the reeds were also trapping a lot of trash which was an eyesore, and the water was "dirty".

Students formulated some goals for this project that went beyond solving the environmental problems they identified. Several times since the start of this project, and again during this consensus discussion, different students brought up the idea that they couldn't believe they were not aware of "any of these issues in their environment" and they were upset that they were not learning about this until they were 11th or 12th grade. Another student responded with "right, but we're the only people in this class – the rest of our school probably doesn't know about these problems either". Project goals allow for coherence from the students' perspective. At any point during these learning experiences if students are asked "Why are you doing that?" they would be able to answer by listing one of their goals.

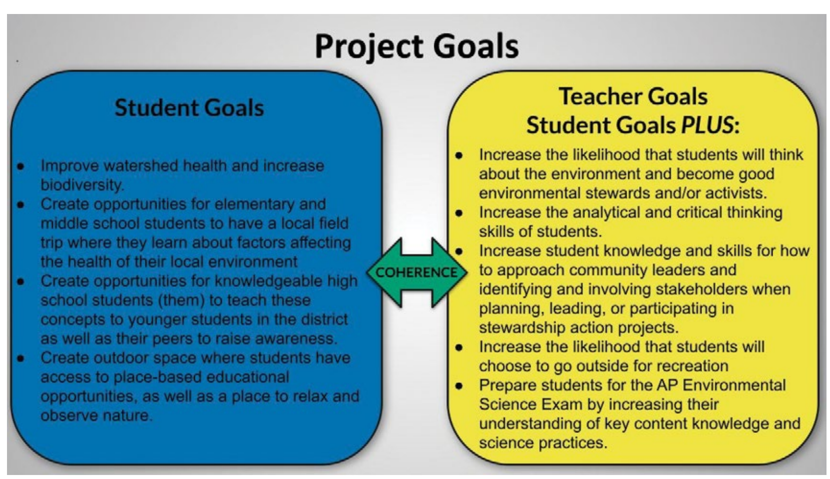


Figure 4. The project goals were identified and are listed next to the additional personal goals I had for this project.

By the same token, if an observer asked me "Why are they doing that" I would be able to list something from each list (Berland et al, 2015).

Creating the Driving Questions Board and Listing Ideas for Investigations

As students added questions to the Driving Questions Board, they realized there was still a lot of information they didn't know and would need to figure out before forming a plan.

- What do we need to figure out to be able to do this?
- What plants do we want?
- Why do we need a pond there? What does it do? Where would the water go otherwise? What are all these big things that look like drains?
- What made the pond show up? Where is the water coming from? (several teachers told students that the pond is "new" and that area used to be a dry field).
- Retention pond/rain garden design - How big will it have to be? Where are all the areas the water drains from, and how much water enters after rain events? Is there a way to figure out how much water needs to be held there?
- How will we find the information? Are there others in the community we can partner with?
- How will we know if our project works?
- Do we need permission to do this? If so, who do we need to ask? Where do we start?
- How can we involve more people in our project?

Students formed task committees to attempt to answer some of these preliminary questions by investigating:

- Soil type and characteristics
- Native plant selection to ensure staggered and overlapping flowering times to support pollinators
- Equipment budget – determine best vendors for tools and other materials we will need.
- Effective and safe methods for *Phragmites* removal and disposal
- Meeting with the Superintendent for project approval

Figure 5. Students collecting more data on the area overgrown with *Phragmites* to help figure out a solution.

Photo Credit: Holly Hereau

As students began to dig deeper into these investigations, they discovered they had even more questions. Their research also uncovered some organizations in our community that could help us learn more about how to assess our project area.

Forming Community, Cross-Curricular, and Cross-Grade partnerships

Student groups came back with some clear first steps. We needed to remove the *Phragmites*. This proved to be a much larger job than anyone would have imagined. While students were still involved in the seemingly never-ending thankless task of removing *Phragmites* we were also busy forming exciting partnerships to help us learn more about our watershed. Partnering with different community groups in our county and state also allowed students to contribute data to different long term monitoring projects. We partnered with Friends of the Rouge (https://therouge.org/rouge-education-project/) and worked with the Rouge Education Project to help learn how to collect physical, chemical, and biological data that indicate the health of streams and rivers. We used this knowledge and skill set

Figures 6 and 6a. Students are in the forest studying a vernal pool to learn about what and how to measure characteristics of pools; students collected data to monitor the health of a nearby stream in the Rouge river watershed.

Photo credit: Holly Hereau

to collect data along a section of the Rouge River near our school to help with the Friends of the Rouge long-term monitoring project. Then students used what we learned to help decide what data we would need to collect and keep track of in our body of water.

Students also identified the need to visit a wetland that was more similar to our wetland, rather than a river that has quickly flowing water to learn about the differences between still and running water to define target values for our ecosystem. We partnered with the Michigan Natural Features Inventory (https://mnfi.anr.msu.edu/) and folks from Nankin Mills (http://www.nankinmills.org/) to collect data about the health of the vernal pools located there. Students learned about the importance of these wetlands for biodiversity and wondered if our target ecosystem would ever be able to support so many different species. Finally, students worked with Inland Seas Education Association to apply what we learned from monitoring streams and pools to collect data aboard *Schoolship* on Lake Michigan in Suttons Bay (https://schoolship.org/).

The students studied wetlands and open bodies of water to compare their vastly different size and important characteristics. However, students successfully used patterns in data to figure out that similar phenomena have similar causes in these systems - and that all these systems are connected. Students also wrestled with scale and the kinds of allowances we need to make to account for scale, proportion and quantity when investigating these different bodies of water, especially considering

Figure 7 and 7a. Students ready to embark on the Inland Seas vessel *Schoolship* to collect data that monitors the health of Lake Michigan in Suttons Bay.

Photo Credit: Kara Clayton

Figures 8 and 8a. High school students host 5th grade classes at learning stations.

Photo credit: Holly Hereau

the differences we noticed in areas way upstream in the Rouge river compared to downstream. Students consistently used NGSS Science and Engineering Practices to uncover Disciplinary Core Ideas and were also developing the ability to use the Cross Cutting Concepts to fully explain the complex interactions that contribute to the problems they noticed. (Schwarz, et al. 2017)

To get more students in our school aware and involved, we reached out to the video productions teacher and co-wrote a grant proposal to support the addition of environmental journalism and reporting to our project. We were awarded the grant from Michigan State's Knight Center for Environmental Journalism (https://knightcenter.jrn.msu.edu/) and began planning ways to draw more students to this project who may not have initially been interested in the science alone. This provided an avenue to create media to share with students and others in our school and beyond. A student wrote a grant proposal and was awarded the prize from kidsgardening.org which allowed us to move forward with the work we planned to include hosting 5th grade students in learning stations and inviting them to join us when we finally installed our plants. Another student won 2nd place in the "hard news" category of the Michigan Association of Broadcasters student awards for a submission about the stewardship action project and how it has a positive impact on student learning, and a group of students presented their work at an Environmental Journalism conference at Michigan State University.

Data Collection and Results

As the project continued into the following year, new students had the same opportunity to complete the community environmental inventory and issue selection process. They also came to a consensus on continuing this project. They worked to develop protocols for data collection and then began to record and collect baseline data. (James Hutton Institute, 2011) Students used the iNaturalist (https://www.inaturalist.org/projects/ths-rain-garden) app to collect information for our project, and also used the Midwest Invasive Species Information (MISIN) app (https://www.misin.msu.edu/) to help identify and report native and invasive species they found in the different areas we investigated. The ArcGIS app (https://www.arcgis.com/features/apps/) enabled students to collect and enter real-time information about the vernal pools we studied into a state database. The information they learned and the data they collected during these experiences helped them understand more about wetlands and our watershed overall and helped contribute data to the body of information researchers use to notice new patterns and identify areas of concern.

Each year, students answered several open-ended survey questions before we started this class and again after the class was completed. For the 2018-19 school year, the survey showed that only 24%

of student answers reflected a positive attitude about Participation in Environmental Stewardship and at the end of the class 53% of student answers reflected a positive attitude about Participation in Environmental Stewardship.

Type of Data	Data Collection Method	Results Fall-Spring of 2017-18	Results Fall-Spring of 2018-19
Plant Biodiversity	Quadrats (student data was ambiguous regarding distribution and abundance)	Aquatic/Emergent: Abundant: Narrow leaf/hybrid cattail. Phragmites. Terrestrial: Patchy: (edges) perennial sow thistle, dandelions Rare: Canada goldenrod, Horseweed, late goldenrod, common milkweed	Aquatic/Emergent: Abundant: Duckweed, narrow leaf/hybrid cattail. Patchy: Phragmites Terrestrial: Abundant: Yellow nutsedge, Prickly Sow thistle, barnyard grass, Patchy: Devil's beggar ticks, Pink weed, Horseweed, Interior Sandbar Willow, creeping thistle, Bull thistle, Ribwort Plantain, Greater plantain, shepherd's purse, lady's thumb, bittersweet nightshade, Canada goldenrod, field thistle, prickly lettuce, American pokeweed, cursed crowfoot, perennial sow thistle, late goldenrod, common milkweed, annual fleabane, Philadelphia fleabane, bog yellowcress Installed and established: Swamp milkweed, Black eyed Susan, Scarlet bee balm, wild bergamot, Blue flag iris, Great blue lobelia, false nettle, golden alexander, rough blazing star, pickerelweed, cardinal flower
Aquatic Macro-invertebrates	D-nets, hand picking from sampling pans and jars with mud and vegetation	Abundant: daphnia, mosquito larvae, midges, Ostracods (seed shrimp), Copepods, leeches, unidentified flatworms (Planaria).	Abundant: daphnia, mosquito larvae, midges, Ostracods (seed shrimp), Copepods, leeches, unidentified flatworms (Planaria). Rare: water boatmen, predaceous diving beetle, dragonfly nymphs (Libellulidae), mayfly nymphs (Baetidae)
Terrestrial Invertebrates	Scouting, sweep nets, pitfall traps	Abundant: earthworms, mosquitos, midges,	Abundant: earthworms, mosquitos, midges, Rare: Ground beetles, Field slugs, Yellow-legged Mud-dauber Wasp, Spotted Lady Beetle, Hoverfly, Various unidentified ant species, various unidentified spiders, field cricket (Gryllus), Spur throated grasshopper, banded wing grasshopper, Horse Fly, eastern yellowjacket, Sowbugs, Unidentified beetle larvae/grubs, Monarch butterfly, cabbage white butterfly, common Whitetail dragonfly, Eastern forktail dragonfly, red admiral
Protists and Algae	Water sample observation using microscopes	Vorticella, amoeba, unidentified ciliates, paramecium (some of these were a result of my students extended study of the pond water succession into the winter.)	Vorticella, amoeba, unidentified ciliates, paramecium (some of these were a result of my students extended study of the pond water succession into the winter.)
Amphibians, Reptiles, Birds, and Mammals	Direct observation	Red wing blackbirds, European starlings, Canada geese, rabbit, brown rat, field mice	Red wing blackbirds, European starlings, robins, Canada geese, Mallards, kildeer, green frogs, a garter snake, rabbits, brown rat, field mice, deer (reported by early morning custodian) painted turtle (the superintendent told me he "transplanted". I did not observe the turtle and asked Brian to refrain from any other "rehoming" activities.
Water quality	Chemical tests and E. coli plates	High nutrient levels, high levels of harmful E. coli, high particulates	High nutrient levels, high levels of harmful E. coli, high particulates (no change)
Measurements of area of runoff pond is catching	Direct measurement and Google Maps	Roof is 31.25m x 38.5m, Roof often gathering area for Canada Geese, and some even build nests up there	Roof is 31.25 m x 38.5 m, Roof often gathering area for Canada Geese, and some even build nests up there (no change)
Measurements of Retention area	Direct measurement	North side "dry side" – deepest part ranged from 10-18 cm in fall measurements (dry for much of last spring/summer). South side "pond side" – deepest part ranged from 42-49 cm in fall measurements.	North "dry side"– never dried throughout the entire spring before school ended. Still 25cm deep in the center. Water disappeared over summer for about a week before heavy rains caused it to fill again. Standing water remained still all through the summer and fall. There were no days this year where that side of the "pond" was dry. South "pond side" – Measurements in the spring were as high as 90 cm after the snow melt and now in August is back to around 60 cm. **Due to the removal of all aquatic emergent species there is less vegetation to absorb water. This is a temporary problem that will hopefully be solved as more natives are re-established. We did anticipate this, but due to the wetter than normal spring water was present all summer and prevented us from planting the species we intended.*

2018-2019 Pre- and Post-Survey Comparison

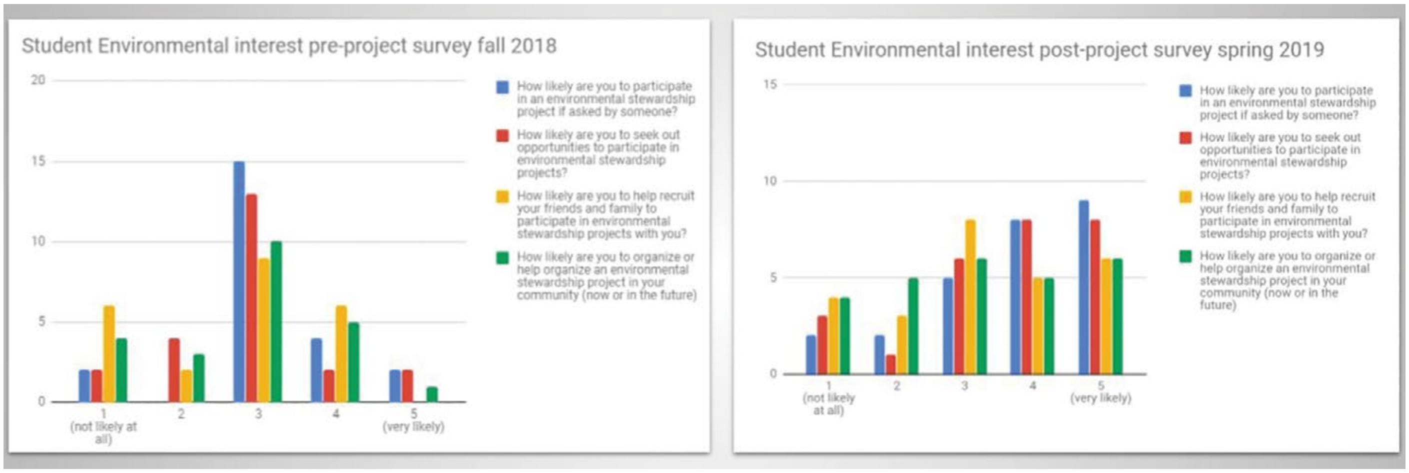


Figure 10. Open-ended survey questions about student participation in environmental stewardship.

About the Author

Holly Hereau is a Science Educator at BSCS and an Adjunct Biology instructor at Macomb Community College in Warren, MI. She previously taught high school biology, chemistry and environmental science in Redford, Michigan for 15 years and was a member of the Achieve Inc. Peer Review Panel for Science. Hereau has worked with educators across the country to support implementation of high-quality NGSS designed units developed by the Next Generation Science Storylines and inquiry Hub teams in addition to working with those teams to develop Biology and Chemistry High School Storyline units. She holds a bachelor's degree in biology from Grand Valley State University and studied Entomology at Michigan State University before earning a master's degree in secondary education at the University of Michigan. She was named the 2019 Michigan High School Teacher of the Year and a recipient of the Presidential Award for Excellence in Mathematics and Science Teaching in 2019. Holly can be reached at hhereau@gmail.com and found on Twitter @hhereau

Conclusion: Designing and Facilitating Units of Instruction with a Student-Chosen Phenomenon or Problem

The long-term success of our project will be determined from seasonal biodiversity audits and water quality monitoring results downstream of our site. Our initial inventory revealed very low species diversity, and the *Phragmites* provided habitat for an undesirable population of rats in addition to other invasive plants and animals. As the garden matures, we expect to see an increase in diversity and abundance of bees, butterflies, and other insects as well as amphibians, songbirds, and small mammals. Additionally, students hope to see the restored wetland used by students and members of the community of all ages for learning and enjoyment. The real success however is the level of engagement from students. Using a process that ensures each student's voice is heard as they participate in the planning and decision-making increases students' interest in this project and provides them a strong scaffold to broaden their environmental awareness and increase the likelihood to seek out other stewardship experiences.

References

Berland, L. K., Schwarz, C. V., Krist, C., Kenyon, L., Lo, A. S., & Reiser, B. J. (2015). Epistemologies in practice: Making scientific PRACTICES meaningful for students. *Journal of Research in Science Teaching, 53*(7), 1082-1112. doi:10.1002/tea.21257

James Hutton Institute, (2011) *Handbook of field sampling protocols for biodiversity.* https://www.hutton.ac.uk/sites/default/files/files/A%20Handbook%20of%20biodiversity%20monitoring%20protocols(1).pdf

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Washington DC: The National Academies Press.

Penuel, W. & Bell, P. (2016). *Qualities of a Good Anchor Phenomenon for a Coherent Sequence of Science Lessons.* STEM Teaching Tools Initiative, Institute for Science + Math Education. Seattle, WA: University of Washington. Retrieved from http://stemteachingtools.org/brief/28

Schwarz, C. V., Passmore, C., & Reiser, B. J. (2017). *Helping students make sense of the world using next generation science and engineering practices*. Arlington, VA: NSTA Press, National Science Teachers Association.

Reiser, B. J., Novak, M., & Fumagalli, M. (2015). *NGSS storylines: How to construct coherent instruction sequences driven by phenomena and motivated by student questions.* Illinois Science Education Conference 2015, Tinley Park, IL.

Reiser, B. J., Novak, M., & McGill, T. A. W. (2017). *Coherence from the students' perspective: Why the vision of the framework for K-12 science requires more than simply "combining" three dimensions of science learning.* Paper commissioned for the Board on Science Education workshop "Instructional materials for the Next Generation Science Standards". Retrieved from http://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_180270.pdf

The Great Water Design Challenge: A NOAA Planet Stewards and Illinois Mathematics and Science Academy (IMSA) Collaboration

Liz Martinez

Abstract

Through generous NOAA Planet Stewards funding, schools in the Northern Illinois area had the unique opportunity to participate in a one-day design challenge that focused on local and state environmental issues. Student teams, which ranged from fifth grade through high school, engaged in research and design thinking to create innovative responses and solutions to address their selected water challenge. Subject matter experts were available, both virtually and in person, for questions, conversations, and insights as teams worked. Simultaneously team sponsors engaged in their own professional development related to the NOAA Planet Stewards Program. Students showcased their work at the end of the day to experts and educator mentors.

The Illinois Mathematics and Science Academy (IMSA, imsa.edu) is located roughly 40 miles west of Lake Michigan. When NOAA Planet Stewards contacted IMSA regarding developing and hosting a Planet Stewards workshop, we immediately thought of the Lake and named the event after Michigan, which means large or great lake, thus the name, The Great Water Challenge.

Planning the event was a team effort between NOAA Planet Stewards and IMSA's Statewide Educator Initiative Team (SEI). SEI's mission is to impact mathematics and science education by supporting educators with relevant professional development in areas such as technology, problem-based learning, the Next Generation Science Standards (NGSS, 2013), and a micro-credentialing program. SEI and NOAA Planet Stewards engage with formal and informal educators as well as students to increase scientific literacy. NOAA's focus on climate literacy (NOAA, 2006) and water-related issues closely aligns with IMSA's focus on the United Nations Sustainable Development Goals (UN, 2015), particularly goals 13-15. Earth and human activity, as well as engineering and design performance expectations from the Next Generation Science Standards, of which Illinois has adopted, are also interrelated.

Table 1. Event Goals

Source	Goal
United Nations Sustainable Development Goals https://sdgs.un.org/goals	Goal 13: Climate Action Goal 14: Life Below Water Goal 15: Life on Land
Essential Principles of Climate Literacy https://www.climate.gov/teaching/essential-principles-climate-literacy/essential-principles-climate-literacy	Essential Principle 6: Human activities are impacting the climate system. Essential Principle 7: Climate change will have consequences for the Earth system and human lives.
Next Generation Science Standards https://www.nextgenscience.org/	**Middle School** Earth and Human Activity: MS-ESS3-2, MS-ESS3-3, MS-ESS3-5 Engineering and Design: MS-ETS1-1, MS-ETS1-1, MS-ETS1-4 **High School** Earth and Human Activity: HS-ESS3-1, HS-ESS3-4 Engineering and Design: HS-ETS1-1, HS-ETS1-2, HS-ETS1-3

Allowing student choice, using local issues, and connecting learners with experts in the field were the best pedagogical practices used as criteria for the project development. These led us to employ a modified design sprint. The function of a design sprint is to identify a problem and solve it within a short amount of time, usually five days, through research, discussion, ideation, and prototyping. As this was a one-day event, teams were not expected to complete a significant portion of the design sprint process. Teams would identify a local environmental problem they wanted to mitigate, research the issue, and develop a plan of action or solution. In order to narrow the field of issues for the students and the teachers, a focused list of locally relevant topics was developed. Categories were selected based on local environmental issues, recent events, appropriate resources, and availability of subject matter experts. Research questions were then developed for each of the categories. Below is the list of topics and questions.

Algal Blooms, Pet Illnesses

- How does the Midwest contribute to harmful algal blooms in the Gulf of Mexico and how can we lessen the impact?
- How do harmful algal blooms affect plants, animals (including pets), and humans?
- What are potential solutions to reducing harmful algal bloom events?

Algae

- Why are algae necessary for the biosphere?
- How can uses of algae positively impact climate change or sustainability?

Biodiversity/Invasive Animal Species

- How is climate change affecting the spread of invasive species (such as zebra mussels)?
- What are the impacts of invasive species (such as zebra mussels)?
- What actions can be taken to control invasive species (such as zebra mussels)?

Biodiversity/Invasive Plant Species

- How is climate change affecting the spread of invasive plant species (such as purple loosestrife)?
- What are the impacts of invasive species (such as purple loosestrife)?
- What actions can be taken to control invasive species (such as purple loosestrife)?

Marine Debris, Microplastics, Plastics

- What are the trends in the use of microplastics and what actions can be taken to reduce what ends up in the ocean?
- Document the presence of marine debris in the Great Lakes and what communities can do to reduce the input.

Human Health Issues, Vector-borne Disease

- How is climate change affecting the incidence of vector-borne diseases?
- What actions can be taken to reduce the incidences of vector-borne diseases?

Nuisance Flooding, Weather Incidents, Shoreline Changes

- What are the impacts of flooding events in Illinois and what strategies are communities using to protect citizens and property?
- Document how climate change may affect the incidences of severe weather. What actions should citizens take to prepare for the new climate future?

During registration for the project, student teams selected the question they wanted to investigate, subject matter experts they wished to hear, and submitted questions they wanted to ask each of the subject matter experts at the event.

Teams were provided with resources to use for preliminary research prior to the event. Many student teams came prepared with extensive background knowledge about their chosen issue. This allowed them to focus on having final questions answered from the experts and to develop solutions and evidence to support their choice.

Planning for a one-day event that provides an immersive experience for students requires an attention to detail. Scheduling for the day included general sessions and customized sessions for each school to meet with their subject matter experts of choice. Identification of and communication with subject matter experts was critical. Presentation materials, topics and questions from teams, schedules, and technical platforms needed to be developed and shared. School and student permissions, schedules, and other logistics for the day also needed to be sent in advance. Some of the responsibilities for the hosting SEI team included facility reservations for large and small group work, food, check in, moderating sessions, obtaining and providing materials for teams, and supervising students. We also wanted to provide the sponsoring teachers with their own professional development. NOAA Planet Stewards Program, NOAA resources, implementation ideas, and other related topics were presented at an educator-only session during the event while the students worked with the subject matter experts.

The day of the Great Water Challenge began with all participants gathered in the auditorium. Subject matter experts introduced themselves, briefly spoke about their jobs, and shared their areas of expertise. From there teams moved following their individual schedules as they met with the subject matter experts either in-person or virtually, who presented additional background information regarding their topics and answered student questions.

Table 2. Sample of Student Developed Questions

- How do you think AI can help solve the issue of invasive species?
- Do invasive species cause long term human health issues? If so, what kind and what have we done in the past to prevent / stop them?

- What does marine debris encompass? Please provide categories or examples.
- Is it possible to introduce catalysts that will re-polymerize microplastics so they can be combined into larger molecules that are easier to extract?
- Are there any projects where algae or bacteria are being used to breakdown plastics or marine debris?

- In what ways do algae benefit the ecosystem compared to what they take away?
- How do algae compare to other marine/aquatic plant life?
- Could there be blooms of any other plant species that cause as much harm as algal blooms?
- What is the main cause of algal blooms? Where is it most prevalent?
- If algae is helpful to ecosystems, how does it also cause harm?
- Could the impact of algae blooms extend as far as the Midwest and affect our drinking water supply?

- Once an aquatic system is thrown off-balance, can it fully recover, and how?
- What types of laws or regulations have been put in place to regulate the use of fertilizers?

Figure 1. Dennis Liu talks with a student about biodiversity and invasive species.
Photo credit: Angela Rowley

Figure 2. Students engage with a virtual expert to learn more about their chosen topic.
Photo credit: Angela Rowley

Each team then began developing ideas to mitigate their selected issue, as well as a presentation and materials for the poster session in the afternoon. For the final session, student teams were divided into groups A and B. This allowed group A teams to present and group B teams to move about and listen to group A team presentations. Roles were reversed so group B teams presented for group A teams. The day wrapped up with awards that recognized creative efforts, scientific accuracy, and clarity of solutions. Teams were also presented with *Drawdown: The Most Comprehensive Plan Ever Proposed to Reverse Global Warming* by Paul Hawken, water bottles, and metal straws.

Impact

The impact of the Great Water Challenge is largely anecdotal in nature. Participant numbers included 25 educators, 87 students, 6 subject matter experts, and 10 IMSA SEI Team members. Comments during the day were very positive from the students, the participating educators, and the subject matter experts.

Participant comments included

- "Our students thoroughly enjoyed the day. They have been talking about their idea to all of their teachers." – *Educator*
- "I didn't know that what we do here bothers the ocean." – *Student*
- "Why aren't there laws to stop that? " – *Student*
- "This is the best day of my life!" – *Student*
- "I met real scientists." – *Student*
- "Students were well prepared. They asked really good questions and had great ideas." – *Subject Matter Expert*
- "They are persistent." – *Subject Matter Expert*
- "It was refreshing – their perspective." – *Subject Matter Expert*

As a pilot project, the design challenge may provide a spring board for more opportunities so that students may interact with subject matter experts regarding a wide range of environmental issues.

References

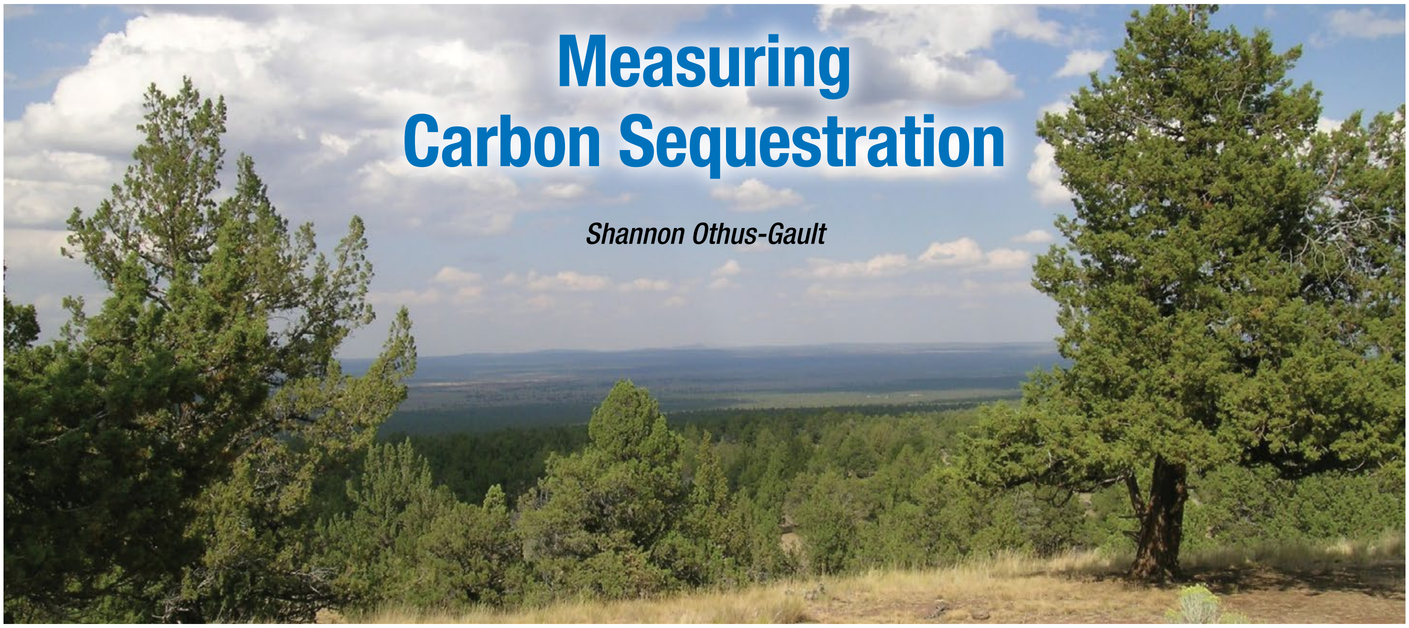
National Oceanic and Atmospheric Administration (NOAA). (2006). *The Essential Principles of Climate Literacy.* NOAA Climate.gov. https://www.climate.gov/teaching/essential-principles-climate-literacy/essential-principles-climate-literacy

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States*. Retrieved April 09, 2021, from https://www.nextgenscience.org/search-standards

United Nations, Department of Economic and Social Affairs. (2015). THE 17 GOALS: Sustainable Development. Retrieved April 09, 2021, from https://sdgs.un.org/goals

About the Author

Liz Martinez is a curriculum and professional development specialist for The Center for Teaching and Learning at the Illinois Mathematics and Science Academy (IMSA) in Aurora, IL. Before she joined IMSA she was a middle school science teacher for 29 years. Liz is a past president and current secretary of the National Middle Level Science Teachers Association. She has been a NOAA Climate/Planet Steward for many years and is appreciative of the support provided by the project. She can be reached at emartinez@imsa.edu.



Measuring Carbon Sequestration

Shannon Othus-Gault

Abstract

Carbon sequestration by plants is one of the most important short-term processes that removes the greenhouse gas carbon dioxide from the atmosphere. As humans continue to release carbon from long term geologic sinks, through the burning of fossil fuels for example, understanding how carbon can be removed from the atmosphere by plants through photosynthesis is an important concept for students to understand. One way to attempt to measure this process is by measuring dry and ash weights of a plant to estimate the amount of carbon sequestered by the plant during its lifetime. This laboratory activity can be paired with the creation of a community garden that allows students to measure how much carbon can be sequestered through the creation of an individual green space and can connect to individual action on climate change. The green space used during the creation of this laboratory activity was funded by the National Oceanic and Atmospheric Administration (NOAA) Planet Stewards Program in 2018 (https://oceanservice.noaa.gov/education/planet-stewards/).

Introduction

The atmosphere is made out of many gases and some of those trace gases are referred to as greenhouse gases. These gases are important for the atmosphere because they absorb infrared and emit their own infrared, heating the lower atmosphere. The heat given off by greenhouse gases creates a livable climate on Earth, a whole 33^{0}C warmer than it would be without the presence of greenhouse gases (ESRL, 2005). One of the most important greenhouse gases is carbon dioxide. Carbon dioxide is also an important gas in terms of plant growth. Plants use carbon dioxide from the atmosphere during the process of photosynthesis to create biomass (NOAA, 2019). This process of obtaining carbon from the atmosphere and holding it in solid form is referred to as carbon sequestration. Carbon sequestration has become more important in recent years with the increase of carbon dioxide in the atmosphere creating an enhanced greenhouse effect and contributing to the warming of our atmosphere. In fact, historical levels of carbon dioxide remained below 300 ppm (parts per million) over the past 400,000 years; yet, since the 1950's, carbon dioxide has increased to over 400 ppm (NASA, 2016).

All humans can help to sequester carbon from the atmosphere by creating their own gardens and increasing biomass on Earth's surface. This goal of this laboratory activity was to teach students about important atmospheric processes, including the greenhouse effect and how atmospheric carbon can be sequestered by plants. Another goal of this activity was to measure the amount of carbon that can effectively be sequestered in a small green space as an example of what they can do in their own home and/or yard.

Methods

Prior to performing this lab activity, my students were provided information on the greenhouse effect and the carbon cycle and also participated in class activities related to biogeochemical cycles and greenhouse gases, such as those provided by the Science Education Resource Center (SERC) through the EarthLabs project (SERC, 2016). This base knowledge was provided to allow students to connect the related lab activity to much larger Earth systems and processes. After finishing pre-lab work, students began to measure carbon sequestration by obtaining a whole-plant sample, including the root system. A sample can be collected from a school garden (as was done for this project) or can be collected from any appropriate place noted by an instructor or even parent. Once the sample was obtained, the whole plant was cleaned to remove as much excess soil as possible so that the most accurate dry weight of the plant sample could be measured. Once cleaned, the plant was dried. I allowed samples to air dry over several weeks; however, you could attempt to dry the plants more quickly in a low temperature, drying oven. Once these samples were dried, they were used by students to measure the carbon sequestered by the plant. To do this, the dried plant was weighed and that weight recorded. Next, the dried plant matter was burned in a controlled manner so that ash can be collected and weighed.

Figure 1: Picture shows the author demonstrating to students how to combust plant samples.

Photo Credit: Shannon Othus

By subtracting the weight of the ash from the weight of the dry sample, students were able to roughly estimate the amount of carbon that was sequestered by that plant. This activity works by essentially combusting the carbon matter in the plant and creating carbon dioxide, which is transferred to the atmosphere, and leaving behind the rest of the noncombustible matter of the plant. By comparing the dry weight with the ash weight, we can make a rough estimation of the carbon that had been contained in the plant sample.

Although measuring the carbon sequestered by a single plant can be useful, students can use plant counts within a garden to calculate how much carbon a larger green space or garden can sequester. During this activity with my own class, we obtained the amount of carbon sequestered by our garden by creating a garden map and counting the number of the different plants present in the garden.

Figure 2: Picture showing the community garden and the distribution of plants used to measure carbon sequestration.

Photo Credit: Shannon Othus

Once students created their map and finished their plant counts, they multiplied the number of each example plant counted by the measurement of the carbon that type of plant sequestered. These final carbon calculations were added together to create a rough estimate of how much carbon was sequestered by our garden during that year's sampling. These easy measurements can potentially allow students to plan for future growing seasons to maximize carbon sequestration with evidence-based observations from past growing seasons.

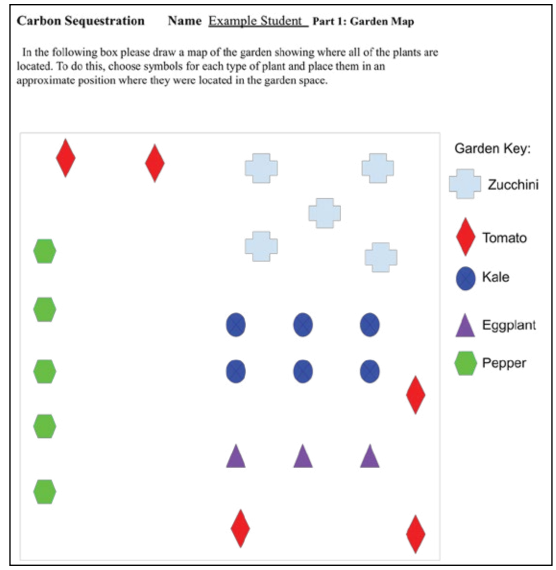


Figure 3: Map shows the placement and number of plants found in the Yamhill Valley Campus Community Garden. The plant counts found on the map were used by students when calculating the total carbon sequestered in the garden through multiplying the number of plants present with the carbon measured by students.

Materials and Suggestions

This is clearly a lab activity that needs to be well supervised by an instructor due to the fact that fire is involved. Also, after students performed this lab activity for the first time in my classroom, I learned several tricks and tips for what materials are more successful for this activity and how to use those materials to fully incinerate the dry plant material. One of the most important materials you will need is a receptacle to burn your dry plant material. I obtained large food cans from the kitchen on our campus and they were big enough to allow for full combustion. You will also want to make sure that there are ventilation holes in these receptacles so that air can mix with the plant material during combustion. Also, make sure that the holes aren't big enough to lose ash material. Another possible tip to allow for combustion to occur more rapidly would be breaking the plant into smaller pieces prior to incineration so the volume of the plant is more compact. I have also found that stem lighters are best for keeping appendages away from the flames but are also useful in continuing the combustion of materials if they need to be set alight more than once. Lastly, I would suggest heat resistant gloves to protect student hands.

Student Assessment

Due to the current pandemic, I have only been able to run this lab activity with two classes using mature plants from my campus's community garden. However, students were able to work together to calculate some estimates of carbon sequestered by the plants in our garden. Some of the dried plants were not able to be fully burned leading to a low overall calculation for the carbon sequestered by plants in the garden, kale plants in particular. Results based on student calculations from the Spring of 2019 can be found in Table 1.

Table 1: Data collected and calculated by students to calculate carbon sequestered within the Yamhill Valley Campus community garden from the 2019 General Science Earth System Science class

Year and Season	Age of Plant	Plant Type	Dry Weight (g)	Ash Weight (g)	Carbon Weight (g)	Number of Plants	Total Carbon Sequestered (g)
Spring 2019	Adult	*Kale	23.6	22.3	1.3	6	7.8
Spring 2019	Adult	Peppers	80.6	11.9	68.7	5	343.5
Spring 2019	Adult	Zucchini	310.0	128.0	182.0	5	910.0
Spring 2019	Adult	Tomatoes	271.1	39.0	232.1	5	1160.5
Spring 2019	Adult	Eggplant	97.6	17.3	80.3	3	240.9
						Total carbon sequestered by adult garden:	**2662.7**

* Incomplete burn of specimen

Once students had finished calculating their measurements, they were then asked to answer several questions to put their carbon measurements into greater context of the greenhouse effect and climate processes, i.e., how does growing plants change the atmospheric concentration of carbon dioxide and, therefore, affect the greenhouse effect? The questions that I posed are as follows:

- How does carbon dioxide behave in the atmosphere (hint: what type of gas is carbon dioxide)? How can an abundance of carbon dioxide in the atmosphere become a problem for Earth's biosphere?
- Vegetation is considered a carbon sink. Based on the word "sink", what do you think that suggests in terms of the carbon that was sequestered by the plants you measured? In other

words, how is the carbon sequestered by plants related to the carbon dioxide found in the atmosphere?

- How can sequestered carbon change the composition of the atmosphere? How could this sequestration affect the greenhouse effect?
- Knowing that this garden was used for food production, how can the harvesting of food from the garden affect the carbon weight measured? How does harvesting food from the garden affect the number that you calculated for the total carbon sequestered by the garden?
- Can you think of any other sources of error that could have affected the calculations you made for carbon weights and the amount of carbon sequestered by the plants in the garden?

These questions allowed students to think deeply about how plants and atmospheric composition are directly linked and how the greenhouse effect can be affected by plant growth. It also asks students to think about errors in their calculations since this activity is truly, a very rough estimation of carbon sequestration.

Conclusion

Allowing students to connect their own personal activity to atmospheric composition and the greenhouse effect is an important lesson to learn as we begin to tackle the effects of anthropogenic climate change. This is a lab activity that is hands-on and allows for teachers and students to use green spaces, whether at school or at home, and for scientific exploration and data collection, which are important aspects of inquiry-based science learning.

A list of materials, methods and lab questions, can be found at:
https://docs.google.com/document/d/1eXa3vbX7uncsJr0hh37Kxz4MOQHbFwPrB1IOLAVqK0A/edit?usp=sharing

References

NOAA Earth System Research Laboratories. *Basics of the Carbon Cycle and Greenhouse Effect*. 2005. https://www.esrl.noaa.gov/gmd/education/carbon_toolkit/basics.html

National Oceanic and Atmospheric Administration (NOAA). *Carbon Cycle*. 2019. www.noaa.gov/resource-collections/carbon-cycle

National Aeronautics and Space Administration (NASA). *The Relentless Rise of Carbon Dioxide*. 2016. https://climate.nasa.gov/climate_resources/24/graphic-the-relentless-rise-of-carbon-dioxide/

Science Education and Resources Center at Carleton College. *EarthLabs*. 2016. https://serc.carleton.edu/eslabs/index.html

About the Author

Shannon Othus-Gault began teaching as an outdoor school and science camp instructor at the age of 16 and has worked in the states of Oregon, Washington, California, New York and Wisconsin. Shannon has been teaching geology and Earth sciences for ten years at several Community Colleges but has committed to a single location, Chemeketa Community College at the Yamhill Valley Campus in McMinnville, Oregon. Prior to teaching, Shannon worked as a natural resource scientist for the Washington Department of Natural Resources in the Forestry department mapping landslides and making landslide hazard maps. She can be reached at othussm@gmail.com

A Deep Sense of Hope: Engaging Students in Coral Restoration

Matt Strand, Ph.D., Derek Hagen

Ryan and Larson, two 9th grade Polaris students, collect data on the health of out-planted staghorn corals at Carysfort Reef as part of the Colorado Coralition citizen science project.

Photo credit: Matt Strand

Abstract

This article describes a NOAA Planet Stewards Education Project where students dive deeply into environmental science and stewardship. The Colorado Coralition focuses on the science of climate change, coral decline, and reef restoration. Middle and high school students from Fort Collins, Colorado worked for an entire year to take part in the learning experience of a lifetime: helping the Coral Restoration Foundation in their efforts to stem the tide of coral reef decline in the Florida Keys. For the culmination of their 2019 project, Coralition students used their scuba diving skills to contribute to ongoing coral restoration research in an in-depth citizen science project at the bottom of the ocean.

An Introduction to Deeper Learning

Jaya, a 7th grader, hovers above a golden thicket of staghorn coral. Below her, purple sea fans wave softly in the current. She checks her regulator before sinking closer to the young corals clinging to the live rock substrate. She finds an algae-encrusted tag affixed to the coral and records the following data on her dive slate:

Genotype: U 41
Cluster: 185

Using her citizen science training, she counts the number of corals in the cluster and observes how many are alive and how many have fused with other coral fragments – both important indicators that out-planting efforts are succeeding on Carysfort Reef.

Alive: 10
Dead: 0
Fused? Yes

She swims over to Mikaela, her dive partner, who is monitoring another cluster nearby. They point enthusiastically to the positive data they have collected. Back on the dive boat, these two

Figure 1. Jaya assesses coral fragment survivorship at Carsyfort Reef.

Photo credit: Matt Strand

Figure 2. Jaya and Mikaela compare their coral monitoring data at Carysfort Reef.

Photo credit: Matt Strand

middle schoolers are as exhilarated as the rest of the Coralition students in spite of this being their final dive before returning home to Colorado.

Coral Decline in the Florida Reef Tract

The Florida Reef Tract is the third-largest barrier reef in the world, covering over 3,800 square miles (NASA, 2012). This expansive ecosystem is home to over 6,000 marine species (Florida Museum of Natural History, 2021). It provides vital coastal protection as well as a significant economic draw for recreation and tourism (NASA, 2012). However, the Florida Reef Tract has faced a precipitous decline in coral cover. Over the last 40 years, this reef system has lost approximately 97% of two of its most dominant shallow-water reef-building coral species: staghorn and elkhorn coral (Bruckner, 2002).

Climate change, the biggest threat to coral reefs around the world, is a primary driver of this decline. Thermal stress events from increasing temperatures cause coral bleaching and mortality. Additionally, global increases in CO^2 compound these stressors, causing the ocean to acidify, which results in severe degradation of coral calcification rates (NOAA, 2020). But there are regional contributors to the rapid decline of staghorn and elkhorn corals as well. The Florida Reef Tract's proximity to the southern Florida watershed has intensified the loss of native coral cover. Agricultural, urban, and suburban runoff results in a toxic blend of fertilizers, sewage, and pollution reaching this important ecosystem, resulting in catastrophic eutrophication and disease (NASA, 2012).

The Coral Restoration Foundation

In Key Largo, Florida, the Coral Restoration Foundation (CRF), a nonprofit focused on reef conservation and recovery, is leading the charge to reverse this precipitous decline. CRF works to support the natural recovery processes of reefs around the world through the large-scale cultivation, out-planting, and monitoring of genetically diverse, reef-building corals. In Florida, this is accomplished by growing finger-sized elkhorn and staghorn corals in offshore nurseries. Corals are grown and harvested for out-planting in the wild on carefully selected out-planting sites. Once on-site, these coral fragments are glued to the live rock substrate using a marine epoxy. Each out-planted coral is tagged with genetic, species, and location information for monitoring purposes. This allows CRF to identify genotypes that are resilient to the many global and regional threats to coral reefs. Since 2012, CRF has out-planted more than 120,000 critically endangered staghorn and elkhorn corals back onto the Florida Reef Tract. Many of these corals have now grown into thriving colonies with the ability to spawn, encouraging the reef's natural process of propagation.

Figure 3. A healthy cluster of elkhorn coral observed on Carysfort Reef.

Photo credit: Matt Strand

Carysfort Reef is the northernmost of eight CRF out-planting sites in the Florida Keys. Much like the iconic lighthouse that sits atop this reef, Carysfort is a beacon of hope for coral restoration. At the close of 2020, CRF has out-planted over 35,000 new corals on Carysfort Reef. Active monitoring and data collection demonstrate an impressive 93% survivorship of staghorn and elkhorn corals at this site, as well as evidence of increased coral cover (Coral Restoration Foundation, 2019). CRF's success with reef restoration has drawn attention from all over the world, including a teacher and his students from Fort Collins who call themselves the Colorado Coralition.

The Colorado Coralition

The Colorado Coralition (https://spark.adobe.com/page/GreDo3zPQVV70/) is a year-long environmental science project at Polaris Expeditionary Learning School (https://pol.psdschools.org/) in Fort Collins, Colorado. Polaris, a K-12 public school in Poudre School District, fosters learning through student-centered, standards-based projects that rely on experts, fieldwork, and real-world application. While Polaris teachers use this experiential project model in the day-to-day curriculum, they also develop week-long enrichment projects, called Intensives, that take place three times a year (in September, February, and in May). Intensive Weeks allow teachers a way to share passions beyond their content area with multi-age groups of students. Polaris students in 6th - 12th grade select their top "Intensive" choices from a menu of options. These experiences typically incorporate the arts, career exploration, adventure, technology, and/or service learning. Whether one teaches math, social studies, foreign language, or music, Polaris teachers are given wide latitude to create powerful learning experiences for kids. It is this invitation to innovate that led Dr. Matt Strand, the 7th and 8th grade English teacher at Polaris, to develop the Colorado Coralition. In 2013, Matt was awarded a grant from Fund For Teachers (https://www.fundforteachers.org/), which supported his efforts to earn his scuba certification and travel to Florida to volunteer with CRF. He participated in multiple dives, seeing firsthand the degradation on the Florida Reef Tract. It was a moving experience, one that gave him a blueprint for designing a similar life-changing opportunity for Polaris students. To make his dream of diving with students a reality, Dr. Strand designed the Coralition so the same cadre of students could participate in all three of his Intensive Weeks throughout the year.

Scuba Certification

The middle and high school students selected to join the Coralition, which has a maximum acceptance of twenty students, start with rigorous study for their Open Water Certification. Divemasters from Colorado Scuba Diving Academy train students in dive theory and practical skills such as buoyancy control. During September Intensive Week, students spend a great deal of time studying in the classroom and practicing in the pool; the week culminates in a trip to Homestead Crater in Utah, a geothermal crater with a depth of 65 feet, for their final diving exams. As regular classes resume at Polaris, these newly certified divers attend weekly after-school meetings focused on research and fundraising. This is where the power of the NOAA Planet Stewards Education Project really takes hold.

Curriculum and Student-Led Presentations

The Colorado Coralition was accepted as a NOAA Planet Stewards funded project during the 2018-2019 school year. Participation in this federally funded program created an opportunity to bolster this third iteration of the Coralition with diverse scientific frameworks and resources. Throughout much of the school year, Dr. Strand and his students met weekly for after-school workshops that focused on an integrated approach to scientific inquiry and literacy. Many of these workshops centered on coral biology, global and regional stressors to coral reefs, rates of decline, and evaluating coral restoration solutions. Educators interested in Next Generation Science Standards (NGSS, 2017) and Cross Cutting learning opportunities that relate to coral decline and restoration practices can look to the following Disciplinary Core Ideas:

- Ecosystems: Interactions, Energy, and Dynamics in Ecosystems (MS-LS2-5, HS-LS2-7)
- Earth and Human Activity (MS-ESS3-2, MS-ESS3-3, HS-ESS3-1, HS-ESS3-4, HS-ESS3-5)

Figure 4. Quinn, a 7th grader, cleans algae from a coral tree in the Coral Restoration Foundation offshore nursery.

Photo credit: Matt Strand

Coral studies provide unique opportunities to integrate an NGSS-based curriculum with Ocean Literacy Essential Principles and Fundamental Concepts (National Marine Educators Association, 2020). These include Principles 3, 5, 6 and 7. Combining NGSS with the Ocean Literacy Framework provides a robust curricular springboard that inspires students to take decisive action.

The Planet Stewards program also bolstered the scientific depth of the Coralition by providing increased access to NOAA resources, data, and experts. Dr. Strand organized live video conferences with experts such as Dr. Mark Eakin, coordinator of NOAA's Coral Reef Watch, as well an in-person visit by Zack Rago, who was featured in the Emmy-awarded 2017 Netflix documentary *Chasing Coral*. After these interviews, students chose from subtopics related to coral science and restoration engineering and prepared presentations that took place during the February Intensive Week. As part of the OtterCares Closed2Open (https://ottercares.org/closed2open) campaign, volunteer employees from Fort Collins-based OtterBox visited Dr. Strand's classroom to give tips and feedback to students as they rehearsed their presentations. This experience helped Coralition students lead an immersive event in the 360° OtterBox Digital Dome Theater at the Fort Collins Museum of Discovery. In front of a large audience that included Dr. Joanie Kleypas of the National Center for Atmospheric Research and US Congressman Joe Neguse, Coralition students provided in-depth details on topics such as the biology of coral, the ecology of coral reefs, the impact of climate change, regional stressors in the Florida Reef Tract, restoration techniques, and ways to reduce the collective carbon footprint on Colorado's Front Range. Clearly, the backing of the NOAA Planet Stewards program had a definitive impact on students' depth of knowledge, confidence, and commitment to environmental stewardship.

Trip Preparation

While researching and preparing presentations for their topics, students also focused on fundraising to support their trip to Florida. Some students started crowdfunding campaigns, while others started small businesses. Group fundraising events such as T-shirt sales and ocean-themed school dances gave students yet another opportunity to work as a team. These students also had additional opportunities to hone their scuba diving skills throughout the year (video of the Christmas tree dive challenge – http://bit.ly/coralitiontraining). These yearlong efforts, combined with the Planet Stewards program, helped make dreams of diving in Florida a reality.

Planet Stewards Project and Results

Upon arriving in Key Largo, Coralition students deepened their scientific knowledge at the CRF Exploration Center, a hub for promoting engagement in coral science and restoration. The CRF website (https://www.coralrestoration.org/) also provides a vast array of information about coral restoration methodology, free standards-based classroom activities, national STEM competitions and challenges, and the OK Coral app-based citizen science program. Coralition students spent half-days engaged in customized lessons and hands-on training with marine biologists before heading out for the CRF dive program.

Table1. Colorado Coralition Monitoring Data: Carysfort Reef (May 31st, 2019)

Genotype	Cluster	# Alive	#Dead	Fused/ Not Fused
U75	112	10	0	NF
U75	114	11	0	NF
U63	145	10	0	NF
M20	44	9	0	NF
U44	165	11	0	NF
K2	428	11	0	NF
B10	97	10	0	NF
B8	90	10	0	F
U41	185	10	0	F
J41	183	7	0	NF
MS	38	11	0	NF
MS	385	10	0	F
UII	185	10	0	NF
NA	NA	1	0	NF
NA	NA	0	1	F
B8	91	9	0	F
J41	184	9	0	F
UNK	UNK	3	2	F
NA	NA	0	4	F
NA	NA	11	0	F
NA	NA	13	0	F
KI	C671	11	0	F
NA	NA	7	5	F
NA	NA	4	9	F
C91	B8	3	0	F
NA	NA	6	0	F
NA	NA	2	0	NF
NA	NA	3	0	NF
NA	NA	4	0	NF
NA	NA	1	0	F
NA	NA	5	2	F
NA	NA	8	2	NF
NA	NA	2	0	NF
NA	NA	2	0	NF
B10	96	8	0	F
U35	129	11	1	NF
UI00	107	10	0	NF
U30	50	11	0	NF
U106	42	9	0	NF
B8	112	10	0	NF
U44	164	10	0	NF
U44	165	9	0	NF
UIS	132	11	0	NF
KW16	35	10	0	NF
KW16	36	11	1	NF
U17	12	9	0	NF
U41	206	9	0	NF
NA	NA	3	5	NF
UI00	107	10	0	NF
U39	50	10	0	NF
U106	42	9	0	NF

Results

Total Recorded Coral Fragments: 435

403 Corals Alive

32 Corals Dead

92.64% Survivorship

Total Number of Clusters: 51

33 Clusters with No Fusion Observed

18 Clusters with Fusion Observed

64.7% Observed Fusion

Coralition students descend in small teams, led by marine biologists and accompanied by dive masters, to tackle a variety of tasks on the ocean floor, such as coral nursery maintenance and coral monitoring.The most powerful learning takes place through these dives.

Underwater Gardening

In the coral nursery, CRF's innovative "coral trees" — large PVC structures with monofilament for hanging coral fragments — allow coral farming to take place. However, much like weeds take to a garden, algae can take over a coral tree. To keep young corals healthy, the trees and monofilament must be regularly cleaned. Coralition students learned how to scrub these underwater structures free from algae and other biofoul. They also learned how to tag fragments with identifying information and "harvest" them from the trees for out-planting. Students did several dives in the nursery, working hard to clean eight coral trees to ensure hundreds of corals would grow healthy and strong.

Citizen Science Data Collection

Coralition students also used their citizen science training to collect data on outplants at Carysfort Reef. Working in pairs, students spread out across the reef and studied coral clusters carefully for signs of disease, mortality, and fusing (coral fragments growing together to form more structural complexity). Students carefully collected

Figure 5. Jaya and a recently out-planted elkhorn cluster on Carysfort Reef.

Photo credit: Matt Strand

identifying information from each coral tag to produce reliable data. During their citizen science project, Coralition students assessed the health of 435 individual coral fragments, observing 92.64% survivorship on Carysfort Reef. These student dive teams also observed that 33 of 51 (62.7%) of observed coral clusters demonstrated fusion.

These student-generated data were compiled by CRF and reported to the NOAA Florida Keys National Marine Sanctuary, the NOAA Restoration Center, and the Florida Fish and Wildlife Conservation Commission. Additionally, the data is available to researchers who utilize CRF facilities, corals, or data to promote coral reef research. Coral monitoring plays a critical role in determining the resilience of specific genotypes and the success of coral propagation. Therefore, Coralition students participated in one of the most essential tasks in bringing endangered reefs back from the brink.

Conclusion

To date, over 50 middle and high school students have participated in the Colorado Coralition. Several have gone on to major in marine biology at the postsecondary level. It is this type of experience that impacts participants in lasting ways. As Noah, a 7th grader in the Coralition shared on the last night of the trip, "The Coralition is something I will never forget, and I will carry the lessons and skills I learned throughout my entire life." Why are real-world problems such powerful learning experiences? Perhaps it is simple as this: there is no answer in the back of the book. Somewhere along the fault lines of the unknown lies the opportunity for meaningful learning for students and their teachers, a place where concern for the state of the natural world inspires a desire for knowledge, innovation, and shared purpose. When students and teachers have the courage to face humanity's most pressing dilemmas, a deep sense of hope fuses with the brilliant light of possibility.

About the Authors

Dr. Matt Strand teaches 7th and 8th grade English and serves as the middle school team leader at Polaris Expeditionary Learning School in Fort Collins, Colorado. He has also served as a national coach for EL Education's Better World Project. He earned his M.Ed. in 2001 in Educational Research and Collaboration from Texas Christian University with an emphasis on experiential models of school reform. He went on to earn his Ph.D. in 2013 in Education and Human Resource Studies from Colorado State University with a focus on authentic professional learning. He has used experiential, project-based, and student-centered assessment models to engage learners for over twenty years. He can be reached at mstrand@psdschools.org.

Derek Hagen is the Education Program Manager of the Coral Restoration Foundation™, leading the internship and volunteer force. With over 1200 hours of public speaking engagements and over 100 educational activities published, his goal is to inspire others and train others to improve the health of the world's reefs, using CRF™ work as an example. Previously, he worked as a professor at Oak Ridge Military Academy teaching courses such as Zoology and Oceanography. He can be reached at derek@coralrestoration.org.

References

Bruckner, A.W. (2002). *Proceedings of the Caribbean Acropora Workshop: Potential Application of the U.S. Endangered Species Act as a Conservation Strategy* (NOAA Technical Memorandum NMFS-OPR-24). NOAA.

Coral Restoration Foundation (2019). *Annual Report: 2019.* https://3a33729f-d81c-4cd6-9541-8bf1b5bd6ec5.filesusr.com/ugd/60a969_fd15db98d13a4d1887634588c31f9120.pdf

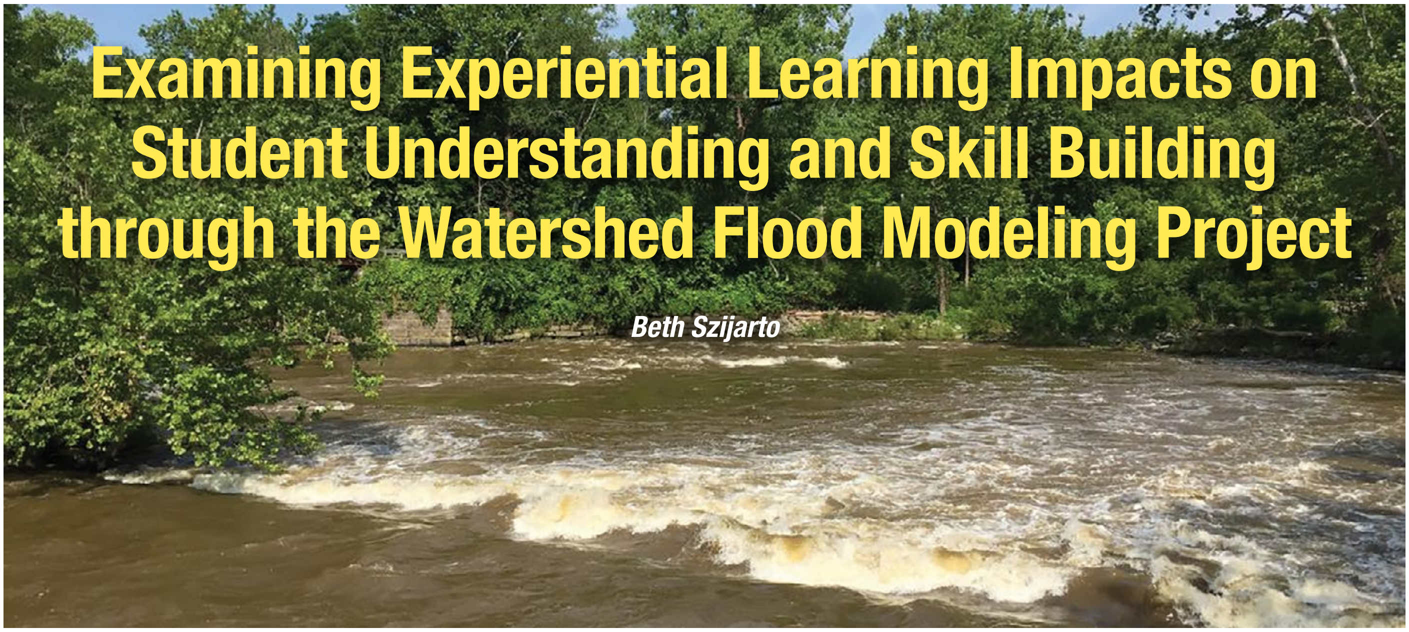
Florida Museum of Natural History (2018,). *Conservation of the Florida Keys*. Retrieved February 1st, 2021 from https://www.floridamuseum.ufl.edu/southflorida/regions/keys/conservation/

NASA (2012). *Detecting detrimental change in coral reefs.* Retrieved January 30th, 2021 from https://www.nasa.gov/topics/earth/features/coral-damage.html

National Marine Educators Association (2020). *Ocean Literacy Guide*. Retrieved April 15th, 2021 from https://static1.squarespace.com/static/5b4cecfde2ccd188cfed8026/t/5eb99cc530a3d76767dc7aea/1589222614314/OceanLiteracyGuide_V3_2020.pdf

NGSS Lead States (2017). *DCI Arrangements of the Next Generation Science Standards*. Retrieved April 15th from https://www.nextgenscience.org/sites/default/files/AllDCI.pdf

NOAA (2020). *How does climate change affect coral reefs?* Retrieved January 30th, 2021 from https://oceanservice.noaa.gov/facts/coralreef-climate.html



Examining Experiential Learning Impacts on Student Understanding and Skill Building through the Watershed Flood Modeling Project

Beth Szijarto

Abstract

Students collaboratively researched and designed an intelligent spatial map that helps predict flash flood damage for the Cuyahoga River Basin. Using Kolb's experiential learning theory, students were given the opportunity to build their skills, understand the connections between the classroom and community, and acquire knowledge. Middle school students developed real-world solutions by researching flash floods before constructing 3D models and geospatial technology. Statistically significant results suggested that there was evidence of an increase in learning and skill building. Students also increased their willingness to problem solve through complex issues and improved their application of technology skills by using 3D modeling and geospatial applications. As a capstone activity, a student leadership team was formed to present innovative prototypes of the predictive maps to the National Weather Service to offer solutions that help warn the public of flash floods.

Introduction

As Planet Stewards, middle school students from both private, rural and suburban schools, Ashland Christian School and Saint Ambrose Catholic School respectively, believe that it is important to take responsibility to care for the environment. Educators within Christian schools have conveyed successful implementation of experiential learning methods in a school-wide capacity, including real-world problem solving (Hedin, 2010). Kolb's experiential learning is a cycle that utilizes different learning styles (Healey, 2000). By engaging with experiential learning, students learn how organizations work, engage in career exploration, and increase leadership skills with the ability to adapt to change (Lee, 2008). It has also been reported that self-directed learning and life-long learning skills emerge through experiential learning implementation (Jiusto, 2013). Other benefits resulting from Kolb's experiential learning theory include students' ability to better understand inquiry through authentic problems and reflection (Morris, 2020). Experiential learning has been reported to be effective through empirical research (Gosen, 2004). However, additional research is needed to study experiential learning by using a treatment and control group to further understand learning and effectiveness (Burch, 2019).

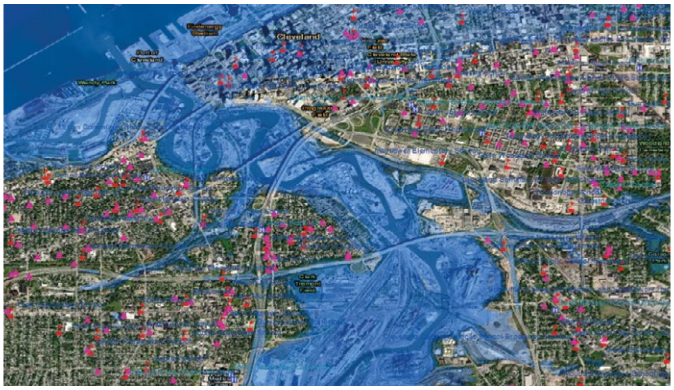


Image 1. The ArcGIS 10.0 (ESRI, 2014) flash flood model above demonstrated 3ft, 5ft, 10ft, 15ft, 20ft, 30ft and above simulation to help the National Weather Service understand flash flood vulnerable areas based on terrain. Photo Credit: Beth Szijarto

An experiential learning study was implemented through two schools that utilized a treatment engagement as well as a pre/post-test. Students met with one meteorologist and one hydrologist from the National Weather Service. These scientists worked with the children collaboratively to research and design an intelligent spatial map that helps predict flash flood damage for the Cuyahoga River Basin. Currently, the National Weather Service is not using a geospatial solution. Students implemented a spatial analyst model to predict the effects of rainfall on specific elevation levels using a digital elevation model (DEM) file. By using this model, the public might be able to make informed decisions for their safety. The National Weather Service has taken the simulated geospatial model and 3D prototypes as a suggestion that could be implemented in the future to help warn the public of impending floods.

Desired Outcomes of the Project

1. Private, suburban and rural middle school students engage in experiential learning to increase their knowledge, skills, and problem-solving approaches.
2. The prototype solutions help prepare citizens for potential flash flood damage, which could help save lives and residential/commercial property.
3. The National Weather Service may use the geospatial model to help warn citizens prior to any flooding. Currently, the NWS only calls citizens to inquire if they had flooding damage.

Image 2. Middle school students from Ashland Christian School develop prototypes that could help people survive a flash flood while in their cars without cell phones. Photo Credit: Beth Szijarto

Program Development & Implementation

Ninety middle school students completed a pre-survey assessment to create a baseline of current flash flood knowledge, tool usage, and problem-solving execution. Students selected which geospatial and 3D modeling tools they had used previously and were comfortable showing someone else how to use.

Additionally, students were asked if they knew how to develop a solution to help prepare the public for flash floods. Overall, students were trying to solve the problem of how to create a geospatial model to warn the public of flash floods. Students also answered a secondary research question that focused on survival options for individuals in a car without a cell phone during a flood.

While students conducted research, they learned about weather careers and flash floods from a hydrologist through the National Weather Service. Students learned about the requirements needed for 3D and Geographical Information System (GIS) models. They began building 3D prototypes using TinkerCAD (TinkerCAD, 2021) and constructed ArcGIS (ESRI, 2014) geospatial layers (churches, residents, schools, hospitals, and businesses). Students engaged in developing a geospatial model by specific rainfall and elevation levels from DEM files and used spatial analyst extensions and math logic functions to produce flash flood predictions.

Images 3 and 4. Middle school students from Saint Ambrose Catholic School developed prototypes that could help people survive flash floods. Students created cars with innovative extensions that filled with air to allow floating of vehicles, tools to break a window, and jetpacks to help people get out of their cars and fly away from the flash floods. Photo Credit: Beth Szijarto

To assist with geospatial simulation construction, data was collected through a geodatabase, from within ArcGIS, where records coordinated locations for specific layer details. This data was collected for potential use by the National Weather Service that could help warn the public of rainfall levels according to elevation. Students took a post-survey assessment through Google Surveys to demonstrate that learning had resulted from the experiential learning treatment engagement.

This project allowed students to demonstrate proficiency in asking questions, developing and using models, and planning and carrying out investigations. The Next Generation Science Standards (NGSS, 2013) performance expectations highlight many societally relevant aspects of earth system science (resources, hazards, environmental impacts) as well as related connections to engineering and technology. Students were able to use the crosscutting concepts of stability and change as they designed a model to warn populations about flash flood hazards. This project most closely provides the development of skills associated with performance expectation of MS-ESS3-2: Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

Evaluation

Data collection methods consisted of using Google Surveys to obtain data about student experiences with flash floods, tool usage, and problem-solving approaches. 3D prototypes were constructed using TinkerCAD 3D modeling software. Geospatial layers were developed using ArcGIS 10.0.

The null hypothesis (H0) is that experiential learning does not increase learning and skill building. The alternate hypothesis (H1) is that experiential learning increases learning and skill building. A paired two-tailed t-test was conducted utilizing pre/post survey data and GraphPad Software (2021). The paired t-test helped to predict the probability of growth in knowledge, tool usage, and problem-solving approaches, which resulted with a statistical significance (P value < 0.0001). Therefore, the null hypothesis (H0) was rejected. The paired two-tailed t-test was used as the statistical test

Table 1. Outlines the type of data, collection method, and data amount that was obtained throughout the grant opportunity.

Student experience with flash floods	Google Survey	90 records
Suburban/Rural tool usage & problem-solving approach	Google Survey	90 records
3D prototypes	TinkerCAD	75 prototypes of individual/ group developed 3D models
Church Layers	ArcGIS layers	Approximately 227,000 records
School Layers	ArcGIS layers	Approximately 208,000 records
Hospitals Layers	ArcGIS layers	Approximately 15,800 records
30 ft flood sample	ArcGIS layers	1 record polygon area
10 ft flood sample	ArcGIS layers	1 record polygon area
3 ft flood sample	ArcGIS layers	1 record polygon area

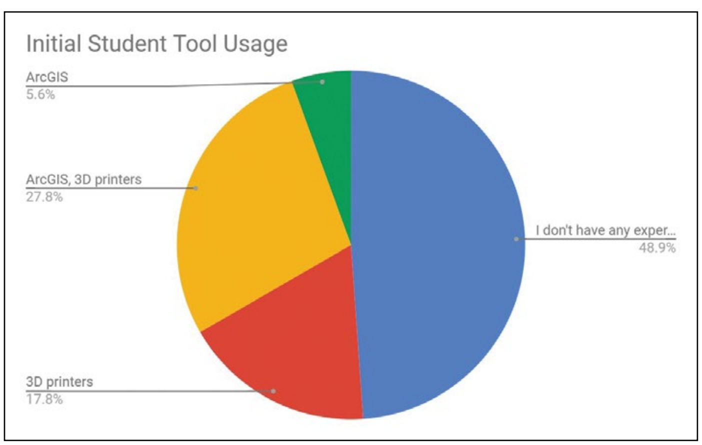


Figure 1. 28% of private school students who participated in the experiential learning study, reported tool usage experience with 3D printers and ArcGIS, while others reported only using 3D printers or ArcGIS. 48% of the participating students reported having no experience with these tools.

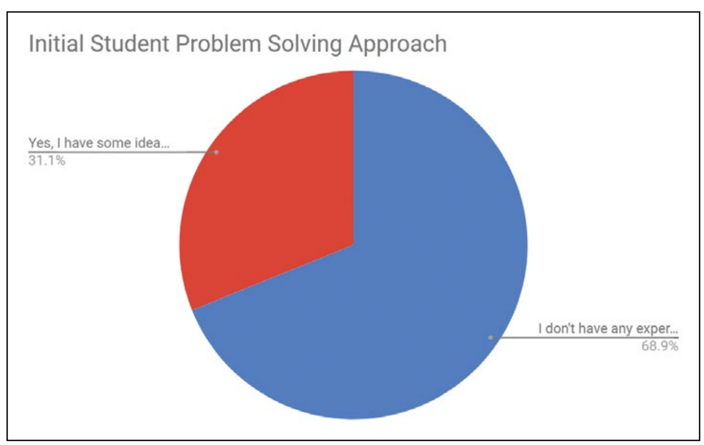


Figure 2. 31% of private school students believed that they knew how to solve the problem and had some ideas on how to accomplish the task. 68% of students initially reported having no experience or ideas on how to solve this problem.

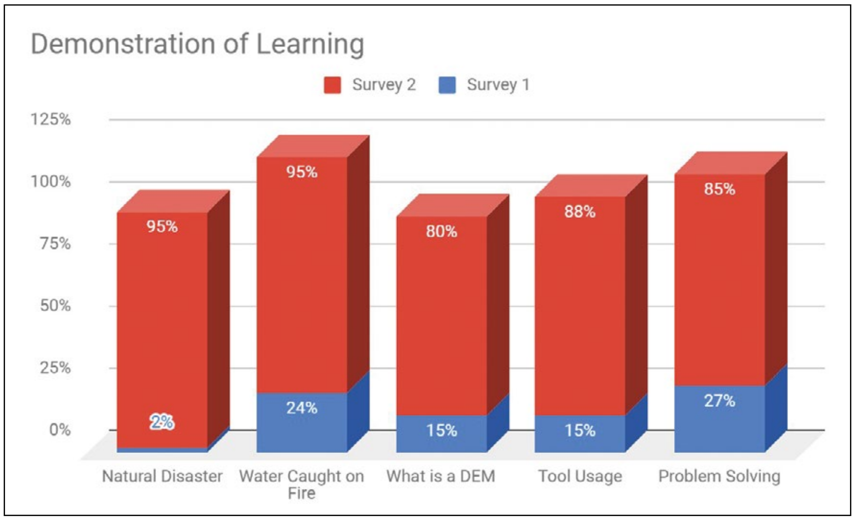


Figure 3. Growth of knowledge between Survey 1 and 2.

because the subjects were the same participants for both the pre/post survey. The purpose of this test was to help predict the probability that the differences between the sample means occurred because increased learning and skill building likely resulted after students engaged in the "treatment" or experiential learning.

In Figure 3, students answered questions about flash floods, tool usage, and problem solving for both a pre/post survey. For Survey 1, students' answers ranged from 2% - 27% measuring knowledge of flash floods, past tools usage involving 3D modeling and geospatial technology, and problem-solving creativity. After students engaged in experiential learning and developed prototypes, Survey 2 data presented a different result, ranging from 80% - 95%. This increase suggested considerable growth with each topic mentioned above for Survey 1. For example, student tool usage increased from 15% to 88%. Additionally, student results for problem solving approaches grew from 27% to 85%, suggesting that student creativity expanded through the experiential learning process.

Conclusion

The Planet Stewards funded this opportunity for middle school students to conduct real-world problem solving. Students demonstrated that their stewardship project provided a solution to help residents and business owners prevent flash flood damage and death and build a better water-resistant structure to protect property, or move property to a different location. The creative 3D model prototype ideas could be used as solutions in the future to help individuals evacuate or survive a flash flood. As Planet Stewards, students demonstrated that they learned about flash floods and how to develop a real-world solution that was then provided to the National Weather Service, which may contribute to saving lives and prevent property damage. Overall, this experiential learning study enforced the importance of being a Planet Steward in private schools by fusing their understanding that it is their responsibility to take care of the Earth with their passion to help others within the community.

References

Burch, G.F., Giambatista, R., Batchelor, J.H., Burch, J.J., Hoover, J.D., & Heller, N.A. (2019). A Meta-Analysis of the Relationship Between Experiential Learning and Learning Outcomes. Journal of Innovative Education, 17(3), 239 - 273. https://doi.org/10.1111/dsji.12188

ESRI ArcGIS Desktop. (2014). Release 10.4. Redlands, CA: Environmental Systems Research Institute. www.esri.com

Gosen, J., & Washbush, J. (2004). A Review of Scholarship on Assessing Experiential Learning Effectiveness. Simulation & Gaming, 35(2), 270–293. https://doi.org/10.1177/1046878104263544

GraphPad Software. (2021). T Test Calculator. https://www.graphpad.com/quickcalcs/ttest1.cfm

Healey, M., Jenkins, A. (2000). Kolb's Experiential Learning Theory and Its Application in Geography in Higher Education. Journal of Geography, 99(5), 185-195. https://doi.org/10.1080/00221340008978967

Hedin, N. (2010). Experiential Learning: Theory and Challenges. Christian Education Journal, 7(1), 107–117. https://journals.sagepub.com/doi/10.1177/073989131000700108

Jiusto, S., DiBiasio, D. (2013). Experiential Learning Environments: Do They Prepare Our Students to be Self Directed, Life-Long Learners? Journal of Engineering Education, 95(3), 195 - 204. https://doi.org/10.1002/j.2168-9830.2006.tb00892.x

Lee, S.E. (2008). Increasing Student Learning: A Comparison of Students' Perceptions of Learning in the Classroom Environment and their Industry-Based Experiential Learning Assignments. Journal of Teaching in Travel & Tourism, 7(4), 37-54. https://doi.org/10.1080/15313220802033310

Morris, T.H. (2020). Experiential learning – a systematic review and revision of Kolb's model. Interactive Learning Environments, 28(8), 1064-1077. https://doi.org/10.1080/10494820.2019.1570279

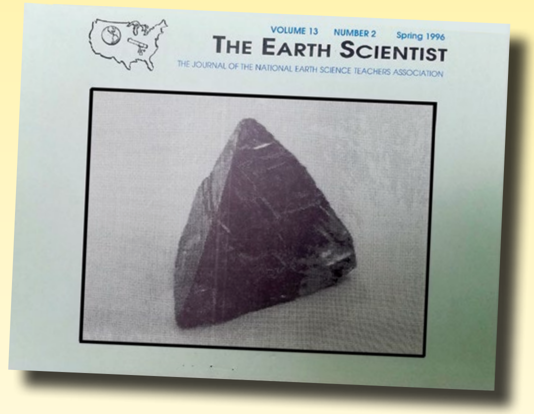
NGSS Lead States. (2013). Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press. http://www.nextgenscience.org/

TinkerCAD. (2021). Autodesk, Inc. www.tinkercad.com

About the Author

Mrs. Beth Szijarto is a doctoral student at Kent State University through Geography/Social & Behavioral Sciences. Her research involves studying competitive environments through rural and suburban schools by implementing prevention programming and utilizing experiential learning methods. She has a Bachelor's Degree in Management Information Systems and a Master's Degree in GIS/Remote Sensing. Since 2015, she has been a STEM Director for private, rural and suburban private schools, and has introduced geospatial technology to students and educators within Northeast Ohio. She worked in the corporate world for 15 years through quality assurance (QA) automation software testing and she has been an entrepreneur, launching educational businesses which promote STEM. She also used geospatial technology and computer programming while working for the federal government for 10 years. By getting the chance to engage with students through problem-based learning within STEM education, she often feels like a kid again. As a young child, she enjoyed adventure and reading *National Geographic, Discovery*, and *Choose Your Own Adventure* books. Over the years, she also participated in 4-H, Girl Scouts, Science Fairs, and Odyssey of the Mind competitions. She can be reached at szijabe@yahoo.com.

25 Years Ago in TES



Twenty Five years ago, in 1996, TES was in its thirteenth year of publication. The focus of this Spring issue was "Mining and the Minerals of Mining". The front cover is a photo of a fluorite crystal, lifted from a "new type of resource", a CD-ROM. The Spring issue led off with an article, as told by NESTA's first Executive Advisor, Dr. Harold B. Stonehouse, recalling his younger days as a Gold Miner. The next article dealt with California Gold mining, as told by Jan Woerner, NESTA's first President. The next article shared information regarding the Men of Mining. This was followed by an article the most important Minerals on Earth. Then there was an article which described a classroom activity about the Rock Cycle. There was an article detailing the author's years' long search for the identity of a rock he'd found. There was a list of 4, classroom, mineral research activities. This was followed by 12 recipes for growing crystals in the classroom. Next was a review of World Wide Web sites for Rocks, Minerals and Gems. And finally, there was a discussion of how Computer Mediated Communication may develop as a two-way technology-assisted communication for possible use in the classroom, to even bring an expert right into the room. Remember now, this was in 1996, 25 years ago.

By Tom Ervin

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