THE EARTH SCIENTIST

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Aurora australis seen over NOAA Atmospheric Research Observatory at South Pole Station. Photo Date: 2013 May 1 Photographer: Ross Burgener, ET, NOAA/OAR/ESRL/GMD

INSIDE THIS ISSUE

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This special themed issue is sponsored by the NOAA Climate Stewards Education Project

NESTA'S MISSION

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

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From the President

This, my final Presidential message, has two parts.

First, it's been my privilege partnering with the National Ocean Service (NOS) Educators and scientists who have produced the enjoyable articles in this themed issue of TES. NESTA gratefully acknowledge support for production of this issue with funding provided by the NOAA National Ocean Service Award. We hope that you enjoy the articles written by the educators involved with NOAA's Climate Stewards Education Project.

The grant also provided support for four professional development workshops provided through the "Earth2Class Workshops for Teachers" at the Lamont-Doherty Earth Observatory of Columbia University. Teachers and students interacted with research scientists to learn about a range of cutting-edge investigations into how our Earth System behaves. For those who could not attend in person, archived versions of the resources developed for these and other E2C Workshops are available at http://www.earth2class.org.

Dr. Allison Wing described how she and others are "Developing a Better Understanding of Hurricanes." (Note: I am very proud to brag that Dr. Wing began her study of Earth Science when she was an 8th grader in my class in White Plains (NY) Middle School!) Dr. Arlene Fiore and Olivia Clifton discussed their investigations into "Air Quality, Climate, and Vegetation Interactions." Margi Turrin and Dave Porter will present an exciting new app, "Polar Explorer: Sea Level Rise." We are especially honored to host Dr. Taro Takahashi, a Columbia University Ewing Lamont Professor and one of the world's leading experts about Earth's Carbon Cycle.

This NOAA-NESTA-E2C partnership provides an effective example of strategies to connect classroom teachers, their students, and research scientists.

Second, about six years ago when my first term as your NESTA President was concluding, I wrote "A Letter to Those Coming Along Behind Me." In the Summer 2010 issue, I began:

> By the time you read this, my two-year term as NESTA's President will have officially ended, and I take up that most delightful of organizational offices, Past President. [Contented Sigh!]

That message continued,

> "Actually, and fortunately, it has been my privilege to lead NESTA during some of our most exciting times."

Little did I know then that I would continue my responsibilities toward NESTA for eight more years, which proved—at least so far—to be even more exciting. When I resumed the Presidency two years ago, I described "Re-Launching my 'Educational Kayak.' I explained:

> Those who know me are aware that kayaking is my passion, and I often make analogies to paddling—hence the title of this message. Whenever I'm on the water and meet other paddlers, I try to instill more enjoyment of our sport. Similarly, as I resume the challenges of serving as your President, I'll try to find ways to enhance your enjoyment of being an Earth Science teacher. I'm hoping to bring some of what I've learned during my 44-year career to shaping effective programs for NESTA members.

During the past two years, NESTA has experienced many changes, so I want to end my last TES Presidential Message with personal thanks and best wishes. Much of what I have been able to accomplish was only possible through the support of Dr. Roberta Johnson, who served as NESTA's Executive Director for nine years and continues to support us from her new position as "First

Lady" of the University of Illinois while her husband, Dr. Tim Killeen, is President. I also want to thank Marlene DiMarco, our former Office Manager, who made the business-end of NESTA go smoothly. Two other behind-the-scenes people who have earned my thanks are Dr. Julia Genyuk, long-time NESTA website manager, and Tom Ervin, the TES Editor for many years.

Many thanks to my immediate predecessors, Missy Holzer and Ardis Herrold, and all who served as national officers, Regional and Appointed Directors, State Contacts, NSTA Workshop and Share-a-Thon presenters.

Now it is time to look ahead and transition into my next term as [Contented Sigh!] Past-President. Your incoming NESTA Leadership—Dr. Carla McAuliffe, Executive Director; Cheryl Manning, President; Belinda Jacobs, President-Elect, and the entire Board of Directors—will continue to work hard for Earth Science education at all levels. They are actively involved in partnerships with our partner professional organizations and others to foster implementation of the Next Generation Science Standards. They are currently engaged in developing an improved NESTA website. They will see to it that NESTA continues to provide valuable services that help you be the best teacher you can be.

As I wrote before:

> During the remaining years of my terms in office, I hope to meet many of your in person at NSTA and other venues—please don't hesitate to introduce yourself. ... With all the challenges facing us, working together is the surest way to make us more effective in our mission to teach about our Planet.

So, thanks for the opportunity to serve NESTA over the past decade and for the next two years. I will have to admit that one other benefit of being Past-President is that I now have more time to go out in my kayak with a clear conscience!

Mike Passow
2014 – 2016 NESTA President

From the Executive Director

We are very excited for the National Oceanic and Atmospheric Administration's (NOAA's) National Ocean Service (NOS) to sponsor this issue of *The Earth Scientist!*

Overall, NOAA strives to "enrich life through science. From the surface of the sun to the depths of the ocean floor", they "work to keep citizens informed of the changing environment around them." NOAA's mission is "to understand and predict changes in climate, weather, oceans, and coasts, to share that knowledge and information with others, and to conserve and manage coastal and marine ecosystems and resources." (from http://www.noaa.gov/about-our-agency)

The National Ocean Service is one of six line offices within NOAA. Although, you may be most familiar with the National Weather Service, the National Ocean Service plays an important role within NOAA. The mission of NOS is "to provide science-based solutions through collaborative partnerships to address evolving economic, environmental, and social pressures on our ocean and coasts." The National Ocean Service has three key priorities: 1) coastal resilience, 2) coastal intelligence, and 3) place-based conservation. (from http://oceanservice.noaa.gov/about/) Encouraging environmental stewardship is essential to the mission and priorities of NOS.

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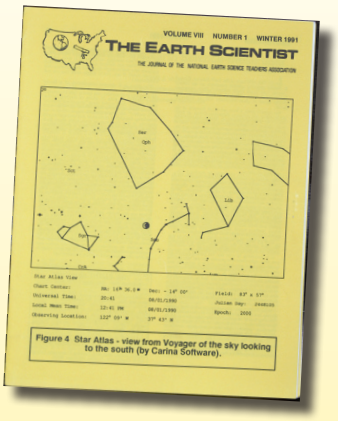
This issue of *The Earth Scientist* highlights the NOAA Climate Stewards Education Project run by NOS. Yet, the National Ocean Service does so much more. Take a minute to check out these education resources http://oceanservice.noaa.gov/education/ and multimedia resources http://oceanservice.noaa.gov/multimedia/ from NOS.

If you will be attending the National Science Teachers Association National Conference in Nashville, Tennessee at the end of this month, then pick up printed copies of this NOS sponsored issue to share with your colleagues. Copies will be available at the NOAA Education booth (#1423) and at our Share-a-Thons in Music City Center, Davidson B. As a NESTA member, your personal printed copy will be mailed to you. I look forward to meeting many of you in person. Be sure to join us for hor d'oeuvres at the Friends of Earth Science Reception on Friday, April 1 at 6:30 PM in the Skyline Junior Ballroom of the Hilton Garden Inn.

So.....the first day of spring, March 20th, is right around the corner. Spring is a time of new beginnings. By the time our next issue of *The Earth Scientist*, the summer issue, is published we will have a new President....Cheryl Manning. I extend a warm welcome to Cheryl. She is a former Outstanding Earth Science Teacher Award recipient and a National Board Certified Teacher. I am very excited to welcome Cheryl to the NESTA presidency! Our current president, Dr. Michael Passow will be moving into the role of Past-President....once again...as he has done this before. I would like to sincerely thank Michael for his enthusiasm and dedication to Earth science education and his service to NESTA. I would also like to recognize and applaud his over four decades of classroom teaching. Happy guilt-free kayaking Michael!

Dr. Carla McAuliffe
Executive Director, NESTA

Twenty-five Years Ago in TES



Twenty Five years ago, in 1991, TES was in its eighth year of publication. The cover of issue #1 featured a representation of what could be seen using one of the new night sky computer programs, in this case *Star Atlas*. This issue led off with an in depth article detailing the frequency of computers, and their use, in American Classrooms. One paragraph of this 1991 article stated, "Today, a majority of United States elementary schools have five or more computers [in the building], and more than half of the secondary schools have fifteen or more computers [and] **26%** of the teachers [report] that they have used a computer as a supplementary method of improving students' basic skills." Amazing!

This lead article was followed by an article titled a "Beginners Guide to Modems", and an article explaining the use of Amature Radio in the Earth Science Classroom. There was an article dealing with Computer-Based Astronomy and calculating the Retrograde Loop of Mars' orbit.

Finally, there was an article announcing the 1990 PAEMST recipients, and among the six was NESTA's (former) President, Linda Knight (TX).

By Tom Ervin

Guest Editor's Message

Welcome to a special issue of *The Earth Scientist* sponsored by the NOAA Climate Stewards Education Project!

What do you think of when you hear the word stewardship? For NOAA Climate Stewards Project (CSEP) educators it means putting their knowledge of climate science into action and engaging their students and communities in hands-on activities focused on mitigating or adapting to the impacts of climate change. These stewardship projects provide a platform for learners to increase their knowledge of climate change, and recognize that their efforts make a difference in our world.

In 2009 CSEP began with 10 teachers in the Washington DC region. Today, over 900 formal and informal educators across the United States participate in the NOAA Climate Stewards Education Project community. To support stewardship project development, CSEP provides professional development in climate science and pedagogy through a nationwide collaborative learning community. Educators benefit from web seminars, discussion groups, conference symposia and workshops. Working in small peer groups, educators develop and refine their stewardship projects through discussion, reflection, and review. Implementation support for projects is provided through a competitive mini-grant process.

The articles featured in this special issue of The Earth Scientist reflect the enthusiasm, hard work and success of NOAA Climate Stewards educators, their students and the community members they've engaged. The high quality activities you'll read about in the following pages include: empowering young women as community leaders; taking actions to reduce energy consumption and food-related waste; increasing recycling behaviors and carbon sinks; and developing activities about Earth's climate system, climate change impacts to habitats on land and in the ocean. Many articles have links to teacher background materials, supporting materials, and student worksheets you can download, adapt, and use for yourself.

We hope you enjoy these articles and consider incorporating some of these innovative ideas and resources into your own classroom or educational setting. If you'd like to take advantage of the opportunities afforded by NOAA Climate Stewards, and engage a national community of teachers working to increase climate literacy and taking action on climate change, come to our web site (http://oceanservice.noaa.gov/education/climate-stewards/) and sign up today!

NOAA Climate Stewards Education Project
Guest Writers of this Editor's Corner
Molly Harrison, Bruce Moravchik, Peg Steffen

The Earth Scientist

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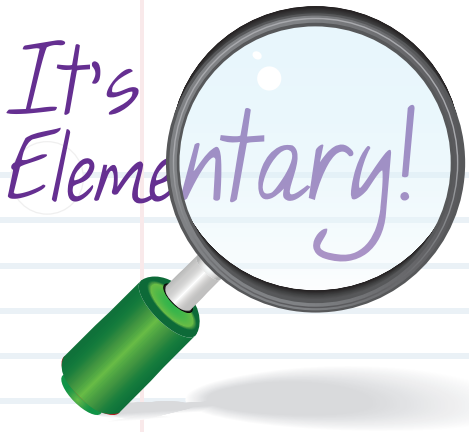


Digital Storytelling:
Creative Applications of Science Content in Grades K-5 Using NOAA Resources

By Peg Steffen, Education Coordinator, National Ocean Science (NOS) Communications and Education Division

Digital storytelling is any combination of images, voice recording, video, music or sounds to tell stories. Digital stories may be published as **multi-media presentations** or as **blog posts or newsletters**. To help students get started, choose images and/or videos from a gallery (Figure 1) and provide these to students to develop a storyboard about an event. Completed stories can be used for student assessment or put into a portfolio to share with peers and parents. Using digital stories in the "elaborate" and "evaluate" phases of the 5Es instructional model (Bybee, R., Taylor, J., Gardner, A., Van Scotter, P., Carson Powell, J., Westbrook, A., Landes, N., 2006) encourages students to apply what they have learned in a new situation or to provide evidence of understanding. Students can also use digital stories to develop public service announcements or even a school campaign to foster stewardship behaviors. Digital storytelling supports the Framework for the Next Generation Science Standards (NGSS, 2013) (Figure 2). In addition, federal websites are considered to be in the public domain and images or videos (with proper attribution) can be used for digital storytelling projects or any other educational use.

Multimedia presentations can be constructed with simple video camera, digital images, posters, and other props to tell a story, highlight an event, or create a newscast. Have students put all of the components together and videotape the entire story to share. An image gallery from the WaterLife game (Games.noaa.gov), *Sea Turtles and the Quest to Nest,* is freely available for students to use in a number of creative projects related to ocean stewardship, beach etiquette, food webs, and environmental careers. Here are a few multimedia presentation ideas for students related to the *Quest to Nest* game:

- Give a tour of sea turtle habitats and their life history.
- Create a "moment in history" with interviews, eyewitness accounts and background information using images from galleries.
- Research your connection to the ocean and develop public service announcements and posters. How can you be part of the solution?
- Create a documentary about a local environmental issue.

Blog posts or newsletters use stories, images, and headlines related to local natural areas, wildlife, or science topics recently discussed in the classroom. Newsletters work well as group projects or as individual assignments. Here is an example of a professionally made newsletter. http://www.nmfs.noaa.gov/pr/pdfs/education/kids_times_turtle_loggerhead.pdf

The following newsletter ideas use content from NOAA:

- Sanctuary Sentinel: The National Marine Sanctuaries conserve and protect the biodiversity and cultural legacy of protected marine areas. Pick one Sanctuary (http://sanctuaries.noaa.gov/welcome.html) and collect information to create a unique newsletter at or develop an informational brochure about ocean etiquette (http://sanctuaries.noaa.gov/protect/ocean-etiquette.html).
- Estuary Examiner: An estuary begins where fresh river water flows into coastal bays and inlets. These areas are driven by tides, like the sea, but are sheltered from the full force of ocean wind and waves, like a river. Pick an estuary (http://nerrs.noaa.gov) near you and delve into the unique species and issues of these important water resources.
- Fish Eye View: What fish species are important to humans for food? Where do they live and what do they eat? Interview local waterman and others in the commercial or sport fishing industries to explore these connections of humans to the marine environment (http://www.st.nmfs.noaa.gov/lfkproject/).

Source	Location
National Ocean Service Ocean Images	http://oceanservice.noaa.gov/gallery/
NOAA Photo Library	http://www.photolib.noaa.gov
Sea Turtles WaterLife game gallery	http://games.noaa.gov/seaturtle/pictures.html
Sanctuaries Photos and Videos	http://sanctuaries.noaa.gov/pgallery/
Coastal Management Multimedia Gallery	https://coast.noaa.gov/gallery/
NOAA Fishes Imagery Gallery	http://www.nmfs.noaa.gov/gallery/images/
Marine Debris Videos and Images	http://marinedebris.noaa.gov/multimedia
NOAA Ocean Today Videos	http://oceantoday.noaa.gov
NOAA YouTube Channel	https://www.youtube.com/user/noaa

Figure 1. Some NOAA Image and Video Galleries.

SEP: Obtaining, Evaluating, and Communicating Information
Obtain and combine information from books and other reliable media to explain phenomena. (3-ESS2-2)
DCI: ESS2.A: Earth Materials and Systems
Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. (5-ESS2-1)
CCC: Patterns
Patterns can be used as evidence to support an explanation. (4-ESS2-2)

Figure 2. Grade 3 Science and Engineering Practice (SEP), Grade 5 Disciplinary Core Idea (DCI), and Grade 4 Crosscutting concept (CCC) supported by Digital Storytelling.

In addition to exploring the NOAA image and video galleries above, be sure to dive into K-5 ocean, coastal, and atmosphere resources available from NOAA Education Resources (http://www.education.noaa.gov/Special_Topics/Elementary_Science_Resources.php). Lessons feature engaging science topics, introduce Next Generation Science Standards concepts, and encourage students to investigate real world science applications.

References

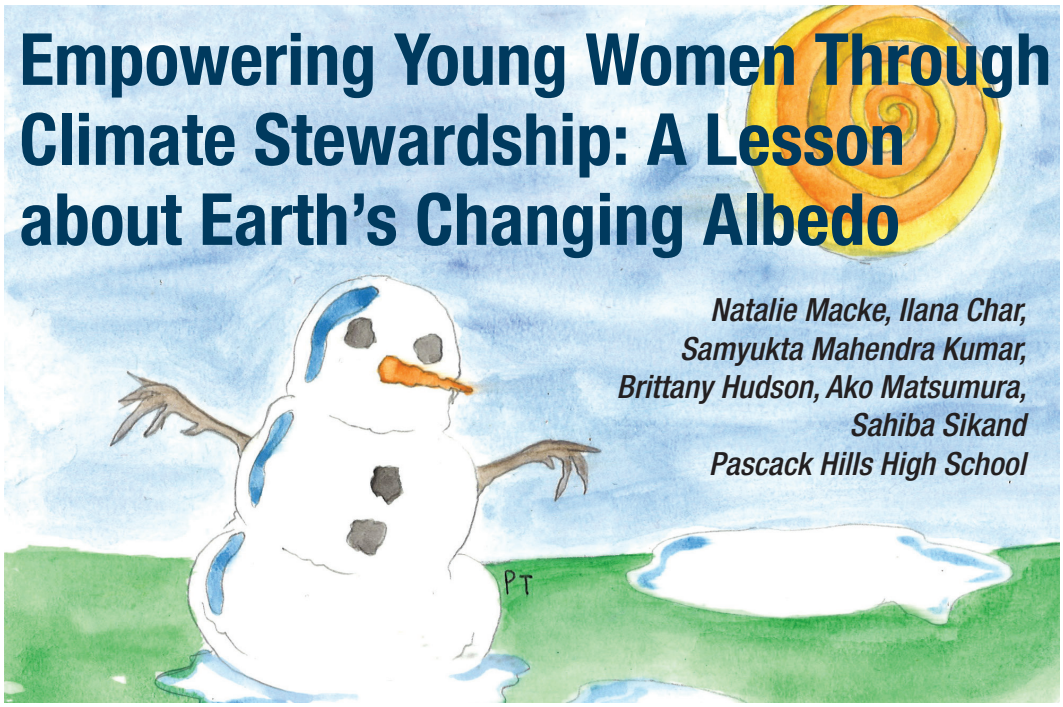
Bybee, R., Taylor, J., Gardner, A., Van Scotter, P., Carson Powell, J., Westbrook, A., Landes, N. (2006) *The BSCS 5E instructional model: origins, effectiveness, and applications* . Colorado Springs: BSCS.

NGSS Lead States. (2013). *Next Generation Science Standards: For states, by states.* Washington, DC: The National Academies Press.

About the Author

Peg Steffen is the education coordinator for the Communications and Education Division of NOAA's National Ocean Service where she leads a development team that provides web-based products, professional learning, and educational games in ocean, coastal and climate science. Her 26 years of classroom teaching included biology, physics, and astronomy/geology at the high school and university levels. She received a National Board for Professional Teaching Standards Certificate for Adolescent and Young Adult Science and many teaching awards in her 40 years of work to bring science education to teachers in the United States, Mexico, Europe and Asia.

Empowering Young Women Through Climate Stewardship: A Lesson about Earth's Changing Albedo



Natalie Macke, Ilana Char, Samyukta Mahendra Kumar, Brittany Hudson, Ako Matsumura, Sahiba Sikand
Pascack Hills High School

Abstract

A Climate Stewards Club, as part of the NOAA Climate Stewards Education Project (CSEP), was established as an after-school high school program to empower young women as community leaders who would be then, both willing and capable of addressing their peers and the public about issues related to global climate change. The student club identified the need to support climate literacy in the middle school by providing opportunities for learners to engage in hands-on activities that assisted in student understanding of how Earth's climate system works. The students and their mentor developed an engaging, hands-on lesson that allows students to learn about the feedback loop that describes the ice-albedo effect. The process of how a team of high school students developed the lesson and associated materials is described. The outcomes of this peer-facilitated lesson as well as the benefits of the after school club focused on climate stewardship are discussed.

Introduction

Finding opportunistic and meaningful ways to connect students with STEM education has often been a challenge. In the NOAA Climate Stewards Education Project, an educator is charged with engaging young people in climate literacy via a climate stewardship activity. In response, an after school Climate Stewards Club was initiated in the Pascack Valley Regional High School District community in Montvale, New Jersey to engage and empower teenage girls to solve relevant problems associated with global climate change. The group was created specifically to provide young women, who are interested in learning more about global climate change, the opportunity to socialize, learn and ultimately give back to their community. As described by the National Research Council, a successful STEM program should consist of a supportive and social environment that engages young people on an intellectual, social and emotional level (National Research Council; Committee on Successful Out-of-School STEM Learning, 2015, p. [Page 21]). Creating a group solely for teenage girls has allowed for a special camaraderie as well as seriousness of purpose that has resulted in a variety of successful public endeavors and learning opportunities for the young

women. In the end, the group decided that it was important for their stewardship activity to teach younger learners about how climate change is both serious and solvable.

Informal Education with Student Driven Goals and Objectives

The Climate Stewards Club started in 2013 with a small group of sophomore girls, age sixteen. When they were approached about their questions, concerns and interests associated with global climate change, their immediate response focused on two criteria: 1) lowering their carbon footprint and 2) engaging younger learners in climate education. The immediate efforts of the group focused on engaging stakeholders at the high school about the potential for solar energy and specifically, the construction of a solar charging station dedicated for student use to charge their school laptops and other personal electronic devices. The team conducted a needs assessment of the students, collaborated with students enrolled in engineering classes, and reached out to a variety of community resources to learn more about solar energy. This outreach manifested in both a field trip to a local company that conducts research to improve photovoltaic cell efficiency and also a visit from a solar energy instructor from a local technical school. Ultimately, the requirements of the project required resources beyond the scope that the team initially anticipated. Having publicly presented the project to the local Board of Education, the team is hopeful that the solar charging station will be challenge adopted by the Climate Stewards at the school in years to come. The group never branded the experience as a failure. Instead, when asked, each of the young women recognized specific learning opportunities the group experienced that they identified as helpful to their emotional and professional growth. All of the group's participants identified the public presentations to the Superintendent of Schools and the local Board of Education, as well as the informal presentation via a videoconference with a school in Taiwan as highlights of their experience.

Figure 1. Climate Stewards Club member uses NASA satellite data to make the lesson maps.

Figure 2. Climate Stewards Club members making Climate Change lesson maps.

The following school year the Climate Stewards Club grew in size to eleven team members, which then included a new group of sophomore girls. The team's focus turned from altering their carbon footprint to engaging younger learners in climate education. All of the students recognized that they had engaged in limited or no formal education about climate change in their middle school years. This statement is supported by National Earth Science Teacher's Association's statistic that only 36% of educators at the middle school level include climate change lessons in their curriculums (NESTA, 2011). The team decided on the theme of "Climate Change is Serious and Solvable" for their lesson. The juniors, now our team's experts in their understanding of solar energy quickly chose the task of developing a lesson to fulfill the solvable portion, while the new sophomores members were charged with the challenge to develop one simple lesson that would demonstrate how serious global climate change was and why immediacy was needed in terms of acting.

The Lesson: Climate Change and Feedback Loops

Addressing the need to help students better understand Earth's climate system, a team of students developed a lesson entitled, *Feedback Loops and Climate Change* (1.usa.gov/1pqGiP8). This need was identified when all Climate Steward Club members were asked to complete The Climate Stewards Education Program Audience

Knowledge Survey (http://csknow.questionpro.com)prior to start of work on club activities. All members gave a rating of "Not very informed" for the question asking how well informed they were about how the Earth's "climate system" works. When the middle school audience was surveyed using the same tool, they too overwhelmingly indicated a lack of knowledge and understanding in this area. The team decided that the goal of the lesson should allow for students to discover how a feedback loop involving a melting cryosphere is impacting Earth's climate (Gardiner, 2007).

Three maps (approximately 4' x 3') modeling a melting cryosphere were drawn using available resources from NASA, NOAA and the National Snow and Ice Data Center (NSDIC) (Figures 1 and 2). Students accessed and used the MY NASA DATA Live Access Server (http://mynasadata.larc.nasa.gov/) to create the map projection and identified the current snow and ice extent in the northern hemisphere using the Atlas of the Cryosphere from the NSDIC (http://nsidc.org/cgi-bin/atlas_north) (NASA, nd.; Mauer, 2015). The estimation for percent ice and snow loss was taken from the NOAA 2012 and 2014 Arctic Report Cards. Decadal decreases in snow cover extent (SCE) were greatest in the spring months. Records show a decadal SCE loss of 17.6% and 19.8% in 2012 and 2014 respectively (NOAA, 2012) (NOAA, 2014). Models predicting future ice loss were created based on those percentages (Figure 3).

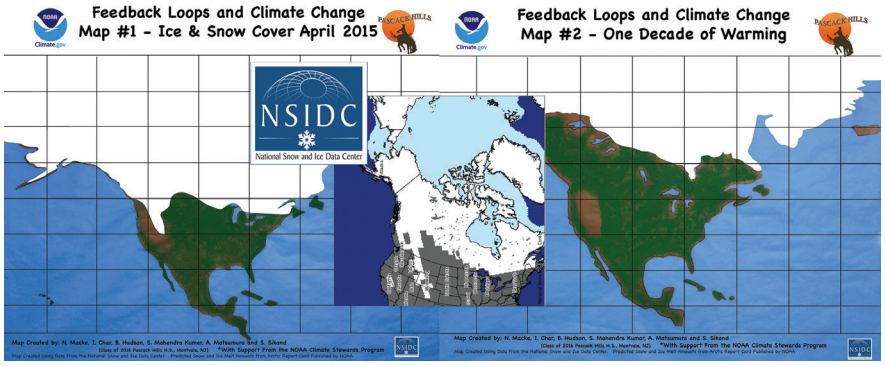


Figure 3. Examples of two maps created using combined data and information from NASA, NOAA and NSIDC.

This investigation, led by the Climate Stewards Club, initially prompted the middle school learners with the question: "How can changing amounts of snow cover in the cryosphere impact Earth's climate?" After an initial discussion, student teams were given PascoTM light sensor probes, a laptop and large maps of the cryosphere (current SCE, less 20% SCE and less 40% SCE). After the middle school students were introduced to the equipment, their teams were asked to identify and discuss the variables in the experiment. As a class, they were charged with developing a procedure that resulted in a controlled experiment. Students quickly identified that the position and angle that the probe was held changed the value recorded. But often, students needed some prompting to identify the light source as a variable that affected the data retrieved from their model. The teams commenced collecting data once the class agreed on a procedure that accounted for all necessary controlled variables (Figures 4 and 5). Students used this datasheet (1.usa.gov/1OVoKPv).

Figure 5. Climate Stewards Club members helping the middle school students collect data using the Pasco™ PASPORT Light Sensor.

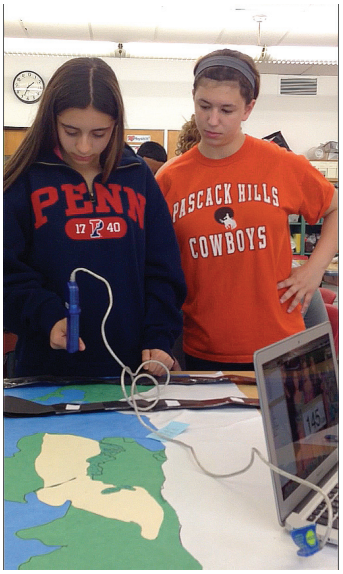


Figure 4. High school student helping middle school student collect data with the Pasco™ PASPORT Light Sensor.

Figure 6. Students arrange cards to discover how a melting Arctic is part of a positive feedback loop that impact Earth's climate.

Feedback Loops

The cause and effect relationship described in a feedback loop was an important crosscutting concept in the lesson. When student groups completed data collection and analysis, they were introduced to the concept of a feedback loop using examples from their daily life. Students were then issued the Feedback Loop card set and asked to organize the pictures (Melting Ice & Snow; Less Reflectivity (Lower Albedo); Warmer Temperatures on Earth) to demonstrate the feedback loop (Figure 6). Upon successful development of the model, students were handed the last card in the set; a car image with the writing, "Use of Fossil Fuels". The learners were then challenged with figuring out how to incorporate this card in their feedback loop model. It was requested that groups discuss their ideas as well as develop questions to ask the facilitators. The "Use of Fossil Fuels" card does not fit directly in the loop. The facilitators only answered questions, clarified misconceptions and kept students focused during this activity. This part of the lesson prompted students to engage in discourse about the impact of using fossil fuels and the role they play in Earth's climate system.

Results of a Climate Stewardship Lesson

This mentored, peer-facilitated lesson that was prepared and conducted with 160 middle school students as part of a NOAA Climate Stewards project, demonstrated successes and also identified future challenges for the group. When the middle school learners were surveyed in 2014 after the completion of the Feedback Loop and Climate Change lesson, 84% of respondents acknowledged that their understanding of Earth's climate system had improved. While the lesson was very well received, the time constraints of the program required the lesson to be edited. Time was devoted to two critical elements that are now part of the lesson. First, the students needed some time to develop an understanding of what the Pasco™ light sensor probes were actually measuring. In response, the lesson was adapted to allow for students to informally experiment with the probes prior to the map investigation, thus discovering the limitations of the measurement tool. Second, the concept of a feedback loop was new to the learners. They needed time to discuss and challenge their understanding of this concept in the context of climate change. In order to differentiate that experience, a discussion format that challenges students to ask questions of the peer teacher was added. This format also allows misconceptions about climate change to be addressed.

Learners were asked specifically about their understanding of the feedback loop concept in the post lesson survey in 2015. Students were asked to choose from a list all of the factors that contribute to Earth's changing climate. Out of 42 respondents 86% of students identified Earth's climate was part of the feedback loop and that the amount of solar light reflected was a contributing factor. This value declined to 74% for submissions that also included "warmer atmospheric temperatures". This indicates, that while most (if not all) students came away with the new vocabulary of "feedback loop", only 74% of them were able to completely parse out what that meant in terms of Earth's changing climate.

The true success of this Climate Stewardship project is the engagement of the young women participating in the Climate Stewards Club. Given the unique opportunity to return to their local middle school and engage young learners in a wanted discussion about the science of climate change, they each have an increased confidence when engaging with their peers or the public about climate change topics. Over two years, the group has identified the challenges they faced when conducting

the lesson and then modified it to address those needs. The ability for students to work over a long period to refine a product is unique to this type of informal education opportunity. The group has continued their efforts to improve the lesson, *Feedback Loops and Climate Change* as well as become involved with other climate research and stewardship activities.

Acknowledgements

The activities and lesson described in this paper were support by a NOAA Climate Stewards mini-grant. Beside the listed authors, student Brittany Van Velkinburgh also contributed to the development of the *Feedback Loops and Climate Change* lesson and supporting documents. Special thanks to Dr. Patricia Sullivan at Woodcliff Lake Middle School for welcoming our Climate Stewards Group to conduct our Climate Change is Serious and Solvable Program.

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Map Resources

Feedback Loop Card Dataset
1.usa.gov/1UYUcnr

Ice & Snow Coverage April 2015 Map
1.usa.gov/1U75tTd

One Decade of Warming
1.usa.gov/24ViuTV

Two Decades of Warming
1.usa.gov/1SGAYCx

About the Authors

Natalie Macke has been a secondary science teacher for more than 15 years in New Jersey. In 2012 her selection for participation in the NOAA Climate Stewards Education Project prompted her to establish a girl's STEM club focusing on Climate Stewardship at Pascack Hills High School. In addition, she developed a fifteen-week honors-level course on Climate Change offered by the Virtual High School (http://thevhscollaborative.org/). In 2015 she was the recipient of the Princeton Distinguished Secondary Teaching Award. Natalie can be reached at nmacke@pascack.k12.nj.us

Ilana Char, Samyukta Mahendra Kumar, Brittany Hudson, Ako Matsumura and **Sahiba Sikand** are all students at Pascack Hills High School in Montvale, New Jersey. These young ladies have been members of their school's Climate Stewards club since 2013 and are responsible for the development and implementation of the middle school lesson shared in this article about Earth's Changing Albedo. They will all graduate in 2016 and may be reached via their teacher, Natalie Macke.

Carbon Footprints, Carbon Sinks, and Carbon Stewardship: A Partnership Between Informal Educators and Classroom Teachers

Krysta Hougen and Jaime Bunting, Pickering Creek Audubon Center

Abstract

Pickering Creek Audubon Center of Easton, Maryland, developed and tested an introductory science unit on global climate change in six, fifth-grade classes. Through a series of lessons led by Pickering Creek educators and classroom teachers, students progressed through the topics of carbon, the carbon cycle, greenhouse gases, and climate change. Students learned how our actions affect the global climate, how climate change impacts local habitats and wildlife, and how we can slow the effects of climate change by decreasing our carbon source intake while increasing the planet's carbon sinks. Pickering Creek educators and classroom teachers dispelled common climate change myths and misconceptions, and provided opportunities for students to learn both in the classroom and outside in the schoolyard. Students engaged in age-appropriate climate change solutions by helping decrease their household's carbon footprint, increasing the schoolyard's carbon sink, and by sharing their knowledge with the community and encouraging others to take action as well. Feedback from teachers, school administrators, and the public has been positive and encouraging, and pre- and post-assessment results show an increase in student knowledge regarding climate change topics.

Introduction

Global climate change is a complex topic with far-reaching consequences that is already changing our natural communities. Maryland's Eastern Shore, like many shorelines nationally, will lose habitat for people and wildlife because of rising sea levels due to climate change. Students need to learn about the issue, its impacts, and what they can do to help mitigate the effects of climate change on their current and future communities. This stewardship project implemented the first climate change curriculum at Easton Elementary School (EES) and used a popular festival, the Waterfowl Festival, as a platform for students to teach their community about climate change.

The Next Generation Science Standards introduce global climate change as a core idea in middle school. Pickering Creek Audubon Center secured funding from NOAA's Climate Stewards Education Project to introduce the topic in upper elementary school. This unit, developed for fifth grade science classes, introduces climate change and ties the global issue to their local communities. By providing opportunities for classroom and outdoor learning, a teacher-led class research project, and a platform for students to publically take action and share their knowledge, students were able to teach their own community about climate change, expected local impacts, and initiate

conversations at home about carbon footprints. Although developed for fifth grade science classes, this program can be easily adapted for middle school.

Classroom Lessons and Action Projects

This series of lessons was written as a partnership between informal educators and classroom teachers. Though informal educators led the majority of the lessons, the program is more effective if the classroom teachers get involved early and develop their own class research projects. The unit includes three, hour-long lessons led by instructors from Pickering Creek Audubon Center and a teacher-led carbon footprint calculation and research project. The lessons include: Carbon and Climate 101, Sinks and Sources, My Carbon Footprint, Teacher-Led Class Research Project, and Community Outreach.

Lesson plans for Carbon and Climate 101, Sinks and Sources, and My Carbon Footprint can be found at the following links:

Carbon & Climate 101: 1.usa.gov/1TwxDHz

Sinks & Sources: 1.usa.gov/1L7y2xl

My Carbon Footprint: 1.usa.gov/1LFn5D0

Carbon and Climate 101

This introductory lesson covers basic climate and climate change information. We suggest meeting with the classroom teacher prior to the lesson to adjust the material based on the students' background knowledge and to potentially incorporate classroom textbooks and materials.

The lesson includes the carbon cycle, how various carbon-based molecules contribute to global climate change as a greenhouse gas, and what global climate change means for people and wildlife. The lesson also addresses three common misconceptions about global climate change: 1) weather and climate are the same thing; 2) climate change is not impacted by human actions; and 3) cold weather events disprove climate change (McCaffrey & Buhr, 2008).

Sinks and Sources

This hour-long lesson is conducted in the schoolyard and requires permission from the school to install a schoolyard garden. If you install a garden, be prepared for year-round garden maintenance. The most successful schoolyard gardens have support and help from teachers, staff, and parents. Or, as an alternative to creating a new garden, ask to add plants to already landscaped areas around the school.

The lesson starts with a review of the Earth's greenhouse effect, carbon sources, and how we use these carbon sources in our daily lives. Students learn the difference between carbon sources and carbon sinks and expand their school's own carbon sink through planting (Figure 1). The lesson ends with a hopscotch game showing how climate change is causing habitats for birds and wildlife to change faster than they can adapt.

Figure 1. Expanding the Schoolyard Garden at Easton Elementary School.

My Carbon Footprint

The classroom teacher leads the carbon footprint lesson. This is a two-part lesson; the first calculation is done prior to the Sinks and Sources lesson and the second calculation is repeated a month later to determine if the student was able to decrease their family's carbon footprint. A "My Carbon Footprint" worksheet can be found at the link provided in the sidebar above. Using the worksheet and online calculator, students determine their current footprint and pledge actions they will take to decrease their footprint and think through how those actions may benefit the environment. Students sign a classroom pledge to be displayed at a public event or in the hallway. The worksheet can be adjusted based on grade level and the chosen carbon calculator. Suggested carbon calculators are listed in the references.

Class Research Project

Classroom teachers developed a class research project, with input from Pickering Creek educators, examining the effects of global climate change on local wildlife. We learned it was best to keep the research focus broad so the teachers would have an opportunity to select a topic interesting to them.

Our partner teachers created the following research projects:

- **Local Animal Study:** each student studied a local animal impacted by global climate change and made a model of the animal with recycled materials.
- **Native Plants:** the class created a poster of native plants found in the schoolyard garden. The poster included pictures created by the students and information about each plant and its wildlife benefits.
- **Migrating Geese:** each student created a goose with construction paper and learned about their habitat requirements. The geese were later displayed as a migrating flock in the hallway.

Community Outreach: Sharing Seed Balls and Knowledge

Pickering Creek instructors led the final hour-long lesson. The lesson started with students sharing how they planned to reduce their carbon footprint. The goal of the lesson was to create a way for students to share their new knowledge with the community and give community members an opportunity to take action towards slowing the effects of climate change. The Waterfowl Festival, a local event in Easton, proved to be an excellent platform for the students to share their knowledge about climate change and carbon footprints. Pickering Creek used their exhibit table at the Festival to display the fifth grade class projects to encourage visitors to the Festival to learn about climate change from the students' themselves and to take action like the fifth graders.

Students created six seed balls each using a soil matrix high in clay and a pinch of native wildflower seeds. Each seed ball was placed in a bag and stapled shut with a message from a student. The students' messages contained facts about wildlife, plants, or climate change, and how planting the enclosed seed ball would benefit wildlife habitat or reduce climate change impacts. Students shared three seed balls with friends and family to encourage habitat creation and spark a conversation about the lesson at home. The remaining seed balls were shared with visitors to the students' display (Figure 2) at the public Waterfowl Festival. Over 1,000 people interacted with the display and 370 families went home with seed balls.

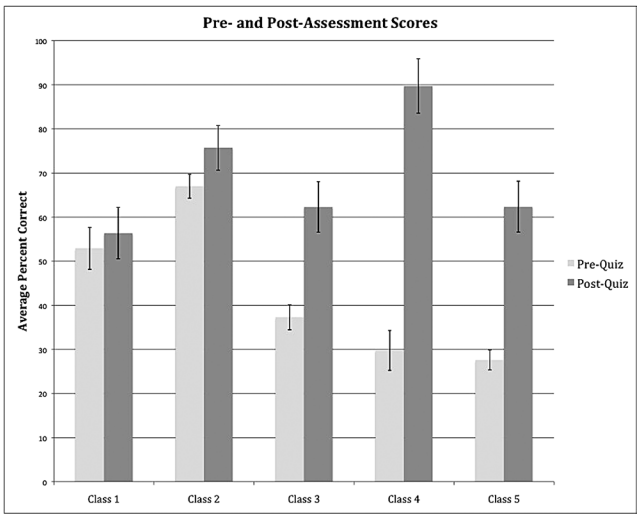
Figure 2. Table at the annual Waterfowl Festival displaying the fifth grader's research projects.

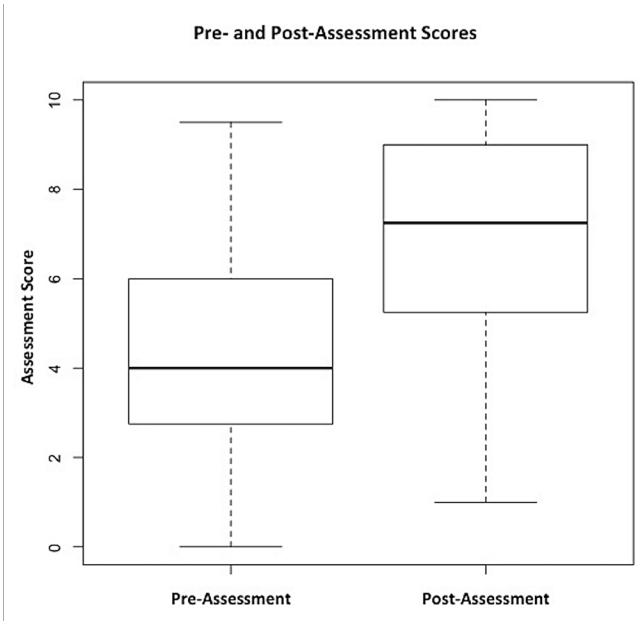
Evaluation and Results

The program was evaluated through changes in student knowledge with a pre- and post-assessment. The assessment covered weather vs. climate, carbon, and climate change and

can be found at (1.usa.gov/1RtmUat). Eighty-four students were evaluated from five classes; the sixth class was not included in the evaluation because the pre-assessment was taken after the first lesson.

The classroom teachers gave the pre-assessment shortly before the program began, and the post-assessment at the conclusion of the final lesson. The mean score (Figure 3) for each class increased while the median score for all students also increased (Figure 4). The mean scores, out of 10 possible points, on the post-assessment (M=6.917 SD=2.387) were significantly higher than the mean scores on the pre-assessment (M=4.208 SD=2.126) ($t(83)=7.76$, $p<0.01$).





Discussion

This program provides an effective introduction to climate change. The lessons were designed for fifth graders but can be adjusted, with a few changes, for middle school. Grade-appropriate changes may be best made in the My Carbon Footprint lesson by choosing a Carbon Calculator appropriate for the age (the calculators listed in the reference section represent varying levels of difficulty) when developing the class research topic.

The program can be led by a classroom teacher; however, the partnership between informal environmental educators and the school made the program stronger. Pickering Creek Audubon Center developed the lessons after participation in climate education professional development trainings and was able to provide grant-awarded funding for materials. Classroom teachers provided much needed time outside of the Pickering Creek-led lessons to clarify any questions or prepare for the next lesson. Asking teachers to develop their own class research topic resulted in thoughtful and creative projects, which helped attract visitors to the fifth grader's display at the Waterfowl Festival and allowed both students and teachers to take ownership of the project as a whole. Though we do not know how public opinion or knowledge changed because of the Festival display, it did initiate many conversations over the three-day public event with visitors and staff from Pickering Creek Audubon Center about the school's climate change education and the impacts of climate change on local wildlife.

Figure 3 (top). Average scores increased from the pre- to post-assessments for each 5th grade class at Easton Elementary during the Fall of 2014. A total of 84 students completed both the pre- and post-assessment.

Figure 4 (bottom). The median assessment scores increased after completion of the program. Data was collected from 84 students in 5 different classes at Easton Elementary during the Fall of 2014.

Conclusion

Knowing their class research projects would be seen by hundreds of visitors at the Waterfowl Festival and that their seed balls would travel the region in the hands of festival visitors kept the students enthusiastic throughout the program. Many students brought their families to the festival to proudly show-off their work and share what they learned. The Festival aspect, in addition to the carbon calculator, worked great at involving students' families in the project.

We started this program prepared to talk with many climate change skeptics, but we have been pleasantly surprised to meet very few. Instead, we have received positive feedback and encouragement from the community to continue climate change education at local schools.

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Acknowledgement

This program was funded through the NOAA Climate Stewards Education Project. We thank the CSEP team for their support and feedback throughout the project. Thank you to the Easton Elementary School fifth grader teachers and the Talbot County Public Schools administration for their support and time. We also would like to thank the Waterfowl Festival for providing an opportunity to share the students' work.

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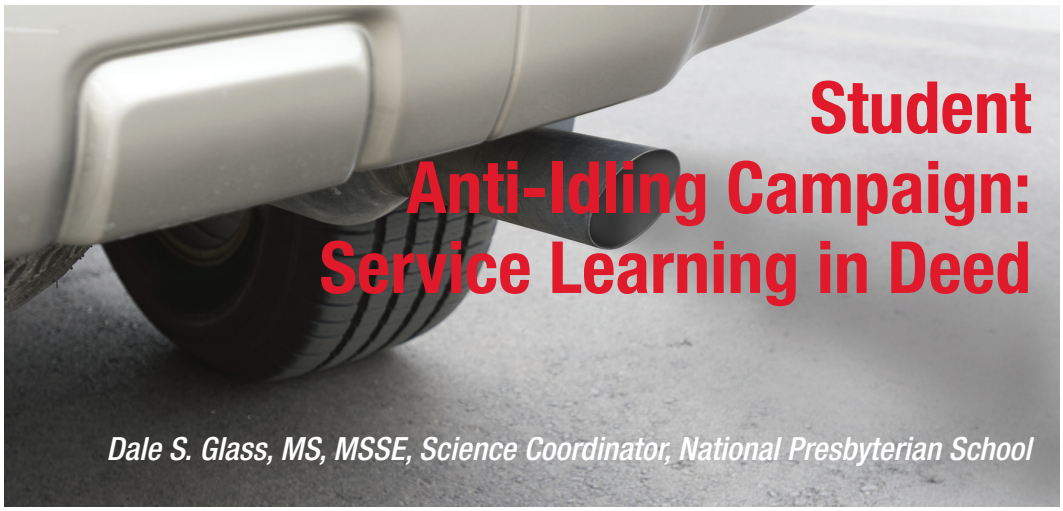

Student Anti-Idling Campaign: Service Learning in Deed

Dale S. Glass, MS, MSSE, Science Coordinator, National Presbyterian School

Abstract

Adding a science service learning project to a standard inquiry-based environmental science curriculum helped fifth grade students learn climate science as they made connections between a real-world problem and their classroom learning. Students brainstormed, researched, and developed a project to address idling in the carpool lane at school. They collected and analyzed data, and used it to build a compelling anti-idling campaign for the school community.

Introduction

Service learning has been shown to help with student confidence, engagement, attitudes, and academic achievement (Berger, 2010). Science service learning is an ideal way to connect science with other curricular areas, to include related social issues, and to provide opportunities for students to explore the outside world; all these practices and skills are recommended in the Framework for K-12 Science Education (NRC, 2012). Science service learning projects combine science coursework and student action to make a difference. The goals of adding the service learning component to the Environmental Science unit were to improve students' understanding of science, involve them in a climate mitigation project, and help them to view scientists (and themselves) as agents of change in the world.

Methods

The science service learning project was interwoven throughout the fifth grade environmental science unit during the spring quarter at National Presbyterian School, an independent Nursery-6th Grade school in Washington, DC. To provide structure to the entire unit, a "Discover, Connect, Take Action" plan based on Berger's steps for service learning (Berger, 2010) was laid out. The plan used some investigations described in the FOSS Environments Module (FOSS, 2005). Assessments were incorporated throughout to evaluate students' knowledge, attitudes, and learning. The service learning project included class work to learn about the environmental impacts of several factors, collecting data, and designing and implementing an action plan. The National Oceanic and Atmospheric Administration (NOAA) Climate Stewards Education Program funded the stewardship project with a mini-grant.

To begin the discovery process, students investigated the impact of some biotic and abiotic factors on different organisms. Once students had an understanding of some of the influences different environmental variables have on living things, they then started to examine the campus

Table 1: Structure of a Science Service Learning Project within an Environmental Science Unit

GOAL	DETAILS
Discover	Learn about environmental factors & preferences Isopods (light/dark, moist/dry); creating a good habitat Guinea pigs (food type or shelter type preferences) Learn about the impact of some environmental factors Bioassay on radish seeds grown in plain, slightly soapy, or very soapy water Fish make tank water acidic (from CO2) Aquatic Plants reduce acidity Fish + aquatic plants = good balance Research biomes (library book research on desert, arctic, savannah, etc)
Connect	**Look at environmental factors at school** **Brainstormed inputs/outputs** • Concept maps of NPS environmental factors • Decided on carpool idling project **Learn about the carbon cycle** **Research impact of idling** (small group projects) • Greenhouse gas and temperature (with demonstration experiment measuring the temperature of soda water and plain water when the sealed bottles were exposed to sunlight) • Acid Rain • Air pollution and health • Gasoline as a fossil fuel **Data Collection** • Brainstorm data collection activities • Collect data - tally sheets of idling cars - time-lapse photos of cars arriving - CO2 probe - temperature probes • Analyze data - calculated CO2 output, pollution output, and financial cost of idling per day - determined daily and weekly averages **Present Anti-Idling Campaign** • Assembly Powerpoint and student speakers • School website • Carpool line outreach **Follow-up** • Post-campaign data collection • Data analysis • Report results
Take Action	**Communicate** • Celebration of Service Chapel • NOAA CSEP Video Contest

Figure 1. Student concept map showing environmental factors around the campus.

Figure 2. Fifth graders using indicator solution to see CO_2 levels in a mini-aquarium containing a goldfish and a plant.

environment. Students brainstormed environmental factors on the campus by drawing concept maps (Figure 1) of the inputs and outputs of the school. They decided to focus on air pollution from unnecessary idling in the carpool line.

Students investigated connections between automobiles and the environment. They played the Carbon Cycle Game (1.usa.gov/1LFnAgt) They learned how to use Vernier data-logging equipment, plunging temperature probes into ice water and exhaling into bottles to measure carbon dioxide. They observed the CO_2 balance between aquatic plants and fish in an aquarium (Figure 2). The fifth graders, working in small groups, researched auto exhaust pollutants, cost of fuel, and impacts of acid rain and greenhouse gases.

Next, students designed a data collection protocol and recorded the number and types of cars, how long they waited in line, and if they were idling (1.usa.gov/1TTIlHK). The CO_2 and temperature probes set up along the driveway generated positive attention from the community (Figure 3). They collected data for five days and calculated exhaust outputs and fuel costs associated with the unnecessary idling (1.usa.gov/1QqYYqF).

No change in atmospheric CO2 or temperature was measured. Over this average week with pleasant weather, 35 of 165 cars (22%) which arrived early for carpool idled for a total of 509 minutes. This put out 75 kg of CO_2, and cost $34.00 in fuel.

Armed with data, students created an anti-idling education campaign. They presented their research findings to the student body during an all-school gathering, and to the parents through the school's weekly e-newsletter and website. They collected post-campaign data on idling cars and analyzed their campaign's impact. Students documented and celebrated their work in an all-school assembly and through a video which was shared with the school community and NOAA.

Figure 3. A laptop computer with two Vernier temperature probes and one CO2 probe was set up in the carpool lane while a time-lapse camera recorded the arrival of cars.

Results

Students reflected on their service and their learning during class discussion, assessments, interviews and surveys. They saw how their actions impacted the school community even beyond their initial goal. Academic achievement was assessed throughout the project with standard FOSS

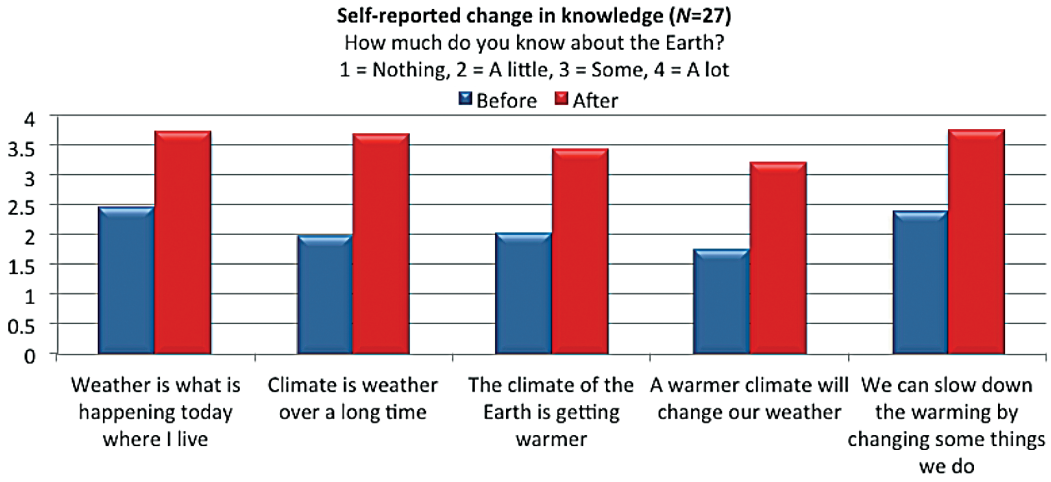

Figure 4. Students self-reported change in knowledge on questions 2 and 3 from the NOAA CSEP Elementary Audience Knowledge Survey.

benchmark quizzes, the NOAA Climate Stewards Education Program (CSEP) Elementary Audience Knowledge Survey (http://cselemaudience.questionpro.com) and a knowledge and attitudes questionnaire developed for this project (1.usa.gov/1QyPqaV). Grades on the benchmark assessments were comparable to the two prior years' students, with a B+ average for all years. Students said they learned about climate during the service learning project, with their self-reported scores moving from an average of knowing "a little" before the project, to an average of "a lot," after the project as shown in Figure 4.

Conclusion

During interviews (1.usa.gov/1VWDsM1), students related that they particularly enjoyed the connection between science class work and the real world, and knowing that they could do something to help. One fifth-grade student said, "When we found the data for our service learning project, it was easier for people to take us seriously."

Participating in a science service learning project changed students' attitudes about science because they were empowered to make a difference. Although there was no significant change in the number of cars that were idling immediately post-campaign (students attributed that to the steamy June weather; folks needed to run the air conditioning), the school responded to the students' actions by implementing several related "green initiatives." These include priority spaces in the pick-up line and parking lot for carpoolers and a public-transportation subsidy for faculty and staff. Fifth grade students who participated in a science service learning project demonstrated academic achievement and enthusiasm for science. The opportunity to apply what was learned in science class to help the environment made the service learning project a success. Connecting classroom activities to service supports learning indeed (Glass, 2013).

Connections to the Next Generation Science Standards (NGSS Lead States, 2013)

The FOSS Environments Module is aligned with the NGSS. The specific areas addressed by the service learning project are:

MS-ESS3.C: Human impacts on Earth Systems
Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.
Typically as human populations and per-capita consumption of natural resources increase, so to the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.
Performance expectation 5ESS3-1: Students who demonstrate understanding can: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

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The Polar Bear Challenge: Local Impact on a Global Issue

Christine Schmitz, Education Curator
Utah's Hogle Zoo

Abstract

The Polar Bear Challenge is 21-day statewide event hosted by Utah's Hogle Zoo. It is designed around the concept that polar bears and people want the same thing – a healthy planet. The Zoo is home to a female polar bear that is an ambassador for her species and a tangible way to teach the public about climate change. The Polar Bear Challenge provides teachers and students with a means to lower their carbon footprint by making small changes in their daily lives and lowering their impact on the planet's natural resources. The Zoo challenges each class to make the changes for at least 21 days (the time it takes to start a new habit). Classrooms that make the greatest differences receive prizes from the Zoo and every participating class benefits polar bear conservation efforts and makes a positive impact on slowing down climate change. Pre- and post-survey results over the past five years have shown an increase in student understanding of climate change science and how their actions can make a difference.

Introduction

Polar bears are an iconic species in many ways. They are top predators in their ecosystem and are a powerful symbol of the strength and endurance of the Arctic. They are charismatic and treading on thin ice – making them an iconic symbol of the effects of climate change on the Arctic ecosystem.

Utah's Hogle Zoo became an Arctic Ambassador Site in 2007 for Polar Bears International (PBI). PBI's mission is to conserve polar bears and the sea ice they depend on. Through media, science, and advocacy, they work to inspire people to care about the Arctic, the threats to its future, and the connection between this remote region and our global climate.

As part of a conservation/education outreach program sponsored by PBI, the author had the amazing opportunity to see polar bears in the wild. It was in October and the bears were waiting for the sea ice to form in Churchill, Manitoba, Canada. That year, the sea ice was six weeks late in forming and the bears were using up what was left of their fat reserves waiting for the ice to form so that they could head out to hunt. We were seeing the effects of climate change in action.

This trip resulted in a desire to create a program that would make a difference with regard to carbon footprint reduction. The program needed to generate action within the Hogle Zoo's community, to

make a difference for the future of polar bears, and to positively affect both the people and wildlife of Utah. Rather than start a large community campaign, the choice was made to focus on the audience the author knew best – kids and teachers.

As an informal educator, I knew that children, when given the opportunity, are excellent environmentalists. In fact, they are often the driving force behind motivating their parents to change their actions. The challenge was to create a program that students and their teachers could participate in, without adding a lot of extra work to the teacher's plate.

Taking on the Challenge

The first step was to design a program that aligned to the Utah Core Standards for Science. The overarching Science Core is the same for each grade level: students are to be able to apply scientific processes, communicate scientific ideas effectively, and understand the nature of science. To do so, they must be able to use the processes of scientific investigation (i.e. framing questions, designing investigations, conducting investigations, collecting data, drawing conclusions), communicate effectively using science language and reasoning, and understand the nature of science. Using these standards, a program was created where students could take action, while developing skills that met the Science Core. This would help teachers meet their teaching goals for the year and provide their students with a "real life" activity to collect data, calculate results and an opportunity to share their project with the community.

Figure 1. Student reducing energy consumption through recycling.

In 2010, the Polar Bear Challenge was launched to elementary schools in the 13 school districts that surround Hogle Zoo. Teachers began by having their classes calculate their carbon footprint. Then they worked with their students to explore ways their class could reduce their energy consumption. The class was then asked to choose an action – many chose multiple actions – and make those changes at their school or in their homes (Figure 1). To participate in the challenge, the classes needed to carry out their carbon footprint reduction actions for a minimum of 21 days over a two-month period. At the end of the 21 days, the class recalculated their carbon footprint. Teachers then

Figure 2. Polar Bear Challenge winners from Harry S. Truman Elementary School, West Valley, Utah.

Polar Bear Challenge Curricular Materials

Resources:
http://uhzpolarbearchallange.org/polar-bear-challenge-resources/

Web Links:
http://uhzpolarbearchallange.org/polar-bear-challenge-resources/polar-bear-challenge-links/

submitted the class' write-up of their project, data and results, along with six to ten photographs of their students doing the project and/or a video. Hogle Zoo staff reviewed each of the projects and the results, and the winning classroom was selected.

The winning students and teacher received Zoo tickets, t-shirts and a large framed photograph of a polar bear, along with $500 of books for their library related to the Arctic, polar bears and actions children can take to make a difference for the environment, as well as an outreach visit to the entire school from some of the Zoo's animal ambassadors (Figure 2). Two classrooms were selected as runners-up. These classrooms received Zoo tickets, photos and a classroom visit from the animal ambassadors for their efforts. The first year of the Challenge, approximately 800 students and their teachers participated.

In 2011, the Polar Bear Challenge was selected as a recipient of a grant through the National Oceanic and Atmospheric Administration's (NOAA) Climate Steward program. The money provided the opportunity to create an information packet to help teachers to create their plan, as well as develop curricular materials and point to web resources to help teachers integrate the challenge into their classroom activities. Students were given pre- and post-tests in order to see, if by participating in the Polar Bear Challenge, students understood the science of climate change and how their actions impacted the issue both positively and negatively (Figure 3). During the five years the challenge has been carried out, student scores between the pre to post-tests have increased by ten percent or more. The results indicate that students not only have a much better understanding of climate change but that they also feel that they can make a difference.

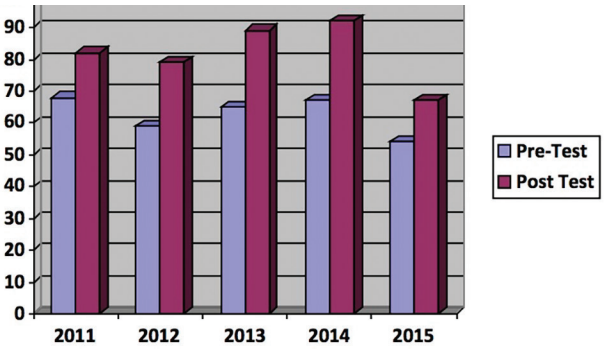


Figure 3. Graph illustrating the results from the pre- and post-testing of student understanding of climate change before and after participating in the Polar Bear Challenge.

The grant also allowed for the expansion of the program to secondary schools in these districts by helping to provide additional teaching materials and prizes. Unfortunately, not as many students have been seen to participate in the program as have been consistently seen from the elementary schools. Based on a follow-up survey, middle school teachers in Utah have a harder time fitting the challenge into their curriculum since they don't teach about climate change. However, we may see interest in the program increase beginning this year — the new Utah Science Standards may be adopted and the grade eight standards include teaching about climate change. The Polar Bear Challenge will provide teachers with curriculum as well as with an action project for their students without a lot of additional training or work on their parts.

Figure 4. Student reducing energy consumption by biking to school.

Program participation has continued to grow overall and has averaged about 2,300 participants in the last two years. Some of the student projects have included: students working with their school district food service companies to serve meatless Monday lunches, getting rid of plastic ware, starting a school composting program, bike-and-walk to school programs (Figure 4) and no-idling campaigns (Figure 5). Often teachers and students choose not only an in-school program but also a project that students can complete at home. These have included monitoring what goes into their trash and making sure it gets recycled, turning off the water when brushing their teeth and unplugging all electronic devices not in use at their homes. Students learn how these

actions reduce energy use as well as how much energy is used to produce the various products. Often, teachers provide feedback that the students have become much more conscious consumers.

In 2015, another grant through the NOAA Climate Stewards Education Project was approved and an app that will help teachers calculate their carbon footprint data in a more standardized way is in the process of being created. Although the curriculum provides the teachers with reputable online calculators, such as the Environmental Protection Agency's Carbon Footprint Calculator, not all data has been calculated correctly and often takes quite a bit of the Hogle Zoo staff's time to recalculate. When completed, the app should not only provide a standardized method of calculation, but also help classes build their portfolio to make their school a GREEN School in conjunction with the Utah Society for Environmental Education's GREEN School Program.

Figure 5. Student note from a No Idling Campaign.

Going the Distance for the Planet

Teachers that participate in the program for multiple years, often expand their efforts. Teachers view participation as a way to encourage students to put their ideas into action and to measure the results. For example, Elizabeth Nafus, a second grade teacher at Harry S. Truman Elementary School in West Valley, Utah has participated in the program for three years.

The first year, under Nafus' and her second graders' leadership, the whole school began a recycling program – both at the school and at home. Students studied what could be recycled, set up appropriate recycling bins and collected the recycling in each classroom weekly. They also set up reusable item bins so that extra pieces of paper, pens, pencils, etc. would have a second life. Her class received an honorable mention that year.

The next year, her students studied how disposable water bottles are produced and chose to rid their school of them. The students worked to find donations of reusable water bottles and then provided each student in the school with one (Figure 6). They then calculated the amount of carbon they prevented from entering the atmosphere from the reusable water bottles, the energy it would take to fill them with water and the energy it would have taken to deliver the bottled water to their school. Again, her students received an honorable mention.

Figure 6. Energy reduction campaign in which every student was given a reusable water bottle.

The third year, her second grade students were determined to win. The class decided that their emphasis that year would be to get the students, and their families, to replace plastic and paper shopping bags with reusable bags. The students and their teacher sought donations from local businesses and each student in the school was given reusable shopping bags. The students then recorded the number of times they were used during the challenge. Students used math skills to determine how many plastic and paper bags they stopped using and the amount of energy they conserved. That year, they won!

About the Author

Christine Schmitz is the Education Curator at Utah's Hogle Zoo. She has worked in informal science education for over 30 years. She holds a bachelor's degree in biology from Scripps College and a master's degree in Curriculum and Instruction from Portland State University. She can be reached at cschmitz@hoglezoo.org.

Each year, "we tie it back to polar bears and mention climate change," Nafus said. This program is changing the school and their community. Four years later, students are still bringing their recycling to the school because they may not have recycling available where they live. Recently, a parent offered to donate bottled water for a school event. His daughter said, "NO!" Instead, they brought pitchers of water and paper cups. This year Nafus' and her students are thinking about how they can create a "No Idling" campaign at their school and in their community – helping to reduce emissions and improve the quality of the air they breathe.

Conclusion

Over the course of the Challenge, the Zoo's education staff have also created more in-depth teaching materials. This has culminated in Climate Care teaching kits and curriculum for elementary school teachers in our targeted school districts. The curriculum and supporting materials compare Utah's habitats and wildlife to Alaska's – using black bears and polar bears as iconic species. The goal is to help students better understand how interconnected these unique ecosystems are and how our actions can positively, or negatively, affect the animals, plants and people who make their homes there. To learn more about our Climate Care Kit, receive any of the teaching materials including pre- and post- tests, or more information regarding the Polar Bear Challenge please visit the website (http://uhzpolarbearchallange.org) or feel free to contact Utah's Hogle Zoo's education staff at http://www.hoglezoo.org/contact_us.

The Biggest Reducer: A Lesson in Waste Reduction

Brandon Smith, Environmental Program Supervisor, Brevard Parks and Recreation

Abstract

The Biggest Reducer program was developed, with a grant from the NOAA Climate Steward Education Project, to educate students about the growing problem of food-related waste and incite them to take action to reduce waste production during their daily lunches. Through recording of weekly waste production and an in-school assembly on waste reduction practices, the program aimed at a 15% waste reduction post-education. After a week of data collection and one random spot check, a 50% waste reduction was seen overall. The program materials are available online for replication.

Introduction

Unnecessary packaging and food waste plague our everyday lives. In 2013, Americans generated 254 million tons of municipal solid waste (Figure 1). The EPA estimates that an individual school lunch produces an average of 67 pounds of trash per year[1]. Through observation of school fieldtrips and summer camps, the staff at Riverwalk Nature Center in Rockledge, Florida noticed a large amount of prepackaged food with excess plastic and cardboard containers. Much of the packaging waste was plastic films and bags which cannot be recycled by most municipal recycling centers. Some of the waste was unnecessary packaging such as cardboard sleeves surrounding plastic containers.

The largest problem of food related waste might not be the food containers but actually the food itself. It is estimated that 30-40% of food produced is thrown away[2]. Food waste comprises around 15% of our waste stream, second only to paper[3]. If just half of that yearly waste was anaerobically digested, it would generate enough electricity to power over 2.5 million homes for a year[4], or roughly the entire state of Nevada. It is estimated that in the US 3,000 pounds of food is wasted every second[5]. That is enough food wasted in one day to feed the states of California and Florida combined.

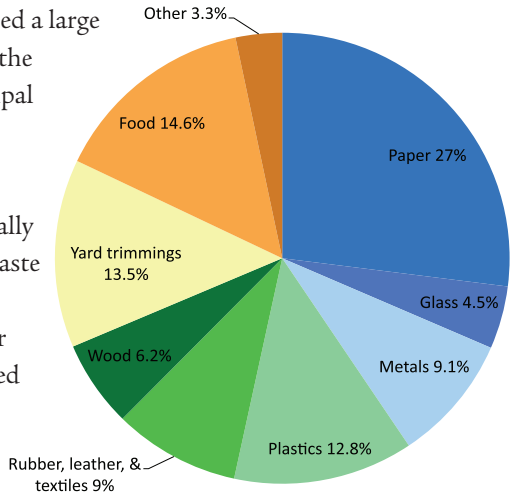


Figure 1. Total Municipal Solid Waste Generation (by Material), 2013, 254 Million Tons (before recycling)

Source: EPA

The Biggest Reducer Was Born

In order to shed light on this issue, a pilot program, The Biggest Reducer, (Figure 2) to teach about the issue of food related debris was devised and tested on children attending Marine Biology Camp at Riverwalk: A Family Park. Children were given reusable Wrap-N-Mat sandwich wraps and tips on how to reduce waste. Changes were seen in the children's lunch packing habits throughout the week. Some even continued these changes in behavior when they returned the following year. After

Figure 2 (above left). Biggest Reducer Logo

Figure 3 (above right). Students at Ralph Williams Elementary weighing waste produced during one lunch period

Figure 4. Student reducing plastic bags by using the Wrap-N-Mat given during program

seeing positive results with just a small amount of education, a decision to expand the program to reach a broader audience was made. Funding of $2,000 was found through the NOAA Climate Stewards Education Project. A formal presentation was developed to be used in school assemblies and was offered to schools to cover up to 500 students. A local school teacher was consulted during the development to ensure school standards were being met through the program.

Upon the initial release three schools signed up to be involved in the program, Ralph Williams Elementary, Imagine School at West Melbourne, and Palm Bay Elementary. A workshop was held to familiarize the participating teachers with the program, insure they knew their responsibilities, and provide them with the supplies needed. Each teacher was provided with a digital hanging scale, data sheets, and a parent letter. Access to the digital copies of the data sheets and parent letter as well as the assembly presentation and supplemental materials was provided through Google Docs. The schools provided trash bags and waste receptacles (Figure 3).

Each classroom was then tasked with dividing out their lunch waste into three categories: recyclables, organic food waste (compostables), and trash. The weight of each category was taken daily and recorded on a weekly data sheet which was reported via a Google Form. The students were given no insight as to why they were measuring their waste for the week. On the final day of their first weigh week, a school assembly was held with the participating classes using the Biggest Reducer program. This program was shared via Prezi, which is accessible for any facility to use. The presentation teaches the principles of waste reduction including how to create a zero waste lunch and ways to expand waste reduction to a community level such as food donation programs and anaerobic food digestion facilities. All participating students were then given a Wrap-N-Mat reusable sandwich wrap to replace at least one disposable plastic bag (Figure 4).

A parent letter was sent home explaining the program's purpose and providing waste reduction suggestions and tips. Students were encouraged to practice their new waste reduction skills while they continued recording their waste the following week. This was then compared to the first week to see the amount of waste reduced. To tell if students were maintaining the waste reduction principles over time, they were then given a follow-up spot check on a randomly selected day several weeks after their initial participation. The spot check day was weighted at 50% of the overall reduction comparison due to the importance of continuing waste reduction practices beyond when they knew they were being monitored.

Results

While the majority of classes saw an overall reduction of waste of up to 54% on the second week, surprisingly two of the classes had an increase in waste, with one as high as 72% (Figure 5). The teacher of Class 1 with a 26% increase attributed this to several less popular menu items being served during that week. The data suggests this is true as Class 1 saw a 642% increase in food waste from week one to two. Interestingly, the same class was the only class to reduce its trash by 100% with zero pounds of trash the second week; however, they increased their recyclables by 142%. When compared with the spot check day, Class 1 still maintained zero pounds of trash and had a reduction of 72% recyclables and 67% food waste. Class 3 with a 72% overall increase from week one to two, surprisingly showed a negligible increase in food waste but had a 226% increase in recyclables and a 318% increase in trash from week one to two. They improved considerably by their spot check with an 84% decrease in recyclables, 99% decrease in food waste, and 86% decrease in trash as compared to week 1. Overall an average of 50% waste reduction was seen between all the classes with an average daily reduction of 2246 pounds of waste. The EPA estimates one pound of waste produces 0.94 pounds of CO_2; therefore, it can be estimated that 2111 pounds of CO_2 was reduced daily.

The category makeup of the waste changed after the educational presentation as well (Figure 6). Before the Biggest Reducer program was implemented, 60% of the waste was trash. After the presentation, the percentage of trash dropped to around 50%. A slight increase in recycling was seen, though due to the light weight nature of most recyclable materials the actual volume may have been more. Teachers reported that the students were most surprised to see the amount of food that was thrown away with their lunch.

Biggest Reducer Resources

Biggest Reducer Presentation

Prezi presentation teaching waste reduction principals created by Brevard County Parks & Recreation: http://prezi.com/3lyacobtnd4z/?utm_campaign=share&utm_medium=copy

Biggest Reducer Resources

Biggest Reducer Data Sheets and Parent Support Letter created by Brevard County Parks & Recreation as well as supplemental materials: https://goo.gl/bAZI5Q

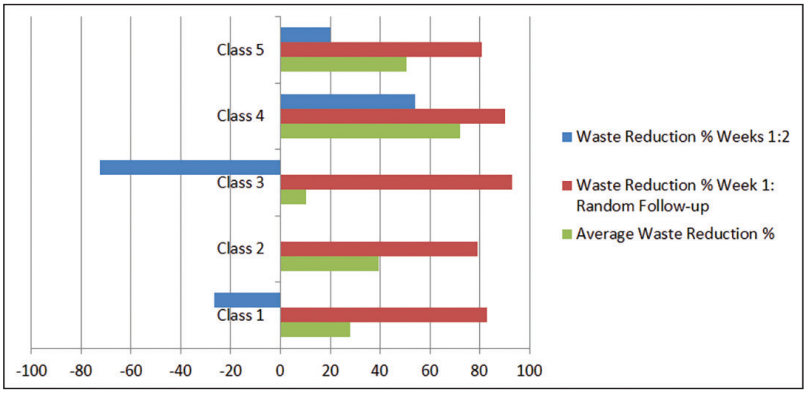
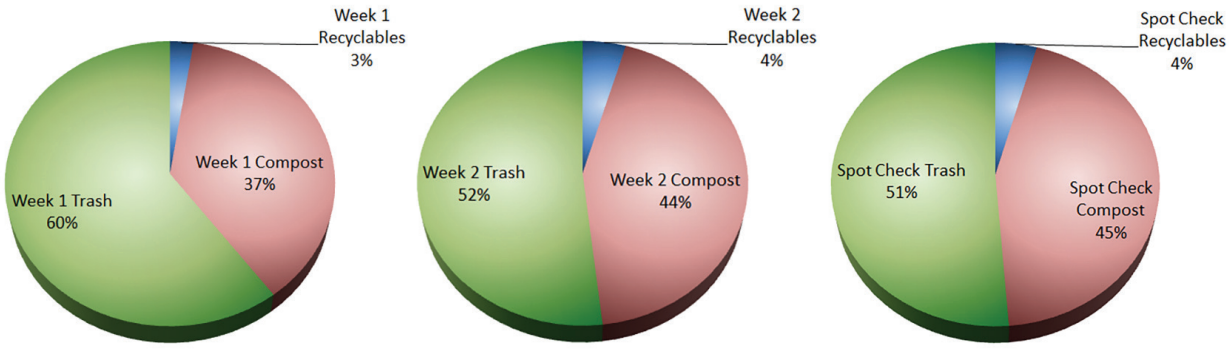


Figure 5 (above). Percentage of waste reduced between five classes participating in the Biggest Reducer

Figure 6 (below). Percentage of waste by category compared by week and random spot check day



Conclusion

When planning The Biggest Reducer, it was hypothesized that at least a 15% reduction in overall waste would be seen. The program was considered a resounding success when over three times that goal was reached. Since concluding The Biggest Reducer, new schools have asked to participate in

About the Author

Brandon Smith is the Environmental Program Supervisor for Brevard County Parks and Recreation at Riverwalk Nature Center in Rockledge, FL. For 15 years, he has taught and designed environmental education programs mainly focused on the Indian River Lagoon estuary. He has served on the boards of the Florida Marine Science Educators Association, Space Coast Science Education Alliance, Sea Turtle Preservation Society, and Friends of the Carr Refuge. He has also had an active role in the National Network for Ocean and Climate Change Interpretation, NOAA Climate Stewards Education Project, and the Florida Master Naturalist Program. He has a Bachelor's degree in Marine Biology from the Florida Institute of Technology in Melbourne, Florida. Brandon can be reached at brandon.smith@brevardparks.com.

the program the following year. The program was also presented at the 2015 Florida Marine Science Educators Association annual conference. All the resources were shared with a packed session allowing them to implement it at their own facilities.

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Biochar for Carbon Sequestration: Investigation and Outreach

Karen Metcalf
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Abstract

Greenhouse gases are currently impacting Earth's climate and will continue to do so at elevated rates until we find ways to mitigate our actions. Biochar production via pyrolysis is a means to sequester carbon in the soil long term. Biochar is highly resistant to breakdown and thus becomes a sink for carbon storage. This strategy is accessible to students and can give a sense of empowerment to make change. In the course of this unit, students learn about the carbon cycle while producing biochar, test biochar's value as a soil amendment, and provide outreach on the carbon cycle to other students and the public.

Biochar

Excess greenhouse gases are linked to the climate change currently being experienced worldwide. One means of mitigation of the human impacts on the concentration of these gases is to hold carbon in sinks in order to reduce the likelihood that this carbon will cycle into the atmosphere. Biochar, which can serve as such a sink, is produced by pyrolysis (high temperature, low oxygen thermochemical decomposition) of organic matter. The production of biochar is one way to sequester some amount of carbon before it enters the atmosphere (Wolf et al, 2010). An additional documented benefit of biochar is as a soil amendment to improve yields (Cornell University Department of Crop and Soil Sciences, 2015). The chemical (negative surface charge density) and structural (high surface area) properties of biochar, when amended to soil, result in increased water retention and nutrient affinity.

Figure 1. Small student-built top-lift updraft pyrloizer made from recycled cans. A fire is lit from the top as biomass (in this case pine pellets) is gasified and the volatile gases combust. When pyrolysis is completed, the remaining material is quenched, leaving behind biochar.

Students as Stewards Sequestering Carbon

Learning about, producing and testing biochar enables students to learn about the carbon cycle while empowering them take action to mitigate climate change (Figure 1). During the fall of 2013, Cornerstone Learning Community middle school life science students produced 45 kg of biochar in a 55-gallon drum pyrolysis unit (see Packard, 2009 for design). Students collected biomass (primarily woody debris) from the campus to add to the top-lift updraft unit made from recycled metal barrels and piping. The design of the pyrolysis unit minimizes the entrance of oxygen to the bottom of the container. The biomass is lit on the top and a flame is produced by the off-gassing combustible compounds, not the combustion of biomass. Once pyrolysis is complete, the char is quenched by spraying with water to ensure that

the char doesn't burn to ash. The biochar produced was ground and mixed at the rate of 45 kg per 4-foot by 10-foot by 1-foot raised bed garden (aging biochar in the soil before planting to enable nutrient and water absorption and bacterial colonization is recommended).

Figure 2. Experimental layout of raised-bed gardens. Treatments from left to right are 1) compost plus biochar, 2) compost only, 3) sand plus biochar, and 4) sand only.

Figure 3. Students measuring biomass produced by plants in different soil treatments.

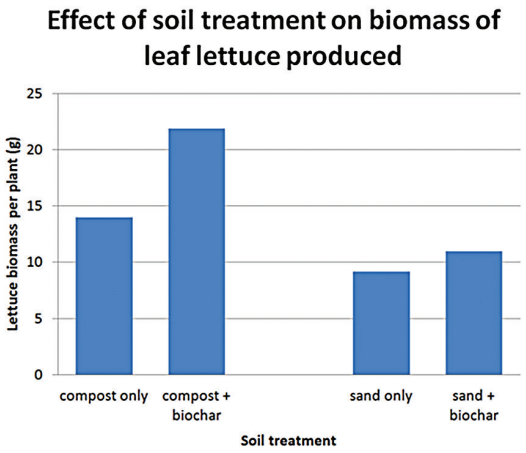

Figure 4. Student experimental data showing biomass produced by leaf lettuce plants in different treatments.

Figure 5. Student-grown vegetables being served at a transitional facility for homeless families.

Students worked collaboratively, consulting a regional planting guide, and then seeded a winter garden that included carrots, radishes, lettuce, cabbage, onions and kale. The experimental design included identical plots, varying only in the type of soil and soil amendment used to test for differences in vegetable biomass produced (Figure 2). The plots used compost, compost plus biochar, sand, and sand plus biochar to test for the effects of soil amendment and type on vegetable production.

Throughout the growing season and as vegetables were harvested, students quantified the growth in each plot and interpreted the effect of soil type on growth (Figure 3). Most vegetables produced more biomass in the compost soil type (as compared to sand) irrespective of the addition of biochar (with the exception of some very large radishes grown in sand). Of those grown with compost as a soil, the plants in plots amended with biochar grew larger. Some of vegetables produced much more biomass in biochar (such as Chinese cabbage and lettuce) (Figure 4) while others were larger, but not significantly so. Following their analysis of growth data, students were expected to generate a scientific argument about the value of biochar as a soil amendment.

Sharing the Wealth

All of the vegetables harvested from the experimental garden became part of the school's once-monthly lunch preparation and service at a local homeless transition facility (Figure 5). Students prepared salads and cooked dishes with the garden harvest. Based on experimental data, the project captured over 24,360 grams of atmospheric carbon that was converted into edible vegetable matter that has provided meals for homeless citizens. This combines with 45 kilograms of carbon that was sequestered for the long term (studies conservatively estimate 100+ years) in the form of biochar remaining in the garden.

Reaching Out to Others to Teach About Carbon

As the students finished up their analysis of the impact of biochar on plant growth, they thought about how to share this information with others. A display was designed and built to coincide with Earth Day (Figure 6). The students were tasked with generating ideas that would convey the message "carbon cycle" to visitors in elementary and middle school grades. The display took shape as a Build a Carbon Catcher activity, a large postcard with carbon cycle themed activities and individual trifold-displays of two of our school's stewardship related activities (the biochar project, model solar car design, construction and racing). Students set up the display at our local Saturday Farmer's Market. Students were able to share and educate passers-by. Visitors made 'carbon catchers' by decorating a small flowerpot and planting either a bean or sunflower seed. Puzzle pages with student-designed activities were distributed to visitors. Students also set up the display for our school Earth Day Festival. Students from kindergarten through fifth grade came to make carbon catchers and sidewalk Earth Day art, hear about biochar, and run a very popular Recycle Relay. This event was all in the hands of the students to run. They took charge of different roles and made it a big success.

Figure 6. Student designed and led Earth Day display and Carbon Catcher activity.

Learning Gains

The results of pre- and post-tests were used to assess improvement in background knowledge about climate change and attitudes about the cause and impacts of changing climate. The survey instrument used for these tests is one from the National Center for Atmospheric Research Spark education group. The climate change questionnaire is from the module "Applications of chemistry through climate science" (Marschke, 2012). Thirty-seven of the objective questions from the questionnaire were used and eight of the questions addressing attitudes about climate change. The average student score on the objective portion of the pre-test was 74%. Post-test averages were three percent higher. Prior to starting the project, 80% of student responses indicated opinions that show urgency about human-induced climate change and the need to take action. These responses also went up three percent after the project was completed. The change in student scores however does not adequately represent the learning that took place through the project. The fact that this survey instrument was designed for high school students may have had some effect on middle school student scores.

Overall, the project was highly successful as it enabled climate change to be woven through the curriculum for the year. The connection to service-learning is an important one for the Cornerstone Learning Community school. Thinking about how to best present the carbon cycle and climate change to younger students in the display gave these middle schoolers a chance to think deeply about how to explain this topic. Their efforts produced an engaging and fun activity booth that they were able to share with others in our community.

Next Generation Science Standards Addressed

SCIENCE AND ENGINEERING PRACTICES	DISCIPLINARY CORE IDEAS	CROSSCUTTING CONCEPTS
• Analyzing and Interpreting Data • Constructing Explanations and Designing Solutions • Engaging in Argument from Evidence	**LS1.C: Organization for Matter and Energy Flow in Organisms** **LS2.A: Interdependent Relationships in Ecosystems** **LS2.B: Cycle of Matter and Energy Transfer in Ecosystems** **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** **PS3.D: Energy in Chemical Processes and Everyday Life**	• Cause and Effect • Energy and Matter • Stability and Change

PERFORMANCE EXPECTATIONS

MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

Acknowledgements

This project was completed with support from the National Oceanic and Atmospheric Administration Climate Stewards Education Project. Thanks to Tony Brown of Longview Farms for valuable discussions and assistance with biochar production.

Resources

Biochar International: Biochar in Schools

http://www.biochar-international.org/teachers/schools

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About the Author

Karen Metcalf is a middle school science teacher and IB Coordinator at Cornerstone Learning Community in Tallahassee, Florida. She was formerly a marine ecologist with a B.S. (Eckerd College), and M.A. (College of William and Mary) in marine science. Ten years in the classroom at the high school and middle school levels have allowed her to bring her love of the process of science and the marine environment to students. Karen's goal is to teach science concepts while encouraging students to value sustainability, practice environmental conservation, and use critical thinking. Membership in NOAA's Climate Stewards Education Project has facilitated special projects that support these goals. She is also the leader of Cornerstone's Maker Club. Karen can be reached at kmetcalf@comcast.net.

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provides access to special capabilities and services on NESTA's premier Earth and Space Science Education website available at http://windows2universe.org, available for only $15/year for NESTA members (50% off the non-NESTA rate).

- One year - $15
- Two years - $30
- Three years - $45

Advertising in *The Earth Scientist*

NESTA will accept advertisements that are relevant to Earth and space science education. A limited number of spaces for advertisements are available in each issue.

Artwork

We accept electronic ad files in the following formats: high-res PDF, TIFF or high-res JPEG. Files must have a minimum resolution of 300 dpi. Ads can be in color.

Advertising Rates

Full-page	7.5" w × 10" h	$500
Half-page	7.25" w × 4.75" h	$250
Quarter-page	3.625"w × 4.75"h	$125
Eighth-page	3.625"w × 2.375"h	$75

Submission Deadlines for Advertisements

Submission dates, shown in the table to the right, are the latest possible dates by which ads can be accepted for a given issue. Advertisers are advised to submit their ads well in advance of these dates, to ensure any problems with the ads can be addressed prior to issue preparation. The *TES* Editor is responsible for decisions regarding the appropriateness of advertisements in *TES*.

Issue	Submission Deadline	Mailing Date
Spring	January 15	March 1
Summer	April 15	June 1
Fall	July 15	September 1
Winter	October 31	January 1

For further information contact
Howard Dimmick, Treasurer –
dimmick@esteacher.org

The Earth Scientist (TES)
MANUSCRIPT GUIDELINES

NESTA encourages articles that provide exemplary state-of-the-art tested classroom activities and background science content relevant to K-12 classroom Earth and Space Science teachers.

- Original material only; references must be properly cited according to APA style manual
- Clean and concise writing style, spell checked and grammar checked
- Demonstrates clear classroom relevance

Format Specifications

- Manuscripts should be submitted electronically – Microsoft Word (PC or Mac)
- Length of manuscript should ***not*** exceed 2000 words.
- All submissions must include a summary/abstract.
- Photos and graphs: may ***not*** be embedded, but must be submitted as separate files, of excellent quality and in PDF, EPS, TIFF or JPEG format. 300 dpi minimum resolution. Color or black and white are both accepted.
  - References to photo/chart placement may be made in the body of the article identified with some marker: <Figure 1 here> or [Figure 1 in this area].
- Website screen shots: If you wish to include "screen shots" within your article, please also supply the direct link to the site, so TES can go online and grab the same screen shots at as high a resolution as possible. ***Note:*** When used, screen shots will produce a poorer image than a digital photograph, thus their inclusion in your article will produce an image that will look less crisp and bitmapped.
- Figures should be numbered and include captions (Figure 1. XYZ.).
- Captions, labeled with a clear reference to their respective photo/chart/image, must be submitted in a separate file, or they may be placed at the end of the manuscript where they can easily be removed and manipulated by the editor.
- If using pictures with people, a signed model release will be required for EACH individual whose face is recognizable.
- Each article must include: author(s) names, the school/organizations, mailing address, home and work phone numbers (which will not be published), and e-mail addresses.

Review

Manuscripts are to be submitted to the Editor, via the email address at the bottom of the page. Manuscripts are reviewed by the Editor for content and language. The Editor is responsible for final decisions on the publication of each manuscript. Articles will then be submitted to our Article Reviewers. Manuscripts may be accepted as is, returned for minor or major revisions, or declined, based on the decision of the Editor. The Editor reserves the right to edit the manuscript for typographical or language usage errors.

Page Charges

A fee of $100 per page is charged to authors who have institutional, industrial, or grant funds available to pay publication costs. Page charges include Open Access, so that the article will be made available to anyone on the NESTA website. The author may also post the formatted and published article, in PDF form, on their own website, on other third-party website article repositories, and circulate their article via electronic means such as email. Authors are urged to assist in defraying costs of publication to the extent their resources permit, but payment of page charges is not required from authors. Payment of page charges has no bearing on the decision to accept or reject a manuscript.

Copyright Transfer Waiver

The lead author of the article shall submit a signed NESTA Copyright Transfer Waiver.

The waiver form may be obtained from the NESTA web page. When completed AND signed it should be sent to the Editor. It may be sent as a printed original by US mail (address below), or as a PDF attachment via e-mail.

We cannot begin the production process until this signed waiver has been received. Please help us to expedite the publication of your paper with your immediate compliance. If you have any questions, please e-mail the NESTA Editor as listed below.

Submission Deadlines

Issue	Submission Deadline	Mailing Date
Spring	December 15	March 1
Summer	March 15	June 1
Fall	June 15	September 1
Winter	September 30	January 1

For further information contact:
David Thesenga, EDITOR
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NOAA Ship FAIRWEATHER in Glacier Bay. Photo Date: 2009 September 29 Credit: Crew and Officers of NOAA Ship FAIRWEATHER