Gardening for Carbon Sequestration

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Abstract

Anthropogenic Climate Change is the challenge of our time. Unfortunately, most educational experiences leave students in a state of despair, missing the opportunity to capitalize on action. In order to affect positive change for our collective future, students must not only understand the mechanisms of climate change, but be empowered to create positive change now within their sphere of influence (Hayhoe 2021). In this project, sponsored by NOAA Planet Stewards, high school students learned about plant growth, biodiversity, and ecosystems before investigating how their consumer choices and actions can impact individual carbon emissions. Finally, students worked to solve this challenge through the creation of a school community garden.

Introduction

It can be a daunting task for students to grasp the magnitude of climate change, attribute it to human causation, and enact meaningful change that will have a lasting impact. With funding from the NOAA Planet Stewards Project, high school students in central New York created a school community garden. This project had two phases. In Phase 1, students assessed, created, and improved the habitat in an enclosed courtyard at our high school. The project responsibilities were divided into student teams. One team researched what were the best trees and shrubs for our soil and climate with the goal of not only carbon sequestration, but to attract birds and other potential pollinators. A second team of students researched birdhouse designs and types of feeders to attract a variety of bird species. Students then selected and planted trees, shrubs, and installed bird houses and bird feeders.

During Phase 2, students created an organic vegetable garden in the same courtyard with the improved habitat. The goal of Phase 2 was to learn the skills and knowledge about the art of gardening, as many had never been exposed to gardening at home and to empower students to translate this skill into their own context in the future. Students gathered information on what vegetables would be best for the school garden; then students planned, designed,

planted and maintained the vegetable garden while incorporating other school groups in their endeavors. They created meals from their vegetables and used these meals as a basis for calculating the carbon cost of food.

Implementation

The project was set to start in February 2020. Students took the Carbon Footprint Calculator (https://www3.epa.gov/carbon-footprint-calculator/) as a presurvey and started researching and gathering information for the implementation of the school garden. Then March 16, 2020 happened and virtual teaching became the new rave. Even with plans scrapped for creation of the outdoor garden, some good was salvaged from the craziness. Through online discussions and videos, 11 students created a vegetable garden for the first time at their homes.

In August 2020, a few students met with an arborist from a local nursery to discuss the best trees and shrubs for attracting and creating habitat for birds and that are best adapted for our soil, drainage and climate. We also received supplemental funding from the State Farm Teacher Assist grants. Planting took place in September and October of 2020. Coordinating the planting was a monumental task but I had both a Boy Scout (future Eagle Scout) and a Girl Scout (future Gold Award) involved in this project and they were tasked with recruitment and task management. They were able to engage their prospective athletic teams, field hockey and baseball, in the physical manpower necessary to plant all the trees and shrubs and to move 12 yards of soil and 12 yards of mulch. Phase 1 was complete.

Image 3. Students working hard preparing the courtyard for planting of shrubs and trees. Photo Credit: John Herrington

Image 4. After planting the vegetables, students work the garden to remove weeds and keep the soil loose and watered. Photo Credit: John Herrington

In March of 2021, students started with the building and placement of birdhouses and bird feeders in the courtyard. Students researched what type of birdhouses would best for our courtyard and shared plans with our schools' production class and had 10 birdhouses built. In May 2021, the organic vegetable garden was tilled and planted. Over the next 6 weeks, students maintained weeding and watering of the garden. The cross-country team wanted to leave a legacy gift, and asked the production class to also build benches so that students could use the outdoor classroom for a mental health respite while also to make seating available for classes that wished to be outside. COVID had really cramped everyone's style at that point, and the addition of benches enhanced the use of the outdoor space.

Image 1. Student showing off some of the produce from the organic vegetable garden. Photo Credit: John Herrington

Image 2. The finished product was a mini ecosystem with bird houses and feeders. Students are able to use the courtyard for science projects and to relax and appreciate the outdoors. Perfect during COVID. Photo Credit: John Herrington

This project would not have been possible without the involvement of many partners. We were surprised how many local businesses were willing to donate, offer at a reduced price, or offer services in kind when the project was explained and they were asked if they could help our budget go further. Materials needed were soil, seeds, containers, wheel barrow and mulch, shovels, rakes, gloves, hose and water and online access for plant research or library resources. Local phenomena were highlighted and student engagement enhanced through Engineering Design Challenges. (NGSS, 2013) and (New York Board of Regents, 2016) Local phenomena included organic gardening using no pesticides and fertilizers and connecting it to reduced local harmful algal blooms. Our project focus was primarily on decreasing fossil fuel usage, but we spent a lot of time discussing and showing how large commercial farms had a negative impact on the environment. Traditional ecological knowledge was incorporated into our garden planning. One of our engineering design challenges was to create a water catchment system to collect rainwater from the flat roof of our high school and water the garden at the roots to limit evaporation and conserve water.

Table 1. NGSS performance expectation

Performance Expectation
HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]
Science and Engineering Practice
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
Disciplinary Core Idea
LS2.C: Ecosystem Dynamics, Functioning, and Resilience • Anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. **LS4.D: Biodiversity and Humans** • Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (secondary) • Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. **ETS1.B: Developing Possible Solutions** • When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. (secondary)
Cross-Cutting Concept
Stability and Change • Much of science deals with constructing explanations of how things change and how they remain stable.

The unit was presented in a 5E (Engage, Explore, Explain, Elaborate, Evaluate) format.

Engage: In the fall, the high school Biology and Environmental Science Students took a carbon footprint and attitudinal survey related to climate change and then connected with special education students to harvest vegetables and create a meal together. Pumpkins and apples were harvested to cook some creative fall recipes. The interactions between these students can be powerful. Students were then challenged to create a "local slow food meal" as school was beginning and local harvests are abundant. They were presented with a focus question: How do consumer choices impact climate change? Students were allowed to source their food out of the school garden, local grocer, or local farmer's market. Favorite recipes were discussed and samples were shared. Students presented their findings on how buying local produce or growing produce at home has a positive impact. In the spring an area for an organic vegetable garden was tilled and weeded, seeds were started in the classroom and eventually planted in the garden.

Explore: Students calculated the food miles (carbon footprint) of their meal (https://www.foodmiles.com/food/calculator), and compared that to an alternate, remotely sourced version. Students also investigated the food miles of their favorite foods (how carbon costly is your guacamole at Moe's)?

Explain: Throughout the year, the concepts of ecosystem composition, nutrient cycling, photosynthesis, growth, biodiversity, and anthropogenic climate change were explored. Students mapped out the courtyard describing the different mini ecosystems present and related them to biodiversity and specific bird habitats. Also, with the use of compost bins, students traced the path of energy through an ecosystem using the compost as a 'fertilizer' for the shrubs and garden.

Elaborate: This portion of the experience happens in late winter/early spring. Students engaged in an engineering design challenge, "What actions can you take to reduce carbon emissions through personal food choices?" One of the student challenges was to design a garden at home (space, sun, soil and water collection) and determine which vegetables would best suit their family. Next students created an action plan to purchase locally grown produce either from local farmers markets or from the handful of local farms in our district that sell produce directly.

Evaluate: This portion of the experience happened in the late spring. Students retook the survey from the beginning of the year. Students presented and implemented their Community Garden ideas and their organic vegetable garden was planted.

Results

Phase 1: Students calculated that approximately 430 lbs. of carbon dioxide is sequestered each year from the trees and shrubs that were planted. National Tree Benefit Calculator (https://www.arborday.org/calculator/)

Phase 2: Students calculated that approximately 900 - 1000 lbs of carbon dioxide is saved from the vegetables and fruit harvested from our garden (food miles eliminated) each year.

The graphs that follow (Figures 1-5) show the Climate Change Pre and Post Student survey results.

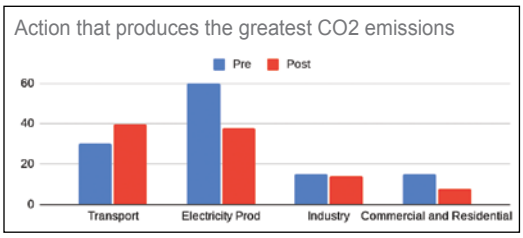

Figure 1. Graph indicates a better student understanding of the cause of the increased carbon dioxide in the atmosphere.

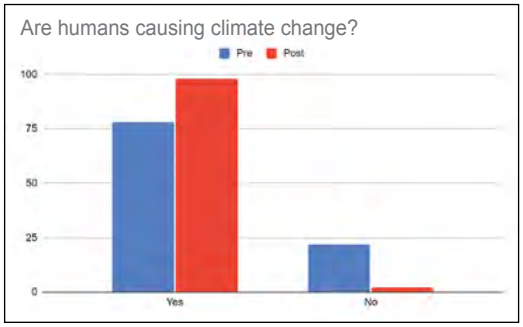

Figure 2. Graph shows an increase in student understanding of the human investment and moral obligation to take action against climate change.

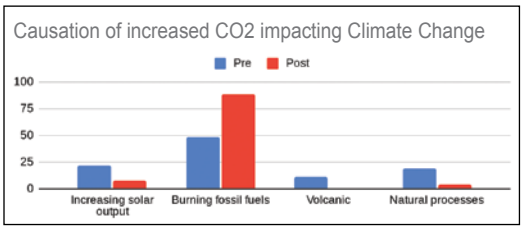

Figure 3. This project focused on the impact gardening and decreasing food miles through buying local produce. Understanding the role transportation plays in the addition of carbon dioxide to the atmosphere is crucial in making changes.

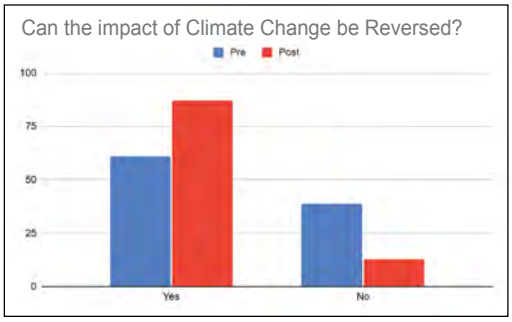

Figure 4. Graph shows a change in attitude about whether climate change can be reversed.

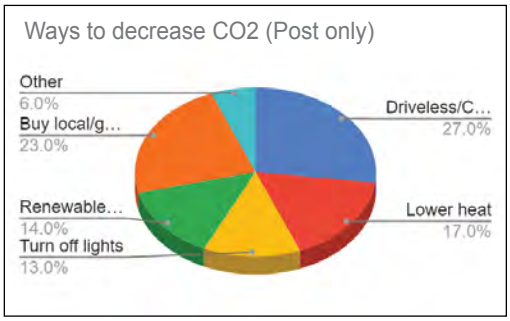

Figure 5. Graph shows what students feel are important ways to decrease carbon dioxide input. The project focus was on ways to drive less and buy local; decreasing fossil fuel emissions.

Discussion

This "Community Garden" project has become self-sustaining thanks to NOAA Planet Stewards and other locally sourced matching funds. The courtyard has created a unique space for student utilization and the student learning that has occurred in this space has been priceless. Students truly enjoy being outside and able to experience firsthand baby birds being fed by their parents, understanding the importance of growing a vegetable garden, recycling of nutrients in a compost bin and making connections between climate change and actions they can take to help reduce the impact of carbon emissions. Science projects and activities allow students to utilize the space to study bird houses/nests and types of birds that feed at the feeders. The garden is a point of focus in our Locavore Unit and the space is used as a place to read and do work. Other teachers in the school take their classes outside to have discussions or work time. A future project is to have the art club create a 3D piece of art from recycled material.

Central New York is home to a state regional farmers market, where students and their families can purchase local foods every week throughout the year. It is famous for apples, not too far away from the Finger Lakes Region (grapes), and only ten minutes from the Onondaga Nation, so the opportunity to infuse traditional ecological practices such as the practice of the Three Sisters from indigenous traditions for soil amendment and crop efficiency on acreage.

Through our partnership with S.U.N.Y Environmental Science and Forestry, a professor visited to talk with students about Traditional Ecological Knowledge (TEK). These ideas were incorporated into students' final projects. Students have tried different ideas at home such as the Three Sisters (Native Seeds, 2016) using no pesticides, using compost as fertilizer and supplying rainwater to their gardens.

East Syracuse Minoa Central School District is a founding member of the CNY STEM HUB and Cleanwater Educational Research Facility (CERF) in the Village of Minoa, NY. Because of these connections, students have the opportunity to engage those visiting our school, participating in "Learning Tours," on their project. Future students also have the opportunity to learn from the original cohort of students and expand the project at CERF, where we have a greenhouse available, courtesy of a previous NOAA Climate Stewards grant. This will extend the season growing and include the practices of aquaponics and aquaculture into this project-based learning unit.

Implementation Tips for other schools that want to start a project like this.

- Involve the entire school community (several teams needed community service hours for graduation or club participation). The first year is labor intensive!
- Diversify funding sources
- Recruit other programs for summer maintenance and to reduce waste
- Create a space for mental health breaks
- Include social media shout-outs for donations from local businesses

Resources

Hayhoe, K. (2021). Saving us: a climate scientist's case for hope and healing in a divided world. New York, NY : One Signal Publishers/Atria Books.

Native Seeds (2016) https://www.nativeseeds.org/blogs/blog-news/how-to-grow-a-three-sisters-garden

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

New York Board of Regents (2016). New York State Science Learning Standards: http://www.nysed.gov/common/nysed/files/programs/curriculum-instruction/hs-science-learning-standards.pdf

About the Author

John Herrington is a 24 year veteran teacher with East Syracuse Minoa Central High School located in Central New York. John has received the NNSTOY New York STEM Fellowship, the Technological Alliance of Central New York award for innovative teaching, is a NOAA Planet Steward, and has been appointed as an adjunct instructor for State University of New York Environmental Science and Forestry. John holds a BS in Environmental and Fisheries Biology from SUNY ESF and an MS in Education from LeMoyne College. As an environmental enthusiast, John co-advises the Outdoor Adventure Club, coaches cross country, and baseball. John can be reached at jherrington@esmschools.org.

Pamela Herrington contributed to this project and article. She is a former NOAA Planet Steward and is the STEM and science instructional specialist for East Syracuse Minoa Central School District.