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

Holly Hereau

Abstract

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

Introduction

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

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

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

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

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

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

Photo Credit: Holly Hereau

Community Environmental Inventory and Issue Selection to Identify the Problem

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

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

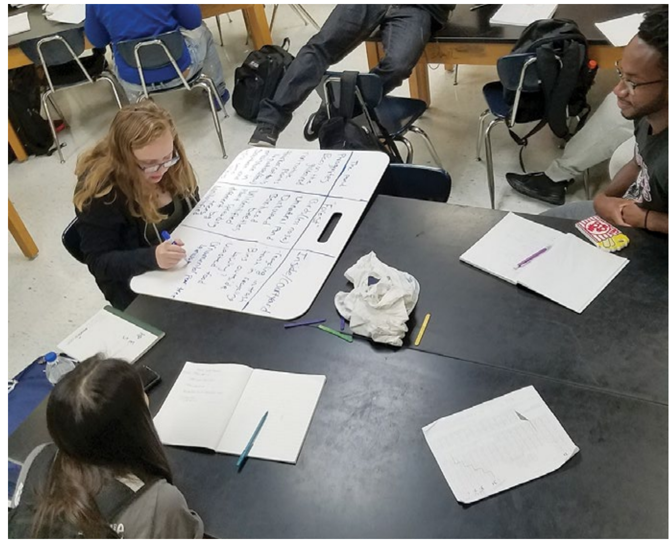

Figure 3. Small groups worked together to do preliminary research on one of the identified issues to present to the class.

Photo Credit: Holly Hereau

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

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

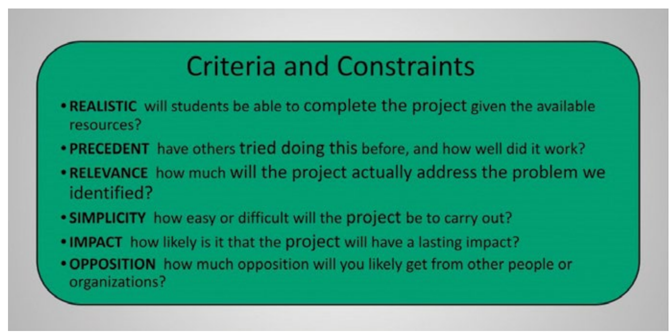

Table 1. Criteria and constraints that the class considered to inform project selection.

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

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

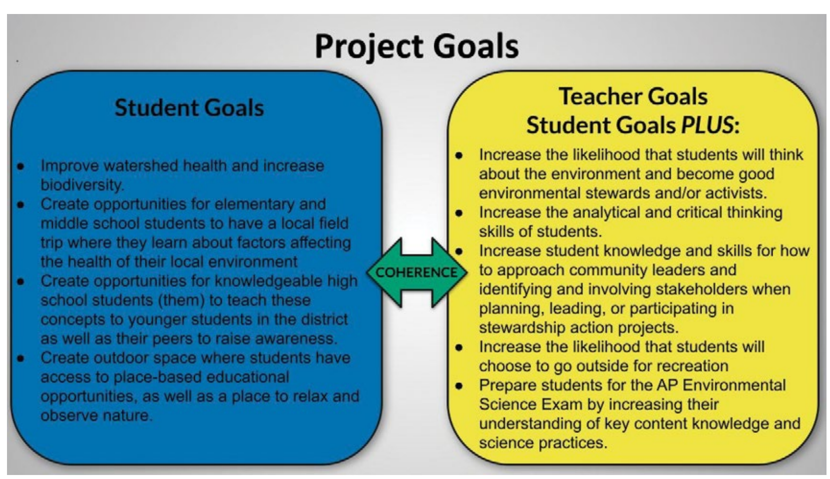

Figure 4. The project goals were identified and are listed next to the additional personal goals I had for this project.

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

Creating the Driving Questions Board and Listing Ideas for Investigations

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

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

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

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

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

Photo Credit: Holly Hereau

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

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

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

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

Photo credit: Holly Hereau

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

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

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

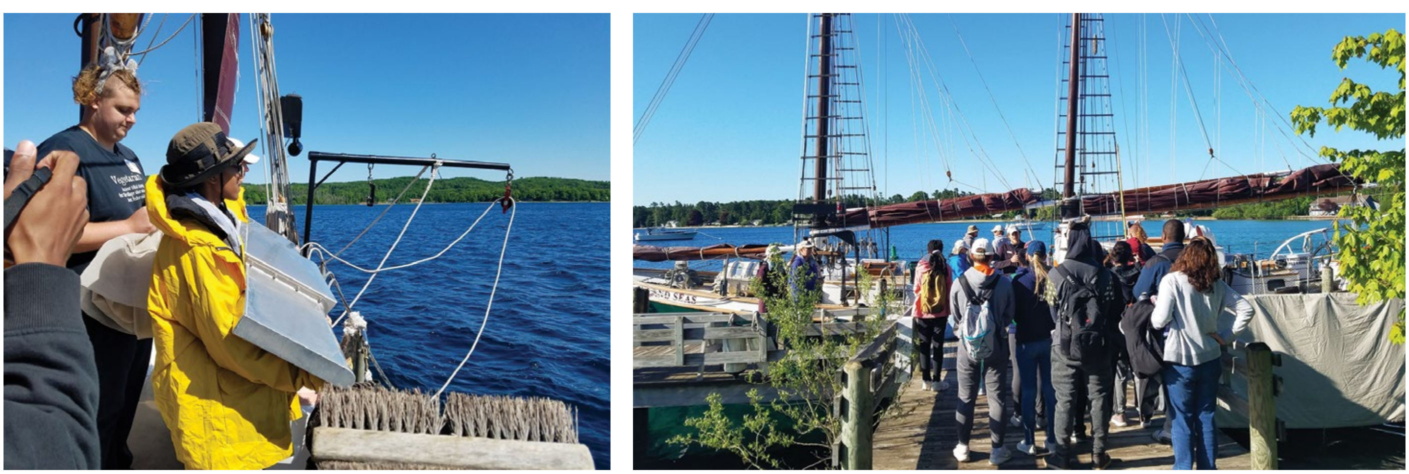

Figure 7 and 7a. Students ready to embark on the Inland Seas vessel *Schoolship* to collect data that monitors the health of Lake Michigan in Suttons Bay.

Photo Credit: Kara Clayton

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

Photo credit: Holly Hereau

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

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

Data Collection and Results

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

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

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

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

2018-2019 Pre- and Post-Survey Comparison

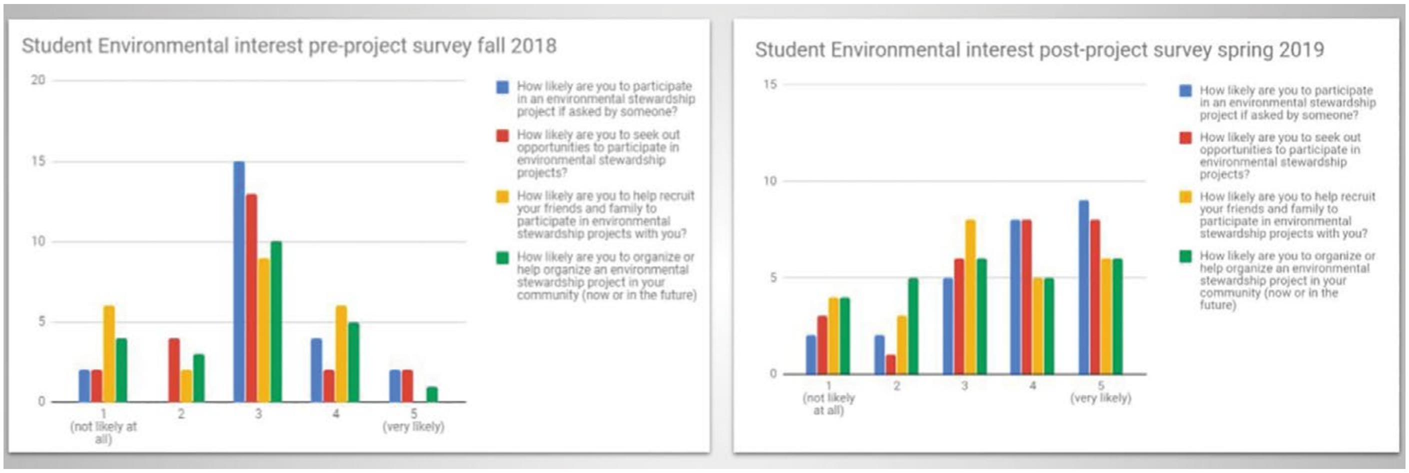

Figure 10. Open-ended survey questions about student participation in environmental stewardship.

About the Author

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

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

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

References

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

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

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

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

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

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

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