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Abstract

The Virginia Commonwealth University's (VCU) three-year National Oceanic and Atmospheric Administration (NOAA) Bay Watershed Education and Training (B-WET) grant worked with four school districts along the James River in Virginia helped teachers and the students they serve understand the role bivalves play in sustaining local watershed ecosystems. Two colleges across three centers at VCU contributed to the grant, which include the School of Education Center for Innovation in STEM Education, and VCU Life Sciences that included the VCU Rice Rivers Center and the Center for Environmental Studies. External partners included the Harrison Lake National Fish Hatchery-US Fish and Wildlife Service, the James River Association and the Chesapeake Bay Foundation to help deliver a comprehensive program. Students shared their stewardship efforts at the Virginia State Capitol. Five free environmental science modules (a collection of thematic lessons coupled with digital media) developed through this NOAA grant are housed at the the Virginia Department of Education "Go OpenVA" education portal. The modules present lessons in the following areas: a) virtual field studies for mussels and oysters, b) online role-play experiences for mussels and oysters, and c) an online simulation integrating the impact and sustainability of mussels in an agricultural environment.

Introduction

As we move past the isolation in our school systems driven by the necessities of COVID, the Virginia Commonwealth University (VCU) School of Education is excited to share the positive outcome and experiences from a three-year National Oceanic and Atmospheric Administration (NOAA) Bay Watershed Education and Training (B-WET) grant for other science educators! This grant allowed working with four school districts (middle schools in Colonial Heights, New Kent County, Charles City County and Newport News) along the James River in Virginia to help teachers and their students understand the role bivalves play in sustaining local watershed ecosystems. We developed a blended (onsite and virtual exploration) of a Meaningful Watershed Education Experience (MWEE) that includes five free environmental science modules for secondary teachers and their students.

The Virginia Department of Education Open Education Resource portal, <u>GoOpenVA</u>, now hosts five modules in a hub titled: <u>VCU Watersheds Education Training Program</u>, which provide a virtual investigative opportunity for students as they explore the role bivalves (mussels and oysters) play in sustaining local

watershed ecosystems. The modules cover present collections of lessons and digital media for both mussels and oysters related to: a) virtual field studies, b) online role-play experiences, and c) an online agricultural simulation with mussels.

Leveraging Bivalves for Learning Middle School Environmental Science

This B-WET grant focused on increasing student understanding of the importance of protecting and restoring their local watershed along the James River that feeds into the Chesapeake Bay. Students were enveloped in a meaningful watershed educational experience (MWEE) using bivalves (oysters and mussels) as a contextual theme to connect all middle school students' efforts under a single "bivalve" umbrella (upriver fresh water ecosystems and downriver brackish/salt water bivalves ecosystems).

Students from participating middle schools engaged in hands-on investigations drawing from, and informed by, cutting-edge research being explored by leading researchers and near-peer graduate students at the VCU Center for Environmental Studies and the VCU Rice Rivers Research Center. Application of the research concerning bivalve ecosystems, their impact on watersheds, their viability to the VA economy, and sustaining their local environment were topics shared as part of the teacher professional development. In turn participating teachers then translated this for their students that included topics, such as the ecological, economic, and cultural impacts along the James River (upriver for fresh water mussels where urban and rural middle schools resided) and downriver where saltwater oyster bivalve ecosystems were discussed.



Figure 1. John (Jack) Reid-Ryan, a Graduate Student in VCU Life Sciences, working with students as they create their own clean water filters to emulate bivalve water filtration.



Figure 3. Casey Johnson (left), a Graduate Student in VCU Life Sciences, assists participating district teachers in stream measurements at the VCU Rice Rivers Center.

Photo Credit: Terry Brown



Figure 2. Dr. James Vonesh helps teachers in hands-on experience in conducting stream study lessons they can do with their students such as water flow, quality, and turbidity.

Photo Credit: Terry Brown

This effort was led by knowledgeable science education experts through <u>VCU School of Education</u>, adept in facilitating the latest pedagogical strategies expressed in the National Academy K12 Frameworks for Science Education (National Research Council, 2012), the Next Generation Science Standards (National Research Council, 2013), and lesson development tools such as, developing rich storylines, grade-level appropriate investigable phenomena, and unpacking and intertwining the disciplinary core ideas of science through science and engineering practices (Tyler, B., & DiRanna, K., 2018).

The VCU team of expert educators, life science researchers, and graduate students worked side-by-side with their in-school teachers and district instructional colleagues from each participating school. Together they forged an effort that

ensured a high impact, science, technology, engineering, and mathematics (STEM) hands-on active learning experience for all participating students in their school. This occurred through integrated classroom activities supported via mini-grants, classroom visits from VCU faculty and graduate students, all tightly coupled to a locally relevant, authentic, and socially impactful environmental issue experienced first-hand through a student-led outdoor watershed project.

An initial <u>summer teacher professional learning model</u> launched the experience at the VCU Rice Rivers Center with hands-on lessons, onsite field experiences, subject matter expert discussions, and facilitated pedagogical teacher-teacher implementation dialog for their unique audiences along the James River continuum:

- oysters versus mussels depending on their location along the James River
- agricultural versus urban themes given their geographic regions along the James River
- environmental themes for mussels: threatened & endangered and invasive species, and
- environmental themes for oysters: commercialism (aquaculture) versus conservation (sanctuaries).

External partners, that included the <u>Harrison Lake National Fish Hatchery</u> with Rachael Mair, The <u>Chesapeake Bay Foundation</u> and the <u>James River Association</u>, also provided keen insights with hands-on tours, lectures, and observation of their role in replenishing mussels for the James River and beyond. The first year culminated with each school bringing teams to the Virginia State Capital where they shared their learning and ideas for their local future stewardship action projects. This effort was a transformative culminating experience, where students were able to showcase their year-to-date efforts to their elected state representatives and the Agriculture Chesapeake and Natural Resources committee. Students were recognized <u>via a proclamation from both the VA congressional house of delegates and senate floors</u> coupled with an National Science Foundation (NSF)-funded effort video: <u>STEM for All Showcase video</u> to document their experience.

Relevant Storylines Drive Meaningful Watershed Investigations

There are powerful James River storylines that were closely intertwined in our efforts that teachers gained practice as part of their professional learning to implement into their classrooms. We conjoined the authentic and locally relevant storylines with local watershed water-quality investigations and related student stewardship projects. VCU faculty and graduate student interactions, synthesized the effort and catalyzed student curiosity and learning through active environmental engagement.

For example, one storyline in the upper James River concerns freshwater bivalves (mussels). These bivalves remove vast quantities of algae and bacteria (among other contaminants) from the river, filtering millions of gallons of water daily. They repackage organic food for aquatic insects, which serve as food for fish, and stabilize the river bottom during high water flows. Not only are native freshwater mussels essential to maintaining a vibrant ecosystem and biodiversity, they serve as our "canaries in the coal mines," providing keen insight as the leading indicators into the health—or precipitous decline—of our global freshwater ecosystems. The United States is home to a significant majority of freshwater mussel species in the world (300 species from the 1,000 across the globe), and Virginia alone is host to over 20 threatened and endangered bivalve species. Students compared and contrasted invasive species threat on native mussels in the Upper James River as they tested water quality linked to their learning about the positive impact freshwater mussels provide for their local ecosystem.

Unfortunately, as students will discover, freshwater mussels are the most diverse threatened and endangered (T&E) freshwater species, and one species (<u>James spinymussel Pleurobema collina</u>) is found in our upper James River. Through hands-on field observation and data comparisons, students uncovered that poor water

quality, changing habitat conditions (chemical contaminants, sedimentation), and invasive species, such as the introduced Asian clam (*Corbicula*), are inflicting a dangerous decline of our native James River freshwater mussels. Simple student-derived questions may arise, such as:

- What is so harmful about the Asian Clam; and how did it get here?
- If the Asian clam shell is harder than the native species, wouldn't that make it hardier and more resilient against contaminants
- If it is larger, wouldn't its filtering capabilities produce more clean water?

This leads to more student-generated questions and opportunities to compare and contrast proposed beneficial and detrimental impacts. Native freshwater mussels play a multidimensional role in the ecosystem. With the James spinymussel's smaller and softer shell, it might be a critical food source, readily available for other animals in a complex food web in which the Asian clam is not. Losing one or two species could cascade into losing many more.

Online Learning: Bivalve Watershed Modules

As COVID restricted classroom access and student field experiences, we shifted to generating a series of online modules for virtual exploration and learning of the bivalve content. We hosted a series of webinars with our teachers to discuss how to implement the NOAA Oysters in the Chesapeake Bay lessons in a virtual setting that included student virtual showcases of what they learned through the lessons and stewardship planning this past year. In addition, we collaborated with our participating schools in planning content to create opportunities for virtual field testing for oysters and mussels as well as accompanying role-play experiences for bivalves and collaborated with Iowa State University to augment their *People in Ecosystems Watershed Integration* (PEWI) agricultural simulation to include the ecosystem services and impacts on mussels in a local stream. Research-based instructional design strategies, formative pilot testing, role-play research, and the 5E learning model were employed to ensure sound instructional resources and adherence to the Next Generation Science Standards (NGSS) (Bybee, R. W., 2015; Dick, W., Carey, L., & Carey, J. O., 2008; G. Wiggins, J. McTighe, 2005; Linser, R., 2019; National Research Council, 2013). In the second article that goes into depth on each module, a close alignment and identification to specific NGSS standards are described.

The Virginia Department of Education Open Education Resource portal, <u>GoOpenVA</u> hosts the five modules in a single hub titled: <u>VCU Watersheds Education Training Program</u> that provide a virtual investigative opportunity for students as they explore the role bivalves play in sustaining local watershed ecosystems. The online environmental science module titles are listed below.

Individual Bivalve Watershed Modules:

- VCU Chesapeake Bay Watersheds Oyster Field Studies: Middle School Lessons
- VCU Chesapeake Bay Watersheds Mussel Field Studies: Middle School Lessons
- VCU Chesapeake Bay Watersheds Oysters Role Play: Secondary Lessons
- VCU Chesapeake Bay Watersheds Mussel Role Play: Secondary Lessons
- VCU Chesapeake Bay Watersheds People in Ecosystems Watershed Integration (PEWI)
 Mussel Simulation

PDF presentations sharing the modules are also available as teacher resources.

- VCU: The Role of Bivalves in Sustaining Watershed Ecosystems.pdf
- VCU: Role-Play Experiences Sustaining Watershed Ecosystems.pdf
- VCU: PEWI (mussel simulation) and Watershed Ecosystems.pdf



Figure 4. VCU faculty and graduate students pictured with teachers from the four participating districts: Colonial Heights, New Kent, Charles City County and Newport News celebrate their learning at the VCU Rice Rivers Center. Photo Credit: Terry Brown.

Summary

A Meaningful Watershed Educational Experience served as the framework for our program design and implementation with teachers. Students shared their plans for their <u>stewardship action projects with representatives at their state capital</u> and via <u>an overview video</u>. A deeper student appreciation and understanding of the important role bivalves play in our ecosystem was confirmed through: a) students field studies and issue identification, our observations and engagement with students during school visits, and the student teams sharing their local stewardship action projects at the Virginia State Capitol.

Online educational support curriculum modules assist teachers with virtual field studies, online role-play experiences and an online agriculture simulation exploring the impact of mussels. The five modules were developed in partnership with the following leadership: Principal Investigator (PI), Dr. Al Byers, Co-PI, Dr. Elizabeth Edmondson and Ms. Sue Kirk, Project Coordinator in the VCU School of Education, Co-PI Dr. Greg Garman, Director at the VCU Rice Rivers Center and Co-PI Dr. James Vonesh, Assistant Director at the VCU Center for Environmental Studies. The resources are assembled into a single hub at the Virginia Department of Education GoOpenVA Open Education Resource portal titled: VCU Watersheds Education and Training Program.

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