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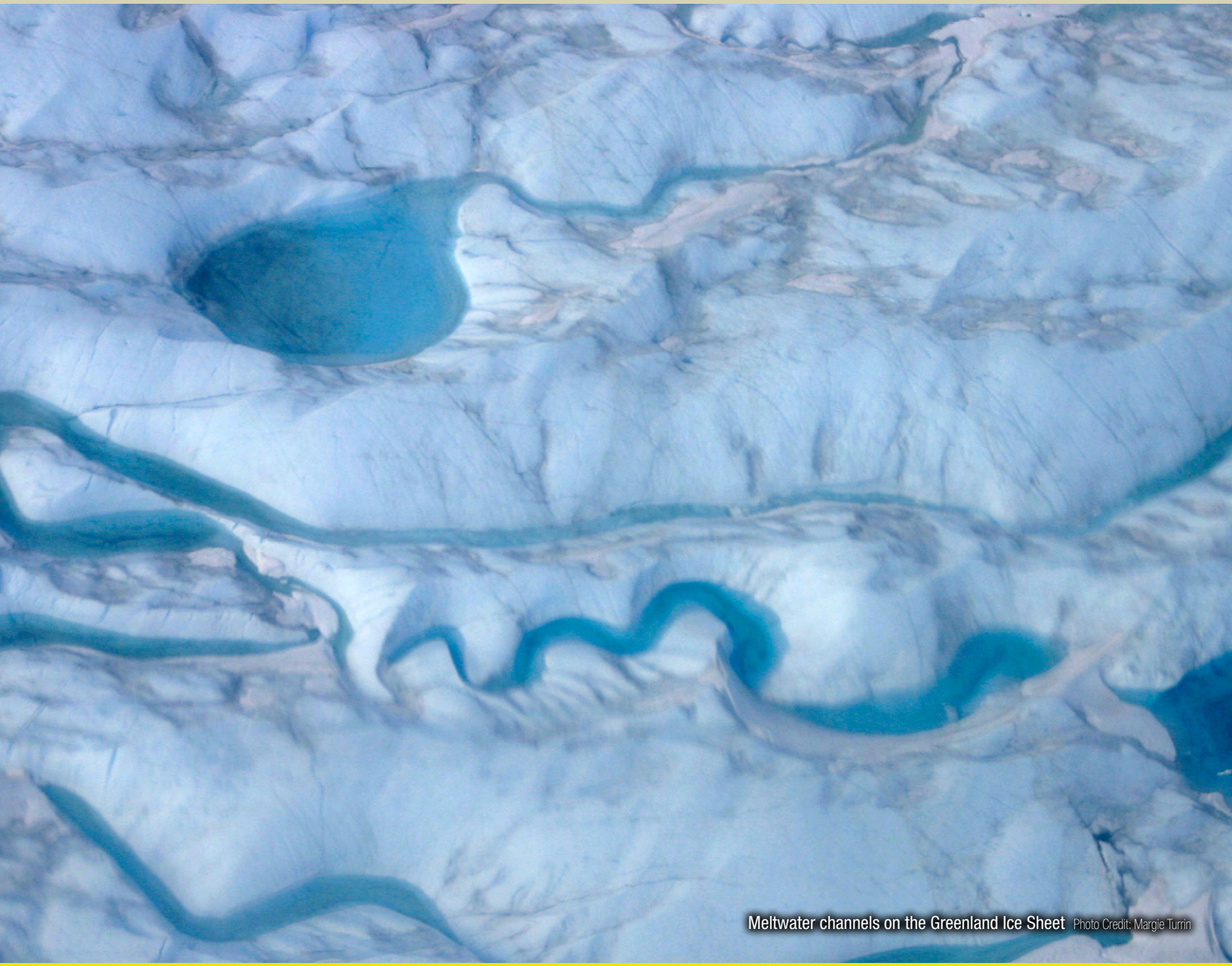

Meltwater channels on the Greenland Ice Sheet Photo Credit: Margie Turrin

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Investigations in Environmental Science: The Role Bivalves Play in Sustaining Local Watershed Ecosystems

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Photo credit: Al Byers

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, GoOpenVA, now hosts five modules in a hub titled: VCU Watersheds Education Training Program, 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.
Photo Credit: Al Byers

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

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

This effort was led by knowledgeable science education experts through VCU School of Education, 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 summer teacher professional learning model 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 Harrison Lake National Fish Hatchery with Rachael Mair, The Chesapeake Bay Foundation and the James River Association, 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 via a proclamation from both the VA congressional house of delegates and senate floors coupled with an National Science Foundation (NSF)-funded effort video: STEM for All Showcase video 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 (James spinymussel *Pleurobema collina*) 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, GoOpenVA hosts the five modules in a single hub titled: VCU Watersheds Education Training Program 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 stewardship action projects with representatives at their state capital and via an overview video. 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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About the Authors

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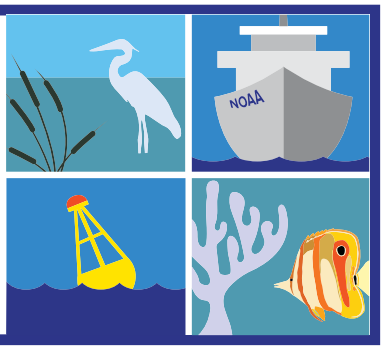
Dr. Greg Garman is an Associate Professor and Director of the Rice Rivers Center at Virginia Commonwealth University. Dr. Garman is a broadly-trained fish ecologist with research interests in coastal rivers, migratory fishes, and invasive species management. Since 2015, he has directed VCU's Rice Rivers Center (ricerivers.vcu.edu), VCU's academic field station on the banks of the tidal James River, Virginia. The Center supports a wide range of environmental research efforts, experiential learning, and community outreach. Greg can be contacted at ggarman@vcu.edu.

Dr. James Vonesh is a Professor and Director of Undergraduate Studies at the Center for Environmental Studies, Virginia Commonwealth University. He has over 20 years of experience in ecological research and higher education where he has worked to advance our understanding of organismal biology and freshwater systems and to build bridges across departments, universities, professional societies, government agencies, and NGOs to create opportunities for students and faculty to engage in immersive field-based learning and research. James can be contacted at jrvonesh@vcu.edu.



Virtual Field Studies, Role-Play Experiences, and Simulations: The Role Bivalves Play in Sustaining Local Watershed Ecosystems

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Virginia Commonwealth University

Eastern Oyster (Crassostrea virginica)

Abstract

Five free environmental science modules, developed by the Virginia Commonwealth University's (VCU) School of Education, the VCU Center for Environmental Studies and the VCU Rice Rivers Center, explore the role bivalves (mussels and oysters) play in sustaining local watershed ecosystems. Developed in collaboration with teachers and their students from four school districts along the James River in Virginia, the modules (a collection of thematic lessons coupled with digital media) are housed at the Virginia Department of Education GoOpenVA Open Educational Resources (OER) Portal. The modules include: 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

To assist teachers in implementing environmental science for secondary school students, five free environmental science modules are available online at the Virginia Department of Education's Open Educational Resources Portal. From this portal, teachers can download, edit, augment and share environmental science lessons with others. The modules elaborate and engage students in learning about the ecosystem services bivalves (mussels and oysters) provide upriver (mussels) and downriver (oysters) feeding into the Chesapeake Bay.

Bivalve Watershed Module Overview and Access

Modules 1 and 2: VCU Chesapeake Bay Watersheds Oyster and Mussel Field Studies: Middle School Lessons

We wanted to provide schools with a sequence of lessons that would allow students to conduct a Meaningful Watershed Education Experience (MWEE) with a focus on bivalves either virtually, hybrid, or face-to-face. We identified the 5E learning cycle as a lesson design framework, incorporated strategies from problem-based learning, and identified technologies that would be useful in virtual and face-to-face environments (See Table 1). The technology employed for modules 1 and 2 included the use of ArcGIS StoryMaps, Google Earth Project, and Thinglink. The oyster and mussel field studies modules may be accessed at the end of this article.

Table 1. Lesson Design Features Used in the Modules

MWEE Components The Meaningful Watershed Educational Experience (MWEE) is a learner-centered framework that focuses on investigations into local environmental issues and leads to informed action.	issue definition, outdoor field experiences, synthesis and conclusions, and environmental action projects
5E Learning Cycle	BSCS Model (Bybee, R. W., 2015): Engage, Explore, Explain, Elaborate, Evaluate
Problem-based learning	Sterling Model (Sterling D.R., 2007): Engage in a real-world problem, find out what students know and want to know, develop a question map to drive instruction and lesson development, conclude solution(s) to the problem.
Technologies Identified	Use of ArcGIS StoryMaps, Google Earth Project, and Thinglink

For the initial lesson, Lesson A, we decided an important first step was to provide an overview of bivalves to students before engaging them in the problem. The next lesson, Lesson B, presents the problem students will work to develop solutions for and has them develop a chart (Lessons C-K) with what they know and want to know (KWL) about the problem. Table 2 provides a description of each of the lessons that follows these two.

Module 3 and 4: VCU Chesapeake Bay Watersheds Oysters and Mussels Role Play: Secondary Lessons

A Role-Play Experience or simulation is "a dynamic artificial environment representing a simplification of a real or fictional social system in which participants interact with one another as roles with given characteristics, objectives and relations (social rules) to one another are provided within a specified scenario (set of conditions/state of affairs)." (Linser, R, 2019). Linser's research suggests that when students are allowed to choose an authentic role with open-ended outcomes and working collectively as a team in their role, their level of engagement and cognitive effort positively increases.

In our Role Play Experience, students explore the science underlying ecosystem management by playing the roles of the various stakeholders (individuals and organizations) involved in oyster and mussel management. Students examine the authentic issues, problems and possible solutions to oyster and mussel management through their investigative efforts as they review articles, videos, data sets, and generate synthesized content to share with other students. Moreover, by participating, they create a collaborative experience by which they learn from each other about the subject under investigation. Each authentic role (where multiple students can imbue a single role) generates a breadth of issues to investigate and discuss, enabling all participants to engage in deeper understanding of the complexity and application of the subject matter.

Students work in small teams and develop a role they select. This experience strongly aligns to the Next Generation Science Standards (NGSS) and the K12 Frameworks for Science Education (National Research Council, 2012; National Research Council, 2013). Deeper learning of the disciplinary core ideas of science are facilitated as students' curiosity is sparked through asking their own driving

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Ties to NGSS

Students will have the opportunity to engage in the following Science and Engineering Practices via the role-play experiences:

- Analyzing and interpreting data,
- Constructing explanations (for science) and designing solutions (for engineering)
- Engaging in argument from evidence (claim-evidence-reasoning)
- Obtaining, evaluating, and communicating information

The following Performance Expectations are investigated and unpacked through the role-play experiences in the following areas:

- MS-LS2-1 Ecosystems: Interactions, Energy, and Dynamics
- MS-LS2-2 Ecosystems: Interactions, Energy, and Dynamics
- MS-LS2-3: Ecosystems: Interactions, Energy, and Dynamics
- MS-LS2-4: Ecosystems: Interactions, Energy, and Dynamics
- MS-LS2-5: Ecosystems: Interactions, Energy, and Dynamics

Table 2. Sequence of Lessons for Mussels and Oysters

The teacher can decide which bivalve they desire to investigate after doing lesson A and B, based on their own preference of bivalve (freshwater or saltwater)

Mussels	Oysters
Lesson A: Bivalves- What are they? This lesson is designed as an engage lesson to introduce students to the two organisms studied in the Bivalves as Ecosystems Sustaining Treasures (BEST) in Bay Watershed Project. Students will engage with images of mollusks to learn which are bivalves.	
Lesson B: An Introduction to the Problem Problem: For many years, scientists have been observing a decline in the freshwater mussel and saltwater oyster populations. This decline is significant as it impacts the ecosystems they live in. From this point in the flow, teachers select which bivalve they desire to investigate with lessons generated for each bivalve (mussels or oysters). (**MWEE Step 1**)	
Lesson C: Background on Mussels Students learn more about mussels, including: • Various Freshwater Mussels • Mussel Classification and Structure • Locations of Mussels • Comparison to Saltwater Mussels • Graphs- Data tables with numbers over time and analysis of data patterns • Use of Mussels through time	**Lesson C: Background on Oysters** Students will learn more about oysters, including: • Various Types of Oysters • Classification and Structure • Locations of Oysters • Comparison to other bivalves • Graphs- Data tables with Numbers over time and analysis of data patterns • Use of Oysters through time
Lesson D: The Role of Mussels in the Ecosystem Lesson is designed to allow students to collect information about the role that mussels play in their ecosystem and the watershed that they live in. • Review abiotic and biotic factors • Determine the abiotic and biotic factors in the mussel ecosystem. • Examine the role of mussels in their ecosystem: what is their function/job? • Learn their place in a food chain and food web. Learn the role of plankton in the chain/web. • Identify their watershed and the watershed of the mussels	**Lesson D: The Role of Oysters in the Ecosystem** Lesson is designed to allow students to collect information about the role that oysters play in their ecosystem and the watershed that they live in. • Review abiotic and biotic factors • Determine the abiotic and biotic factors in the oyster ecosystem. • Examine the role of oysters in their ecosystem: what is their function/job? • Learn their place in a food chain and food web. Learn the role of plankton in the chain/web. • Identify their watershed and the watershed of the oysters
Lesson E: Mussel Life Cycle Students collect information about the life history of mussels. Explore the life history of mussels and the components that can be impacted by variations in their ecosystem	**Lesson E: Oyster Life Cycle** Students collect information about the life history of oysters. Explore the life history of oysters and the components that can be impacted by variations in their ecosystem.
Lesson F&G: Water Quality in their Ecosystem Students use standard water-testing equipment to test and record precise measurements of water quality for samples from local natural sites. Through analysis of the data, they will relate water-quality parameters' relevance to aquatic ecosystem health. (**MWEE Step 2**)	
Lesson H: Human Impact Students are introduced to the impacts of human activity on the health of watersheds. Both point source and non-point source pollution are investigated and used to evaluate the health of the Chesapeake Bay and the James River. Finally, students will be asked to consider ways the human impact can be modified to improve water quality and bivalve habitat.	**Lesson H: Human Impact** Students are introduced to the impacts of human activity on the health of watersheds. Both point source and non-point source pollution will be investigated and used to evaluate the health of the Chesapeake Bay and the James River. Finally, students will be asked to consider ways the human impact can be modified to improve water quality and bivalve habitat.
PEWI Simulation (separate module) Students test out various scenarios impacting water quality and mussel population size.	**PEWI Simulation** (separate module) While focused on mussels, this sim could be used to consider various impacts on water quality and biodiversity for those interested in oysters.

Mussels	Oysters
Lesson I: Restoration Efforts This lesson is designed to allow students to learn about restoration efforts at the Harrison Lake National Fish Hatchery including: • The role of hatcheries in restoring fish and mussel populations • How mussels are raised in a laboratory setting and how that is similar and different from their life history in their natural habitat	**Lesson I: Restoration Efforts** This lesson is designed to allow students to learn about restoration efforts through the Virginia Oyster Shell Recycling Program (VOSRP). Students will: • Brainstorm reasons why oyster populations in Virginia need to be restored • Learn about the role of VOSRP in restoring oyster populations in the Bay • Learn about how restaurants, nurseries, haulers, and volunteers make VOSRP possible • Learn how a shell is recycled. • Learn which months are for preparation and which months are for oyster larvae attachment
Lesson J: Synthesizing our Learning Students will identify, synthesize, and apply evidence from their investigations to draw conclusions and make claims about the issue, problem, or phenomenon. They convey data and information about their investigations, conclusions, and claims to audiences ranging from classrooms to the larger public community. The focus is on putting together what they have learned about the overarching question rather than inspiring action. (**MWEE Step 3**)	**Lesson J: Synthesizing our Learning** Students will identify, synthesize, and apply evidence from their investigations to draw conclusions and make claims about the issue, problem, or phenomenon. They convey data and information about their investigations, conclusions, and claims to audiences ranging from classrooms to the larger public community. The focus is on putting together what they have learned about the overarching question rather than inspiring action. (**MWEE Step 3**)
Lesson K: Taking Action Once students have generated a conclusion, they should work in small groups or as a class to brainstorm and evaluate solutions, and then take action! Throughout this process, teachers play an important facilitation role by forming groups, moderating, and answering questions, while students drive the decision-making, planning, and implementation in an age-appropriate way. Action projects may include stewardship, civic action, or a combination of both. Students reflect on the action and determine the extent to which the action successfully addressed the problem, challenge, or opportunity reflected in the conclusion. Students may also share proposals for sustaining or extending the action. (**MWEE Step 4**)	

questions to locally authentic challenges in the world in which they live.

Pilot testing is critical to improve the effectiveness of newly developed lessons (Tessmer, M. 1993). The input from practitioners implementing the lesson based on desired learning outcomes with students was invaluable and part of any rigorous instructional design model (Dick, W., Carey, L., and Carey, J.O., 2008; Wiggins, G. and McTighe, J., 2005). This effort involved in-depth teacher and student feedback on the module lessons. In addition, we asked whether it altered their view, and if so, how? We collected anonymous student work products, gathered tips for implementation, and asked how to augment the lesson for different student audiences. Teacher feedback was incorporated into revisions.

Teacher Feedback Questions Guided Revision

Please describe the adequacy of the information presentation and activities, practice, review and/or assessments for these experiences.

- Was there sufficient instructor scaffolding in the material to help you implement it with your students, such as background information for teachers, and detail for activity implementation?
- If you were recommending one or more of the lessons to colleagues, what "critical" tip would you suggest to help them improve the lesson's effectiveness?
- Given your student-make-up, how might the lessons be augmented for those with particular special needs, gifted, or ELL students?

The objective for the role-play experiences for students is to critically investigate and understand the complexities of oyster and mussel management in the Chesapeake Bay area and its rivers. Students explore how oysters and mussels sustain our watershed ecosystems.

Figure 1. Volunteers at the VCU Rice Rivers Center shovel recycled oyster shells from 60+ restaurants that are seeded with baby oysters (spat), returning millions of oysters to sanctuaries in the Chesapeake Bay. Photo Credit: Todd Janeski

The big picture components for the role play includes the following:

- Students assume interactive roles such as watermen, consumers, environmentalists, scientists, and government administrators.
- Students working in teams (2-4) explore how their roles intersect in complementary and competing ways and debate their unique role agendas & issues.
- Problem-solve authentic challenges addressing conservation versus commercialism (oysters) and threatened & endangered species (mussels).
- Students use data as evidence to support their claims / reasoning and to advance their agenda issues via student-student discourse. Teachers facilitate.

The role-play experiences aim to familiarize students with the scientific concepts underlying:

- how organisms within an ecosystem are dependent on one another and on non-livingcomponents of the environment.
- the interactions within and among populations in a biological community such as competition, cooperation, social hierarchy, territorial imperatives and influence they have on each other.
- the adaptations of organisms to biotic and abiotic factors, and their dynamic changes over time.

One of the most fundamental aspects of any role-play simulation is the persistence of students' 'suspension of disbelief' and identification with their role. They must come to believe that they embody the roles they play, and in their relationships and interaction with other roles within the authentic context and scenario. Thus, teachers must emphasize to students that they are acting on behalf of their organizations and constituencies, not as themselves.

Each role play begins with an authentic scenario where students are then led to ask their own driving questions, investigate articles, resources that support their unique role and organization.

Mussels Die-Off Scenario: What do we know and what can we do about it?

This authentic scenario addresses land-use practices and their related issues such as: a) sedimentation rates, water quality, and stream-channel mobility. Freshwater mussels filter out algae, silt and pollutants, making waterways habitable for other aquatic life. Recently, many different species of mussels are experiencing mass die-offs. Researchers are struggling to understand why.

The Challenge: Review and identify the causes and possible solutions to mussel die-offs, and to evaluate the scientific evidence for managing and reversing the stresses on the mussel population in the Chesapeake Bay, and to use this data as evidence to support their position through student-student discourse, voting on issues and actions to share with others via a conference.

There are five discrete stages to the role play:

Stage 1: Students review actual roles that they can select (scientists, engineers, regulators, environmentalists, etc.)

Stage 2: Students review the role profile with the team, generate a role profile and create a position statement to share (identify a single agenda for the profile and organization)

Stage 3: Interview other roles, review other role profiles, create position statement

Stage 4: Host moderated conference where different roles share out their issues, vote on the top 5 issues across all organizations, generate resolutions for action regarding the challenge

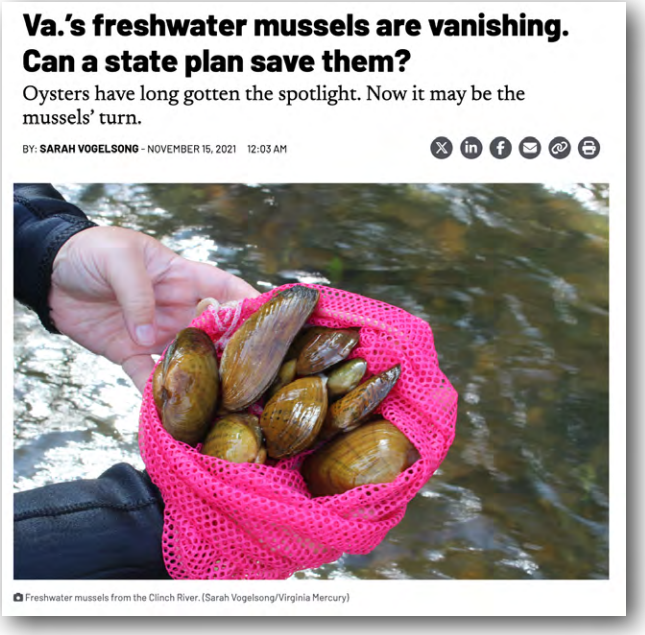
Stage 5: Students debrief about the experience, reflecting on their position, how difficult or easy it was to collaborate with others, and did their position change in light of the student-student discourse.

Mussels Die-Off: Guiding Questions

1. What programs have been initiated or planned by your organization to overcome the issue?
2. What scientific evidence supports these programs? And what further research would your organization recommend?
3. What does your organization need to be able to implement such programs? In what ways can other organizations help your organization to achieve its aims?
4. What are the difficulties that you encounter in your efforts to achieve the aims of your organization?

Figure 2. A male and female life science ecologist prepare to scuba dive in the James River to restore the mussels in sacks grown at the Harrison Lake National Fish Hatchery, a partner of the VCU Best in Bay Watersheds grant. Photo Credit: Al Byers

Students take on the roles of specific individuals whose career function is highlighted in Table 1. Roles include actively employed environmentalists, researchers or elected state regulatory agency individuals. Digital media (articles, video and audio are provided as links in the modules) to assist students in researching their various roles.


Va.'s freshwater mussels are vanishing. Can a state plan save them?

Oysters have long gotten the spotlight. Now it may be the mussels' turn.

BY: SARAH VOGELSONG - NOVEMBER 15, 2021 12:03 AM

Freshwater mussels from the Clinch River. (Sarah Vogelsong/Virginia Mercury)

Figure 3. Sample article from many identified as resources for students' investigations based on their selected team for the role-play experience and student-student argumentative discourse.

Photo Credit: Sarah Vogelsong

Oyster Management Scenario: What can we do to revive the population of Chesapeake Oysters?

Eastern oysters make up one of the Chesapeake Bay's most valuable commercial fisheries. Oysters are also filter-feeders that help to clean the waters and provide food and habitat for animals. *Over-harvesting, disease, and habitat loss* have led to a severe drop in oyster populations. Scientists, environmentalists, and resource managers are working to manage harvests, establish sanctuaries, overcome the effects of disease, and restore reefs.

To this end, the Secretary of Natural Resources in the Office of the Governor of the Commonwealth of Virginia, Matthew J. Strickle, together with the Chesapeake Bay Commission, have called for a conference of stakeholders to present their programs and efforts and to discuss their needs.

The aim of the conference is to review the various oyster-recovery programs in the Chesapeake Bay and evaluate the scientific evidence that supports them. Further, the Commonwealth of Virginia also seeks suggestions from stakeholders on further integrating the scientific evidence to improve its Environmental Literacy program.

The Challenge: Achieving a balance between the needs of the stakeholders is crucial to the success of the oyster-recovery program.

Students select their role to work as a team of 2-4 in a group assuming the career duties of real people across different agencies, universities and non-profit environmental organizations.

Below are questions to address as you prepare to attend the conference, support your position given the role you will play and the organization's mission you are supporting (watermen/fishermen, farmers, consumers, environmentalists, scientists/researchers, government administrators, and individuals representing the media).

The conference (scheduled approximately 2 weeks into the role play experience) seeks to produce draft resolutions to guide further efforts. Digital media (articles, video and audio are provided as links in the role-play modules) to assist students in researching their various roles. One example includes the actual audio from a Virginia Marine Resources Commission meeting (3:46 min) that debates opening up an oyster sanctuary along the James River.

Oyster Management: Guiding Questions

1. What programs have been initiated or planned by your organization to overcome the issues above?
2. What scientific evidence supports these programs? And what further research would your organization recommend?
3. What does your organization need to be able to implement such programs? In what ways can other organizations help your organization to achieve its aims? And what are the difficulties that you encounter in your efforts to achieve the aims of your organization?
4. Finally, in what ways does your organization support the Environmental Literacy program? And what suggestions do you have to further this project with the aid of government agencies and other organizations?

In closing the discussion on the oyster and mussel role play modules, the process is one that allows students to learn the science and engage in the practices of argumentative student-student discourse through a claims-evidence-reasoning approach espoused in the NGSS.

The roleplay modules employ a strategy to help students facilitate evidence-based discussions using "accountable" talk sentence stems (Tyler, 2018). These help students frame their question to an opposing group in the RPE that may be presenting an alternative view on an issue (mussels or oysters). Students should ground their arguments, explanations and claims with scientific data to support their positions. Using sentence starters like these below move the dialog to one that is based on scientific evidence drawn from research versus a passionately expressed opinion.

These sentence starters will help students frame how they might engage with those in another group of the Role-Play Experience, e.g., watermen talking with governmental agencies on the length of a harvest season, or the type of harvesting permitted (scrapping or hand tonging), or which oyster beds might be opened for aquaculture (based on impact and sustainable growth data). Similarly for the mussels scenario, agricultural farmers may have different positions to those of environmentalists in their discussions with government officials on regulations and incentives regarding farming along local tributaries.

Examples to model and encourage students to use as they frame their exchanges might be:

- Ask questions: Why do you think __? I was wondering about. .
- Clarify what others are sharing: Say more about that idea. Tell me how you got that information. Explain your evidence that supports your idea.
- Agree with what is being shared: My data also supports ___because__.
- Disagree with what is being shared: That's interesting, but my data show___. or I hear you saying___, but I think ____, because___.

The technology employed for modules 3 and 4 included the use of Camtasia, FLIP video and Padlet. The oyster and mussel role play modules may be accessed from the list of resources at the end of this article.

Module 5: VCU Chesapeake Bay Watersheds – People in Ecosystems Watershed Integration (PEWI) Mussel Simulation

This series of lessons is designed to support student learning on the impacts of human activity on the health of watersheds and more specifically the freshwater mussel population in Virginia.

Learning Objectives

- Given a description of human activity, the students will be able to identify possible effects of the activity on the quality of both local and remote freshwater.
- Given a description of a type and source of pollution, students will be able to categorize it as either point source or non-point source.
- Students will interpret data to determine the health of specific characteristics of the James River.
- Students will predict how different watershed land-use arrangements might impact the watershed and freshwater mussel populations.

The BEST team collaborated with the Natural Resource Ecology and Management program at Iowa State University to modify their People in Ecosystems Watershed Integration

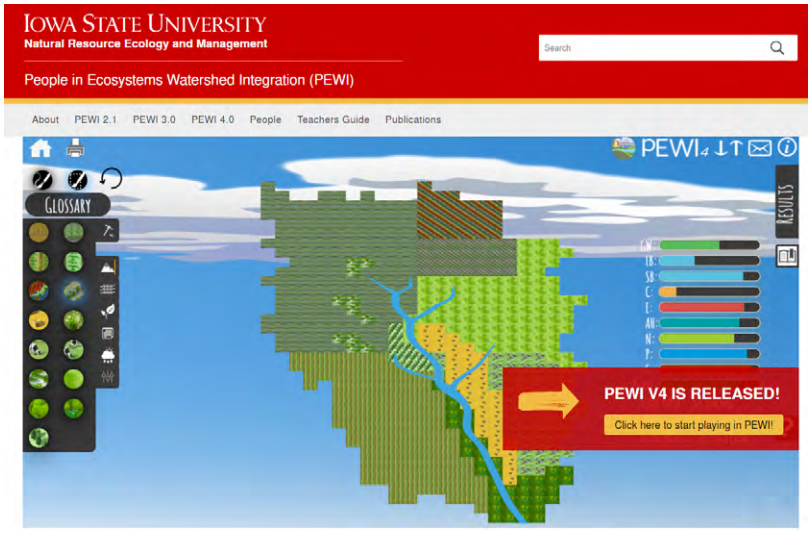


Figure 4. People in Ecosystems Watershed Integration (PEWI) simulation
Screen Captures credit: Sue Kirk

(PEWI) simulation to include the impacts of different land uses on freshwater mussel populations (part of their modifications to PEWI version 4).

The lessons begin with an overarching scenario, in the box below, that provides authenticity for the PEWI

Overarching Scenario

We have been studying different types of pollution as well as freshwater mussels. The VDEQ would like for us to use simulation software to test several scenarios and then report back our findings.

experience, emulating how scientists use simulations to test ideas and future actions, such as by the Virginia Department of Environmental Quality (VDEQ). Students complete an introductory activity (Activity 1) and then using the PEWI Simulation analyze data across four different scenarios for the VA DEQ.

Activity 1: Preparing for the PEWI (several days)

Students investigate point source and non-point source pollution to evaluate the health of the James River (Lesson H: Human Impacts in the VCU Chesapeake Bay Watersheds Mussels Field Studies: Middle School Lessons Collection). The PEWI simulation then helps students investigate ways to modify human impact to improve water quality and bivalve habitats.

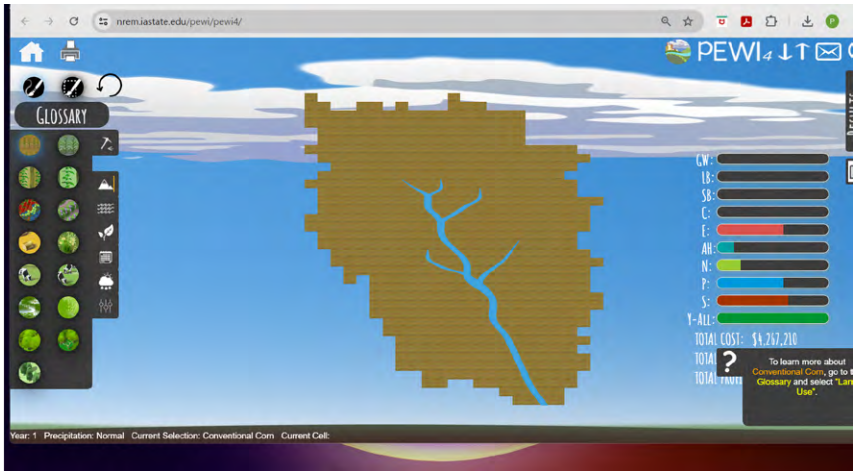


Figure 5. People in Ecosystems Watershed Integration (PEWI) simulation Screen Captures credit: Sue Kirk

Activity 2: Introducing the PEWI (40-50 minutes)

Introduces students to the PEWI simulation and how to use various tools, such as the 15 different land uses, precipitation, and land-management practices.

In activities three through six, students test different scenarios that help them understand how sensitive freshwater ecosystems are to changes. Activity seven provides a synthesis of findings. Students will realize that small changes in land use can eliminate the entire mussel population. Students consider what a pristine environment looks like and conclude by looking at how changes in land coverage impacts nutrient load and stream sedimentation.

Activity 3. Scenario 1: Pristine Landscape to Single Crop Use (40-50 min)

Students begin with a pristine landscape that supports mussels and add different crops to examine the impact of this change on the mussel population.

Activity 4. Scenario 2: Mixed Land Use with multiple crops (40-50 min)

Students select multiple land uses in an effort to maintain the mussel population.

Activity 5. Scenario 3: Restoring Mussel Populations and maintaining profitability by altering Land Use (approximately 90 min)

The scenario provides several options to try that would allow mussel populations to be maintained and allow students to examine the profitability of changes made to land use.

Activity 6. Scenario 4: Land Use Impact on Nutrients and Sediments (50 min)

This final activity has students consider not only the impact on mussels, but also the impact of changes on nutrient levels and sediment load. This activity helps pull together the variables impacting mussel survival.

Activity 7. Synthesis of PEWI experience

Students synthesize their findings into a report addressing the scenario using the Claim, Evidence, and Reasoning Framework (Scientific Explanation).

Conclusion

Five modules were developed in partnership with the VCU School of Education, the VCU Rice Rivers Center and the VCU Center for Environmental Studies to support teachers in their environmental education for secondary students.

We are excited to make these freely available to anyone. The modules are now housed at the Virginia Department of Education "GoOpenVA" OER portal for public review, sharing, augmentation and use in their classrooms. The 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 hub for the five modules below are free and available at GoOpenVA: VCU Watersheds Education and Training Program

Go Open VA OER Portal: Individual Watershed Modules

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

PDF PowerPoint Overviews for modules (teacher background information)

- 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

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