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

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

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Eastern Oyster (*Crassostrea virginica*) Photo Credit: (c) Jessica Utrup, [some rights reserved \(CC BY-NC\)](#)

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.

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-living components 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.



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

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?

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.



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

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](#)

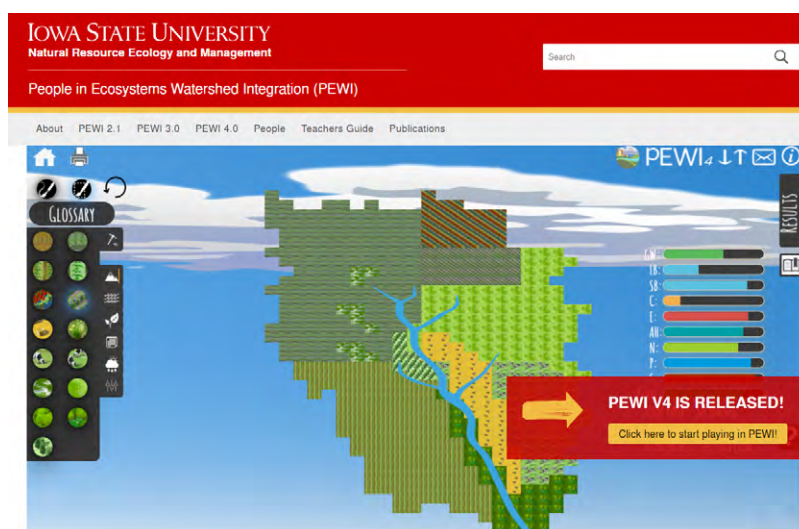


Figure 4. [People in Ecosystems Watershed Integration \(PEWI\)](#) simulation

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.

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.

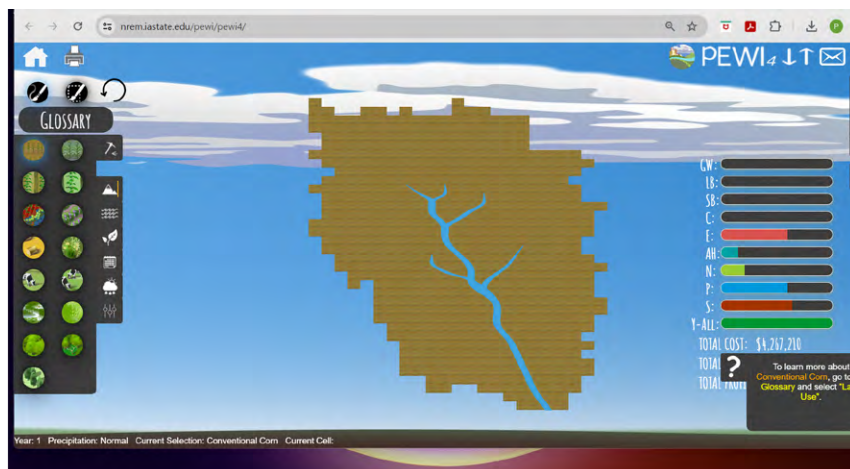


Figure 5. [People in Ecosystems Watershed Integration \(PEWI\)](#) simulation Screen Captures credit: Sue Kirk

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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About the Authors

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The Earth Scientist (TES)

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

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