Photographs: Jennifer Weible

Stewardship in Appalachia

Learning about water quality issues with an action-oriented, place-based pedagogy

By **Jennifer L. Weible** and
Heather Toomey Zimmerman

WORLDWIDE, people are increasingly aware of the factors that impact the quality of their water. In rural Appalachia, many of these issues are painfully apparent. There are problems associated with agriculture such as the contamination from pesticides and nutrients and associated with daily life such as runoff from roads and litter. Also, while new industries and natural gas development can benefit local communities by providing jobs, they also raise concerns. In particular, the effects of fracking to produce natural gas (hydraulic fracturing shale rock by injecting chemically-treated water to gas) and policies about underground water and mineral rights are being questioned by many residents who have strong generational ties to the land.

Because students here play and work outdoors and often engage in subsistence hunting and fishing, their everyday lives intersect with both the economic and ecological concerns that adults face. We posited that lessons that use a place-based perspective would help teachers connect students' lived experiences to the complex issues surrounding water quality and seek connections that help learners become environmental stewards and advocates for the health of the resources within their community.

To study how this might work, we — two researchers from Penn State —partnered with two biology teachers in a poverty-impacted high school in rural Appalachia. Together, we worked with 74 9th and 10th grade students from four biology classes. We collaborated to re-develop a unit on watersheds that focused on the water quality within the students' community. Our intention was to work together to foster deeper place-based connections that would support the students' learning as well as develop an action-oriented mindset towards water-related issues.

An Action View of Environmental Knowledge

It is commonly understood that place-based perspectives have been successfully used to increase students' understandings of environmental topics. More problematic however is teachers' success in changing behaviors— even when they build action-specific strategies into their curriculum requirements. In previous years, the biology teachers we worked with had found that, while students demonstrated an understanding of the science content, there was little change in their ability to apply these new understandings towards solutions to environmental problems. In particular, some of the former students who firmly grasped the scientific concepts had difficulties connecting the topics to their community or their personal lives.

According to B.B. Jensen[1], educators can better support students to make sense of science content and develop

environmentally sound actions by recognizing these different elements. Using his work as a conceptual tool helped us become more intentional in our educational designs specifically when aiming to develop action-oriented, problem-solving strategies; and foster connections to the students' own rural community.

The high school biology class we worked with took part in a three-week inquiry unit into watersheds and included a stream study. To emphasize the place-based perspectives, the teachers selected a stream for the study that fed the community's reservoir. Because this stream eventually provided the high school with their drinking water, the quality of the water in the stream was relevant to the students' daily lives. Also, students relied on the reservoir for fishing, boating, and picnicking throughout the year.

Serving as both the town reservoir and local recreational area, this lake was relevant to the lives of the students.

Because B. B. Jensen's work has informed our own, we've structured our findings below, according to his four categories of outcomes:

1. Understanding the issues

Before the field study, students participated in several activities that focused on developing their knowledge base about watersheds, as well as the health problems associated with water quality. First, to create local connections to the science content, the learners mapped and made models of their own watershed. Students customized their models with community landmarks and with the places they lived, worked, and used for recreational purposes. The maps and models were used to start discussions about environmental responsibility, runoff, and point and non-point sources of pollution.

Second, the students learned the scientific procedures that scientists use to measure water quality. Time was spent in the classroom learning how to interpret the results of various investigations to determine the health of a stream. To keep the unit place-based, the students collected samples from their homes to analyze in class. The students were trained on the protocols for investigating biological (macro-invertebrates) and chemical parameters of a stream. In addition, the students learned about cartography (creating a map of the stream) and the stream's physical parameters (volume, velocity, temperature).

By analyzing students' work, we found evidence of new understandings of the environmental health issues in their watershed. The students used data from the stream study to determine the health of their local stream, and displayed their findings for their community on a webpage. We used students' mind maps as a pre- and post-assessment tool and found over half of the students developed significantly deeper understandings about watersheds. The number of scientific ideas that the students held about watershed increased after participating in the local field study. The students also demonstrated a more sophisticated vocabulary related to environmental health. For example, many students first used the word "chemicals" as a way to describe pollution in the lake and "critters" to talk about the macroinvertebrates. After the unit, students used the words "iron," "nitrates," and "dissolved oxygen" to describe the chemical parameters of the watershed. The students used biological terms such as "sensitive species," "mayfly larvae," or "stonefly nymphs" when discussing the animals that were found during the kick net inquiry.[2]

Also, during this current iteration of the redeveloped watershed unit, increased connections between watershed concepts and the students' everyday lives were found in the reflections written at the end of the unit. For example, as Matt stated, "Now I realize that [the trees and the water] help each other and we need to take care of them.[2]" By the end of the unit, Matt, like many of his peers, understood that the components within the watershed were parts of biological systems that were connected to his everyday life.

2. Knowledge of the causes

Our project supported the development of students' understandings of what things determined the health and quality of their water. Although the students learned all four protocols (identification of macro-invertebrates, chemical parameters, physical parameters, and stream mapping) in the classroom, during the field experience they were assigned to only two of the four protocols during the stream study. The rationale for this specialization was to allow the students to have more time for data collection and analysis on-site. Our goal was to help them build deeper expertise. The data from each station was shared with classmates on a wiki to allow all students access to all of the available data and results. Also, students were required to take photographs of the protocols and results, so that they could be used as evidence to support their determinations.

From discussions with the students and by examining their final projects, we learned that the high school students felt that participating in the in-class and stream study activities helped create the connections between the scientific concepts and the problems associated with the local water reservoir. By collecting evidence of people's everyday actions at the stream — such as littering, applying pesticides, gasoline and oil runoff, and building objects near the streambed —the students understood how humans are part of the ecological system and how human activity contributes to multiple environmental imbalances within the system. For example, Sean wrote in his reflection, "Before this I wouldn't think twice about a gas line in the middle of a stream but now that I realize that that gas line is destroying the streams' buffering capabilities …". Although Sean, and other students, recognized the causes of many problems after the stream study and made connections between their lives, actions, and the health of the stream, they proposed no actions to address the causes or effects of the issues.

3. Exploring multiple perspectives

To provide multiple perspectives on the health of the stream, the teachers asked educators and scientists associated with their county's Conservation District, local Park Rangers, and representatives from Rails to Trails and Trout Unlimited, to facilitate stations in the field. The community members also led students on a walking tour around the reservoir. These community members discussed local issues and problems with the group members as they walked through the forest and along the trails and roads bordering the reservoir's dam. Conversations focused on the human uses of the stream and reservoir (jobs, sustenance hunting and fishing, and recreation), governmental regulations, and personal choices. One member showed the students how the soil provided evidence of a forest fire over 100 years ago, which highlighted the connections between human actions, past, present and future. The students talked about the perspectives of the multiple users of the local water supply, including the Amish community and industries such as gas-well tending, farming, and logging, and hunters, fishers, boaters, and hikers.

Bringing in community members to share their points-of-view supported learning. The students reflected that the guided walk of the water reservoir in their community was one of the most influential aspects of the field study. Their end-of-unit assignments included statements about the economic and recreational activities as well as explanations about their scientific knowledge about watersheds and the environmental issues surrounding water quality. In their final projects, the students shared how their points-of-views about watersheds and streams changed due to the different perspectives that were revealed to them on the nature walk. For example, Lori said: "When the project started, I didn't know what a watershed was or biodiversity and its importance. For example, like the importance of what kind of creatures are in the water [and what] they can tell you… now I have a lot more respect."

4. Knowledge of strategies

To help the students develop a better understanding of individual and collective strategies that could address environmental problems affecting their community, the teachers enlisted the local scientists and environmental educators. Although many community members highlighted current and possible future issues, they only started to address possible resolutions for the problems and issues that they observed.

One of our assumptions within this unit was that the students' civic literacy from a required Civics course where they learn about the legislative processes would be used to make connections between the Civics lessons on legislation and the environmental problems identified during the watershed project. Because of this assumption, the Biology teachers did not provide the students with any additional instruction on the processes utilized by local and state governments to address environmental problems.

Through our research, we found the development of knowledge of how to address the environmental issues to be the least successful. Even though students observed and understood the problems in their local environment, they did not deepen their action-oriented environmental understandings. Students stated that they felt connections between their activities and the health of the local watershed, but the students did not suggest actions to protect the water quality— other than picking up litter. Students indicated that in the future (when they were adults), they would advocate for change; however, they believed that they could not engage in advocacy now since they were "only" teenagers. For example, Lacey wrote, "I now know about all that harms a watershed …I mostly can't stop that. At least I am able to know and that will impact my future decisions that I make as an adult." Although many students saw the quality of the local water source as a future issue, they did not identify an immediate individual or collective action to address the environmental health of their stream.

Supporting Place-Based Education

Based on the results of our watershed partnership project and the prior research studies, we have identified four strategies to help educators design lessons with a more action-oriented perspective.

Create opportunities for deeper learning within and about students' community

- Adopt a *jigsaw pedagogy* in which students become experts in specific scientific or community areas of their interests. Students can then share their expertise with others in small groups. Allow students to engage with the information and data for longer periods of time, through personalized instruction and more choices. This differentiation gives students more time to develop a depth of knowledge about a specific topic and talk to each other about, in this case, their community's watershed, leading to conversations in-class and online about environmental health.
- Create an environment in which *students collaborate and communicate information*. By sharing ideas and making their thinking visible to group members, students develop fundamental 21st Century skills. In our study, we utilized digital cameras and a website (a wiki) to capture and share data and expertise across all groups and classes. These products were actively used by other students as they continued their research; the wiki created by the

students was used as a benchmark for the water quality at Community Stream and Lake during the field study the following year.

- Choose *science phenomena that are important to students' community.* Selecting a local body of water that flowed into the drinking water reservoir created a unique learning opportunity. The stream was relevant to the students' everyday lives because it eventually flowed into the drinking fountains in their school. The field study helped them to see a place where they swam, hunted, and fished through a new lens — water as a community resource. A careful selection of the study site by the teacher will challenge students' prior thinking and encourage them to think about their role in their community's environmental health. In this study, the students saw their lives and issues affecting water quality intersect, which impacted their learning positively, even though they were not prompted to action. These connections were jumping off points for the youths' further investigation!

Use technology to engage students

- Use *collected data and evidence as starting points* for discussions. Students loved using the digital tools to capture (and later share) data and evidence. They referred to their digital photographs when discussing implications of their watershed study, and these pictures helped the students engage in scientific discourse about the topic.
- Capture *photographs of students engaging in the scientific work*, not just the data. An unexpected finding was that the students took photographs that positioned themselves as scientists! The learners took pictures of themselves using kick nets, conducting macro-invertebrate counts, and measuring the stream's velocity. All of these students' photographs fostered the view that the students can act scientifically within their community.
- *Encourage students to talk to an outside audience* about the results of their study; we utilized a wiki to share data and results. Connecting to the community outside of the school allowed students to view themselves as members of a larger collective.

Provide instruction about taking civic action

- Provide *models of engaged, scientifically-literate, place-conscious citizenry* in the classroom, in conjunction with the environmental content. Show the students what others' action-oriented learning looks like. While much of our project involved amazing experiences in local places, just observing scientifically and analyzing data was not enough to prompt students to enact change. Using case studies about local issues or from online resources, educators can demonstrate how everyday people, including students their age, can work together to advocate for change.
- *Bring in community members* who work with and impact the areas in which the students live, work, and play to provide the students with concrete examples and lived-experiences of those who work to affect change on a daily basis. This can help students develop relationships with organizations that provide mentorship and support for stewardship activities outside of the school setting.

Utilize cross-curricular possibilities

- *Make connections between multiple school subjects* (civic, history, science) to promote community stewardship; students need specific instruction to identify problems and enact change that matters to their community. To address action-oriented environmental issues, environmental education must become more than just science education. Even in our case where students were taking these courses at the same time, they separated the information.
- *Use other school experiences* to deepen scientific understandings. For example, students could read a non-fiction book on environmental health topics, discuss the creation of governmental regulations or the EPA, or learn about the procedures for lobbying for changes in the legislature. Together with the stream study, these activities could help create a model of action-oriented environmental knowledge.

As educators engage students in place-based learning experiences, we can impact the connections that students make between the scientific knowledge and their community by thinking differently about the types of knowledge that we hope students learn. In addition, students need support to gain action-oriented environmental knowledge that can develop the knowledge of stewardship actions that can help their community. We believe a better understanding of these four types of knowledge outcomes can inform all education programs, curriculum, and experiences, as we develop strategies for individual and collective action that can become part of the K-12 curriculum.

Jennifer L. Weible is an assistant professor of educational technology at Central Michigan University. She has taught high school chemistry and physical science for over 20 years, and worked in a technology leadership role in a K-12 school district. **Heather Toomey Zimmerman** is an associate professor of education at Penn State University. Her professional work experience includes being a museum educator, wetland educator, and learning scientist. Contact them at j.weible@cmich.edu and heather@psu.edu.

References

1. Jensen, B.B. (2002). Knowledge, action, and pro-environmental behavior. *Environmental Education Research*, 8, 325-334. doi: 10.1080/13504620220145474

2. Zimmerman, H. T., & Weible, J. L. (2016). Learning in and about rural places: Connections and tensions between students' everyday experiences and environmental quality issues in their community. Online in Advance of Print, 1-25. *Cultural Studies of Science Education*. doi: 10.1007/s11422-016-9757-1