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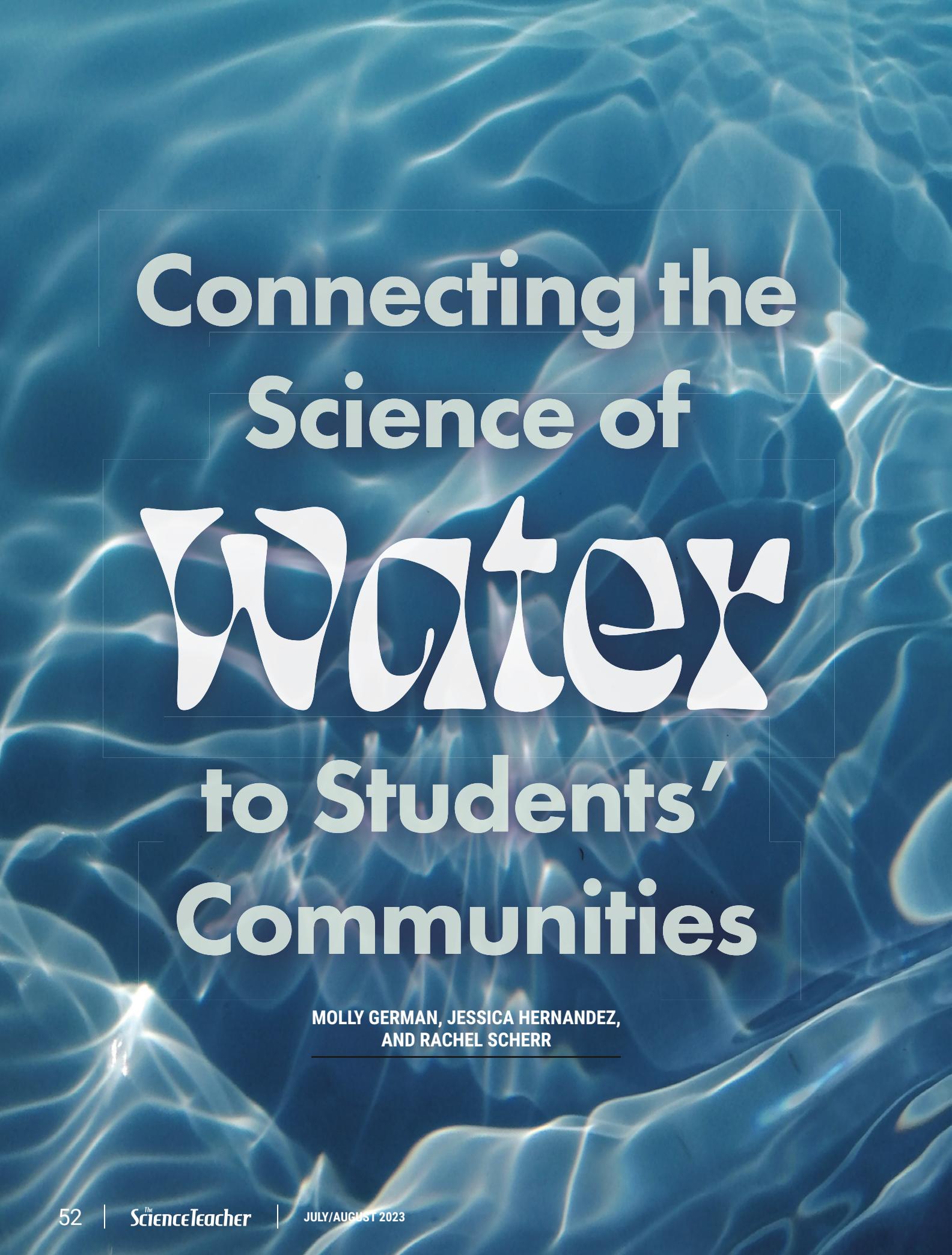
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Connecting the Science of Water to Students' Communities

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School education often directs students' attention away from their own lived experiences toward knowledge developed in other places by people they will likely never meet (Smith 2002). Students in traditional science courses commonly learn from reading texts, listening to lectures, and completing worksheets rather than direct encounters with the world around them. Place-based education, by contrast, acknowledges that for many students, “valuable knowledge... is knowledge that is directly related to their own social reality, knowledge that will allow them to engage in activities that are of service to and valued by those they love and respect” (Smith 2002). Place-based education fosters understanding of one’s surrounding landscapes, environments, and communities; it engages learner-based, inquiry-oriented, interdisciplinary approaches to explore the ecological, cultural, and economic perspectives of a community (Deloria Jr. and Wildcat 2001).

In the past several years, teachers at my school have been working to incorporate into our teaching human impacts on the environment and relevant environmental justice issues. Place-based education, which is rooted in historic and Indigenous educational practices, strongly supports environmental stewardship (Cajete 2000). During my chemistry teaching, I increase student engagement by helping students see connections between the analytical problem solving supported by a typical school chemistry curriculum and their own lives, families, and cultures. Water is an effective anchor topic to connect cross-disciplinary academic learning with real-world experiences (Endreny 2010; Santelmann et al. 2011). My students and their families have many memorable experiences with water that I felt would connect well to this science unit. In this article,

I describe the place-based educational experiences I supported for my students in their studies of water in chemistry. Student learning goals for this unit included

- recognizing the role that water plays in their everyday lives, individually and communally;
- connecting the science of water learned in school to their personal experiences of water, as well as family and cultural sources of knowledge about water;
- identifying community issues and concerns about water; and
- identifying ways they can use their knowledge to work for change.

Instructional and community context

The following activities added nearly two weeks to the beginning of my traditional water unit and a few extra days scattered throughout the unit for research and/or experiments related to students’ chosen topics. The original topics in our school’s water unit included cohesion, polarity, solubility, ionic vs. covalent bonds, and macroscopic properties of various substances (such as salt vs. sugar) understood in terms of their microscopic structure. This series of activities is typically taught in four sections of a 10th-grade chemistry class that is taken by nearly all sophomores. Class sizes range from 25 to 32 students.

The lesson sequence that follows is not a set lesson plan but rather a flexible, multipurpose set of activities to use in various subject areas, such as chemistry, Earth science, environmental studies, or another subject area. Teachers who implement this lesson sequence should adapt it to their specific circumstances, addressing specific learning goals that are appropriate for their local context. These activities could be adapted for middle or high school students. Student collaboration through working in groups provides much of the support needed for students with special needs, such as those who struggle with executive function, auditory or visual processing, and/or reading. A written worksheet provides structure for students to refer to as they carry out their investigations.

Implementation

At the beginning of this unit, we spent about three days on a water filtration challenge (Figures 1 and 2). On the first day, we made dirty water, using soil, cooking oil, food coloring, coffee grounds, garlic powder, and students' leftover drinks. We discussed what we would do if we didn't have access to clean drinking water. For the next two days of the activity, students had to figure out how to clean the water. In some experiments there is value in having students draw a design ahead of time before implementing a lab procedure, but in this case it seemed more appropriate to let them start experimenting and then refine their design and procedure as they went. Some students knew about filters for use at home or while camping, and this was an effective access point for many of them: Most designs used some combination of sand, gravel, coffee filters, or paper towels. Other groups pursued the strategy of boiling the water. This led to some great discussions about which parts of the contaminated water would evaporate and what would stay behind, and how to engineer an apparatus that would collect and condense the evaporated water.

After filtering their water and reflecting on what was successful and what they could improve, students were prompted to share a personal story or experience with water as we transitioned to thinking about ways that access to water affects our lives. We watched part of the documentary video *Thirsty for Justice* (EJCW 2014), which presents various water concerns in different communities in California. The goal was to get students thinking about local water issues in our community that they could research. Students also interviewed a community member about water; several students talked to family members who were concerned about the water quality of their well water or city tap water. One student interviewed his

Materials (for water)

- Various materials to add to the water to make it dirty
 - Coffee grounds
 - Garlic powder or other spices
 - Dirt, leaves, other organic material
- Ring stands
- Funnels
- Beakers or water bottles (We used inverted soda bottles and water bottles with the base cut off to serve as funnels, which cleanup.)
- Filter paper, coffee filters (towels can also be used.)
- Gravel and sand

FIGURES 1 AND 2

Water filtration challenge



FIGURES 3 AND 4

Students collecting water samples from



FIGURE 5

Test strips after several water sour



grandmother about her experience with polluted water in their hometown of Zacapala in Puebla, Mexico. He learned how people in the town worked together to draw attention to the problem and succeeded in getting a new well built. He reported that “Many people who have water issues are able to create change. They are able to unify and try to influence their region.” I was encouraged by the success of these informal interviews in helping students see connections between the knowledge that comes from their families and the knowledge they learn at school.

After watching *Thirsty for Justice* and conducting informal interviews, students had the option to research a local water topic of their choice. They could work individually or in small groups of two or three students. Some students who fish frequently investigated mercury contamination of fish from past gold mining in the nearby foothills. Others investigated Indigenous water rights and the effects of nearby hydroelectric dams on ecosystems, especially salmon health. Most students chose to test the water quality of a local water source, such as the irrigation canal (Figures 3 and 4) behind our campus (our school is surrounded by walnut orchards and rice fields). We provided test strips (Figure 5) designed for drinking water that included 15 different tests such as nitrates, pH, and water hardness. The results prompted questions about what levels of these various factors were healthy or dangerous and led students to research the safe range of various results. Student research projects culminated in presentations including slide shows, posters, and videos.

Safety notes

- Wear goggles, gloves, and aprons.
- Use caution when working with glassware. It can shatter and cut or puncture skin.
- Immediately wipe up any spills (slip/fall hazard).
- Follow your teacher's directions for disposing of waste materials.
- Wash hands with soap and water immediately after completing this activity.

Successes

Students loved incorporating outdoor experiential learning into their school day. As a result of this project, one of my goals is to find more ways to get students outside to interact with our local environment. It was exciting to see what students noticed and wanted to investigate, such as catching tadpoles and building boats to see how fast the water was moving. It gave me numerous ideas and reminded me of how creative students can be when teachers release some control and let them explore.

These experiences also allowed students to be the experts and teachers. When we walked to the irrigation canal during class, many of the students shared personal experiences and expertise about the canal and local irrigation that I as the teacher had not known, such as what times of the year the canals have water and which crops use the most water. Other students wondered where the canal water came from or if it would be better or worse to drink compared to the school tap water.

Future development

As a result of their water testing, students learned that our city water has a relatively high pH value, between 8.5 and 9.0. In the future, I would like to use this to introduce acid-base chemistry, the biochemistry of the human body, and an analysis of drinking water trends (such as alkaline water and chlorophyll water).

In the future, I would like to partner with local scientists with expertise in water quality in our area, including one who is an alumnus of our school and one who is a parent of recent alumni. I would also like to include a greater component of "What can we do about what we learned?" I have recently been introduced to the process of community-based participatory research (Jull et al. 2017), where students partner with members of their community and local organizations to design and conduct research to meet genuine needs in the community. For example, it would

be great to develop some action steps as a class to educate community members about what we learned, or take steps to design solutions to some of the water issues we found. Designing solutions to problems we identified would also be an authentic application of the NGSS engineering design standards.

Conclusion

Place-based learning taps into student curiosity and interests. Most student observations or questions can be steered toward relevant scientific concepts while still keeping what got them curious in mind. Every time I teach this unit, I continue to learn from my students and colleagues, and these lessons become richer than they were the previous year. Possible expansion in future years will hopefully include more ongoing place-based and experiential learning, local connections to climate change and environmental justice issues, traditional ecological knowledge from local Maidu and Wintu tribal members, cross-curricular opportunities, and a continued emphasis on student voice and choice.

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ONLINE CONNECTIONS

Introduction to Water Research Project: <https://bit.ly/3M7Pcgm>
Thirsty for Justice worksheet: <https://bit.ly/3o2n1HP>
Personal Water Check-In: <https://bit.ly/41EK1KA>
Connecting to the *Next Generation Science Standards*: <https://bit.ly/42KM80H>
Chico Traditional Ecological Stewardship Program: tekchico.org

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