Water and Life

Exploring Water's Connection to Life As We Know It.
A Place-Based Education Unit Designed by Erik Miller

Wilderness Inquiry Place-Based Education Professional Development
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Introduction

Water and Life was an interdisciplinary unit developed for Patrick Henry high school's HAP program and was implemented in October 2014. The unit was a 4-day place-based program, with 25 high school juniors and seniors participating. Students who successfully completed those days as well as classwork and a project-based assessment earned partial credit in Social Studies, English, and Science.

Each day of the program, a different layer of water's relationship to our lives unfolds. The relationship being appropriate to the place they visit that day, students gained an appreciation for water, Minneapolis, and the Mississippi River. Students learned the importance of access to clean water and the responsibility of a community and it's citizens to maintain the supply.

Goals

- Students will explore the various roles that water has in supporting our modern way of life; our bodies, our environment, our society, and water as a force of nature.
- Students will understand the relationship between the water in our rivers and lakes, the municipal water supply, and our bodies.
- Students will examine the health of our municipal water system and understand its fundamental role in a healthy, developed society.
- Students will explore water and its forces upon nature, causing changes to ecosystems, to the planet, and life itself.

Objectives

Each of four days of programming led to an overall objective that connected to the overall theme of water's place in our lives.

- Camden Community Pond: Students will explore the relationship between their bodies and access to clean water. Excretory (kidney) function is demonstrated in a hand-on activity using nearby water. Kidney function is compared to the pond and its vegetation as a filter of that local water, as it then enters the Mississippi watershed.
- Theodore Wirth: Students will explore the relationship between water and the environment by investigating the relationship between local macroinvertebrates and water quality and discussing how a beaver dam can create an ecosystem, and the health of the ecosystem depends on water.
- St. Anthony Falls: Students will explore the relationship between water and power. Generating electricity at Excel and witnessing the dramatic separation into two cities at the falls are two great examples, and with an included visit to Mill City Museum students also explore the Mississippi's powering of an entire economy and the urbanization that occurred as a result.
- Carl Kroening Interpretive Center: Students explore the relationship between clean water and a modern society. Students also conduct water quality testing in the

Mississippi. A demonstration of porosity filtration is done across the river from the Minneapolis Ultrafiltration plant, which cleans and provides water to the metro area.

Overview

This program was designed for and implemented with 25 juniors and seniors at Patrick Henry High School in October 2014. These students were enrolled in the HAP program (Henry Achievement Program), were considered 'at-risk' and were credit deficient. Programming was designed to allow students to recover credits in a hands-on, interdisciplinary unit with real-world themes. Place-based, outdoor education suited this type of programming well. These place-based lessons also coincided with classroom work centered around a student-designed eco-friendly farm that would address the importance of a clean water supply. Out of 25 HAP students, 18 finished the entire program, participating in all days of programming and completing all assessment work, resulting in a 72% success rate. The other 7 students completed either half or ¾ days, resulting in partial credits earned.

This type of hands-on environment suited the needs of these students, helped build community and relationships at the beginning of the school year, and brought their academic achievement together with real-world issues.

MN Science Standards/Benchmarks 9-12

The unit was interdisciplinary, with English and Social Studies teachers also providing programming at the places visited. I designed the Science components of this program, so that is what standards are included in this document.

The Nature of Science and Engineering

9.1.3.4: Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.

- 9.1.3.4.1: Describe how technological problems and advances often create a demand for new scientific knowledge, improved mathematics, and new technologies.

- 9.1.3.4.3: Select and use appropriate numeric, symbolic, pictorial, or graphical representation to communicate scientific ideas, procedures and experimental results.
- 9.1.3.4.4: Relate the reliability of data to consistency of results, identify sources of error, and suggest ways to improve the data collection and analysis. *For example:* Use statistical analysis or error analysis to make judgments about the validity of results.

Physical Science

9.2.2.2: An object's mass and the forces on it affect the motion of an object.

- 9.2.2.2.3:Demonstrate that whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted by the second object back on the first.

9.2.3.2: Energy can be transformed within a system or transferred to other systems or the environment, but is always conserved.

- 9.2.3.2.2: Calculate and explain the energy, work and power involved in energy transfers in a mechanical system.

9.2.4.1: There are benefits, costs and risks to different means of generating and using energy.

- 9.2.4.1.1: Compare local and global environmental and economic advantages and disadvantages of generating electricity using various sources or energy.
- 9.2.4.1.2: Describe the tradeoffs involved when technological developments impact the way we use energy, natural resources, or synthetic materials.

Earth and Space Science

- 9.3.3.2.3: Compare and contrast the environmental conditions that make life possible on Earth with conditions found on the other planets and moons of our solar system.

9.3.4.1: People consider potential benefits, costs and risks to make decisions on how they interact with natural systems.

- 9.3.4.1.2: Explain how human activity and natural processes are altering the hydrosphere, biosphere, lithosphere and atmosphere, including pollution, topography and climate.

Life Science

9.4.1.1: Organisms use the interaction of cellular processes to as well as tissues and organ systems to maintain homeostasis.

- 9.4.1.1.1: Explain how cell processes are influenced by internal and external factors, such as pH and temperature, and how cells and organisms respond to changes in their environment to maintain homeostasis.
- 9.4.1.1.2: Describe how the functions of individual organ systems are integrated to maintain homeostasis in an organism.

9.4.4.1: Human activity has consequences on living organisms and ecosystems.

- 9.4.4.1.2: Describe the social, economic and ecological risks and benefits of changing a natural ecosystem as a result of human activity.
- 9.4.4.2.4: Explain how environmental factors and personal decisions, such as water quality, air quality and smoking affect personal and community health.

Chemistry

- 9C.1.3.3.1: Developments in chemistry affect society and societal concerns affect the field of chemistry.

- 9C.2.1.2.7: Explain the role of solubility of solids, liquids and gases in natural and designed systems.

Physics

- 9P.2.2.2.2: Describe and calculate the change in velocity for objects when forces are applied perpendicular to the direction of motion.

Lesson 1: Water and You

Location: Camden Community Pond

Students will explore the relationship between their bodies and access to clean water. Excretory (kidney) function is demonstrated in a hand-on activity using nearby water. Kidney function is compared to the pond and its vegetation as a filter of that local water, as it then enters the Mississippi watershed.

Students rotated through three 30-minute stations:

1. Water clarity testing with turbidity tubes
2. Mussels as filter feeders
3. Demonstration of water's role in body functions: excretory system, sweating, urination

Students draw connections between these three and understand that water plays a fundamental role in the distribution of nutrients and materials to and in organisms.
The excretory demonstrated the connection between blood, kidneys, and sweating in maintaining a healthy blood volume. Kidney function is also compared to the filtration that happens at the nearby storm-drain system at the community pond, and the filtering that mussels provide fresh water.. A model excretory system is prepared using a funnel, tubing, a screen, and a 'bladder' (see photos). Model 'blood' is also prepared using helpful visuals that represent components of blood.

Materials:

Funnel	'Bladder' -boxed wine bag, freezer bag	Jelly beans: glucose
Vinyl tubing	Pail	Peanuts: protein
Screen	Pinto Beans -white blood cells	Chocolate chips: fat
Tape	Black Beans -red blood cells	Other beans: platelets
	Salt	Urea powder

A funnel → tube → bladder is constructed as shown in photo. Water from the nearby water source is collected, as the majority of blood is made of water. The above ingredients are added 1 by 1 as a discussion of the components of blood are discussed.
Students then hypothesize about what urine contains. Seeing the relative sizes of the various components, students can correctly predict that the only components that make it through the filter are water, salt, and urea. The rest of the components are returned to blood. However, there is a smaller volume of blood. The visual demonstration allows the teacher to show how blood volume is lost to perspiration, caffeine, alcohol, etc. The connection between sweating and staying hydrated can also be shown and discussed. Negative feedback loops and homeostasis Life Science standards can be connected and shown as well. Finally, students can see the fundamental importance water has in their body functions, especially when worked or stressed.

Participation Questions:

Connected to Water: Water and Your Body

4 weeks. 8% for full participation each week. 14% for completion of final project

Your body is about 65% water. You can only live without water for about 3 to 5 days. Water is important to your survival, as it helps keep a balance of the things your body needs and allows these things to get transported around. An important part of keeping this balance is the **excretory system.**

What is the primary function of the excretory system?

What is in blood?

What components of blood end up in your urine?

Where and how do the components of your blood that don't belong in urine get filtered out?

As far as your excretory system is concerned, describe why it is important to stay hydrated and have a balanced diet?

Lesson 2: Water and the Environment
Location: Theodore Wirth Park

Students will explore the relationship between water and the environment by investigating the relationship between local macroinvertebrates and water quality and discussing how a beaver dam can create an ecosystem, and the health of the ecosystem depends on water.

Students explored the five themes of geography through the eyes of a beaver. Using the creek that runs through the park, and knowledge of beaver habitats and beaver behavior learned in class, students investigated the landscape and decided where a beaver should create its habitat. Students then modeled the changes to the landscape and ecosystem that would occur as a result.
Students also played the 'fur trade game' to make a connection between beavers, early settlers/fur traders, and water, and did macroinvertebrate testing in the nearby pond.

Understanding that water is an essential molecule for life, students were then able to expand on that though through subsequent discussions on water's role in ecosystems, especially the wetlands, ponds, and lakes created by beavers. The connection with the fur-trade was a great demonstration of overusing of a finite resource, which had devastating effects on ecosystems where beaver populations were decimated.

Participation Questions:
Answer these questions based on the first two water lessons.

1. Describe any similarities between the effect that Beavers and kidneys have on water.

2. Describe (in detail) some ways that water is 'cleaned' naturally. Think mussels, beavers, wetlands, excretory systems. Consider diagrams!

3. Compare and contrast water quality data from week 1 and 2. I'm looking for qualitative and quantitative analysis. You may need to collect data

4. How do you expect the water quality of the Mississippi to compare to Camden Pond and Bassett Creek? (Quantitative and qualitative!)

5. What are your thoughts, in general, about the first two field trips? Were they fun, did you learn a lot, or were you just plain **cold?**

Lesson 3: Water and Power
Location: St. Anthony Falls/Excel Energy Plant/Mill City Museum

Note: Due to time and weather constraints, this lesson was not implemented together with the other three in the unit.

Students will explore the relationship between water and power. Generating electricity at Excel and witnessing the dramatic separation into two cities at the falls are two great examples, and with an included visit to Mill City Museum students also explore the Mississippi's powering of an entire economy and the urbanization that occurred as a result.

Using the Mill City Museum as a resource, their hands-on interactive exhibits demonstrate the power that the river provided the milling industry, which took the Twin Cities area from a fur-trading and logging town to an agricultural processing powerhouse, producing more flour than anywhere else in the world. The "Round the Mills" lesson offered to school groups incorporates the power of water in milling production well, and an interactive exhibit allows students to manipulate water power and understand the power conversions that happened.

As a follow up investigation, students can predict why and how various river dimensions will affect the force, and thus hydroelectric generation. A detailed guide on this lesson can be found here.

As a bonus activity nearby, a rock skipping activity could be applied to Physics and ideas about force, friction, and velocity. This activity could be designed as a competition with students working on the following:

Rock Skipping Bonus Questions
Observation: Rocks skip differently depending on their size, shape, how and from where they are thrown
Hypothesis: Make a hypothesis on the following variables, then test with a partner. Be sure to use several tests for more accurate data!
How are skips affected by throwing the rock closer vs. farther away?
Hypothesis:

Result:

How are skips affected moving higher up on the shore?
Hypothesis:

Result:

How are skips affected moving higher up on the shore?
Hypothesis:

Result:

How are skips affected by throwing the rock harder?
Hypothesis:

Result:

Think of one more *variable* to test. Write your own hypothesis and test the result.

Lesson 4: Water and Modern Society
Location: Carl Kroening Interpretive Center

Students explore the relationship between clean water and a modern society. Students also conduct water quality testing in the Mississippi. A demonstration of porosity filtration is done across the river from the Minneapolis Ultrafiltration plant, which cleans and provides water to the metro area.

By now, students have made connections between the water in their bodies and the water they see in their city. What they may not fully appreciate is that it is all the same water, with our city water being drawn directly from the Mississippi and our sewers draining right back in. Having fully realized water's necessity, they will now understand the importance of keeping our communities, and hence our water, clean.

The lesson takes place across the river from the Minneapolis Ultrafiltration Plant, which filters water through a series of steps. A scaled-down model is demonstrated at the river.

Materials:
Two liter bottle
Gravel
Sand
Activated Carbon (often found in fish supply sections)

The filter was prepared as shown on the right, except with the layer of carbon at the bottom

Using water drawn from the Mississippi, students give a visual assessment of the water quality. Discussing the mussels which live in the riverbed provides a good discussion prompt on the health of the water and ecosystem. Also, having done turbidity testing the students make a descriptive assessment of the clarity of the water.

Water is then filtered through the model filter while an overview of the treatment of the same water across the stream at the plant is discussed. Students observe a dramatic difference in the quality of water after filtration, even from a simple device. The water testing reinforces the quality of water before treatment.

Water and Society: Keeping Our Water Clean

The Earth is 70% water. What % of that is fresh water? What % is actually attainable, and why?

What are some good reasons why we should protect our supply of fresh water?

What is the sole source of fresh water for Minneapolis and the surrounding suburbs?

Describe the process of treating the water at the Minneapolis ultrafiltration plant.

Describe how the activated charcoal. What is microporosity? How does it get water cleaned?

Final follow-up questions:

If you haven't already, answer these questions based on the first two water units. I'm looking for detail and reasons.

1. Describe any similarities between the effect that Beavers and kidneys have on water.

2. Describe (in detail) some ways that water is 'cleaned' naturally.Compare and contrast these various ways.

3. How might a beaver be considered a 'keystone species' in an ecosystem?

4. Compare and contrast water quality data from week 1 and 2. I'm looking for qualitative and quantitative analysis. You may need to collect data

4. How do you expect the water quality of the Mississippi to compare to Camden Pond and Bassett Creek? (Quantitative and qualitative!)

5. What are your thoughts, in general, about the first two field trips? Were they fun, did you learn a lot, or were you just plain **cold?**

Reflection

As noted previously, 72% of students completed the entire program. These were a mixture of juniors and seniors who were credit deficient and considered 'at-risk' of not graduating by Patrick Henry High School. By most measures, the program was a success. Having the program at the beginning of the year definitely assisted with group cohesion and relationship building at the beginning of the school year. The hands-on nature of the lessons was also effective for a group such as this who had struggled in traditional classroom settings. A student survey indicated that place-based education was among the most memorable and favorite experiences from first semester. Photos, quotes, and other information were also included in a display case featured outside of classrooms. Also, later in the year, students would occasionally ask "When will we get to go outside again?"

Place-based education was not without it's challenges during this first try. Planning for weather, proper materials, and coordinating timing were the most significant.

Place-based education can be difficult to plan during the school year in Minnesota. The students involved were part of a newly created alternative learning program, so even though planning for this unit began right away in the school year, October was the earliest we were able to implement the unit, and by the end, students were cold. It became difficult to keep students focused and engaged during the cold.

Breaking out of the routine of classroom teaching takes a teacher out of their comfort zone. Simple materials taken for granted in a classroom needed to be planned for outdoors. Whiteboards to display information, clipboards, pens, etc. all needed to be thought of ahead of time. This came easier with experience, but is something to be considered when designing new place-based units.

Timing of lessons has always been a difficult part of teaching for me. Add other challenges associated with place-based learning, and it can be difficult to manage. In a classroom, it is easier to leave a lesson unfinished and return to it in the next day. Place-based education and

the planning that goes into them are much more of a one-shot scenario. When the lesson takes timing goes awry and the goals of the lesson are not met, it is much harder to make that learning up.

Trialling place-based planning was a great experience as a teacher. As I've grown and crafted my teaching style and philosophy, I discover more and more that the atmosphere of a productive teaching environment requires careful construction from the ground up. I firmly believe that place-based learning helps foster this type of atmosphere, where students are curious, engaged and focused. Taking students out of a traditional setting, where the normal day-to-day challenges of student engagement exist and taking them to a relevant location outdoors sparks interest and questions. When the lesson is carefully planned and orchestrated, the learning and engagement of students is unmatched.

Improvements

Future success of a similar program could grow with the following improvements.

Materials were a concern during the first attempt at place-based learning. Upon reflection, creating a sort of 'traveling classroom' would make other excursions easier to plan. A bag with clipboards, pens, tools for measurement, whiteboards, etc. would be a great companion for place-based education.

Extended investigations, assessment, or project options could be more seamlessly planned and implemented in conjunction with the place-based lessons. Careful planning was done to connect the place-based lessons together with each other, but more could have been done before and after lessons in the classroom to reinforce concepts, build prior knowledge, and have students complete a final assessment project.

Links

https://education.state.mn.us/mdeprod/idcplg?IdcService=GET_FILE&dDocName=005263&RevisionSelectionMethod=latestReleased&Rendition=primary

http://www.who.int/mediacentre/factsheets/fs310/en/

http://www.webmd.com/hw-popup/urinalysis

http://blogs.cdc.gov/niosh-science-blog/2011/08/12/heat-2/

https://www.minneapolisparks.org/parks_and_destinations/parks_and_lakes/theodore_wirth_regional_park/

http://www.threeriversparks.org/parks/north-mississippi-park/kroening-interpretive-center.aspx

http://www.nps.gov/miss/planyourvisit/stanfall.htm