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Designing A Place-Based Education Water Cycle Curriculum In Order To Impact Middle School Science Students' Depth Of Understanding And Attitude Toward Science

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DESIGNING A PLACE-BASED EDUCATION WATER CYCLE CURRICULUM IN ORDER TO IMPACT MIDDLE SCHOOL SCIENCE STUDENTS' DEPTH OF UNDERSTANDING AND ATTITUDE TOWARD SCIENCE

By

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CHAPTER ONE

INTRODUCTION

The Water Cycle and Me

The water cycle is the continuous process of water circulating on and through the Earth. We grew up across the road from a lake that had a river entering through one end of it and exiting through the other. I was in touch with the water cycle and the importance of keeping our waters healthy. In the spring, we would venture to the river flowing into the lake. Its water would be teasing the banks and with one good rain or spring snow event, the lowland surrounding the river would succumb. At this time of the year the river ran fast and cold; we often had to sneak down to the river because our parents were wary of the dangers of us falling into the frigid, swift moving waters. With the leaves beginning to pop, the woods on way to the lake would become humid and ridden with mosquitos and ticks. And so, as spring moved to summer, the river's flow would slow and we would turn more of our attention to the lake. Days were spent swimming, wading through the channel where one lake flowed into the other, collecting water bug specimens, catching crawfish, frogs, fish, turtles, and basically any living organism the lake supported. My parents' garage became a holding tank for my collections. I loved to go seining with the neighbor boys, knowing I would be able to add more specimens to my garage collection. We also had an undeveloped area behind our house and the female turtles would make their way up the hill and across our yard to dig nests to lay and bury their eggs. One of my favorite times would be when the turtle hatchlings would parade through the yard, downhill and to the lake. Every few years we would get heavy summer downpours that would flood the park and swimming beach. These were exciting times for us as children. We would wade around the flooded park, the carp would come into the shallow, warm water, their dorsal fins looking like sharks cruising around the temporary habitat created by the rains. We attempted to catch them bare handed and were rarely successful. When the water would eventually recede, the park was left with rotting decay that had been washed ashore. By late August, the water would begin to turn greenish. Some years it would develop a green skin on the top of the lake. The green algae growth was due to the many farms fields and manicured lawns that bordered the lake. These were sad days for us; my mother would not allow us to go down to swim when the water was in this condition. In the fall, we would shift our attention back to the river. After long days in school, I would go back to the river alone to find peace. There was something about moving water that calmed my soul. The water would slowly being to cool, along with the leaves turning. At this time of year, I would have to be careful of the hunters who would be out waiting for low flying waterfowl to take down, the waterfowls' flight path in control of their success. Shortly after the waterfowl migration, we would wait for the lake to freeze solid enough for us to venture out onto its surface. It was a risky time, we so badly wanted to skate. Every year, it seemed, at least one of the neighborhood kids took a turn unsuccessfully "testing out" the ice. We would hear the story of the kid that had to go home and face the wrath of the angry and terrified mother. We would cross our fingers that it would not snow too much before the ice was thick enough for us explore. We did not want anything to slow the freezing process. Once the lake was frozen, it was like another whole world to explore. We would skate from one end to the other, avoiding places near the shoreline where we knew natural springs would create unsafe ice. The moving water at the channel, located between the two lakes on the chain, was also another spot to avoid. I can remember the eerie sounds the ice would make when it was freezing, the cracking ice echoing beneath our feet. By the time spring was rolling back around, we were unfazed by the sounds and ready for the ice to melt. Open water would start snaking into the lake from the channel, we would hope for rain and windy days to weigh down and break up the ice. When the ice was gone again, we would venture back to the river.

As I grew, I never stayed away from the water for too long. I went to school on Lake Bemidji and began taking trips to the Boundary Waters Canoe Area in my twenties after my daughter was born. It was a magical place and my husband I shared this with our children. They were fascinated by the clarity of the water, trampoline-like bogs, waterfalls, beaver dams and living on the water for at least a week each summer. Seeing the BWCA through the eyes of my children excited brought me back to my own childhood. There was much to be learned by spending time out in nature, so many questions to ask and things to explore.

Present Day as a Teacher

Unfortunately, I am not seeing excitement for the outdoors and the environment in many of the students who walk through my classroom door. Kids are not spending time outside as much as they have in the past. Between electronics, scheduled activities and parental fears of harm coming to their children, unstructured time outside has decreased (Gray, 2011). The Alliance for Childhood, a nonprofit advocacy group, stated, "Compared to the 1970s, children now spend 50 percent less time in unstructured outdoor activities" (Juster, et.al, 2004). The natural processes are no longer things students learn through personal exploration and discovery, but through their science classes. Many 8th grade science students in my classes have no difficulty recalling basic information pertaining to the water cycle, but they do not have the same personal connection I felt. To many, it is rote knowledge needed to pass an assessment. Do they truly understand the water cycle components of runoff, transpiration, evaporation, condensation, precipitation and infiltration as they happen in the world beyond our classroom walls? Why are these processes important? What do they look like in their part of the world? Why should they care? Do they have a connection to the water cycle and how it plays into their lives?

For students to truly meet the state mandated water cycle standards, they must be able to not simply make connections between the content, but make connections between real places and problems in their community.

The Adult Influencers in My Childhood

Given my deep connection to and understanding of the water cycle in my community, and given the textbook and laboratory methods through which that content has been taught in the past to 8th graders at my current school, I wanted to find a way to help students develop an understanding deeper than the textbooks and closer to my own understanding. Reflecting on my own learning in science from others, my most powerful and enduring lessons--other than the ones I created for myself on the land and water around my home--came when adults in my life facilitated hands-on experiences with the concepts directly related to and occurring in the natural areas in my community.

My mother and my second grade teacher are the two main reasons I am a science teacher today. I have learned much from these two extraordinary women. They nurtured my love for the outdoors and encouraged me to get outside and discover the world right outside my door. It is their encouragement to explore that has made me who I am today: a learner and explorer.

As a young child, my mother would bring my siblings and me out into the woods near our home every spring. She would teach us the names of the spring flora and fauna; bloodroot, cowslips, and pussy willows are a few I distinctly remember. I learned how to identify the bloodroot by the reddish orange juice that oozed and stained my hands when I broke open the stem. We picked wild strawberries and raspberries that my mom would turn into jam. Later in the summer, we would harvest chokecherries that she would boil into syrup and hazelnuts that we would dry and snack on throughout the winter. She fostered in me a connection to the natural world. As an adult, I am always on the lookout for edibles when I have the opportunity to go out into the woods: berries in the BWCA, wild leeks and hazelnuts at our hunting land and morels in my own backwoods.

This connection to nature that my mother fostered was bolstered by my second grade teacher. Mrs. Pundsack was my idol: she did not wear makeup, she had long hair she would put into two braids, she played the guitar and —most impressive of all to me— she lived on a hobby farm. I remember her talking about going out to the chicken coop to grab eggs for breakfast. I thought she had the coolest life.

It was in her class that I learned about monarch butterflies. She taught us how to identify the eggs and the larvae. She explained the monarch's life cycle and then she brought in live monarch caterpillars for our class to watch go through metamorphosis. My classmates and I would bring in milkweed for the caterpillars. I gathered my milkweed from the field behind my house. Our class watched as the caterpillars grew and transformed. We were fascinated when they spun their chrysalises into a brilliant green that looked like it was sewn shut with black and gold thread. We marveled as the chrysalises became transparent and we could see that each caterpillar had transformed into a butterfly. We watched as the monarchs emerged and pumped their wings before we released them back into the wild. Throughout the lesson, we journaled, we predicted, and we learned not only about the life cycle of the monarch, but of their great migration to Central America. We identified suitable habitats in our community and identified the basic needs of the monarch.

After this lesson, I needed to watch this miracle of nature happen again. I needed to find the monarch eggs and caterpillars. I also constantly reminded my parents to avoid hitting the butterflies with our family car. I flipped over every milkweed leaf I encountered, looking for their eggs. I looked intently for the yellow, white and black striped caterpillars. I began to collect the caterpillars and eggs and hatch my own monarchs in my garage. To this day, I still flip over milkweed leaves hoping to find eggs or looking for the striped caterpillars. It is this excitement, curiosity, and deep engagement I want to foster in my students. I want to be their Mrs. Pundsack.

The Pond

The local soil and water conservation district recently completed a runoff pond on our school property. The pond catches runoff from University Avenue and creates multiple learning opportunities for our students. At the beginning of the school year I brought my students out to make observations of the pond.

When I brought the students out, they were fully engaged. I asked them to make 30 observations of the pond and its surrounding environment. The students went wild. They were all over the field, out on the peninsula, traveling to edges of the boundaries I had set. When I saw their excitement for this area, I knew I had to incorporate this into my curriculum. It would be an injustice to my students and myself if I did not.

This area could become their monarch butterfly. It can be their door to diving deeper into science and developing a sense of place in an area where they are living and growing up. It can be where they gain a deeper level of understanding and appreciation for the resources around them.

I want my students to ask complex questions -- think critically and reflect--. I want them to experience the water cycle in action first hand. I also want them to see the negative impacts of water pollution to see how they can be the change that creates solutions-- not only to their investigations, but for their community.

Current Research

Gruenewald (2003) stated, "[t]he public or explicit agenda of schooling is to prepare citizens to participate in a basically just and equitable society, one that is becoming more just and equitable through the democratic process" (p. 629). Since the implementation of No Child Left Behind, assessment has become the sole focus of many schools. Left behind are the real-world, experiences that will deepen students' understanding of the importance of their education and the concepts tied into the standards. The type of assessments that are typically occurring are those in which the learning can be contained within the walls of the school instead of extending into their community. By community, I mean even on the school grounds where real-life, authentic, student-driven, investigations can be implemented. (Straus, 2015).

Schools thus are reinforcing the disconnect between place and learning. As educators, we need to foster a connection of place into our curriculum to help students develop a sense of importance in what they are learning. Using a school pond and surrounding area as an outdoor classroom will allow students to connect to outdoor space within their community. As Orr (1994) noted in his writing about place, “We relate to the environment around us in different ways, with differing intensity, and these bonds have different sources. At the most common level, we learn to love what has become familiar” (p. 137).

Place Based Education

Place-based education(PBE) is defined as interdisciplinary education aimed to connect students to the local community and environment, and to increase student engagement through a love of, or connection to place (Center for Place-based Learning and Community Engagement, 2015). To incorporate a pond into the 8th grade Earth Science curriculum, I will need to create a PBE unit focusing on the local water cycle. The geological and hydrological features of a school’s property and the surrounding area will be incorporated into the unit. Students will study how pollutants invade our water, what is being done to keep our water clean, and what our students can do to prevent additional pollutants from entering the water.

As a young child I did not understand Mrs. Pundsack was using a PBE model, I only knew that learning about the life cycle of the Monarch caterpillar was the most interesting learning experience I had in my short academic career. I also knew that the woods surrounding my neighborhood was a magical place that I felt connected to, especially in the spring and throughout the summer. It is this exposure early on that led me to where I am today and my educational philosophy that student-led engagement utilizing the PBE model leads to a deeper level of understanding and appreciation of nature.

This leads to my capstone topic, *Designing a place-based education water cycle curriculum in order to impact middle school science students' depth of understanding and attitude toward science.* I want the curriculum I write to be a catalyst to deeper scientific inquiry than they can do in the classroom. Dean, Hubbell and Pitler found that when students generate and test their own hypotheses, their learning and engagement is deepened because they are forced to use the critical thinking of analysis and application (2012). In addition, the learning becomes personal--they take ownership of their development of their knowledge. I want this curriculum to connect students to their local watershed, helping them develop a deep sense of place and respect for the natural world around them while allowing them to build deeper scientific understanding. As Sobel (1995) said, "Wet sneakers and muddy clothes are prerequisites for understanding the water cycle" (p. 5).

Conclusion

In my next chapter, I will introduce early the implementers of PBE prior to the term being coined. I will then introduce contemporary educational supporters/ researchers of PBE. Next, I will detail educational theorists in regards to middle school students' cognitive ability to construct knowledge using community spaces and resources available using a PBE model. Following that, I will demonstrate how PBE has an effect on middle school students' attitude toward science education and their increased depth of understanding. After that, I will address the challenges of place-based education. Then, I will review the state standards pertaining to the water cycle and the water cycle itself.

Continuing on, I will reinforce its importance in the unit development. Finally, I will communicate why using PBE with this unit benefits students.

CHAPTER TWO

REVIEW OF LITERATURE

Introduction

The purpose of this literature review is to give the reader the necessary background information to understand the importance of PBE's role in science. First, I will review the long history of PBE including those who continue to champion for PBE in the present day. Next, I will review 8th grade middle school students' cognitive development, and how PBE supports middle school learners. Following that, I include information regarding current implementation of PBE in the science classroom. Then, I explain how Webb's Depth of Knowledge (DOK) aligns with PBE assessment practices. Finally, I explain the two of the benefits of PBE, deeper understanding and intrinsic motivation. With this background information the reader will be prepared to understand my curriculum design model, *Designing a place-based education water cycle curriculum in order to impact middle school science students' depth of understanding and attitude toward science.*

History of PBE

Place-Based Education is defined by the Center for Place-Based Learning and Community Engagement (n.d.) as an experience that "places students in local heritage, cultures, landscapes, opportunities and experiences, and uses these as a foundation for the study of language arts, mathematics, social studies, science and other subjects across the curriculum." With PBE, the students' local communities make learning relevant. Students learning within their local community helps them to develop student-centered, community -based questions. It is the same community and connections the students make within the community that eventually helps them to unlock the answers to their questions. Although the term PBE had not yet been coined, PBE has been around in some form or another since the times of Aristotle and quite possibly earlier. It is important to understand who the early theorists behind the PBE movement were and how their contributions added to make PBE what is today.

Aristotle. Aristotle (384-322 B.C.E.), a famous Greek philosopher, was believed to use PBE-like instruction. Aristotle was not only known to the world as a great philosopher, but an educator as well, his most famous student being Alexander the Great. Aristotle was considered an early implementer of PBE because of his beliefs that students' experiences and understandings (prior knowledge) were tantamount to their ability to learn (Spangler, 1998). Aristotle believed that people learned by doing, through active hands-on activities that they could connect to prior knowledge (Hummel, 1989). The current day PBE model also focuses on students experiences and connecting prior knowledge (mainly their community) to new learning and social action (Sobel, 2004).

Pestalozzi. Another notable educator who used what today is presently known as PBE was Johann Heinrich Pestalozzi. Pestalozzi (1746 – 1827) was a Swiss educational reformer educated in Zurich. Pestalozzi believed one should educate the whole child and children should be not be educated out of textbooks alone. Children should be given the tools to use hands-on methods to generate meaningful questions on and not be given teacher driven answers. By discovering the answer themselves, it gives the learning deeper meaning. Students can satisfy their own curiosity. (Pound, 2012).
Pestalozzi(1898) stated, "Nature, by virtue of which the near is always more firmly impressed upon the child than the distant,…"(p. 239). This supports the idea that local,

hands-on inquiry learning creates a deeper impact than learning concepts that are detached from the student's community.

Dewey. John Dewey (1859-1952) is considered to be the of father of experiential learning in the United States. His ideas align with many of the current day PBE philosophies (Visnovsky, 2006). Dewey believed the curriculum should not be separated from a student's life experiences, saw this happening in traditional schools. Dewey expressed students in traditional schools had to disconnect from the world outside their school walls and with their innate curiosity with natural phenomena. Students had shift to learning about the same natural phenomena using books and classroom lessons (1959). Dewey saw the difference in mind shift between the lab and traditional schools when he and his colleagues created a lab school at the University of Chicago at the turn of the 19th century. Dewey (1902) noted in traditional schooling, "[f]acts are torn away from their original place in experience and rearranged with reference to some general principle" (p. 6). Dewey wrote further about the isolation of from the student's life and traditional schooling here (1956),

> From the standpoint of the child, the great waste in the school comes from his inability to utilize the experiences he gets outside the school in any complete and free way within the school itself; while on the other hand, he is unable to apply in daily life what he is learning in school. That is the isolation of the school–its isolation from life. When the child gets into the schoolroom he has to put out of his mind a large part of the ideas, interests and activities that predominate in his home and neighborhood. So the school being unable to utilize this everyday experience, sets painfully to work on another tack and by a variety of [artificial]

> means, to arouse in the child an interest in school studies. … [As a result there is a] gap existing between the everyday experiences of the child and the isolated material supplied in such large measure in the school. (pp. 75–76)

Dewey's Laboratory School of the University of Chicago has been recognized as the one of the United States first primary schools to use PBE- like instruction as the structure for their curriculum. Dewey did so by developing PBE- like science and social studies instruction with his colleagues. Students studied local maps of the area and were able to take field trips to some of the geographical landmarks nearby to connect the classroom learning to the real-world. They also cared for gardens and raised animals. In doing so they learned what used to be taught out of a textbook through real-life, hands-on processes (Buxton & Provenzo, 2012).

Because of the lead these educators took, contemporaries like David Sobel, David Greenwood (formerly Gruenewald), and David Orr were able to further develop and support PBE as explained in this next section.

Contemporary Place Based-Theorists/Supporters

In recent decades, there has been a re-emergence of the popularity of place in the science curriculum. David Sobel, David Greenwood, and David Orr, among others, have published works and spearheaded organizations supporting PBE. There have been a plethora of books, studies, and websites that have been dedicated to PBE and its implementation. I will highlight below a few of the contemporaries behind this powerful educational movement.

Sobel. David Sobel is an educator on staff at Antioch University. His roles in education have been diverse, from an elected school board member to authoring numerous books and journal articles on PBE. He is the co-director of the Community-based School Environmental Education, a PBE initiative that helps to implement PBE in New England's rural and urban communities. He is also a consultant to schools to support the PBE movement and lectures nation-wide on the importance of PBE.

In Sobel's book, *Place-Based Education: Connecting Classrooms and Communities* (2004) he has defined PBE as "the process of using the local community and environment as a starting point to teach concepts in language arts, mathematics, social studies, science, and other subjects across the curriculum" (p. 7). He goes onto state that PBE not only teaches subjects across the board, it also connects students more deeply to their community while providing hands-on, real-world learning experiences that increase achievement levels and foster commitments to service learning (Sobel, 2004).

Sobel helped develop principles and strategies for implementing PBE programs in schools and environmental learning centers. The two principles are to: "[m]aximize ownership through partnerships and engage students in real-world projects in the local environment and the community" (2004, p. 53). Within these principles, making connections with local organizations, community-based boards, and higher learning institutions to help bring in experts and facilitate learning is key. Engaging students in real-world projects can be as simple as taking care of the school's decorative flower gardens or helping to make repairs around the school ground --anything that gets the students involved in and making contributions to their community (2004, p. 53).

As mentioned above, Sobel has been instrumental in developing strategies for educators who are striving to implement PBE. Here is an overview of the core strategies of PBE Sobel (2004) laid out in his book *Placed-Based Education: Connecting Classrooms and Communities*:

1. Every program needs an environmental educator. This person in not a classroom teacher. They are there to help to enhance the curriculum, serve as a liaison between the program and the community, arrange experiences with in the community for students, serve as a local historian and science expert.
2. Form teams to plan and guide the program. The team should not consistent solely of teachers, but should include an environmental educator, a faculty member from an institution of higher education, an administrator, an non-teaching staff member and a few community members.. This team helps to create professional development opportunities for staff as well as prioritizing educational initiatives, they may present to the school board and they can communicate with the community through website, newsletter and social media.
3. Organize action forums to build connections between the programs and the greater community. The committee would hold an event with a large number of community members to identify their priorities in establishing projects to partner with. The main goal is to build meaningful relationships between the community and the PBE programs.

4. Be mindful not all will agree your environmental education curriculum. With this strategy Sobel suggests that educators are mindful because not everyone sees environmental education as a valid science. Implementers of PBE may run into those who believe that PBE is “propaganda” and has no place in their communities. In Montana, educators struggled with this until they found a way to collaborate with the Montana Cultural Heritage program. They were able to embed the environmental education within a cultural lens that was considered to be acceptable.
5. Continue to improve the program through professional development. As the strategy states, don’t rely on the immediate groundswell of response to keep the program going. The “shine” may wear off, but by continuing to plan engaging professional development opportunities, staff and students will continue to be engaged.
6. Foster community involvement. One simple example of this given by Sobel is to open up the school or center and invite the community in for an evening where students showcase their learning through an arts night or science showcase night. This will foster support from the greater community.

Sobel has outlined two major guiding principles involving community connections and engaging students in real-world projects that are relevant to them and their communities. Sobel has also defined clear strategies for educators to follow when creating a PBE program that will lead program facilitators to success. Through his work, he has become a driving force in PBE movement across the country.

Greenwood (Gruenewald). While Sobel is a driving force behind the implementation of PBE, David Greenwood, formally Gruenewald, is currently publishing articles and books analyzing the idea of place and what it is and what means to education. Greenwood began his career as a high school English teacher and he is currently a professor at Lakehead University in Thunder Bay, Ontario and holds the Research Chair of Canadian Environmental Education.

Greenwood's view on PBE centers around "critical, place-based pedagogy" (Buxton 2010; Gruenewald, 2003). This combines traditional PBE with social inequities and injustices. With this combination of concepts, students through the act of doing, discovering and developing ideas through experiences constructed in the students' local communities but they also address the challenges their communities are facing (Gruenewald, 2003). Gruenewald (2003) claimed, "[p]lace-based pedagogies are needed so that the education of citizens might have some direct bearing on the the well-being of the social and ecological places people actually inhabit" (p. 4). Students not only study the place, they also study the people, populations, socio-economics and inequities that face the place they are studying. This shapes the social-action the students may take.

Greenwood brings to light that a critical pedagogy of place connects a socio-cultural analysis piece to the ecological piece of PBE. This drives students to use their critical thinking skills to make connections between the two: what are effects of cultures interactions with the ecosystems surrounding them? What can be done to identify these effects, are they harmful and how can students take action to change them (Gruenewald, 2003). Traditional PBE models (Bullard, 1993) do not necessarily take into account the inequities that and marginalized populations that may affect those connected to the the place in ways the dominant culture do not experience (p. 23).

In addition, Greenwood also describes five “dimensions of place” in his journal article, *Foundations of Place: A Multidisciplinary Framework for Place-Conscious Education*. It is these dimensions that help to shape the development of the aforementioned socio-ecological place conscious education. The five dimensions are listed as the perceptual, the sociological, the ideological, the political and the ecological, they are all connected to develop a greater sense of place in PBE (Gruenewald, 2003). I have created a table to briefly describe each of Greenwood’s dimensions.

Table 1

Dimension	**Description**
Perceptual	Teachers and students alike must perceive the world around them as alive (Gruenewald, 2003). In doing so, the learning becomes real. Being taught out of a book, inside a building does not lend itself to this perceptual dimension (Bigelow, 1996).
Sociological	“Places are what people make of them. Schools must provide opportunities for students to participate meaningfully in the process of... shaping what our places will become” (Gruenewald, 2003, p. 627).
Ideological	Gruenewald (2003) states that, “[t]his dimensions focuses on the beliefs, thoughts and actions that shape who we are as a people” (p. 627). It also examines the role of education in facilitating certain ideologies,

	particularly those that promote preparing students to compete in a global economy rather than preparing them to be good citizens in an "equitable society" (Gruenewald, 2003, p. 629).
Political	Educators must facilitate learning of place in respect to marginalized populations. Students must be pushed to consider questions like, What is the history of marginalized people in this place? How did they become marginalized? How does the political landscape play into this? How is the marginalization occurring (Gruenewald, 2003)?
Ecological	The focus of this dimension of place is to connect students with their local ecological systems. Students examine where their goods come from and what the ecological impacts are of producing, shipping and disposing of used goods is within their communities. Thus broadening their connection on local economics vs. global economics and how all the dimensions are interconnected (Berry, 1978).

Orr. The last contemporary highlighted will be David Orr. Orr is currently a Professor of Environmental Studies and Politics Emeritus as well as a senior advisor to the president at Oberlin College and Conservatory in Oberlin, Ohio. He has been a champion for the environment and environmental education, authoring eight books and hundreds of journal articles related to the environment and environmental education. He was integral in laying the groundwork for the Annenberg Rural Challenge, the first national project to use the term "place-based learning" and make it a key piece of the curriculum requirement for all projects being entered in the challenge. Orr has also served on the board of the Aldo Leopold Foundation, among others, and is currently a trustee of the Alliance for Sustainable Colorado and the Children and Nature Network.

Orr (1992) identified four reasons PBE should be integrated into a curriculum. The first reason focused on being able to combine “direct observation, investigation, experimentation, and skill in the application of knowledge” (p.127). The second reason was about integrating all aspects of place; human history, geological history, ecosystems, etc. into its study (Orr, 1992). The third reason promoted good living, people caring about the places they live and wanting the best for their place. The final reason identified that when you know your place and where you come from, it helps you to know yourself. (Orr, 1992).

Place-Based Education

Buxton and Provenzo (2011) found, “[o]ne of the advantages of a place-based approach to science teaching is that it supports students in developing the skills of thinking like a scientist” (p. 41). Scientists lead their own investigations and create their own questions; in PBE, students are thinking like scientists by driving their own learning. Due to this, students are deeply engaged in the learning process. A PBE model implores students to use critical thinking skills and allows them to develop a deeper level of understanding related to the content they are studying. This calls for deeper engagement and endurance over a longer time span than most lessons that occur in the traditional classroom setting (Buxton & Provenzo, 2012).

What it looks like. In PBE, learning happens in the community and places that are important to the students. It is focused on local themes, extending to issues and problems in the community. This results in the learning contributing to the well-being of the community. It is full of student centered questioning and investigations. Therefore, the students feel a personal connection and because it takes place locally, it is culturally relevant.

With the learning being well-connected and contributing to the well-being of the community, it is naturally supported by the local community and they are involved with and invested in the learners. The learning is multi-disciplinary and works towards the goals of the school and the community. These learning experiences also serve as bridges for the students to understand civic duty and the importance of supporting their community (Promise of Place, n.d.; Society, 1998).

Benefits of PBE. Implementation of a PBE model has proven to increase intrinsic motivation and promote deeper understanding of content, including special education students. (Blank, 1997; Dev, 1997). Deci and Ryan (2000) stated, "[i]ntrinsic motivation is defined as the doing of an activity for its inherent satisfactions rather than for some separable consequence" (p. 56). Translated to education, this means students are performing tasks because they want to, they are not driven by external rewards like grades. Numerous studies conducted have provided evidence that PBE increases students' intrinsic motivation (Powers, 2004; Skinner, E. A., Chi, U., & The Learning-Gardens Educational Assessment Group, 2012).

In results from a 2004 study of 4 PBE analyzing the strengths and challenges along with trends in teacher practice, Powers (2004) stated, "By fostering the growth of partnerships between schools and communities, PBE works simultaneously to boost student achievement and improve a community's environmental quality and social and economic vitality" (p. 17). When students feel a connection to place, they are more likely to want to learn more about the place, care about the place, take action when necessary to protect the place.

Studies involving garden-based education--which is a form of the PBE model in which students plant, grow, and harvest produce as an integrated portion of their science class-- have shown a connection between PBE and intrinsic motivation. Notably, a study conducted by Skinner, Chi and The Learning-Gardens Educational Assessment Group (2012), where middle school students participated in a garden-based education model and were surveyed for their level of engagement and intrinsic motivation, students who participated in the study showed an increase in the intrinsic motivation. They connected to the place they were caring for and became motivated to continue to invest in the place.

Studies have also reported findings from the surveys of students. Powers (2004) reported that students said that they, "learn better when the school work has a purpose" (p. 27). By using a PBE model, students will experience their connection and the importance of their water usage firsthand to their local water cycle. Students who experience a sense of control over their own learning tend to excel. The same study also cited that students displayed higher levels of maturity and engagement when working on projects benefiting the community (Powers, 2004).

Deeper understanding or internalization of the content is a goal of PBE. A study of the effects of implementing a PBE model with special education students found that special education students performed at a higher level than they did with other traditional educational models (Powers, 2004). Not only did the special education students perform at a higher level, there were also additional benefits such as the ability to work independently at a higher level than if they were in a traditional classroom lecture setting, increased peer respect, the ability to engage with community members involved in the place-based setting and overall, and achievement in the general education setting (p. 26).

Connecting Middle School Students' Cognitive Development and PBE

Understanding past and present theories of PBE leads into why PBE is an excellent match with the developmental needs and abilities of middle-school students. It is important to understand how the middle school mind functions and develops in order to understand how students process information introduced in a PBE curriculum. Piaget's developmental stages (Piaget, 1983) and Vygotsky's Zone of Proximal Development (Vygotsky, 1978) help clarify how and why middle school students are at the right developmental level for engaging in PBE in order to gain deeper understanding of concepts such as the water cycle. It also helps to understand why using a PBE approach increases collaboration among students, higher order thinking, and connection to community for this age group.

Piaget. Jean Piaget's (1896-1980) work supported the idea of place-based education. Powers (2004) noted that, "though research into the effectiveness of place-based education in particular has been slim, some of the most pivotal educational theory, including that of Piaget, is inextricably linked to the underpinnings of place-based education" (p. 18). Piaget believed strongly that educators must strive toward intrinsically motivating and engaging students in active learning. Aligning with the placed-based education model, Piaget also believed that experiences shape the child. (1983). Piaget was convinced that children need hands-on experimentation and to have real-life experiences in their communities to shape and develop their intellect (Pound, 2012).

Piaget found most middle school students are moving from the concrete operational thought process to formal operational thought. The formal operational thought process is necessary for students to be able to gather data in place-based investigations and studies. The concrete operational thought process involves the ability to understand and comprehend concrete objectives. Teacher-led investigations are common at this developmental level. While the transition to formal operational thought involves a shift to abstract thinking, students who are near or have reached the latter stage are able to form hypotheses, they can look at more than just one view of an investigation or problem, and are able to create student led-investigations (1983).

Vygotsky. Vygotsky (1896-1934) was a Russian psychologist whose work in developing social learning theories linked how people learn to their social environments. He believed cognitive development comes before social development (Moll, 2014). Vygotsky's (1978) noted, "[l]earning is a necessary and universal aspect of the process of developing culturally organized, specifically human psychological function" (p. 90). Basically stated, learning facilitates brain development.

In PBE, students are exposed to and move through lessons that allow them to reach the next level of cognitive development. They are given the freedom to create their own investigations, develop their own ideas, and then find the data that supports or refutes their ideas. They do this while collaborating with peers and receiving guidance from experts in the field. This guidance collaboration corresponds with Vygotsky's theory of the Zone of Proximal Development (ZPD) (1978). This theory explained how children who are close to the next level of development can be guided to the next developmental level by peers who are already at the next level or under adult guidance.

Another main feature of ZPD is exposure to next-level problem solving which will help them move into the next level of development (Vygotsky, 1978).

With Vygotsky, students are within the ZPD for being able to create a student-led investigation when given parameters (rubric) by their teacher. Vygotsky believed that collaborative, culturally-connected, student-led investigations and guidance by the experts in the field of study are all ways in which students develop. Vygotsky was essentially describing the PBE model.

However, Vygotsky's theory is different from Piaget's because Vygotsky's view is that children are in a continuous state of cognitive development and learning, while Piaget sets distinctive levels of cognitive development. However, they both are connected to the ability of a student to develop a deeper understanding of content through a place-based model. With Piaget, the students will learn through doing. At the middle school level, students are not only developing physically and socially-emotionally, they are also progressing in their cognitive development. Piaget has outlined the transfer between cognitive stages at this age (concrete operational thought to formal operational thought), while Vygotsky believed the cognitive development comes through the act of doing. Piaget and Vygotsky believed learning is what leads to the development of higher order thinking and understanding (Blake & Pope, 2008). While their theories of what drives cognitive thinking are different, they are both related to learning and can demonstrate how PBE fits into and aids these areas of cognitive development. Understanding this developmental level of most 8th grade students, allows development of the appropriate amount of rigor in regards to a place-based curriculum. The hands-on piece in a place-based approach connected to the water cycle will allow students to see the bigger picture the water cycle plays in their daily lives.

Assessing for Deeper Understanding

Place-based education has been proven to increase academic achievement and help students to connect with the natural world. It has been proven that creating learning opportunities within local communities provides students with the ability to see the relevance and context of what they are learning, and to increase depth of knowledge (DOK) in their learning process (Bransford & Schwartz, 1999; Powers, 2004). With PBE, educators are able to assess at higher levels because students gain a deeper understanding of concepts. Buxton and Provenzo found that while some assessments do not assess high-order thinking skills, students retain factual information at a higher rate through placed-based learning than from simply reading about the information (2012). The American Institutes for Research found that students are able to retain information longer when it has been built through an inquiry-process such as PBE (2005). Also, according to the same research study conducted for the State of California by American Institutes for Research, at-risk students who participated in an outdoor science school demonstrated gains in six areas as compared to those who did not participate: self-esteem, conflict resolution, relationship with peers, problem solving (largest area of increase), motivation to learn, and behavior in class.

Aligning Webb's DOK with the PBE curriculum. Norman Webb is a professor who is an expert in the field of aligning standards and assessments. Webb's work has added clarity to the levels of rigor when creating assessments. In addition, Webb's DOK guides added rigor in assessments and connects naturally with the principles of a PBE model.

Webb's Depth of Knowledge (DOK) combined with Bloom's Taxonomy can be useful tools in creating assessments that can measure learning from PBE. Hess (2009) has aligned Norman Webb's DOK Level's with Bloom's Cognitive Process Dimensions (See Appendix A). Both approaches indicate levels of progression in depth of understanding: Bloom's (2001) taxonomy moves from recall to creation while Webb's (2002) moves from recall to extended thinking.

When adding rigor connected to PBE and student assessment, teachers take into consideration many different variables. Each level is detailed in "Webb's Alignment Tool" (1997) which is briefly outlined below.

DOK Level 1 *Recall* assessment questions include tasks relating to recall and reproduction. At this level students are able to recall information--for example, facts such as vocabulary words. An appropriate assessment example would be matching, fill-in-the-blank or providing definitions. When related to the a science curriculum, students would simply be expected to memorize information given to them.

DOK Level 2 *Skill/Concept* questions boost the rigor another step beyond simple recall. It is here students take given information and apply it to a given situation. At this level, students might be asked to create a data table and a graph with information given. It is referred to as the "Basic Application" level.

DOK Level 3 *Strategic Thinking* is where the connection to PBE begins in terms of assessing students for higher levels of understanding of the concepts being taught. Within a DOK 3, students will begin to create their own plans to solve a problem. At this level there can be multiple ways to solve problems correctly; in Levels 1 and 2 there is only one possible correct answer. One example of a DOK Level 3 assessment is when students are given open-ended type essay questions to answer. They need to use their own experiences and knowledge to answer this level of questioning.

DOK Level 4 *Extended Thinking* is the level Webb describes as using complex reasoning. In a PBE model, this level includes using the ability to design, carry out and synthesize the results of an experiment (2002). Here is the piece where in PBE students can apply what they have learned to benefit the local community, help to solve a problem, and assess next steps that can be taken.

Webb's Depth of Knowledge (1999) helps assess how PBE increases a student's critical thinking skills and deepens their understanding. In this curriculum development the aim is for students to reach at least the third assessment level, strategic thinking and culminate to the fourth and final level, extended thinking. At the third level, students are able to analyze and evaluate.

Webb's higher DOK levels aligns seamlessly with the PBE theory. In PBE, experiments could be planned and designed by students and conclusions could be evaluated in a summative fashion using Webb's higher level DOK.

Challenges

PBE is not without its challenges. Challenges can be as basic as needing more time to a more complex systematic challenge of how to obtain quality professional development pertaining to PBE. This section will explain some of the more common challenges that face educators who are striving to implement PBE.

The first challenge faced that was cited in Powers' study, was an external factor -- time (2004). All four programs expressed the need for additional time to develop the curriculum. Some solutions presented in the study related to this particular challenge included seeking outside experts to and community members to assist in the curriculum planning. The second challenge that was addressed pertained to lack of administrative buy-in. Unfortunately, there was no solution listed for this particular challenge.

The final challenge I choose to highlight pertains to staffing needs in PBE programs. All four programs in Powers study identified the need for extra assistance in implementing the actual curriculum.

Although implementing a PBE program may be challenging, there are solutions to most of the challenges. Teachers can enlist in the help of others in the school community. For this particular challenge there were multiple solutions including; hiring a teacher's aid to provide an extra set of eyes during activities as well as to complete smaller time consuming tasks such as preparing lesson materials and team teaching to allow teachers to support one another. They can also reach out to the greater community to lend a hand in making the curriculum a success.

Conclusion

This literature review gave an overview of the history of PBE. It also introduced PBE's contemporary supporters and their individual beliefs in PBE. It continued with linking PBE's effectiveness within a middle school due to the increased cognitive and social development happening at this stage. Due to the engaging nature of PBE and its connection to the community, intrinsic motivation and deeper understanding for all students demographics were also shown to be directly linked to PBE through Powers studies. It also addressed some of the challenges a PBE model faces and possible solutions to those challenges. The later portion of the literature review covered the topic of assessing deeper knowledge using Norman Webb's Levels of DOK and how it aligns well with the PBE model.

This chapter also showed how with a PBE water cycle unit the more students learn about the water in their community, the more they will want to investigate how to protect it. The more they investigate, the more they will want to take an active role in protecting it. In turn, benefiting the community while they gain a greater depth of understanding of the water cycle in their community and why they should take care about it.

In Chapter Three, I will discuss the methods I will use in creating the PBE curriculum surrounding my topic, *Designing a place-based education water cycle curriculum in order to impact middle school science students' depth of understanding and attitude toward science.* It includes the purpose of my capstone, followed by the principles that guided my planning. Then, the framework I used to plan my PBE unit. Finally, the participants and setting the PBE unit is written for.

CHAPTER THREE

METHODS

Purpose

The purpose of this capstone project is to enhance student learning through the creation of an engaging PBE unit connecting students to their local community and to address the following topic: *Designing a place-based education water cycle curriculum in order to impact middle school science students' depth of understanding and attitude toward science.* The end goal of this curriculum is to deepen the understanding through personal connection and engagement that students experience in regards to water on Earth and the water cycle. Through research supported, place-based curriculum all students will have the tools to master the district's learning targets and state mandated benchmarks through hands-on and inquiry-based activities. These activities are centered around the school pond (any reservoir can be substituted), thus connecting a sense of place with the learning targets and benchmarks.

Guiding Principles

PBE. In using PBE to create this unit on water, I first need to locate a water source that I want my students to connect to and develop a sense of place with. Second I need to be sure they have opportunities to connect with this place I want to them to care about. Third, I need to create a connection to local community resources that are connected to the place I want them to care about. Fourth, I need to find resources for my students to use in the classroom that connect to this place the curriculum is centered around. And finally, I need to allow students to be the drivers of the learning.

DOK Level 4. In preparing to use a DOK level 4 summative assessment, I need to think about how my students are going to progress to this level of understanding. Tasks associated with this level demand critical and creative thinking processes. They require extended time frames in which students can complete investigations that are student-led. Students are looking to solve problems that relate to real problems within their communities that have solutions they cannot predict. In this level, students need to be able to reflect and make necessary adjustments to their investigations based on those reflections. Endurance is required at this level due to the length of time it may take to solve the student-identified problem.

Water resources protection. Life on our planet is possible due to the presence of water. According to the NOAA website (n.d.), "The hydrologic cycle involves the continuous circulation of water in the Earth-Atmosphere system. At its core, the water cycle is the motion of the water from the ground to the atmosphere and back again" ("The Hydrologic Cycle", para. 1). Clean water is a valuable natural resource. In order to continue to have ample water, it is important students understand the water cycle, the role our watersheds play in providing clean water, and the roles they play in continuing to access clean water. The Cary Institute of Ecosystem Studies (n.d.) also noted,

> Teaching about the water cycle can be made more realistic and valuable for students by incorporating what they know about water--where it comes from, what happens to it after they use it, and what problems are associated with its use. Watersheds, the land area draining into a single body of water, can be considered a basic unit of the landscape that determines water availability, movement, and quality. When students study watersheds, they learn in a personal way about the

importance of water, and how land use affects surface and groundwater (Balancing the Water Budget of a Leaf, para. 1).

The Minnesota Board of Soil and Water Resources, et al. (2004) states that, "[w]ith more than 10,000 lakes, 100,000 river and stream miles, and extensive groundwater systems, water is a major part of Minnesota's culture, economy, and natural ecosystems"(p. 4). It is also part of the national, state and district learning outcomes for Earth Science students. In addition, the school where I am employed has access to a pond that the students can study. Many students are already familiar with the pond and it makes sense to use a local resource to help continue to build the connection.

Using a water source on or near a school's property that is familiar to the students, along with a PBE model to teach the water cycle, will help students understand how the area is a mini-watershed. Understanding clean water is necessary for life on Earth to exist. It is of the utmost importance that students understand the water cycle and how their actions are directly connected to the water cycle and their watershed. Students will also understand through water quality testing how the actions of those who use the land surrounding this mini-watershed contribute to the quality of water. The implications of the quality and the effect it has on the life in and around the water will also be examined. Students will be able to understand how their actions affect the mini-watershed and what they can do to protect this mini-watershed. This learning and new awareness will culminate in their final assessment when they present their water quality findings and ideas on how to keep the pond from becoming polluted to the local community.

Setting and Participants

This unit was written with a suburban, 8th grade middle school science classroom in mind. The demographic of the population in mind is a public middle school in suburban Minnesota with approximately 1,250 students in attendance. There are 78 adults in teaching positions along with 26 paraeducators: 19 special education paraprofessionals, 4 instructional paraprofessionals, and 3 one-on-one paraprofessionals. This building is comprised of 62.1% white students. The rest of the student population consists of students of color, with African American students as the next highest racial group at 16.8%. In this suburban setting, there is significant socioeconomic diversity. Forty six percent of the students qualify for free and reduced lunch this school year. This middle school has the highest percentage of low-income families in the district. There are also two special education programs in the school, a DCD (Developmental and Cognitive Delay) program and a LAUNCH (Learners with Autism with Unique Needs and Challenges) program for those who have an autism diagnosis that can require significant support - either educationally or socially-emotionally.

Planning Process

UBD- Understanding by Design. To guide my writing of this unit, I utilized the Understanding By Design (UBD) approach (McTighe and Wiggins, 2012) to align with PBE. This framework is based on big ideas, essential questions, and what I want the students' overarching understandings to encompass. Backwards planning-- defining the desired outcomes first and then designing a plan to achieve those desired outcomes -- was used. Having identified learning outcomes and plans to reach those does not mean that this will be a teacher-led curriculum, however. There is much room in planning to allow for student-directed learning.

Step 1 in the planning process was to develop *essential questions* for each lesson. These are questions that are developed by turning the MN content standards and district learning targets (Table 2) into a question form. Step 2 entails planning a summative assessment for the students. The summative assessment needs to follow the DOK level 4 parameters. Then students' prior knowledge needs to be assessed by pre-assessments to guide instruction. Writing of assessments of prior knowledge is followed by creation of daily formative assessments that can be as simple as applying new knowledge to new situations. Again all of this is done via the PBE model which connects students to local resources while developing a sense of place.

Once essential questions and assessments have been determined, step 3 in the backwards planning process is to figure out how to get students to meet the learning targets. This step hinges on deciding an appropriate order of the objectives and essential questions, then planning engaging daily lessons. The daily lessons need to offer opportunities for students to connect with the place the unit is focused on to help draw them into developing a connection with this place. This can be done by using the place for multiple lessons and inviting outside community members in who have a connection to it. The daily lessons follow a layout of stating the standards and objectives, followed by the essential question and vocabulary. Then the lessons offer an overview, procedure, and formative assessment. The lessons also include additional materials and links to complete each lesson.

The final step in the planning process is to think about and address little details such as safety, arranging guest speakers and audiences, the layout of the lesson plans, materials needed, and timing. In addressing safety, I need to decide if I need an extra set of eyes when using the outdoors as a classroom. I also need to decide how far in advance I need to arrange my guests and how I will connect with local agencies to which my students can present their final summative projects. I needed to develop a lesson plan outline that I could use for all my lessons, so I created a template that included objectives, essential questions, an overview, a materials list, the time frame to complete the lesson, the procedures, and any assessment materials used by students. I also had to take into consideration the need for materials the science department may not already have. How would I order these materials? Is it in our budget? What outside agencies might be able to help support our need for materials for this unit? Finally I need to time out all the lessons - including the order. What order should they follow? How much time is sufficient to complete the tasks set forth in each lesson?

Table 2

8th Grade Learning Target	Minnesota State Learning Benchmark	Essential Vocabulary
1- I can explain how a water molecule moves through the water cycle.	8.3.2.3.2 - Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle. 8.3.2.3.2 - Describe how the water cycle distributes materials and purifies water.	● Precipitation ● Evaporation ● Condensation ● Transpiration ● Runoff ● Infiltration ● Groundwater

2- I can identify the location and composition of Earth's reservoirs.	8.3.2.3.1- Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle. 8.3.2.3.1 - Describe the location, composition and use of major water reservoirs on the Earth, and the transfer of water among them. 8.3.4.1.2 - In order to maintain and improve their existence humans interact with and influence Earth systems. 8.3.4.1.2 - Recognize that land and water use practices affect natural processes and that natural processes interfere and interact with human systems.	● Reservoir ● Salt water ● Fresh water ● Aeration ● Filtration ● Pollutant ● Watershed
3 - I can explain why scientific research is limited by constraints such as money, politics, and ethics.	8.1.3.3.1 Students will be able to explain how scientific laws and engineering principles, as well as economic, political, social, and ethical expectations, must be taken into account in designing engineering solutions or conducting scientific investigation	● Constraints ● Ethics

Conclusion

These guiding principles and process will allow me to develop a curriculum that improves students' depth of understanding and attitude toward science while also connecting them to the community around them. In the next section, I will lay out the curriculum. It will begin with general background information on the water cycle and an introduction of the vocabulary. Then it will involve a pre-assessment of students overall prior knowledge of water on Earth including the water cycle. The curriculum will include all formative assessments, as well as the final summative assessment. Finally, I will give a more in-depth look at the final summative assessment, a collection of student-designed research projects which will be presented to local community organizations with water-quality interests.

CHAPTER FOUR

This chapter discusses the outline of the water cycle unit I created. First I will discuss general unit information including vocabulary words that are covered in the unit. Second I will go over the activation of prior knowledge and how the unit pre-assesses students. Third I will discuss how the daily activities build on one another. Finally I will discuss the formative and summative assessments that will be given throughout the unit. Throughout the design I will also explain how I integrated PBE into the unit to address my topic, *Designing a place-based education water cycle curriculum in order to impact middle school science students' depth of understanding and attitude toward science.*

General Overview

At the school there is a pond that has recently been created by the local watershed district as a catchment basin. A catchment basin is a place where all the runoff from the surrounding area collects in an area of lower elevation. This pond is used as the focal point of the culminating research project. In the unit, this will be converted to a generic water source so it can be used at any school. Labs and classroom activities are used to increase background knowledge which further supports the PBE curriculum. Minnesota State Science Benchmarks (MSSBM), Learning Targets (LT), and Essential Vocabulary associated with the district's Eighth Grade Earth Science Water Unit (see Appendix A) to guide the creation of this curriculum.

Pre-Assessing and Vocabulary

The unit begins with students reflecting where their water comes from. They will their water usage and making predictions on water their personal water usage. This pre-assessment is meant to get the students thinking about water as more than just something that flows out of the faucet.

Day two begins with the basic processes of the water cycle. Many of the vocabulary words are identifying process in the water cycle. This station activity is set-up to demonstrate all the processes so the students will be able to make a visual connection to the vocabulary. The vocabulary will also be applicable to the school's mini-watershed.

Day three, students write or draw all they can remember in connection with the water cycle. For those students who have been in Minnesota, they have some prior knowledge from the elementary school standards on the water cycle to activate. This pre-assessment not only gives me a measure of what they know, it also allows students to see growth when they compare they the pre- and post-assessments.

Day four entails students applying vocabulary to their sketches of the pond. They will review the table they created identifying the processes and then, for those who need further clarification, there will be a short PowerPoint going over the vocabulary. The vocabulary will then be used when they write a short story incorporating the school's pond into the water cycle.

Day five introduces reservoirs to the unit along with associated vocabulary. Students will brainstorm a list of Earth's reservoirs as a class. They will then make predictions about the amount of Earth's water in each of the reservoirs which serves as a pre-assessment. The vocabulary is used throughout the lesson in context.

Day six students are introduced to watersheds and, more importantly, their local watershed. An employee form the watershed district will be out to discuss the watershed the school belongs to. The employee will be pre-loaded with the essential vocabulary to incorporate into her presentation. In addition, through analyzing water drainage maps and making inferences, students will again be using the unit's vocabulary in connecting the maps to tell a story.

Day seven and eight are all about pollutants in Minnesota. Students will become even more familiar with the vocabulary as they research pollutants and how they enter our watershed. They will then use essential vocabulary to pass on the information of Minnesota water pollutants to their classmates.

Day nine through twelve the students start to pull it all together. They design a water quality testing field study. They need to make predictions before they do the actual testing. Once the testing is finished, they will move onto their final tasks of the unit--creating an action plan and public service announcement for the greater community. In their final presentations, students will be required to incorporate the essential vocabulary.

Throughout the unit, students will be continuously incorporating the essential vocabulary into the their learning and research. Using the words repeatedly--in context orally and in their research writing--will help to deepen their overall science vocabulary understanding.

Daily Activities

The daily activities throughout the unit are designed to help students to develop the background information necessary to complete their final summative project. They are also used to develop a connection with the pond and surrounding area. This is done by spending time out near the pond, studying areas around the pond and welcoming local experts into the classroom to talk about the pond and surrounding areas.

This PBE model will guide the students through the water cycle in a way that will increase students' depth of understanding in this area. Students will review the basics of the water cycle and delve deeper using our school pond to understand why keeping our watersheds pollutant-free is extremely important. They will actively engage in water-quality testing and then report their results to our local watershed district. The end goal is to have students develop ways to prevent pollutants from entering our watershed, a level four in regards to DOK assessment.

Students are learning about threats to pond in terms of pollutants and the roles we as community members must take to protect our natural reservoirs from pollutants. Students are learning how the pollutants might enter our watershed and also from where. In developing the background information, students are learning through the local environment, thus strengthening their connection (see Table 3 for a complete outline of daily activities).

Table 3

DAY #	Lesson Plan
1	**MN Benchmark:** 8.3.2.3.2 - Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle. 8.3.2.3.2 - Describe how the water cycle distributes materials and purifies water. **Objectives:** I can explain how a water molecule moves through the water cycle. I can identify the location and composition of Earth's reservoirs. **Essential Question:** Where does my water come from and how much do I use per day? **Lesson Summary:**

	Students will brainstorm where they believe their water comes from and how much they use as a raw resource daily. They will then analyze how much water it takes to produce the food they typically eat in one day. **Assessment:** Pre -assessment bellringer, Where does my water come from? Post - Analysis and reflection questions
2	**MN Benchmark:** 8.3.2.3.2 - Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle. 8.3.2.3.2 - Describe how the water cycle distributes materials and purifies water. **Objective:** I can explain how a water molecule moves through the water cycle. **Essential Question:** What are the processes included in the water cycle and what do they look like? **Lesson Summary:** Students will use any previous knowledge from the water cycle to help them make predictions about the different water cycle processes. This will serve as an introduction activity to the essential vocabulary. **Assessment:** Complete water cycle process identification table and complete the analysis questions.
3	**MN Benchmark:** 8.3.2.3.2 - Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle. 8.3.2.3.2 - Describe how the water cycle distributes materials and purifies water. **Objective:** I can explain how a water molecule moves through the water cycle. **Essential Questions:** Who should have a voice in protecting this place? What role does this place play in the water cycle? **Lesson Summary:** To introduce students to the pond and areas around the pond, students will spend 25 minutes journaling around the pond. Students will describe their

	observations in words and drawings on graph paper provided keeping the essential questions in mind. Students should include vegetation, animals, and structures in their notes and drawings. Small group and then a larger class discussion will follow. **Assessment:** Pre-assessment in the beginning of class, in pictures or words, tell all you know about the water cycle.
4	**MN Benchmark:** 8.3.2.3.2 - Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle. 8.3.2.3.2 - Describe how the water cycle distributes materials and purifies water. **Objectives:** I can explain how a water molecule moves through the water cycle. **Essential Questions:** Who should have a voice in protecting this place? What role does this place play in the water cycle? **Lesson Summary:** To introduce students to the pond and areas around the pond, students will spend 25 minutes journaling around the pond. Students will describe their observations in words and drawings on graph paper provided keeping the essential questions in mind. Students should include vegetation, animals, and structures in their notes and drawings. **Assessment:** Students will write a short story using their drawing and notes as references. They will need to include all the essential vocabulary to describe the water cycle as it could occur on the school property (5-7 sentences).
5	**MN Benchmark:** 8.3.2.3.2 - Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle. 8.3.2.3.2 - Describe how the water cycle distributes materials and purifies water. **Objective:** I can identify the location and composition of Earth's reservoirs.

	Essential Question: How is water distributed on Earth? **Lesson Summary:** Students will estimate the percent of water contained in each of Earth's reservoirs using a bin to model the ocean and beakers and graduated cylinders to model the remaining Earth's Reservoirs. Then they will be given the correct amounts to complete their data table. They will use their data table and inferences to complete the analysis questions. **Assessment:** Data table with analysis and inference questions
6	**MN Benchmark:** 8.3.2.3.2 - Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle. 8.3.2.3.2 - Describe how the water cycle distributes materials and purifies water. **Objectives:** I can explain how a water molecule moves through the water cycle. I can identify the location and composition of Earth's reservoirs. **Essential Questions:** Where does water flow to and from, on and around our school property? What can I tell about water flow from analyzing maps? **Lesson Summary:** A local expert, an employee from the local Watershed District or the local County and Soil Conservation District will present information about the pond on the property and its importance to the local watershed. The employee will explain how the pond is a catchment basin for sediment. This prevents sediment from entering the stream that eventually flows into the Mississippi River. By building this catchment basin, it will help to preserve and possibly improve the health of the watershed. Students will then analyze three different maps of the surrounding area; an elevation map, a drainage map and a storm drain map. **Assessment:** Map My Watershed - Map Analysis Questions
7	**MN Benchmark:** 8.3.2.3.2 - Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle.

	8.3.2.3.2 - Describe how the water cycle distributes materials and purifies water. **Objectives:** I can explain how a water molecule moves through the water cycle. I can identify the location and composition of Earth's reservoirs. **Essential Questions:** Why is clean water important? What are threats to our clean water? **Lesson Summary:** Students will research five of the top ten pollutants in Minnesota and fill in the table provided. They will begin to create a presentation on their group's pollutant of choice. **Assessment:** Data table
8	**MN Benchmark:** 8.3.2.3.2 - Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle. 8.3.2.3.2 - Describe how the water cycle distributes materials and purifies water. **Objectives:** I can explain how a water molecule moves through the water cycle. I can identify the location and composition of Earth's reservoirs. **Essential Question:** Why is clean water important? What are threats to our clean water? **Lesson Summary:** Students will complete their presentation and then present to other groups during a gallery walk. **Assessment:** Presentation, analysis questions and class discussion
9	**MN Benchmark:** 8.3.2.3.2 - Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle. 8.3.2.3.2 - Describe how the water cycle distributes materials and purifies water. 8.1.3.3.1 Students will be able to explain how scientific laws and engineering principles, as well as economic, political, social, and ethical expectations, must be taken into account in designing engineering solutions or conducting scientific investigation **Objectives:**

	I can explain how a water molecule moves through the water cycle. I can identify the location and composition of Earth's reservoirs. I can explain why scientific research is limited by constraints such as money, politics, and ethics. **Essential Questions:** How does the water cycle affect the quality of our watershed? How does human activity affect the quality of our water? How can I design a reliable field investigation? **Lesson Summary:** Students will review what makes a good field investigation. They will learn about the different water characteristics they may test in their investigation. Students then choose three to further research and record information. They then choose two to test and form groups based on what they want ot test. **Assessment:** Will be not be assessed today.
10	**MN Benchmark:** 8.3.2.3.2 - Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle. 8.3.2.3.2 - Describe how the water cycle distributes materials and purifies water 8.1.3.3.1 Students will be able to explain how scientific laws and engineering principles, as well as economic, political, social, and ethical expectations, must be taken into account in designing engineering solutions or conducting scientific investigation. **Objectives:** I can explain how a water molecule moves through the water cycle. I can identify the location and composition of Earth's reservoirs. I can explain why scientific research is limited by constraints such as money, politics, and ethics. **Essential Question:** How does the water cycle affect the quality of our watershed? How does human activity affect the quality of our water? How can I design a reliable field investigation? **Lesson Summary:** Students will design their field investigation and practice testing their water properties with tap water.

	Assessment: Teacher will assess throughout investigation design by initialing their design step-by-step checking for a quality study.
11	**MN Benchmark:** 8.3.2.3.2 - Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle. 8.3.2.3.2 - Describe how the water cycle distributes materials and purifies water. 8.1.3.3.1 Students will be able to explain how scientific laws and engineering principles, as well as economic, political, social, and ethical expectations, must be taken into account in designing engineering solutions or conducting scientific investigation **Objectives:** I can explain how a water molecule moves through the water cycle. I can identify the location and composition of Earth's reservoirs. I can explain why scientific research is limited by constraints such as money, politics, and ethics. **Essential Question:** How does the water cycle affect the quality of our watershed? How does human activity affect the quality of our water? How can I design a reliable field investigation? **Lesson Summary:** Students will collect their water samples, make observations and test their samples recording their data. **Assessment:** No assessment today.
12	**MN Benchmark:** 8.3.2.3.2 - Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle. 8.3.2.3.2 - Describe how the water cycle distributes materials and purifies water. 8.1.3.3.1 Students will be able to explain how scientific laws and engineering principles, as well as economic, political, social, and ethical expectations, must be taken into account in designing engineering solutions or conducting scientific investigation

	Objectives: I can explain how a water molecule moves through the water cycle. I can identify the location and composition of Earth's reservoirs. I can explain why scientific research is limited by constraints such as money, politics, and ethics. **Essential Question:** How does the water cycle affect the quality of our watershed? How does human activity affect the quality of our water? How can I design a reliable field investigation? **Lesson Summary:** Students will analyze their results and share their results with the class. Students will provide evidence to discuss the quality of the pond water. **Assessment:** Analysis questions on their results and class discussion sharing results.
13	**MN Benchmark:** 8.3.2.3.2 - Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle. 8.3.2.3.2 - Describe how the water cycle distributes materials and purifies water. 8.1.3.3.1 Students will be able to explain how scientific laws and engineering principles, as well as economic, political, social, and ethical expectations, must be taken into account in designing engineering solutions or conducting scientific investigation **Objectives:** I can explain how a water molecule moves through the water cycle. I can identify the location and composition of Earth's reservoirs. I can explain why scientific research is limited by constraints such as money, politics, and ethics **Essential Question:** How can I control the amount of pollutants entering our water cycle? **Lesson Summary:** Students will design a presentation and develop an action plan to improve water quality. **Assessment:** On Final Day
14	**MN Benchmark:**

	8.3.2.3.2 - Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle. 8.3.2.3.2 - Describe how the water cycle distributes materials and purifies water. 8.1.3.3.1 Students will be able to explain how scientific laws and engineering principles, as well as economic, political, social, and ethical expectations, must be taken into account in designing engineering solutions or conducting scientific investigation **Objectives** I can explain how a water molecule moves through the water cycle. I can identify the location and composition of Earth's reservoirs. I can explain why scientific research is limited by constraints such as money, politics, and ethics **Essential Question:** How can I control the amount of pollutants entering our water cycle? **Lesson Summary:** Students will continue to create their presentation and action plan **Assessment:** On final day (15)
15	**MN Benchmark:** 8.3.2.3.2 - Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle. 8.3.2.3.2 - Describe how the water cycle distributes materials and purifies water. 8.1.3.3.1 Students will be able to explain how scientific laws and engineering principles, as well as economic, political, social, and ethical expectations, must be taken into account in designing engineering solutions or conducting scientific investigation **Objectives** I can explain how a water molecule moves through the water cycle. I can identify the location and composition of Earth's reservoirs. I can explain why scientific research is limited by constraints such as money, politics, and ethics **Essential Question:** How can I control the amount of pollutants entering our water cycle? **Lesson Summary:**

	Students will present their water quality results and action plans **Assessment:** Summative presentation with all components laid out in the rubric.

Assessments

Formative. Throughout the unit I will be assessing students' progress along the way. In nearly every lesson there is a formative in place. The formatives take different forms, some are drawings, some involve writing a paragraph using essential vocabulary while others involve analyzing different to tell the story of a place. One piece all the formatives do have in common is that they are all related to the same place, the pond. While one tells a story of the water cycle involving the pond, another highlights the possible pollutants that may enter the pond and the harm they may cause. Along with discussions led by analysis questions, I will be able to gauge my students progress towards mastery of the standards and their ability to develop a deeper understanding of the local water cycle.

Summative. Here, students identify research questions and design scientific experiments along with developing scientific models. This will relate to the students developing an investigation they will conduct at their local water source analyzing water quality. In aligning level 4, extended thinking, students conduct an investigation, beginning with identifying a specific problem to designing and carrying out an experiment, to analyzing its data and forming conclusions. This is the ultimate goal beyond level 3 where students only design and carry out the experiment. Level 4 is done over an extended period of time. Students will also apply the results of their student-led investigation related to the water cycle and develop an action plan to present to the local watershed district or related community organization.

In addition, if I were to implement this unit curriculum, I would also give students the identical unit summative I have been giving my students over the preceding years prior to using the PBE model to teach the water cycle. This would provide data to compare the impact this unit curriculum has had on students in terms of measuring growth from year-to-year. Finally, I would survey students pre- and post-implementation PBE implementation using a Likert scale to measure student interest in each unit studied throughout the Earth Science curriculum. This would give me data on their change in attitude in science.

Conclusion

Chapter Four has outlined my curriculum unit and how I will implement PBE model to deepen the understanding of the local water cycle while improving students' attitudes toward science. In my next chapter I will detail the difficulties I faced in creating this curriculum unit. I will then explain what it would take to implement PBE and what is next in terms of future PBE curriculum development.

CHAPTER FIVE

CONCLUSION

This final chapter will first give you an overview of the difficulties I encountered while attempting to meet my three goals in the unit I planned. Next, it will explain the steps I would need in order to implement this PBE unit curriculum as part of my teaching practice. Finally, it will address what is next in terms of creating additional PBE units or expanding on this unit to include other water resources.

Difficulties

While attempting to meet the three goals as I planned my unit I encountered various challenges. The first challenge I encountered was figuring out how to help my students connect with the pond. Many of my students are not excited to go outside for academic purposes and have never been outside in a school setting for a class other than gym class. I had to be sure to make the curriculum was engaging and relevant to them so they wanted to go outside. I also had to be sure students would connect the importance of this place in the local water cycle and the community. Some of the hurdles including the planning itself and deciding who I would bring into to the classroom to help create that connection between the greater community and the students. In planning guests to come in, I had to be sure to take the time to communicate what the ultimate goal of the unit was and then ensure the guests could communicate on level that would be engaging and the students would understand.

The second difficulty was staying true to the PBE model. This unit is only one unit. PBE is not currently being used in the school I where teach, so it was difficult to conceptualize all the moving parts involved in implementing a true PBE curriculum and connecting them to the state standards. The standards are broad and my district targets are narrow, so I ended up dropping out a few of the district targets from the water unit that I knew I could "pick up" in other units. As explained in Chapter 2, a true PBE curriculum is a team effort in which environmental educators are involved, community members, teachers, and administrators among others come together to support and build the curriculum (Sobel, 2004). That sort of collaboration would have made meeting the targets and all the standards less burdensome. In this unit creation, however, I was a one woman team. Our school is far from implementing PBE at grade level, much less school-wide, so the support is not there at this time.

The final difficulties that I had in creating this curriculum included short class periods, the seasonal timing, school policies, funding, and staffing. We have a 46 minute class period and it is difficult to conduct an investigation that involves going outside, taking samples, and testing the samples all within one class period. Second, the timing of the unit can be tricky. This year had a late spring, so taking the students outside to study the pond area would have been difficult with the late snowfall and late ice-out. The unit would have to be shifted to later in year to ensure the curriculum activities could happen as planned. The shift would require the consensus of the 8th grade science team as we all teach the same units along the same timelines. Third, small pieces such as school policies cause difficulties. We only have one door through which we can enter our building once we are outside. This door is at least a three minute walk from the pond; there is then an additional minute to get back to the classroom once inside the building. In a 46-minute class period, that is a significant chunk of time if we were to go outside on a regular basis. The next difficulty is finding the funding the proper equipment to implement the curriculum. Quality water testing kits are a minimum of $300 and will not provide enough supplies for all classes. Waders are also needed to access the pond since taking samples from only the edges of the pond would not provide valid testing results. The science budget is not large enough to provide for all materials needed and outside donations and fundraising would be required. The final difficulty is with staffing. To be able to ensure student safety around the pond and for students to be held accountable for the work they are expected to complete while outside, additional staffing is necessary. Since these outside experiences may be new to students, they may need to be taught how to learn in the outdoor classroom. There are so many possibilities for distraction outdoors, especially in the beginning, that it would be beneficial to have an additional staff member outdoors to assist with behavior. In addition, when conducting the water quality investigation, multiple students would be entering the pond to take water samples. At this time it would be helpful to have an extra set of eyes to ensure no one is literally getting in over their head.

Implementation

In order to implement the PBE water cycle unit curriculum, I would have to develop a plan to overcome many of the difficulties I mentioned above. Referring back to Chapter 2, I would need to form a committee to stay true to the PBE principles, the first stage in implementation would be to get approval from the principal. Being that my school does not follow a PBE model, I would also want to arrange for professional development with all who would be involved, from the building principal to the support staff. The professional development would aim at shifting the mindset from inside-only to community-based, inquiry science learning (Sobel, 2004).

After gaining approval, forming a committee, and arranging training, parents would need to be made aware of the new curriculum. Most importantly, parents need to be alerted to the possible danger posed by their child being near a body of water. Another reason would be so students were prepared in terms of proper clothing and allergy medication. Parents may also be more inclined to volunteer in the outdoor classroom if they understand the reasoning for the shift in the curriculum model; this increase in volunteerism could mitigate the difficulty of finding and affording extra staffing.

Connections within the community would need to be made. In Chapter 2 I explained how a big part of the PBE model is problem-solving for real issues in the community through student-centered projects (Gruenewald, 2003; Orr, 1992; Sobel, 2004). Students would need consultants from the greater community that are directly connected to the problem the students are striving to solve. Developing the community-to-school-connection is a major piece in the PBE model.

The biggest piece in a successful PBE model is student buy-in. For students to be invested, they must believe in what they are doing. Proper planning, the right quality and quantity of supplies, and both community and school-wide support would show the students this curriculum--though more rigorous--is worth the effort and time investment.

The Future

Beyond implementing the water cycle unit, it would be amazing to expand this unit to include other local bodies of water. There is a nearby regional park along the banks of the Mississippi River that is staffed by a National Park Ranger. To expand this unit to include field trips to the river and investigations in one of our country's major waterways could only strengthen the understanding they gain about the importance of protecting our clean water sources. It would also be interesting for students to bring in water samples for the investigation from places near their homes or perhaps cabin lakes, places that are important to them and their families, not just the school community.

In expanding PBE throughout 8th grade science, I would love to have at least one PBE unit each trimester implemented into the curriculum. By slowly pushing for this shift in the teaching model, I believe it would be easier with every unit in terms of student motivation. If they are able to see the connection between the unit and their community and lives, it will make the students more interested in and committed to the learning.

Ultimately, I would love to be able have cross-curricular integration of PBE so we are working with other subject areas on a common theme. This would take a shift in the current teaching model of many teachers as well as require training for the entire staff. I am not sure I see this happening in the near future; however, I do know that every year we are taking small steps to connect the students to the greater community, enabling deeper understanding and, we hope, improved attitudes towards science in general.

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Appendix A: Hess's Cognitive Rigor Scale

TOOL 2

HESS COGNITIVE RIGOR MATRIX (MATH-SCIENCE CRM):

Applying Webb's Depth-of-Knowledge Levels to Bloom's Cognitive Process Dimensions

Revised Bloom's Taxonomy	Webb's DOK Level 1 Recall & Reproduction	Webb's DOK Level 2 Skills & Concepts	Webb's DOK Level 3 Strategic Thinking/Reasoning	Webb's DOK Level 4 Extended Thinking
Remember Retrieve knowledge from long-term memory, recognize, recall, locate, identify	o Recall, observe, & recognize facts, principles, properties o Recall/ identify conversions among representations or numbers (e.g., customary and metric measures)	Use these Hess CRM curricular examples with most mathematics or science assignments or assessments.		
Understand Construct meaning, clarify, paraphrase, represent, translate, illustrate, give examples, classify, categorize, summarize, generalize, infer a logical conclusion), predict, compare/contrast, match like ideas, explain, construct models	o Evaluate an expression o Locate points on a grid or number on number line o Solve a one-step problem o Represent math relationships in words, pictures, or symbols o Read, write, compare decimals in scientific notation	o Specify and explain relationships (e.g., non-examples/examples; cause-effect) o Make and record observations o Explain steps followed o Summarize results or concepts o Make basic inferences or logical predictions from data/observations o Use models /diagrams to represent or explain mathematical concepts o Make and explain estimates	o Use concepts to solve non-routine problems o Explain, generalize, or connect ideas using supporting evidence o Make and justify conjectures o Explain thinking/reasoning when more than one solution or approach is possible o Explain phenomena in terms of concepts	o Relate mathematical or scientific concepts to other content areas, other domains, or other concepts o Develop generalizations of the results obtained and the strategies used (from investigation or readings) and apply them to new problem situations
Apply Carry out or use a procedure in a given situation; carry out (apply to a familiar task), or use (apply) to an unfamiliar task	o Follow simple procedures (recipe-type directions) o Calculate, measure, apply a rule (e.g., rounding) o Apply algorithm or formula (e.g., area, perimeter) o Solve linear equations o Make conversions among representations or numbers, or within and between customary and metric measures	o Select a procedure according to criteria and perform it o Solve routine problem applying multiple concepts or decision points o Retrieve information from a table, graph, or figure and use it solve a problem requiring multiple steps o Translate between tables, graphs, words, and symbolic notations (e.g., graph data from a table) o Construct models given criteria	o Design investigation for a specific purpose or research question o Conduct a designed investigation o Use concepts to solve non-routine problems o Use & show reasoning, planning, and evidence o Translate between problem & symbolic notation when not a direct translation	o Select or devise approach among many alternatives to solve a problem o Conduct a project that specifies a problem, identifies solution paths, solves the problem, and reports results
Analyze Break into constituent parts, determine how parts relate, differentiate between relevant-irrelevant, distinguish, focus, select, organize, outline, find coherence, deconstruct	o Retrieve information from a table or graph to answer a question o Identify whether specific information is contained in graphic representations (e.g., table, graph, T-chart, diagram) o Identify a pattern/trend	o Categorize, classify materials, data, figures based on characteristics o Organize or order data o Compare/ contrast figures or data o Select appropriate graph and organize & display data o Interpret data from a simple graph o Extend a pattern	o Compare information within or across data sets or texts o Analyze and draw conclusions from data, citing evidence o Generalize a pattern o Interpret data from complex graph o Analyze similarities/differences between procedures or solutions	o Analyze multiple sources of evidence o Analyze complex/abstract themes o Gather, analyze, and evaluate information
Evaluate Make judgments based on criteria, check, detect inconsistencies or fallacies, judge, critique	"UG" – unsubstantiated generalizations = stating an opinion without providing any support for it!		o Cite evidence and develop a logical argument for concepts or solutions o Describe, compare, and contrast solution methods o Verify reasonableness of results	o Gather, analyze, & evaluate information to draw conclusions o Apply understanding in a novel way, provide argument or justification for the application
Create Reorganize elements into new patterns/structures, generate, hypothesize, design, plan, produce	o Brainstorm ideas, concepts, or perspectives related to a topic	o Generate conjectures or hypotheses based on observations or prior knowledge and experience	o Synthesize information within one data set, source, or text o Formulate an original problem given a situation o Develop a scientific/mathematical model for a complex situation	o Synthesize information across multiple sources or texts o Design a mathematical model to inform and solve a practical or abstract situation

APPENDIX B: Unit Plan

Lesson #1 - Day 1

Water is more than what comes out of the faucet

Learning Objectives:

National

ESS2.C: The roles of water in Earth's Surface Processes - How do the properties on movements of water shape Earth's surfaces and affect its systems?
ESS3.A: Natural Resources- How do humans depend on Earth's resources?
ESS3.C: Human impacts on Earth's systems-How do humans change the planet?

State

MN Benchmark 8.3.2.3.2 - Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle.
MN Benchmark 8.3.2.3.2 - Describe how the water cycle distributes materials and purifies water.

District

LT 1- I can explain how a water molecule moves through the water cycle.
LT 2- I can identify the location and composition of Earth's reservoirs.

Essential Questions:

Where does my water come from and how much do I use per day?

Time Needed: 1- 45 minute class period

Overview:

Students will brainstorm where they believe their water comes from and how much they use as a raw resource daily. They will then analyze how much water it takes to produce the food they typically eat in one day.

Materials needed:

Computers needed - students calculate water footprint
Google classroom preloaded with questions and link below to answer questions and write a reflection paragraph.

Procedure:

Post bellringer to answer in science journal - Where does my water come from?
Direct students to the assignment under today's date on the Google Classroom.

Questions:

1. Before you begin, predict how much water it will take to produce your school lunch.

Now create a lunch by clicking on the foods in the link below that you would typically eat. http://graphics.latimes.com/food-water-footprint/

2. How much clean water did it actually take to produce your school lunch?

3. What are your thoughts regarding your personal water consumption? (Both to produce your school lunch and amount from the water calculator)

4. What impacts do you think your eating habits will have on the future of water availability?

5. Predict the amount of water in gallons you use per day.

Now calculate your water footprint using this this link *https://www.watercalculator.org/wfc2 - your water footprint*

6. Was your prediction accurate?

7. Did the amount surprise you? Why or why not?

8. Where did you use the most water?

9. Were there ways you were using water you hadn't realized before calculating your water footprint? What were they?

10. List 3 personal actions you can take to reduce your water consumption/footprint.

1.

2.

3.

Write a paragraph reflection answering the following questions and explain your reasoning. What surprised you about your own water consumption? Will this change what you eat or how you use water?

(Don't forget to submit your answers.)

Share with shoulder partner/table and then be be prepared to share with the class.

Wrap up- final connections:

Watch video clip: http://channel.nationalgeographic.com/breakthrough-series/videos/our-water-footprint/

After watching the video clip shown, in terms of amounts, how is your lunch water footprint connected to your personal water footprint?

Day #2 -Lesson 2
Water Cycle Demos
Learning Objectives:
National
ESS2.C: The roles of water in Earth's Surface Processes - How do the properties on movements of water shape Earth's surfaces and affect its systems?
ESS3.A: Natural Resources- How do humans depend on Earth's resources?
ESS3.C: Human impacts on Earth's systems-How do humans change the planet?
State
MN Benchmark 8.3.2.3.2 - Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle.
MN Benchmark 8.3.2.3.2 - Describe how the water cycle distributes materials and purifies water.
District
LT 1- I can explain how a water molecule moves through the water cycle.

Time Needed: 1- 45 minutes class period

Essential Questions: What are the processes included in the water cycle and what do they look like?

Essential Vocabulary:

Evaporation	Infiltration
Condensation	Transpiration
Precipitation	Runoff
Groundwater	

Overview: Students will use any previous knowledge from the water cycle to help them make predictions about the different water cycle processes. This will serve as an introduction activity to the essential vocabulary.

Materials Needed:

7 stations to demonstrate each of the processes in the water cycle
Station 1 - Hot plate, 400 mL beaker and water
Station 2 - Light, a water bottle with cold ice water
Station 3 - Light, ice cube, plastic wrap, water, clear bin
Station 4 - Gravel, sand, clay, potting soil, 4 ring stands, 4 funnels,
Station 5 - Plant with a plastic bag over it and a light
Station 6 - Stream table, sand, water, pitcher, tube, 5-gallon bucket
Station 7 - Large beaker filled with gravel and water filled to below the rock line
Data table for each student to complete to as they visit each station. (See Below)

Procedure:
Set up stations 1-7 as follows:

Station 1 - Put 300 mL of water in the beaker and bring to a boil on the hot plate. Place warning HOT sign in front of burner.

Station 2 - Place a water bottle with ice water under a heat lamp.

Station 3 - Put 2 inches warm water in the bottom of a small clear bin, cover tightly with plastic wrap, place an ice cube on the plastic wrap over the center of the bin and position a heat lamp to shine at an angle on the top of the bin.

Station 4 - Fill each of the funnels with one of the soil types: gravel, sand, clay, or potting soil. Place the funnels on the ring stand with a beaker below each funnel, then pour 10 ml of water into funnel

Station 5 - Place a plastic bag over a plant, direct a heat lamp at the bag and plant.

Station 6 - Fill a stream table with sand, attach a drain tube, and direct it into a 5-gallon bucket. Pour water into the stream table with a pitcher.

Station 7 - Fill large beaker with gravel, then add water until it reaches the height of the gravel. and water just to the rock line.

Have students move from station to station. Leave instructions for students to pour water into the funnels at Station 4 and into the stream table at Station 6; at all other stations they are making observations only.

At the end of class, have a discussion about each station. What process did students think matched each station and what was their evidence? Were there any common misconceptions?

What Process am I? Name_______________________ Hour_______

LT 1- I can explain how a water molecule moves through the water cycle.

Purpose: To identify the processes in the water cycle using prior knowledge and to introduce essential vocabulary.

Procedure: At each station, make observations and decide the process being demonstrated.
Stations 1-3: Make observations and complete data table.
Station 4: Pour 10 mL of water into each funnel and observe, complete data table.
Station 5: Make observations and complete data table.
Station 6: Pour 1 L of water into the stream table, observe and complete data table.
Station 7: Make observations and complete data table.

Use the following **essential vocabulary** words to help you determine the process that is being demonstrated at each station:

Condensation
Evaporation
Infiltration
Groundwater Collection
Transpiration
Precipitation
Runoff

Water Cycle Process Identification Table

Station #	Process	Evidence from observations
Station 1		
Station 2		
Station 3		
Station 4		
Station 5		
Station 6		
Station 7		

<u>Analysis Questions</u>

1. What was "powering" many of the water cycle processes?

2. What does this look like in the "real world"?

3. Name the processes that are supported by this "power"?

4. What **force** was behind several of the processes demonstrated? (It is one that keeps us here on Earth.)

5. What processes were driven by this **force**?

6. What essential vocabulary words from the list above do understand?

7. What essential vocabulary words are you still struggling with?

Lesson Plan #3 - Day 3 and 4

The Water Cycle in My World

Learning Objectives:
National
ESS2.C: The roles of water in Earth's Surface Processes - How do the properties on movements of water shape Earth's surfaces and affect its systems?
ESS3.A: Natural Resources- How do humans depend on Earth's resources?
ESS3.C: Human impacts on Earth's systems-How do humans change the planet?

State
MN Benchmark 8.3.2.3.2 - Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle.
MN Benchmark 8.3.2.3.2 - Describe how the water cycle distributes materials and purifies water.

District
LT 1- I can explain how a water molecule moves through the water cycle.

Essential Questions: Who should have a voice in protecting this place? What role does this place play in the water cycle?

Time Needed: 2 - 45 minute class periods

Essential Vocabulary: Infiltration, Evaporation, Condensation, Runoff, Precipitation, Groundwater, Transpiration

Materials: Day 1- Clipboards for every student
Graph Paper
Colored Pencils
Science Notebooks
Day 2- PowerPoint on the Water Cycle
Student sketches and notes from the previous day
Colored Pencils
Pre-Assessment from previous day
Science Notebooks

Procedure (Day 1):

1. Pre- assessment -In pictures or words, write or draw all you can tell me about the water cycle. (Collect them from students for the next day.)

2. Provide students with a picture of the area they will be studying. Can be a map that will be used in lesson five.

3. Students will copy and answer the following questions in their science notebook based on the picture/map of the area shown.

What is this place?
Why is this place important?
Does this place need protection? Why or why not?
Who should have a voice in protecting this place?
What role does this place play in the water cycle?

To introduce students to the pond and areas around the pond, students will spend 25 minutes journaling around the pond. Students will describe their observations in words and drawings on graph paper provided keeping the essential questions in mind. Students should include vegetation, animals, and structures in their notes and drawings. (You can substitute any body of water for the pond.)
*Remind students to think about the scale of the area compared to their graph paper.

When students return to the classroom, they will share their observations and drawings with their table groups. They will discuss their thoughts on the two essential questions first.

Then students will discuss the place of the pond in the water cycle as an entire class.

Day 2
Procedure:
Show a short video of the water cycle as the intro.
https://www.youtube.com/watch?v=ZzY5-NZSzVw

Have a class discussion about the water cycle.

- Does the water cycle have a beginning or end?
- What terms were used for the processes in the water cycle?
- What powers the water cycle

Have students review the Water Cycle Process Table and analysis questions from Lesson #1 again. Then, have students take notes on the water cycle from the short PowerPoint shown in class if they are still struggling or missed class the day of the water process activity.

Then students will take their sketches and notes from the previous day and label where the different processes of the water cycle could occur.

Formative Assessment- Students will write a short story using their drawing and notes as references. They will need to include all the essential vocabulary to describe the water cycle as it could occur on the school property (5-7 sentences). Students may have another student in class review their work. Then hand back the pre-assessment and have the students compare the two. What is different? What new information could they add? Have the students staple both together and turn in.

Essential Vocabulary:	Infiltration	Evaporation
	Condensation	Runoff
	Precipitation	Groundwater
	Transpiration	

Lesson 4 -Day 5 How Much Water?
Learning Objectives:
National
ESS2.C: The roles of water in Earth's Surface Processes - How do the properties on movements of water shape Earth's surfaces and affect its systems?
ESS3.A: Natural Resources- How do humans depend on Earth's resources?
ESS3.C: Human impacts on Earth's systems-How do humans change the planet?
State
MN Benchmark 8.3.2.3.2 - Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle.
MN Benchmark 8.3.2.3.2 - Describe how the water cycle distributes materials and purifies water.
District
LT 2- I can identify the location and composition of Earth's reservoirs.
Essential Questions: How is water distributed on Earth?
Essential Vocabulary: Reservoir Salt Water
Fresh Water Aeration
Filtration Pollutant
Overview: Students will estimate the percent of water contained in each of Earth's reservoirs using a bin to model the ocean and beakers and graduated cylinders to model the remaining Earth's Reservoirs. Then they will be given the correct amounts to complete their data table. They will use their data table and inferences to complete the analysis questions.
Time Needed: 1- 45 minute class period
Materials: Teacher Notes (See Below)
You will need enough of each below for groups of 3

- Reservoir Lab Directions - (See Below)
- 16 Quart Clear Bin
- Blue Food Coloring
- 6- 200 ML beakers
- 3- 50 mL Graduated Cylinders
- Water
- Dropper
- Calculators
- Labels Oceans, Freshwater Lakes, Inland Seas/Salt Lakes, Rivers, Ice Caps/Glaciers, Atmosphere, Groundwater
- Handouts with tables and analysis questions for each student

Water Reservoirs Lab - Teacher Notes

1. Show the students a map of the world or the globe. Ask them what the color blue represents **(water)**. Ask them what percentage of the globe/earth is covered in water (**72%**). Is it all usable by humans?

2. Ask the students to identify the various reservoirs of water on Earth other than oceans. As they give answers, make a list on the board in the front of the room. Students' responses may include reservoirs like dams, which would be included with lakes or rivers; wells, which come from groundwater; springs, which may be included in rivers, and so forth. The final list should be ice caps /glaciers, groundwater, freshwater lakes, inland seas / salt lakes, atmosphere, and rivers.

3. When the list on the board is complete, pass out the water distribution worksheet and divide the students into groups.

4. Give each group 10 liters of water in a bucket (approximately 2.5 gallons), three graduated cylinders, eye droppers and six 200 mL beakers. Explain that the 10 liters represent all the water on the Earth.

5. Have the students label the six small containers with the various water reservoirs (ice caps / glaciers, groundwater, freshwater lakes, inland seas / salt lakes, atmosphere, and rivers).

6. Ask the students to estimate the percentage of water in each reservoir. Have them measure the appropriate amount of water for their estimate of each reservoir and record their data on the water distribution worksheet. Remind them that they will leave the ocean water in the bucket.

7. Discuss the results of the groups' estimations. Where did they think most of the water was located? Do they think there more water in rivers or in the atmosphere?

8. After discussing the initial estimations, have the class the measure the actual amounts found in each reservoir (found on the table on the first page of this activity). Be sure to have the class fill in the correct amounts on the student worksheet.

Actual Percent and Measurements:

RESERVOIR	**APPROXIMATE % OF THE TOTAL AMOUNT**	**MEASUREMENT**
Oceans	97.25	All water left in bucket
Icecaps/glaciers	2.0	200 mL
Groundwater	0.7	70 mL
Freshwater lakes	0.03	3 mL
Inland seas/salt lakes	0.004	4 drops
Atmosphere	0.001	1 drop
Rivers	0.0001	1 flick

9. Discuss the remaining conclusion questions on the back of the activity.

RESERVOIRS LAB DIRECTIONS

Introduction:
Your group will use 10 liters of water to represent all the water on Earth. You will first estimate the percentage for each water source in relation to the total amount and then you will divide the 10 liters of water to demonstrate this.

Materials:
2.5 gallon water container, 3 graduated cylinders, eye droppers, 10 liters of water, and 6-200 mL beakers.

Background:
Approximately 72% of the Earth is covered with water. Sources of water are the oceans, icecaps and glaciers, groundwater, freshwater lakes, inland seas and salt lakes, the atmosphere, and rivers.

In this activity, 10 liters of water in a container are used to represent all the water on Earth. Follow the procedure to fill out the table below for the percentage of each water reservoir in relation to the total amount, and the appropriate measurement for each reservoir.

Procedure:
1. Estimate the **percentage** of water in each reservoir. Write your estimates in the "Approximate % of the total amount" column of your data table.

2. Now that you have figured out the percentage of water for each reservoir, multiply each percent by the total amount of water (10 liters, or 10,000 mL). Write these values (in mL) in the "Measurement" column of your data table.

3. Using the measurements (in mL) from your data table, carefully distribute the water from your large container into each of the 6 beakers. Remember to keep some water in the large container because the large container represents the oceans.

4. Line up your beakers in order from the most to least amount of water.

5. Assign a label to each beaker to show the various reservoirs.

Name: ____ Hour: _________

Learning Target: I can identify the types of water reservoirs on Earth.

Water Reservoirs Lab

Data Table 1: Our Group's Estimate

RESERVOIR	APPROXIMATE % OF THE TOTAL AMOUNT	MEASUREMENT (mL)
Oceans		All water left in bucket
Icecaps/glaciers		
Groundwater		
Freshwater lakes		
Inland seas/salt lakes		
Atmosphere		
Rivers		

**Conversion Hints: 1 Liter = 1000 mL 1 mL = approx. 5 drops

As your teacher demonstrates the true percentages and measurements record the data below and fill your containers.

Data Table 2: True Percentages and Measurements

RESERVOIR	APPROXIMATE % OF THE TOTAL AMOUNT	MEASUREMENT
Oceans		All water left in bucket
Icecaps/glaciers		mL
Groundwater		mL
Freshwater lakes		mL
Inland seas/salt lakes		drops
Atmosphere		drops
Rivers		

***The percentage of usable freshwater is reduced by pollution and contamination. Therefore, the actual amount of water that is usable by humans is very small (approximately 0.00003 percent).*

<u>Reservoirs Lab Conclusion Questions</u>:

1. What percent of the Earth is covered by water?

2. What is a reservoir?

3. In which reservoir is most of the Earth's water located? What kind of water is located here?

4. In which reservoir is the least amount of Earth's water located? What kind of water is located here?

5. Compare your estimate (Data Table 1) with the actual amounts (Data Table 2). What reservoir did you initially think held the least amount of water?

6. How much of the water on Earth is actually available for human use?

7. Will the melting ice caps increase the amount of usable water on Earth? Explain your answer.

8. In Minnesota, we have over 10,000 lakes; why should we be concerned with the amount of fresh, usable water on Earth?

Adapted from: Breyer, B. (2013). *Reservoirs lab.* Unpublished manuscript.

Lesson #5 - Day 6 **Map My Watershed**

Learning Objectives:
National
ESS2.C: The roles of water in Earth's Surface Processes - How do the properties on movements of water shape Earth's surfaces and affect its systems?
ESS3.A: Natural Resources- How do humans depend on Earth's resources?
ESS3.C: Human impacts on Earth's systems-How do humans change the planet?
State
MN Benchmark 8.3.2.3.2 - Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle.
MN Benchmark 8.3.2.3.2 - Describe how the water cycle distributes materials and purifies water.
District
LT 1- I can explain how a water molecule moves through the water cycle.
LT 2- I can identify the location and composition of Earth's reservoirs.
Essential Questions: Where does water flow to and from, on and around our school property? What can I tell about water flow from analyzing maps?
Time Needed: 1- 45 minute class period
Overview: A local expert, an employee from the local Watershed District or the local County and Soil Conservation District will present information about the pond on the property and its importance to the local watershed.
The employee will explain how the pond is a catchment basin for sediment. This prevents sediment from entering the stream that eventually flows into the Mississippi River. By building this catchment basin, it will help to preserve and possibly improve the health of the watershed. Students will then analyze three different maps of the surrounding area; an elevation map, a drainage map and a storm drain map.

Materials needed:
One each of the following for each group:
- Elevation Map A of school property and surrounding area
- Drainage Map B of school property and surrounding area
- Storm Drain Map C of school property and surrounding area
- Map Analysis Questions worksheet for each student

Procedure: Students in small groups of 2-3 will analyze the three maps provided to answer the questions on their analysis sheet. Before leaving, the class will discuss the story the maps told and their predictions on possible pollutants in the area. (This will be an intro to the next day's lesson.)

Map My Watershed - Map Analysis Name____________________ Hour_____

LT 1- I can explain how a water molecule moves through the water cycle.
LT 2- I can identify the location and composition of Earth's reservoirs.

What is a watershed?

Answer the following by looking at the maps provided:

1. Record the map name
   A.
   B.
   C.

2. Look at the keys for each map, what information do they give you?
   A.

   B.

   C.

7. What is the purpose of each the maps?
   A.

   B.

   C.

3. Record the contour interval of the Map A as noted on the map explanation.

4 . Look at the edges of the map. You will notice that the contour lines end there. Does the landscape actually end at the edge of the map? Explain your answer.

5. Describe the appearance of map contour lines at the pond compared to University Avenue, Dogwood Street and the parking lot.

6. Looking at Map A, answer the following:

   Where is the highest elevation?

   Where is the lowest elevation?

7. Using the contour lines of the map; where is the water on the map located? Ponds, ditches, streams, etc.….

8. On each map, where is the water flowing from? To?
   A. Water is moving from____________ to___________.

   B. Water is moving from____________ to___________.

   C. Water is moving from____________ to___________.

9. What effects do you think humans have had on the landscape? How can you tell ?

10. Explain how the maps work together to tell a story.

11. Make predictions on the types of pollutants that might be found here based on what you know about the surrounding area.

12. What conclusions can you draw from looking at all three map

Lesson #6 - Day 7 & 8

Top 10 Ten Water Pollutants in MN

Learning Objectives:
National
ESS2.C: The roles of water in Earth's Surface Processes - How do the properties on movements of water shape Earth's surfaces and affect its systems?
ESS3.A: Natural Resources- How do humans depend on Earth's resources?
ESS3.C: Human impacts on Earth's systems-How do humans change the planet?
State
MN Benchmark 8.3.2.3.2 - Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle.
MN Benchmark 8.3.2.3.2 - Describe how the water cycle distributes materials and purifies water.
District
LT 1- I can explain how a water molecule moves through the water cycle.
LT 2- I can identify the location and composition of Earth's reservoirs.

Essential Questions: Why is clean water important? What are threats to our clean water?

Essential Vocabulary: Pollutant, Filtration, Reservoir, Watershed

Time Needed: 2- 45 minute class periods

Materials: Laptops, poster paper, markers, colored pencils, pollutant table for each person

Procedure:
Place students in groups and give them the following directions:

1. Using the table to guide you, research from the given websites, the five specific water pollutants assigned to your group. (You will do this individually before discussing your findings with our group.)

https://www.pca.state.mn.us/water/pollutants-and-emerging-concerns
http://www.cleanwatermn.org/#
http://www.waterontheweb.org/

Pollutants: (Highlight those assigned to your group, you must research all assigned individually.)

Lawn clippings	Ammonia	Motor Oil	Nitrogen	Mercury
Pet waste	Phosphorus	Road Salt	Sediment	Bacteria

2. Compare your findings with others in your group. What information do you have in common with your group? Decide as a group how you are going to present your information to the school. (Project Examples: Commercial, tweets from the pond, a facebook page, a rap, from the perspective of an organism affected by the pollutant, etc… No slideshows allowed.)
3. As a group, choose one pollutant to present to the school.
   Your presentation must include the following information:
   A. The name of your pollutant
   B. Point of Origin
   C. How it gets into the water
   D. Effects on animal/aquatic life
   E. Possible treatment/prevention
   F. Pictures/Diagram

*Have students sign up for their pollutant to ensure there are no duplicate presentations.

Day 2
Procedure:
1. Finish up your presentation.
2. Gallery walk - you will present your project the room, one person will be at your project at all times to explain and answer questions.
3. Bring your table with you to fill in the missing information on the pollutants you did not research.
4. You will have 3 minutes at each project.
5. Return to your seat and answer the post-gallery walk questions. (Below the tables.)
6. Be ready to discuss you questions
7. Class discussion
8. Hand in Post-Gallery Walk Questions

Use the table to fill in information you researched (Day 1) and information gained during your gallery walk (Day 2).

Name of Pollutant	Motor Oil	Nitrogen	Pet Waste	Mercury	Ammonia
Points of origin (Where does it come from?)					
How does it contaminate/find its way into the water?					
Effects: Animal and aquatic life					
Possible Solutions (Treatment/preve ntion)					

Name of Pollutant	Phosphorus	Road Salt	Sediment	Bacteria	Lawn Clippings
Point of origin (Where does it come from?)					
How does it contaminate/find its way into the water?					
Effects: Animal and aquatic life					
Possible Solutions (Treatment/prevention)					

Post-Activity Questions to answer before class discussion:
Name___________________________ Hour_________

Why do you think I chose for you research these particular pollutants?

What pollutant do you believe poses the greatest threat to our clean water sources? Why?

What pollutant do you believe would be the easiest to clean-up? Why?

What pollutants, if any, do you as a middle school student have control over entering our clean water sources? What would your action plan be?

How will learning about these pollutants change your choices or behavior? Why or why not?

Lesson #7
Days 9-12
Water Quality Investigation

Learning Objectives:
National
ESS2.C: The roles of water in Earth's Surface Processes - How do the properties on movements of water shape Earth's surfaces and affect its systems?
ESS3.A: Natural Resources- How do humans depend on Earth's resources?
ESS3.C: Human impacts on Earth's systems-How do humans change the planet?
State
MN Benchmark 8.3.2.3.2 - Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle.
MN Benchmark 8.3.2.3.2 - Describe how the water cycle distributes materials and purifies water.
MN Benchmark 8.1.3.3.1 Students will be able to explain how scientific laws and engineering principles, as well as economic, political, social, and ethical expectations, must be taken into account in designing engineering solutions or conducting scientific investigation
District
LT 1- I can explain how a water molecule moves through the water cycle.
LT 2- I can identify the location and composition of Earth's reservoirs.
LT 3 - I can explain why scientific research is limited by constraints such as money, politics, and ethics

Essential Questions: How does the water cycle affect the quality of our watershed? How does human activity affect the quality of our water? How can I design a reliable field investigation?

Essential Vocabulary:

Reservoir	Freshwater	Evaporation
Infiltration	Condensation	Transpiration
Precipitation	Runoff	Groundwater
Filtration	Pollutant	

Time Needed: 4 - 45 minute class periods

Overview: In groups of 3-4, students will research and design an investigation centered around the school's pond water quality (other water sources at your location may be substituted). Students will use their knowledge of the water cycle, watershed and common pollutants to guide the design of their investigation.

Materials needed:
For each group:
- Water Testing Materials (Lamotte FreshWater Aquaculture Kit)
  -Will differ depending on what students decide to test
- Water Test Kit Instructions for the following
  - Alkalinity
  - Ammonia nitrogen
  - Carbon dioxide
  - Chloride
  - Dissolved oxygen
  - Hardness
  - Nitrate Nitrogen
  - pH
- Water Sample Containers
- Waders to access the pond
- Laptops
- Investigation Packet including:
  - Characteristic Background Info (See Below)
  - Investigation Design (See Below)
- Cameras
- Safety Goggles
- Clipboards
- Rope for measuring depth
- Sketches and notes from Lesson 3
- Analysis questions from Lesson 5
- Pollutant table and analysis questions from Lesson 6
- Tape
- Markers
- Large container to collect water
- Tape measure

Day 1 - Research and Design

Procedure:

1. Review what makes an investigation reliable. Students should have prior knowledge based on previous investigations they have conducted.
2. Introduce the characteristics of water that are available to test (teacher)
3. Choose three to research (students do this individually)
4. Help guide the research by asking the following questions:
    - What does the presence or absence of these characteristics mean for the quality of the water?
    - What are acceptable levels?
    - What happens when to the water when the levels are too high?
    - What happens when they are too low?
5. Discuss the findings with the class; did they find similar information?
6. Form groups of 3-4 students based on the 2 characteristics they want to test.
7. Determine role of each group member
8. Begin designing investigation
9. Check in with teacher, have investigation question approved (teacher will initial)

Day 2 - Investigation

The teacher will pass back all classwork from Lessons 3, 5, and 6 for students to reference.

Procedure:

Have students:

1. Finish designing investigation
2. Have investigation approved by teacher
3. Practice water testing that will be completed with pond water tomorrow with one sample of tap water. (If testing dissolved oxygen, a pond water sample will be taken today.)
4. Predict what results you will get when testing the pond water
5. Record your predictions

Day 3- Collect Water, Make Observations and Test
Teacher must go over safety protocol for water collection. If possible, have another adult from a water-focused agency in the community or possibly college students come to assist with water collection and testing.

Procedure:
Have Students:

1. Gather supplies for outside:
    - Waders
    - 6 Sample containers
    - Large water collection container
    - Camera/ Cell Phone- for pictures
    - Clipboard
    - Pencil
    - Field Investigation packet
    - Rope for measuring depth
    - Tape
    - Markers
2. Collect the 3 water samples.
3. Record the depth you took your sample from
4. Record where water is flowing in and out of the pond
5. Take pictures of the area.
6. Record weather observations include air and water temperature
7. Record land formation surrounding pond
8. Record soil type
9. Record wildlife present
10. Record human development in the area
11. Hang up waders
12. Bring water samples inside
13. Find testing procedure for each sample
14. Take necessary safety precautions
    - Safety Goggles
    - Protective Gloves
    - Proper Disposal of chemicals (Give to teacher)
15. Conduct testing
16. Record results in data table
17. Clean up

Day 4 - Analyze Results

Procedure:

1. Go over the results of each of your tests.
    - Look at your predictions, were they accurate?
    - Did the results vary from sample to sample?
    - Why might have caused the variations?
    - What do the results tell you in regards to the water quality?
    Prepare to share your results with the class
2. Have a class discussion - share your groups results
3. Go back to your small group and discuss the following:
    - Do you believe there are pollutants present? Provide evidence from your investigation results or the results others shared in the class discussion.
    - What could be done to improve the water quality?
    - If the water quality is high, what can be done to ensure it stays at this level?
    - Start to think of an action plan to improve or maintain the water quality.

Water Quality Investigation: Name __________________ Hour______

LT 1- I can explain how a water molecule moves through the water cycle.
LT 2- I can identify the location and composition of Earth's reservoirs.

Describe what each characteristic indicates as far as water quality.

- ○ Alkalinity
  - ■ What are acceptable levels?
  - ■ What happens to the water quality when the levels are high?
  - ■ What happens when they are low?
- ○ Ammonia nitrogen
  - ■ What are acceptable levels?
  - ■ What happens to the water quality when the levels are high?
  - ■ What happens when they are low?
- ○ Carbon dioxide
  - ■ What are acceptable levels?
  - ■ What happens to the water quality when the levels are high?
  - ■ What happens when they are low?
- ○ Chloride
  - ■ What are acceptable levels?
  - ■ What happens to the water quality when the levels are high?
  - ■ What happens when they are low?
- ○ Dissolved oxygen
  - ■ What are acceptable levels?
  - ■ What happens to the water quality when the levels are high?
  - ■ What happens when they are too low?
- ○ Hardness
  - ■ What are acceptable levels?
  - ■ What happens to the water quality when the levels are high?
  - ■ What happens when they are too low?
- ○ Nitrate Nitrogen
  - ■ What are acceptable levels?
  - ■ What happens to the water quality when the levels are high?
  - ■ What happens when they are low?
- ○ pH
  - ■ What is an acceptable level?
  - ■ What happens to the water quality when the level is high?
  - ■ What happens when it is low?

Choose three characteristics from above to research further and answer the following questions about each:

Characteristic 1:
Is this naturally occurring in water?

How does it enter the water cycle?

How can it be harmful to organisms?

Characteristic 2:
Is this naturally occurring in water?

How does it enter the water cycle?

How can it be harmful to organisms?

Characteristic 3:
Is this naturally occurring in water?

How does it enter into the water cycle?

How can it be harmful to organisms?

Group Field Study

Group Members: Roles: Water Collector/Test Assistant, Water Tester, Data Recorder, Photographer/Direction Reader

Name ________________________ Role__________________________
Name_________________________ Role__________________________
Name_________________________ Role__________________________
Name_________________________ Role__________________________

1. Our group's question is: _______________________________________
   ____?

Teacher Initials _________

Water characteristics we are testing: 1.______________________________
2.______________________________

Predictions:

Materials: **Teacher Initials**________

Procedure: (Remember, number each step and begin with a verb) **Teacher Initials** ____

<u>Outside</u>
Observations:

Air Temp. ______

Water Temp _____

Time of Day_____

Human development in area:

Soil Type______

Water Depth at Sample Site_____

Date________

Wildlife/organisms present:

Describe the landscape: (Possibly sketch and label)

Sketch pond - label where water is entering and exiting, vegetation, human structures present, etc.

Other observations made:

*Don't forget to take pictures

<u>Inside</u>
Record your water quality test data here:

Analyzing the Results:

1. How did your actual results compare to your predictions?

2. Did your results vary from sample to sample? What might have caused the variation?

3. What do your results mean in regards to the quality/health of the water?

*Prepare to share your results with the class.

Answer the following questions AFTER the class discussion.

4. Do you believe there are pollutants present? Provide evidence from your water quality results or those of your classmates.

5. Discuss in your small group what action could be taken to improve the water quality based on your results. Take notes here:

6. If the water quality is high, what can be done to ensure it stays healthy?

Lesson #8 Create Action Plan and PSA
Day 13- 15
Learning Objectives:
National
ESS2.C: The roles of water in Earth's Surface Processes - How do the properties on movements of water shape Earth's surfaces and affect its systems?
ESS3.A: Natural Resources- How do humans depend on Earth's resources?
ESS3.C: Human impacts on Earth's systems-How do humans change the planet?
State
MN Benchmark 8.3.2.3.2 - Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle.
MN Benchmark 8.3.2.3.2 - Describe how the water cycle distributes materials and purifies water.
MN Benchmark 8.1.3.3.1 Students will be able to explain how scientific laws and engineering principles, as well as economic, political, social, and ethical expectations, must be taken into account in designing engineering solutions or conducting scientific investigation
District
LT 1- I can explain how a water molecule moves through the water cycle.
LT 2- I can identify the location and composition of Earth's reservoirs.
LT 3 - I can explain why scientific research is limited by constraints such as money, politics, and ethics
Essential Questions: How can I control the amount of pollutants entering our water cycle?

Essential Vocabulary:	Reservoir	Freshwater	Evaporation
	Infiltration	Condensation	Transpiration
	Precipitation	Runoff	Groundwater
	Filtration	Pollutant	

Time Needed: 3- 45 minute class periods (2 to prepare and 1 to present)
Overview: Students will use the results of their water quality testing to produce a public service announcement (PSA) to present to the school board, Soil and Water Conservation District, Watershed District, EPA, or city council.
Materials needed:
- Laptops
- Results of Water Quality Testing
- All work from Lessons 3 and Lessons 5-7
- Rubric (See Below)

Procedure:

1. Gather all your data from Lessons 3 and Lessons 5-7
2. Research possible pollutants in the pond, using your water quality results and those of your classmates to guide you
3. Identify a pollutant
4. Create a diagram using the essential vocabulary showing how the pollutant enters the water cycle and pond (If the water quality is high, create a diagram of how water enters and leaves the pond)
5. Describe the effects of the pollutant on water quality, surrounding area, organisms.
6. Create an action plan to prevent the pollutant from entering the water cycle or how you will restore the water quality
7. Explain who will carry out the action plan (students, city, Watershed District, etc.) **and why**
8. Decide who you will present the information to [Watershed District, another science class (6th or 7th grade, maybe an elementary school) County Soil and Water Conservation District, School Board, City Council, etc.]
9. Decide why this information is important to the audience you chose and find the best way to present your action plan and data.
10. Decide what format you will use to present the information, a poster or Google Slide Show is not an option.
11. Have fun!!!

Action Plan Rubric **Name** ____________________________________

Identifies pollutant	_____/1
Includes data from water testing to identify pollutant	_____/2
Diagram created and labeled using essential vocabulary for pollutant entering water cycle	_____/5
Describes effects of pollutant on water quality, surrounding area, organisms	_____/3
Create action plan on how to prevent selected pollutant from entering water cycle (Pond)	_____/10
Identifies who will carry out the action plan and why	_____/2
Presentation format fit audience	_____/2
Presentation was at least five minutes in length	_____/5
Total	_____/30

APPENDIX C: Earth Science Interest Survey

Earth Science Interest Survey

Circle the number that best matches your interest in each unit studied in Earth Science this year.

	5 Very Interested	**4** Somewhat Interested	**3** Neutral	**2** Somewhat Disinterested	**1** Very Disinterested
Matter	**5**	**4**	**3**	**2**	**1**
Astronomy	**5**	**4**	**3**	**2**	**1**
Minerals	**5**	**4**	**3**	**2**	**1**
Rocks	**5**	**4**	**3**	**2**	**1**
Weathering and Erosion	**5**	**4**	**3**	**2**	**1**
Plate Tectonics	**5**	**4**	**3**	**2**	**1**
Geologic Time	**5**	**4**	**3**	**2**	**1**
Water	**5**	**4**	**3**	**2**	**1**
Atmosphere	**5**	**4**	**3**	**2**	**1**
Weather	**5**	**4**	**3**	**2**	**1**