FOSTERING ENVIRONMENTAL LITERACY THROUGH THE USE OF HANDS-ON SCIENCE, PLACE-BASED EDUCATION, AND ROLE-PLAYED CASE STUDY

By

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ABSTRACT

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The purpose of this project was to develop environmental literacy in freshmen taking high school biology, using hands-on science labs, place-based education, and a role-played case study. Students participated in hands-on labs that allowed them to quantitatively describe the effects of pollution and eutrophication. Students also participated in an all-day field trip at Bay City State Park, where they studied ecological concepts in "place". The unit culminated in a role-played case study in which students were assigned roles, researched them, and attempted to solve the problem of the eutrophication of Saginaw Bay in a town hall meeting.

To evaluate student learning, students were given a pretest and posttest that covered ecological topics taught during unit activities. The analysis of these assessments using a paired T-test showed that the teaching methods successfully increased student understanding of ecological topics, and an increase in environmental literacy. Additional subjective data, including conversations with students, and analysis of student writing during the unit, support that student environmental literacy increased during the unit. However, it was shown that environmental literacy is not something to be obtained in one unit, or even one year. It is a lifelong process to which a strong science foundation should be provided in science classes, from the primary level to the secondary level and beyond.

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INTRODUCTION

Environmental Education – Where It Has Been

Most definitions of effective environmental education emphasize the responsibility of the individual and society to take appropriate actions to care for the environment (Coyle, 2005; Gough, 2002; Knapp, 2000; Palmberg & Kuru, 2000; Stables & Bishop, 2001; Venkataraman, 2008). Said another way, someone who has not only environmental and ecological knowledge, but also the attitudes and skills to participate in environmentally sound ways is said to be environmentally literate (Stables & Bishop, 2001). Environmental literacy is also described as the ability to read the environment as text. Students view the environment as they would any text; they decode, analyze, and identify causes and effects. In the United States, environmental education has had a rocky journey, which has led to very low levels of environmental literacy. After 35 years, it is still not a core subject, and it shows. Coyle (2005) reports that "the average American adult, regardless of age, income, or level of education, fails to grasp essential aspects of environmental science, important cause/effect relationships, or even basic concepts such as runoff pollution, power generation and fuel use, or water flow patterns." In a 2006 study of student understanding concerning environmental issues, the United States ranked 34th out of 57 nations (Programme for International Student Assessment, 2009). This is a problem, especially when considering that each person needs an understanding that all actions and decisions do indeed impact the environment. This applies not only to each citizen but to those who govern as well. Those who are elected to office will be the ones who make environmental decisions that could impact the world for years to come. It is critical that global leaders understand these environmental problems as they make decisions that concern all citizens

(Sorenson, 2005). Given the prevalence of environmental education in the United State, it is necessary to consider possible reasons for this apparent disconnect between education and environmental knowledge, and ultimately environmental literacy..

At its inception, the thinking in the field of environmental education was that human behavior can be changed simply by making people more knowledgeable about the environment and aware of its accompanying issues. For many years, research has not supported this viewpoint (Hungerford & Volk, 1990). And yet, what passes for environmental education is really only environmental information (Coyle, 2005). Few significant changes and improvements in environmental literacy have been made.

As environmental education evolved in the 1970's through the 1980's (and even today), it was popular to teach about the environment by focusing on ecological disasters caused by man, even in the primary grades. Sobel (1996) contends that this is akin to child abuse: "…students felt hopeless and disempowered… My fear is that our environmentally correct curriculum will end up distancing children from, rather than connecting them with, the natural world. The natural world is being abused and they just don't want to have to deal with it."

Further contributing to the negative image of environmental education is that many educators use their positions to "preach from the pulpit". Many citizens see environmental education as a way to preach political agendas rather than as an accountable educational process that can empower and educate (Knapp, 2000). The fact that environmental issues have become highly politicized alienates many, and promotes emotional arguments over scientific ones. Additional complications arise from the fact that for students today, the media, where misinformation and sensationalism abound, accounts for nearly all of the environmental

information they obtain (Coyle, 2005). Current research suggests that the environmental education students receive is too scattered and out of order to build a foundation of knowledge upon which to build environmental literacy. This further emphasizes the need for a real, deep environmental education curriculum grounded in basic science.

Outdoor activities have always been an important part of environmental education. Historically, these activities have focused on minimum impact behavior (such as disposing of trash properly while hiking) and encouraging aesthetic appreciation without any conscious thoughts concerning ecological health (Slattery & Lugg, 2003). Ironically, these outdoor experiences were usually taught and facilitated by physical education teachers, not science teachers (ibid). Additionally, many of these outdoor educational experiences focus on outdoor play while being *in* nature, and more recently *about* the nature, but they do not include learning *from* or *with* nature (ibid).

Knapp (2000) suggests a number of reasons why environment education has failed. First, he attributes it to environmental education's marginalized place in the curriculum. He proposes that environmental education must be treated as a core subject, and not scattered throughout the curriculum. Knapp also credits "The Activity-Guide Mentality" as a reason for failure. Rather than develop deep programs that promote thinking and long-term learning, many have taken the easy way out by using prepackaged activity guides that may show small, short-term gains, but fail to have larger, significant gains. Finally, Knapp claims that environmental education has failed due to a lack of teacher preparation and in-service training. Bennett and Heafner (2004) support this argument, stating that lack of preservice educator

instruction has contributed to the failure of environmental education, specifically in the area of outdoor education.

Stables and Bishop (2001) argue that environmental education as it is currently taught only stimulates part of the mind, in a limited range of context, and with a limited view of Earth. Students can easily compartmentalize knowledge gained through this form of environmental education, and may not make connections to art, literature, culture, and history. Without seeing the relevance of environmental education in all areas of life, they are less likely to become environmentally literate. The authors contend that a holistic view that makes these connections will harness hearts as well as minds.

Gough (2002) synthesizes the views of Stables and Bishop (2001) with those of Knapp (2000). She describes that historically, environmental education has been viewed as a parasite in traditional science education. However, recent trends show that interest in traditional science is lagging while at the same time students are becoming more concerned for the environment in a context of marginalized environmental education. The traditional view of environmental education as an emotional or abstract endeavor needs to be married to rigorous science (which Knapp also proposes). This would create a mutualistic relationship in which science strengthens environmental education by adding scientific accountability, while environmental education creates real connections and meaning to students of science. Great improvement has already been seen in areas in which environmental education is integrated into existing curriculum, including physics and engineering, as well as when taught as prerequisite core subjects (Gilmiarova, Tsvileneva, Kranogorskaya, Khalikov & Smejtekl, 2000).

The National Environmental Literacy Project: A Baseline Study of Middle Grade Students in the United States (McBeth, William & Volk, 2010) has confirmed what environmental educators have been discovering over the past few decades. In the assessment, these researchers found that students score higher in knowledge/content and verbal commitment, and much lower in skills/application and action commitment. In other words, many times students know what the appropriate and responsible action is, yet they choose not to do it in their own lives. These data show that while students are learning about the environment, they are not developing into environmentally literate citizens. Coyle (2005) does a succinct job of summing up the state of environmental education in the United States: "One way to describe the current condition of environmental education in America is as a gifted child who has yet to reach his or her potential. U.S. environmental and sustainability education is still in its youth compared to many other academic subjects." This calls for a careful examination of teaching methods and styles that foster true environmental literacy among students.

Solutions: Making Environmental Education Effective and Meaningful

As environmental education has developed, many effective strategies have been implemented that include best practices in science education, as proposed by Knapp (2000), as well as strategies that account for culture and the humanities, as necessitated by Stables and Bishop (2001). Collectively, these strategies combine to form a mutualistic relationship as described by Gough (2002). These practices will be explored in depth in this section.

Coyle reports in The National Environmental Education and Training Foundation's publication "Environmental Literacy in America" (2005) that staples of effective environmental

education programs include hand-on activities, science investigations, out-of-the-classroom experiences, and student directed learning. Real change can emerge when using these strategies because they give learners a sense of involvement and ownership. Through these activities, students are able to construct their own understandings and subsequently decide for themselves, not because of coercion or guilt, what environmental stewardship means and when and how to take action. In addition, role-play and environmental case studies have also been shown to encourage independent thinking as well as the opportunity to examine multiple viewpoints, which is critical to the development of environmental literacy (Hungerford & Volk, 1990; Slattery & Lugg, 2003). More recently, a multidisciplinary variation known as place-based education has emerged. Place-based education occurs in a "place" instead of a classroom, and incorporates not only knowledge of local ecology and environments, but can include language arts, local culture, and community involvement (Gruenewald, 2003). This paper will reveal how each of these teaching strategies can be utilized to increase environmental literacy.

One of the challenges facing environmental education is the perception that it does not have a track record of being scientific enough. Because it is often included in small units across the curriculum, environmental education typically does not include science labs. In these programs in which environmental education is scattered throughout the curriculum and throughout all subjects make it difficult to discern what environmental education is and what it is not. "If environmental education is all things for all people, it then becomes nothing to anyone" (Knapp, 2000). In these cases, it can seldom be described as scientific. Students have been shown to have a very superficial understanding of environmental issues such as littering and pollution and can only describe them in the most qualitative of ways (Coyle, 2005; Slattery

& Lugg, 2003; Palmberg & Kuru, 2000; and Gilmiarova, et. al, 2000). However, without information backed with data, environmental education will only head into the realm of emotive and political discussion (Knapp, 2000). By grounding environmental education in real science investigations, including hands-on laboratory activities, students will be able to quantitatively describe environmental issues. Issues will become clear, and will allow students to discern the difference between factual and ill-informed public perceptions (Van Weelie & Wals, 2002). Additionally, teacher training in these science investigations as well as outdoor environmental education has been shown to make these experiences more memorable and meaningful to students (Bennett and Heafner, 2004). Research has also shown that the inclusion of park rangers, interpretive guides, and other science professionals in environmental education creates an authentic and authoritative atmosphere (ibid).

The case study approach is another method in which successful instruction of environmental literacy can take place. Case studies use real-life narratives to explore content and seek to actively engage students. Studies have shown that case studies can improve test scores, particularly in questions which require higher order thinking skills (Chaplain, 2009). A good case study has an interesting plot, explores a current problem, contains an element of suspense, includes colorful characters, promotes empathy among participants, forces decision making, and has a strong pedagogical purpose (Hildebrandt & Santanello, 2005). In addition, cases should be open-ended with no clear or obvious answer. To solve a case, students engage with and critically evaluate multiple sources (Cook & Deaton, 2012). Case study teaching encourages students to communicate and collaborate with peers as well as to consider multiple viewpoints before making decisions. A case studies approach to solving an environmental

problem is ideal because cases can be chosen or designed around issues relevant to the communities in which students live (Cook & Deaton, 2012). The best cases are those that stick with the student and instructor long after the session concludes (Honan & Sternman Rule, 2002).

Place-based education is a form of environmental education that includes the study of nature, history, culture, and human concerns of an area, or 'place' (Coyle, 2005). Place-based learning has some generally accepted attributes as described by Gruenewald (2003). First, they emerge from the particular attributes of a place. In other words, each place is unique, and scripted lesson plans would not apply to every place, as each place has its unique features. Next, it is multidisciplinary in nature. Science will undoubtedly be studied, but social science, history, and even art and literature may be included as well. Third, it always includes some form of experiential learning. Place based education happens at the place itself, it does not rely solely on abstraction from within the walls of the classroom. Finally, it provides great potential to connect a person to his or her community.

Smith (2002) states that place-based education is effective because it grounds learning in local phenomena and students' lived experience. Culture studies, nature studies, real-world problem solving, and induction into the community process are all attributes of place-based education. Smith (2002) promotes place-based education, and at the same time critiques traditional classroom teaching when he says: "We do not ask children to pitch and catch and run by asking them to read books or watch video tapes… real learning comes from involvement in the actual game."

Place-based education provides a vehicle by which students can become directly connected to their community and the natural environment in which their community is located. Martin (2007) says that without a direct relationship with nature, students cannot care *for* nature, only *about* it. Students develop this relationship as they would with any friend: by spending time with it, learning about it, and sharing. When students see the reciprocity that can be had with nature, they are more likely to take social action. After all, they are sticking up for a friend (ibid). When education happens in a 'place' this relationship is more easily fostered and maintained.

Gruenewald (2003) and Gahl Cole (2007) strongly emphasize that communities are respected and will be appreciated more when a special emphasis is placed on the history and culture of a place. Gahl Cole (2007) contends that in order to effectively teach environmental science, authentic connections with the sociocultural issues or race, class, gender, and justice that have shaped the place being studied must be made, lest indigenous ways of knowing be devalued. To a certain degree, these statements echo what Sobel (2004) says in his book *Place-Based Education*, "Generic textbooks designed for the big markets of California and Texas provide the same homogenized, un-nutritious diet as all those fast-food places on the strip." By studying 'place', students have an opportunity to not only deeply connect with the environment, its beauty and its problems, but the rich cultural identify from which they have come as well.

Rationale

During the course of the researcher's teaching career, he has observed in students an indifference to the natural world and the "biology" that surrounds them. They are in effect, "desensitized to the flowers, trees, shrubs, and animal life surrounding them as they go about their everyday routines." (Walker-Livingston, 2009). The writer has also observed wariness and skepticism in students when environmental issues come up in discussion. Some students simply feel that one person, particularly a young one, cannot make a difference. Also, many students merely echo the politically charged and emotive statements of their parents before looking into the issue themselves as a student of science. Still others show blatant apathy as to how their choices and decision impact their environment and community. The knowledge that students do have regarding environmental and ecological issues remains knowledge – it does not translate into decision making. It is quite possible that the natural world is being irrevocably changed… and students do not seem overly concerned. Scientist and nature writer Carl Safina (2011) wrote in *A View from Lazy Point: A Natural Year in an Unnatural World* a quote that this writer feels sums up the general way in which students experience their world: "A cooped chicken doesn't realize that its ancestors were wild birds. Most young people don't know what isn't there, don't sense their inheritance plucked from them. They don't even think about it; bullhorns and billboards call their attention elsewhere." It is the goal of this researcher to empower students with not only a strong scientific background in ecology and environmental issues, but one that enables students to become environmentally literate stewards, conscious of place, that care deeply and think independently.

The purpose of this classroom research study was to develop in students not only an increased awareness and knowledge of the natural world and environmental issues, but build

towards environmental literacy, which Stables and Bishop (2001) define as the ability to read the environment as text. As a student decodes words, he or she synthesizes the reading to prior knowledge, seeks context clues, uses strategies such as "chunking" to decipher and interpret unknown words. In the same way, an environmentally literate citizen reads the environment, can connect causes to effects, understands situations in context, and can discern emotional arguments from factual ones based on scientific data. Armed with this ability, the writer expects students will be able to make the important leap to making environmentally-appropriate decisions and actions. When motivated this way, decision making and social action are a natural extension of an environmentally literate citizen, not an afterthought or something coerced out of guilt.

The hypothesis on which this study is based is that by incorporating authentic hands-on science experiments involving pollution studies, students will be able to quantitatively describe how and to what extent pollution effects organisms rather than relying on emotive qualitative descriptions. It is also hypothesized that authentic outdoor scientific and cultural investigations that occur in "place" utilizing interpretive guides from the Department of Natural Resources will increase the ability of students to describe the area in which they live and the phenomena that affect it. Additionally, it is hypothesized that by engaging in a case study involving an environmental issue that impacts the Saginaw Bay region, environmental literacy will increase as students struggle to find a balance between the environment and economy. The null hypothesis was that these teaching methods will have no effect on student learning. The overarching hypothesis is that these teaching methods will have an effect on student learning. This overarching hypothesis was assessed using a pretest and posttest that measures

environmental and ecological knowledge as well as decision making regarding environmental issues. Statistical significance of the results was assessed using a paired T-test.

School Demographics

This study was conducted at a private, parochial high school located in mid-Michigan. The school's current enrollment is 370 students, 115 of which were freshmen during the school year in which this study was conducted. Out of 96 seniors, 92 indicated that they would attend a two or four year college. Approximately 10% of the students participate in the special needs program, which provides help for at-risk students or those with learning needs.

The study was conducted in five sections of biology, which is taken by all freshman students and students who transfer to the school as sophomores and have not taken the course. The test subjects included 91 freshmen and 1 sophomore. The student body is 89% White, 4% Asian, 2% Black or African-American, and 5% Hispanic. Approximately 5% of students receive free or reduced lunch, while approximately 33% of students receive financial aid that is applied to tuition.

IMPLEMENTATION

Outline of Activities

This ecology unit designed to increase environmental literacy in high school biology students in the 9th grade took 25 class days to complete. The lessons and activities included mini-lectures, hands-on labs, student reflections, internet videos with online quizzes, a vocabulary photo scavenger hunt, student art, small group and whole class discussion, a field trip to a local state park, and a case study in which students participated in role-play to solve a real and local environmental issue. Each segment of the unit was intentionally designed to challenge student misconceptions about ecology and environmental issues, address ecological features found within the local ecosystems in which students live, promote means by which students can discover positive social actions that contribute to the overall health of their local ecosystems, and transfer the knowledge gained about ecosystems close to home to those far away. All of the activities included in this unit were new to the curriculum, and all were either created or modified by the researcher. Table 1 contains an overview, or day-by-day approach of the unit.

Table 1: Unit by Day – Table 1 is a list of activities for the unit as well as the goal the activities.

Day	Activities Sequence	Objective
2 weeks prior	Hand out parental consent and student assent forms	Obtain test subjects
Day 1	Students take the unit pretest / Photo-scavenger hunt is introduced	Obtain data for statistical analysis / Introduce vocab assignment
Day 2	Drawing Yourself Into Your Environment / Intro to Ecology	Students consider their view of nature, and how they fit into it / Develop a conceptual framework of ecology
Day 3	Discuss art / Begin photo-scavenger hunt in school yard (sets 1 and 2)	Students reflect on their drawings / Begin to become comfortable with local ecosystems.

Table 1 (cont'd)

Day 4	'What is pollution?' mini-lecture / Intro to Bioassays, and Bioassay: The Effect of Salt on *Daphnia* Mortality in 60 Minutes	Students address misconceptions about pollution and build real scientific knowledge about how pollution affects organisms
Day 5	The Effect of Salt on Radish Germination lab setup	Students prepare concentrations of salt and set up a bioassay
Day 6	Collect data on radish germination / Groups review set 1 and 2 vocab by sharing photos	Students collect data and begin to draw conclusions
Day 7	Collect data on radish germination – students discuss results, analyze them, and draw conclusions	Students collect data and discuss the tolerance of radishes to salt, a pollutant
Day 8	Setup for 'Eutrophication in a Bowl' activity / Assigned 'Into the Watershed: Part 1' video and quiz	Students explain a local phenomena
Day 9	Discuss watersheds / Students construct food chains and webs in class / Assigned 'Into the Watershed: Part 2' video and quiz	Students explain the interconnectedness of ecosystems
Day 10	Sketch a wetland / The importance of wetlands mini-lecture / Assigned 'Into the Watershed: Parts 3-5' videos and quiz	Students identify the importance of wetlands to a healthy watershed
Day 11	Land use discussion and mini-lecture / Eutrophication in a Bowl data collection	Students role play and solve a land use issue
Day 12	Discuss and analyze results of Eutrophication in a Bowl	Students explain their data using ecological principles
Day 13	Discuss field trip expectations and behavior / Ecological review worksheet	Students understand field trip guidelines and review concepts thus far
Day 14	Field trip to Bay City State Recreation Area	Student apply ecological concepts and science skills to a local ecosystem
Day 15	Field trip debriefing and discussion	Allow students time for processing, sharing, and internalizing field trip
Day 16	Retest water from Eutrophication in a Bowl / Assign field trip paper	Students obtain data and explain why it took longer than planned for eutrophication to occur
Day 17	'Life or Death Food Chain Decision'	Students address and challenge misconceptions about energy flow
Day 18	Researcher assigns student roles for the case study	Students identify attitudes/contributions of their role
Day 19	Students prepare for their role in the resources center	Students identify attitudes/contributions of their role

Table 1 (cont'd)

Day 20	Students prepare for their role in the resources center	Students identify attitudes/contributions of their role
Day 21	Students watch 'Jungles' from the BBC documentary Planet Earth	Students transfer local ecology topics to other biomes
Day 22	Town Hall Meeting: 'Solving an Environmental Issue'	Students try to solve a real issue by implementing their roles
Day 23	Town hall meeting debriefing and reflection assignment	Students get an opportunity to express their reactions
Day 24	Class review of ecology unit	Students review concepts
Day 25	Postassessment	Obtain data for statistical analysis

Description and Analysis of Activities: Day By Day

Two weeks prior to the beginning of the unit, the researcher handed out parental consent and student assent forms (Appendix A). The students were instructed that they would be participating in a research project involving science education. The students had many questions, and some even expressed concern that if they did badly, the researcher would receive a poor grade. The forms were taken home by the students, signed by student and guardian, and returned to the academic dean of the school. The forms were kept in her office until the semester officially ended on Friday, January 18th, when they were handed over to the researcher.

Overall, 95 parental consent and student assent forms were received out of 116 students. The researcher was somewhat disappointed that 21 students failed to turn in a form; however, no extrinsic rewards were given for returning the forms, so this should be expected. 93 students were granted permission from their guardian to participate in the study. The pretest and posttest data will be analyzed for 92 students as one student with permission was absent and failed to make up the posttest.

Day 1: Pretest and Vocabulary Scavenger Hunt

The pretest (Appendix B) was given to students before any exposure to the lessons, and consisted of a short stem describing the state of Saginaw Bay, a graph, and eight short answer questions with which students could use information from the stem or their own knowledge to answer. The students worked very diligently on the pretest, as was evident in the effort to answer each question. The pretest revealed valuable information that guided instruction during the course of the unit. As predicted by the researcher, student answers revealed misconceptions in three major areas. First, students lacked a clear definition and description of pollution and how it affects organisms. Second, students could not describe a scientific means by which the effect of pollution could be measured. Third, student responses to social action were similarly shallow to what Pamberg and Kuru (2000) report, such as "stop littering" and "pick up trash". These actions, while concrete, were not connected to reducing the amount of waste or recycling.

After the pretest, the researcher introduced the ecology vocabulary photo-scavenger hunt (Appendix C1). The goal of this activity was to allow students to discover and construct their own meanings to these words and concepts through photography. Vacca (1990) states that when vocabulary is isolated to words lists and tests, students are unable to connect concepts together. In this regard, the photo-scavenger hunt was a success, and enabled students to see interconnectedness in ecology. Many students came to the realization that one great photograph could demonstrate many of the levels of classification or multiple ecological interactions. Students felt this project was daunting, because they seemed used to traditional vocabulary assignments. One student complained, "How can I take a picture of a predator-prey

relationship – am I supposed to wait for a coyote to kill my cat??" This provided an opportunity for what Cook and Deaton (2012) call "just-in-time" instruction, an important scaffolding technique in which teachers assist as students construct their own understandings. Students were encouraged to think outside the box, to not only think of larger predators. Some students even used clay to construct their own images or manipulated stuffed animals and toys to recreate some of the ecological interactions. It was intriguing to hear the students explain how their images related to the terms. One student had photographed her sister digging through clothes in her room. When asked by other students, "How does *that* relate to ecology?" the student smiled and said, "My sister is a parasite." Students submitted these assignments electronically to the class Edmodo page, where they were assessed using the photo-scavenger hunt rubric (Appendix C1) at various times throughout the unit.

Day 2: Drawing Yourself into Your Environment/Intro to Ecology

Students were given white printer paper and asked to draw a picture that included trees, a mountain, the sun, a stream, a fish, a deer, and finally to draw themselves in the picture. This lesson was developed by Dr. Stephen Thomas, a member of the zoology faculty at Michigan State University. The goal is for students to identify their feelings about nature, and consider how they view nature. Where students put themselves in the picture, reveal some of their joys and reservations about nature. Many students depicted themselves climbing a mountain or fishing – these students view the outdoors as an escape or for recreation. Other students drew themselves relaxing or observing the animals and plants – these students show an affectation for nature, a place to seek solitude. A few students were silly and drew

themselves riding the deer. Still other students had difficulty assigning themselves a place. It is the opinion of the researcher that these latter groups of students had difficulty identifying their place because they do not see themselves a part of it. Overall, the students enjoyed the activity very much, and it led to a good discussion to introduce ecology. Permission slips for the field trip to Bay City State Recreation Area (Appendix D1) were also handed out.

Day 3: Drawing discussion / Photo-scavenger hunt in the schoolyard.

For five minutes groups shared their drawings from the day before. Then, armed with digital cameras and smartphones, the classes headed to the schoolyard to begin collecting vocabulary pictures for the photo-scavenger hunt. It was a beautiful day, and the students enjoyed the change of pace. Sobel (1996) states that early in child development, children are eager to explore the areas around their homes and yards. As they progress through development, their world expands to include their neighborhoods and local parks. Louv (2005) argues that most children skip these fundamental steps of nature exploration in favor of indoor activities and technology. This assignment served to allow students the opportunity to explore their schoolyard and the areas around their homes before moving to larger areas during the field trip that occurred during this unit. The researcher benefited by overhearing and at times participating in discussions about how certain pictures represented vocabulary and concepts.

Day 4: What is Pollution? / Intro to Bioassay

This lesson began with PowerPoint slides used in conjunction with a student notes page (Appendix C2, C3). Students were shown a picture of a cup of coffee and a barrel of

trichloroethylene, and asked to guess which would poison a human the fastest using the least amount of substance. Students were shocked that the lethal dosage of caffeine is less than that of trichloroethylene. Additionally, students were asked to consider if throwing chocolates at a parade is pollution. Many students said no until the researcher showed a picture of a puppy. Most students knew from experience that dogs cannot eat chocolate, but they did not know that dogs lack a key enzyme to digest it, and therefore it is a pollutant that can disrupt their physiology. The students enjoyed this whole-class discussion. These illustrations as well as the guided notes page, challenged students in their misconceptions about pollution, and how pollution affects organisms.

Additionally, the students read a handout on bioassays (Appendix C4) and then read a lab that the researcher had performed, in which *Daphnia* were exposed to increased levels of salt (Appendix C5). Students interpreted the data for this lab and answered questions for homework. Students were instructed they would be participating in a similar bioassay involving plants the following day.

Day 5: The Effect of Salt on Radish Germination setup

Students were given the lab handout (Appendix C6) and asked to read the stem and then develop a possible answer to the lab question. As groups developed their hypotheses, some members began to make salt solutions of different concentrations, while others labeled bags and counted seeds. The lab setup went smoothly, although some groups barely finished on time. Students were excited to see at what level salt would inhibit seed growth.

Day 6: Checking the data

Students checked the bags of various salt concentrations for seed germination and recorded their data. Many groups obtained germination results after one day. Groups that finished early were encouraged to share the progress of their photo-scavenger hunt, which many groups did.

Day 7: Checking the data / Analyze, discuss, and conclude

By the second day, all student groups had obtained results. Students found a clear relationship between the amount of salt and the amount of seeds that germinated. Groups developed graphs that told the story of their data and worked through the questions in the lab packet together. The researcher was pleased with the quality of student graphs as well as the conclusions that students came to about the effect of salt on radish germination. The students were able to articulate at what levels salt became a pollutant for radishes and hypothesized that the tolerance to salt could vary among plant species.

Day 8: Eutrophication in a Bowl / Into the Watershed video

The activity, Eutrophication in A Bowl (Appendix C7), was adapted from an activity produced by the Mid-Atlantic Center for Ocean Sciences Education Excellence. The researcher desired for this 'cookbook' style lab to be more discovery based, so the students could generate a definition of eutrophication as they collected and interpreted their data. Pond water was obtained by the researcher and tablets were obtained from LaMotte Company for testing nitrates and nitrites (N), phosphates (P), and dissolved oxygen (D.O.). Students added various

amounts of fertilizer to five plastic bottles and tested the water for D.O., N, and P. They recorded their initial data and placed their bottles on the light stand so the algae could photosynthesize.

Additionally, the first of five videos produced by the Lake Macatawa Watershed Project and accompanying quiz (Appendix C8) were assigned to be completed at home. The video series was produced educate the community about the importance of wetlands, stormwater, agriculture, and land use, and explain how these things impact the overall quality of the Macatawa watershed. The award-winning videos include entertaining animations featuring students from Holland High School. This style of teaching and learning known as the flipped classroom requires students to interact with material at home and come to class ready for enrichment activities (Milman, 2012). Video one was entitled *Into the Watershed: Part 1 Intro*. Additionally, students were to watch a one minute video clip from a show coproduced by the Environmental Protection Agency and The Weather Channel called *What Is a Watershed?* Quizzes were taken online through the class Edmodo website (transcriptions of the quizzes are in Appendix C8). Overall, students performed well, and they began to develop an understanding of both watersheds and the process of eutrophication. However, many students forgot to watch the videos and take the quiz, claiming that they were not used to online homework. As Milman (2012) states, this is a common challenge when using the flipped classroom.

Day 9: Watershed Discussion / Food Chains and Webs

The researcher was able to formatively assess student understanding of the videos by asking a series of questions. Students who either did not understand or had not yet watched the videos benefited by listening to the explanations of their peers.

The student notes page (Appendix C2) used in the pollution lesson was utilized again, as the second half of it contained brief information about food chains and webs. This is a topic that many students were somewhat familiar with, as shown on the pretest. Students who were more familiar with food chains and webs paired up with students who were unfamiliar with them, which was a strategy that worked well and was repeated later in the unit. This was an opportunity for students to construct their own knowledge. Any misconceptions picked up at this point were addressed later in the unit. Additionally, the video *Into the Watershed: Wetlands* was assigned with its accompanying quiz.

Day 10: Sketch a Wetland / The Importance of Wetlands

The researcher was able to formatively assess student understanding of the video, *Into the Watershed: Wetlands*, by having students make a sketch of a wetland. Students who had successfully completed the video quiz drew an upland, a riparian zone, and an aquatic zone. Many included animals and plants that inhabit these zones. However, it was clear that many students had not watched the video and taken the quiz. The researcher instructed the students to tell him how to draw a wetland on the board, and also instructed students who were behind to follow along and draw carefully. Together, the class debated how this should be done and was able to work through their misconceptions.

After following student instructions to draw an accurate representation of a wetland, the researcher then drew a sponge and a kidney on the board. Both objects were presented in the previous night's video as metaphors for wetlands. The researcher asked students to explain how these images were appropriate analogies for wetlands, and collectively the students identified that like a sponge, wetlands hold water, and like a kidney, they filter the water. After a brief poll on what restaurants students prefer, the researcher erased the upland zone and drew a Panda Express (the restaurant of choice for one class period) as well as a parking lot and busy street. Students considered how this would impact the function of wetlands. Then the researcher erased most of the riparian zone plants to build a walkway in which people could better appreciate nature. Students strongly objected to these developments and correctly suggested that this would lead to an increase in pollution and a possible increase in floods. Students were assigned the final video segments, 3-5 of *Into the Watershed*. These segments include the topics of stormwater, agriculture, and land use.

Day 11: Land Use Discussion / Eutrophication in a Bowl Testing

In order to formatively assess student understanding of how land use impacts watersheds, students were presented with a hypothetical land use decision and were asked to discern whether the economic benefits outweighed the ecological risks. This led to much discussion, and students were frustrated that the answer to the problem was not cut and dry.

After this discussion, students used the LaMotte® testing kits to retest their bottles of pond water with varying amounts of fertilizer for evidence of eutrophication. For the most

part, the data were nearly identical to the initial test. This surprised students, as they expected the dissolved oxygen to have diminished during eutrophication.

Day 12: Eutrophication in a Bowl Discussion

Lab groups discussed possible reasons for the inconclusive data and a consensus was reached that the water should be tested after more time had passed. As students learned more about eutrophication, they came to the hypothesis that the amount of algae in each bottle was not significant enough to have already died and begun the process of decomposition, thus lowering the amount of dissolved oxygen. Students agreed that the bottles should be retested after more time had passed.

Day 13: Field trip preparations

Expectations for behavior and attentiveness regarding the upcoming field trip to Bay City State Recreation Area were discussed. Students were very excited about the upcoming trip, not only for a change of pace in the everyday school routine, but they were also eager to put what they had learned so far in the classroom to the test in the field.

Day 14: All Day field trip to Bay City State Recreation Area

The field trip was a huge success. The students not only worked *in* nature and learned *about* nature, but they also learned *from* and *with* nature, key elements to becoming environmentally literate (Lugg and Slattery, 2003). Students were placed in groups of 15 with an adult chaperone supervising each group. There were eight groups total, and enough

chaperones were obtained so that the researcher could move from group to group checking in with each chaperone as needed.

Throughout the day, students moved among modules that had been designed to help students answer this question: 'With all of the pollution in our area, is Tobico Marsh a healthy or a damaged ecosystem?' Each module included a chemical or physical test that enabled students to answer this question. An activity packet (Appendix D2) was provided for students to work on as they moved through the modules.

The first module was a macroinvertebrate survey, in which students sifted the water at the shoreline with nets to obtain aquatic invertebrates. Then, with the help of DNR volunteers, they identified species and recorded the total amount of each species. Included in the field trip packet provided by the Department of Natural Resources was a list of sensitive, somewhat sensitive, and tolerant species. By calculating the species index value, students could determine the water quality. Many students were hesitant and somewhat grossed out at first, but this module was the most memorable and most discussed by students.

The second module was a shoreline assessment hike. With the guidance of DNR volunteers, students hiked around the shoreline looking for physical indicators of water quality. The water color and odor, plants growing in and around the bank, and evidence of human disturbance were all noted by students on the field trip handout. Students also learned about the impact of invasive species such as phragmites, purple loosestrife and mute swans on this portion of the trip.

The third module included taking a turbidity test of the marsh from the deck that extends into the middle of the marsh. Students took measurements with Secchi discs,

measuring the pond depth as well as the photic zone from several locations, and were able to determine the turbidity index of the pond.

The fourth module included recording temperature of the water at the surface and at the bottom of the marsh at several locations. Students noted weather information as well.

The fifth module included many of the same chemical tests that students used in the classroom, included dissolved oxygen, phosphates, and nitrates. Additionally, they tested the pH, the amount of carbon dioxide, the total hardness and the silica content. With the help of DNR volunteers, students interpreted these results.

The sixth module included a large watershed model where students learned about point source and nonpoint source pollution. Students were able to manipulate the model, releasing "pollutants", after which they used a watering can to "rain" upon this city. They found the "reservoir" that collected water to be extremely polluted after this. Then the DNR volunteer instructed students to add buffer strips near the farm and golf course and to put up erosion barriers near the construction site. Additionally, students used organic fertilizers (a different substance) and fewer pesticides. After using the watering can again, the students found the small steps they had taken to have a large impact as the collection reservoir was much clearer than the first time.

The seventh module included time in the visitor center's museum. Students read about the wildlife found in our state, as well as the history of the area and the impact that humans have had as the area has been developed.

Day 15: Field trip debriefing and discussion

Student filled out the student debriefing form (Appendix D4) followed by a class discussion about the trip. The reaction was largely positive and many students wanted to go back. Several students commented that they felt they have obtained skills to adequately read an environment, which is essentially the goal of environmental literacy. Another student commented that she was very nervous about the trip beforehand because she felt safer within a classroom, but afterwards she reported that the knowledge gained in the classroom was supported and she could see how it was applied in the real world.

Day 16: Eutrophication in a Bowl

As planned earlier, students retested the water in bowls, and this time obtained the expected results. The dissolved oxygen had decreased significantly in the bottles with higher concentrations of fertilizers. In groups, students graphed the results and answered the 'analyze and conclude questions'.

In addition, students were assigned the 'Water Watchers' Field Trip Assignment (Appendix D3), which was graded using the attached 'Water Watchers' Rubric.

Day 17: 'Life or Death Food Chain Decision'

This lesson, 'Life or Death Food Chain Decision' (Appendix C10) was adapted from an activity produced by educator Martin Shields (2005). Students were presented with a hypothetical scenario in which the class is stranded on an island, and only has one cow and 50 bushels of wheat. Students debated the order in which they should eat the food that would

enable them to survive the longest. Many students insisted upon keeping the cow alive and drinking its milk, while other students said correctly that the class would get much more by eating the cow immediately and keeping the wheat for the humans. It provided a great opportunity to discuss how organisms use the energy from food to perform important life processes, and not all of the energy will get passed on after it is consumed.

Day 18: Introduction to case study / Case study roles assigned

The students were informed by the researcher that they would be participating in a role-played case study. Students were handed 'Part 1: Can the Saginaw Bay Be Restored?' (Appendix E1) as well as 'Part 2: The Case – Can the Saginaw Bay Be Restored?' (Appendix E2). After reading these papers and discussing the basics of the case, students began wondering what role they would receive. The researcher then handed out role cards (Appendix E3) to students. The roles were distributed randomly, with the exception of the two board members and town hall moderator. Because these roles are critical for managing the role-play, students with developed interpersonal skills were chosen ahead of time by the researcher. Yet, it was important to make sure these leading roles were heterogeneous, with males and females, students of varying academic ability, and of different learning styles (Usluata, 1997).

Students met their assignments with both eagerness and trepidation. Each role card included a brief description of the role, along with several tips as to how this stakeholder may be affected by the problem and its solutions. As students began to research their the case and their role in the case, the researcher acted as facilitator, guiding students to appropriate resources when necessary, and prompting students with questions when they ran into dead

ends in their research. Students also had access to a series of pictures that depict various parts of the environmental problem (Appendix E4). In doing so, the researcher was consistent with case study teaching styles where the teacher acts as a facilitator, assisting students in gathering appropriate resources (Cook and Deaton, 2012). During an independent research gathering activity, it can be difficult for an instructor to keep students on track as well as assess how well they are gathering information and learning. The researcher provided students with a handout (Appendix E6) on which to record notes. This researcher required that students check in with him at least three times during the research portion to discuss what has been learned. The researcher kept track of each meeting by initialing student handouts.

Day 19: Case study research

Students continued to gather information from independent as well as instructor facilitated resources. The researcher met with students and initialed student handouts after each meeting. The researcher also provided the town hall moderator and board members an 'email' from a secretary (Appendix E5) which including the names and roles of those who would be in attendance at the meeting. This enabled meeting leaders to prepare a summary of the case as well as develop questions to ask individual attendees. Additionally, the researcher encouraged students with different roles to collaborate with other students who had received similar roles (for example, there were several 'homeowners').

Day 20: Case study research

The researcher was ill this day. Students were instructed to continue their research and to prepare for the town hall meeting the following day. Teachers covering these classes were instructed to initial student note pages after sharing what they had learned. Upon returning to school, several teachers informed the researcher that students appeared excited about the meeting and were impressed with their level of preparation.

Day 21: Planet Earth: Jungles – Transferring Ecological Concepts

The researcher was ill again, and prepared a video lesson using the BBC's production of Planet Earth. Students were provided with a worksheet (Appendix C9) that discussed many of the ecological concepts discussed in the unit. As they watched the Jungles episode, they were to identify these concepts in an ecosystem that is far away. In doing so, students transferred the knowledge they had learned about Michigan ecosystems to different ecosystems in faraway places. Students also informed the researcher that they had appreciated the extra day to mentally prepare for the town hall meeting.

Day 22: Town Hall Meeting – Can the Saginaw Bay Be Restored?

Upon arriving to class, students took their places around the room with the town hall moderator and the board members taking positions at the front. The leaders did a commendable job of calling the meeting to order, summarizing the case, and asking the stakeholders to express their positions and concerns. The researcher was pleased to see normally quiet students get into their character, having fun while learning. Two memorable exchanges occurred between a feedlot operator and a resident (who had taken upon herself to

add vegan to the role), and a city councilman producing evidence (a stick-figure drawing) of the chemical plant public relations specialist actually dumping chemicals into the river. Humorous interludes aside, the students took the case very seriously, shared what they had learned, contributed to solving the overall problem, and attempted to come up with solutions that were in line with the best interests of as many stakeholders as possible. Overall, the town hall meeting was a huge success, and the researcher cannot recall a time in which it was more evident that engagement and learning were taking place among his students.

The town hall meeting was assessed using a rubric (Appendix E7) that enabled the researcher to assess the contributions of each student. This was somewhat difficult due to the varying nature of each role. Some roles had a great deal to contribute throughout the role-play, while others had important, although lesser roles. The rubric enabled the researcher to assess students fairly.

Day 23: Case study discussion and reflection assignment

Students had many positive things to say about the role-played case study. Some commented that several classmates had not researched their own role enough to effectively contribute, which took away from class solutions and added an element of silliness to the case. One student claimed, "I found it educational, yet fun, which is an unusual combination." Another student commented, "I learned more during the debate than I would have by reading a newspaper article or going onto Wikipedia." It was evident that this form of learning and assessment challenged student thinking, "We had to think on our feet – if you did not speak up and have a ready response, the debate passed you by." In the end, many students commented

that while a great amount of information was presented, it was difficult to agree on solutions. Students expressed frustration with this, but one student concluded "I learned that environmental problems are not solved as easily as one would think because there are so many people with different interests involved – one solution may help, but it could affect someone else's livelihood." Students appreciated the chance to "act like real adults at a town hall meeting." After this discussion, the *Solving an Environmental Problem Reflection* assignment (Appendix E8) was handed out to students.

Day 24: Unit review

The researcher led students in a review of the concepts and content from this unit Students discussed the concepts in small groups. Student interactions were positive and they collaborated positively.

Day 25: Posttest

Students took the posttest (Appendix B) seriously; however several students commented they felt they did not write as much as they could have because they were tired of the course content. Other students, upon remembering that these were the same questions from the pretest, commented that they were sure their results would be much better than before.

RESULTS AND DATA ANALYSIS

Overall, the teaching of this unit showed statistical significance between the pretest and posttest scores, rejecting the null hypothesis that the unit had no effect on student learning. Each of the eight questions on the pretest and posttest were assessed using a rubric that indicated whether a student showed weak understanding (0 points), developing understanding (1 point), or mastery understanding (2 points). The average pretest and posttest scores for each question are shown in Table 2.

Table 2: Pretest and Posttest Averages by Question. Table 2 shows the pretest and posttest averages for each question on the assessment, as well as the total change. Each question was scored from 0 points to 2 points, and n=92.

Question #	Pretest Average	Posttest Average	Total Change
1	0.707	1.434	0.727
2	0.478	1.836	1.358
3	0.282	1.206	0.924
4	0.461	1.0	0.539
5	0.597	1.413	0.816
6	0.782	1.641	0.859
7	0.673	1.239	0.566
8	0.826	1.489	0.663

Collectively, the pretest and posttest contained a total of sixteen points. The pretest average was 4.809 points, with a standard deviation of 2.14, for a score of 30.0%. The posttest average was 11.26 points, with a standard deviation of 2.75, for a score of 70.3%, a significant improvement over the pretest results, as shown in Table 3.

Table 3: Average Scores of Pretest and Posttest. Table 3 compares the mean scores of the pretest and posttest.

Test	Mean Score (out of 16 points)	Percentage
Pretest	4.809	30.0%
Posttest	11.26	70.3%

A paired T-test was run on these data utilizing the paired T-test calculator from the College of Saint Benedict & Saint John's University (http://www.physics.csbsju.edu/stats/Paired_t-test_NROW_form.html). With a t value of -25.5 and 91 degrees of freedom, the probability of this result, assuming the null hypothesis, is 0.000. These data show that the difference in average for pretest and posttest is significantly different, suggesting that the teaching methods used in this unit had an effect on student learning, and the null hypothesis is rejected.

Analysis of Individual Questions

All pretest and posttest T-test comparisons showed significant changes at p = 0.000.

Question 1

The first question on the assessment was, "What is pollution?" The average pretest score was 0.707 and the average posttest score was 1.434. On average, students moved from weak-developing understanding to developing-mastery understanding. A student response that meets the target for question 1 is as follows: "Pollution is something that is harmful to the environment and nature. It can be man-made or can even come from nature. Some examples of pollution are littering, smog from factories, soil eroding into the river, and even cow manure going into our watershed with phosphorus and nitrates."

Question 2

The second question on the assessment was: "What is the difference between point source and nonpoint source pollution?" The average pretest score was 0.478 and the average posttest score was 1.836. On average, students moved from weak-developing understanding

to developing-mastery understanding. Additionally, this question showed the greatest overall change from pre-post instruction. A student response that meets the target for question 2 is as follows: “Point source is when you know where it is coming from, such as a chemical factory. Nonpoint source pollution is when you don’t know where it’s coming from, such as fertilizers, pesticides, manure, loose soils, gas leaks, and road salting.”

Question 3

The third question on the assessment was, “How could the water of Saginaw Bay considered polluted if there are so many living things (cyanobacteria and algae) in it?” The average pretest score was 0.282 and the average posttest score was 1.206. On average, students moved from weak understanding to developing understanding, with some students showing mastery understanding. A student response that meets the target for question 3 is as follows: “The Saginaw Bay is considered polluted because a lot of phosphates and nitrates are in the water, which makes algae and cyanobacteria grow excessively. That is called eutrophication and when it occurs there are low amounts of dissolved oxygen in the water, and the water becomes mucky.”

Question 4

The fourth question on the assessment was, “Do all types of pollution affect organisms the same way? Explain.” The average pretest score was 0.461 and the average posttest score was 1.00. On average, students moved from weak-developing understanding to developing understanding, with a few students showing mastery understanding. This question showed the

smallest increase between the pretest and posttest. A student response that meets the target for question 4 is as follows: “Not all pollutants affect organisms the same way. For example, dogs get sick and can die from eating chocolate. However, humans can eat chocolate without being harmed. The salt water affected radish germination, but the tamarisk tree can tolerate more salty conditions.”

Question 5

The fifth question on the assessment was, “How could you tell scientifically (using a controlled experiment) what level of pollution is dangerous to organisms?” The average pretest score was 0.597 and the average posttest score was 1.413. On average, students moved from weak-developing understanding to developing-mastery understanding. A student response that meets the target for question 5 is as follows: “You would use a bioassay (a controlled experiment). You would show the toxicity level by taking several organisms of the same species and exposing each one to a different level of the same pollutant.”

Question 6

The sixth question on the assessment was, “What is a food web? How do you think the death of so many mayflies disrupted the food web of the Saginaw Bay region? Draw a hypothetical food web that contains mayflies (space on the next page).” The average pretest score was 0.782 and the average posttest score was 1.641. On average, students moved from weak-developing understanding to developing-mastery understanding. A student response that meets the target for question 6 is as follows: “A food web is a diagram showing the flow of

energy from one organism to another. The death of these mayflies was a hit to the food web, because they were a vital source of food for other organisms. Because the mayflies are gone, the organisms that eat them will have to find other organisms to eat or die." To receive mastery, students were to draw a small food web that correctly modeled energy transfer.

Question 7

The seventh question on the assessment was, "What are some practical strategies that local and federal governments could use that would help curb pollution in our region? In other words, what could be done to ensure that the recovery efforts of Saginaw Bay continue to be successful?" The average pretest score was 0.673 and the average posttest score was 1.239. On average, students moved from weak-developing understanding to developing understanding. A student response that meets the target for question 7 is as follows: "They could make a law and continue to enforce it against fertilizer containing phosphorus (already done), limit salt put on roads, hold factories responsible for pollution, monitor farming techniques such as pesticide application and make sure they use buffer strips to prevent soil erosion."

Question 8

The eighth question on the assessment was, "What could individual citizens do to ensure that these solutions are accomplished?" The average pretest score was 0.826 and the average posttest score was 1.489. On average, students moved from weak-developing understanding to developing understanding, with some students showing mastery

understanding. A student response that meets the target for question 8 is as follows: “There are many, many things. We could recycle more, use organic or less fertilizers, wash our cars on the lawn, start composting, all sorts of things like that. Although if we say we’re going to do it, we need to do it.”

DISCUSSION

General Discussion

The null hypothesis which stated that the activities in which students participated had no impact on student learning was not supported by this research. Statistical analyses of the pretest and posttest data show that the difference between the two averages was indeed statistically significant. The p-values were essentially zero. This confirms the hypotheses that hands-on science activities, role-played case study, and place-based education all have a positive influence on student learning.

The question on which students improved the most from the pretest to the posttest was question number 2, from 0.478 pretest to 1.836 posttest. This average of 1.836 was also the highest average for any of the eight questions. Question two involves specific environmental knowledge of point source and nonpoint source pollution, but the question is a basic knowledge question and low on Bloom's taxonomy. The students had no context during the pretest, and therefore scored low as a group. After the many instances to apply this knowledge, it was easy for students to differentiate between point source and nonpoint source pollution.

On question four, students scored an average of 0.461 on the pretest and an average of 1.0 on the posttest. This represents both the lowest average score on the posttest as well as the smallest overall increase between pretest and posttest averages, with only a modest increase of 0.539. Question four involved not only identifying that pollutants impact different organisms in different ways, but also required students to provide an explanation of this. Many students were unable to explain cause and effect relationship or describe a specific example in which the

same pollutant affects organisms differently. This question is higher on Bloom's taxonomy, requiring student to combine a basic scientific explanation to a real world example. It is also possible that given the subjective nature of written responses, some students did not understand what was required of them in the second part of the question, which was further explain their answer.

The ultimate problem this researcher sought to address was increasing environmental literacy in students. While the data analysis from the pretest and posttests comparisons shows significant differences, the question of whether or not environmental literacy was increased during the course of this unit is complex, multi-faceted, and difficult to answer. Environmental literacy is not something that can be developed during the course of one unit of study, or even in one year long course. The path to environmental literacy is a lifelong process that should begin as early as possible, and approached in developmentally appropriate ways (Sobel, 1996).

It is difficult to apply any standard measurement as it is likely that no two research participants were at the same level of environmental literacy at the beginning of the study. Because of this, the researcher looked to qualitative measures and student comments as an additional means to identify growth in environmental literacy. All three of the major activities in which students participated during the unit, the hands-on science labs, the field trip to Bay City State Recreation Area, and the role-played case study, provided insight that showed student environmental literacy to be increasing.

The hands-on science labs, particularly the bioassays, allowed students to quantitatively describe the way in which pollution affects organisms. After performing the bioassay using salt, students considered the effect of annual road salting on local ecosystems. Many students also

questioned the impact that other common pollutants would have on local ecosystems. This knowledge was taken even further on the field trip, as students learned about how to determine the health of a body of water by identifying the amounts of sensitive, somewhat sensitive, and tolerant macroinvertebrates. The ability to transfer this scientific knowledge to new environmental situations or problems shows not only awareness, but the ability to comprehend causes and effects that are associated with environmental literacy (Coyle, 2005).

The field trip to Bay City State Recreation Area provided many opportunities for students to increase their environmental literacy. One amazing aspect happened during the welcome and introduction, which occurred before students had broken into their small groups. Students were asked to raise their hand if they had ever been to the park before. The researcher did not have adequate time to count hands, but estimated that less than half of the students had ever visited this state park. Because most students live within an hour of the park, and many closer, it was surprising that more students had not visited the park with their families. Despite this, the level of enthusiasm during the field trip was palpable. Many students were squeamish about some of the modules, such as the macroinvertebrate study, but ended up enjoying them immensely. Their laughter and eagerness to share their discoveries with other students, chaperones, park staff, and the researcher, showed not only a depth of understanding, but an ability to communicate their knowledge to others. The written assignment also allowed the researcher insight into the development of environmental literacy in the students. Many students effectively combined the data from all of the modules to communicate clearly and concisely that despite all of the pollution in the Saginaw Bay region, the Tobico Marsh is healthy for aquatic life, and for human use if well managed and cared for.

For the remainder of the school year, students often recalled memorable experiences from the field trip. This did not occur just in idle talk; rather, students brought up these experiences as examples of topics in units later in the year. This level of retention supports what Slattery and Lugg (2003) say about the value of meaningful outdoor educational experiences that are well organized, well operated, and are grounded in basic science.

The role-played case study involving the problem of eutrophication in Saginaw Bay also provided students a chance to develop environmental literacy. Students enjoyed the opportunity to interact and debate with others during the town hall meeting. They discovered and identified that environmental problems involve many people and stakeholders and that the solutions are not easy. They learned that their impact on the environment could affect other citizens, even those who live far away. They understood that any decisions made could possibly impact another's livelihood, and that compromises that benefit both the environment and its stakeholders should be reached whenever possible. The written response to the town hall meeting revealed additional insight. A common theme in these responses was that there are not enough educational opportunities available for citizens to learn about the environment and the actions they can take to be a good steward. While the literature states that knowledge itself does not promote social action (Coyle, 2005), a substantial number of students feel that most citizens, themselves included, are simply not aware of how they may be contributing to environmental issues, and subsequently feel that they are unable to help. The fact that each of the five town hall meetings, students came to the conclusion that educating citizens on environmental concerns and reasons for helping is vital. It was mentioned many times in the written assignments as well which validates the knowledge-building component of

environmental literacy. It should also be noted that students indicated that a large part of this knowledge base should be built around easy, low impact solutions (i.e., mulching grass clippings, recycling, washing cars on the lawn, using phosphorus free fertilizer) that when done on a large community scale can have a positive impact. The way in which many students thought critically about how to make others environmentally literate reflects their own growth in this area.

Perhaps the best indicators of increasing levels of environmental literacy came from conversations with individual students. One student explained how she was concerned after her father put winterizing fertilizer on their lawn, and excess fertilizer had spilled onto the sidewalk, driveway, and street. She explained to her father the concept of a watershed, and how stormwater carries all sediment, including their fertilizer, into the Saginaw Bay. Together, they swept up the excess fertilizer and applied it to the lawn. Additionally, she told her father, an avid car washer, that washing the car over the grass as opposed to the driveway keeps detergents from running off into the watershed. This student, who did not help her father with these activities before, now helps and takes an active role in using environmentally sound practices.

A second student approached the researcher after the unit was completed and explained that because of what she had learned during the course of the unit, her family now actively recycles. Even though the recycling service had been available in her community for some time, her family had never taken advantage of it. She explained her family did not think that one non-recycling family would make a difference and it was easier to simply put all trash items into one bin. The student said that the role-played case study made her realize the

widespread implications of nonpoint source pollution, and the responsibility that each citizen has to putting a stop to it. She stated that her family now believes that even if one family cannot stop the solid waste problem by recycling, it is still the right thing for them to do. These conversations reflect what Smith (2002) says about students becoming the leaders in their families and communities as they become environmentally literate. These are two instances in which students took the time to converse with the researcher about social actions. It is likely that more students reflected on the environmental attitude of their families and considered actions but did not inform or discuss them with the researcher.

Other conversations occurred that, while not specifically describing social action, still reveal strides in the development of environmental literacy. One such conversation started prior to the field trip to Bay City State Recreation Area. The student expressed concern regarding her safety while being in the outdoors. She believed it would be safer to remain in the classroom and watch videos, and suggested the park interpreters could come to the school instead of the class heading outside for a day. The researcher encouraged her and tried to provide some level of comfort and assurance, and ultimately told the student the field trip would be good for her. After the field trip, this student indicated that she had learned a great deal about plants and animals on the pond habitat survey hike. She also reported enjoying the chemical testing of water because it occurred in the visitor center lab. She said that while she did not enjoy all of the modules on the field trip, particularly the macroinvertebrate survey, she acknowledged that her fears came mostly from a lack of experience in nature. Knowing the names of common plants and animals helped to alleviate this fear. This student still prefers learning from books in the classroom, but she did acknowledge the trip was a positive

experience because not only was she exposed to nature, but she also identified a connection between the knowledge gained in the classroom and the real science that occurs in the environments in which we live. Though this student has not contributed any social actions, the shift in her viewpoint of the natural world represents an increase in environmental literacy.

Analysis of Project

With so many new activities, the researcher designed the unit so that much of the course content that would normally be delivered by an instructor in class was explored by students outside of class, utilizing what has become known as the "flipped' classroom. This occurred with the vocabulary photo scavenger hunt as well as the Lake Macatawa watershed project videos and quizzes. As Milman (2012) states, the flipped classroom is effective when all students participate in the portion of the lesson completed at home and come to class ready with questions and comments. The flipped classroom is less effective, and can hold the class back, when some students choose not to engage in the at home portion (ibid). It was apparent that many students were forgetful of these activities, and class time that was designed to be saved was spent building what should have already been in place. One solution the researcher found to this problem was to have the students who had participated in the at home portions teach those who had not, further solidifying their developing knowledge while at the same time assisting those did not do the work.

The second concern is that outside of the all-day field trip to Bay City State Recreation Area, and the ongoing photo scavenger hunt vocabulary assignment, most of the learning occurred in the classroom and not in "place". While the unit described in this study contains

many strong elements of place-based education, there are components of place-based education that could simply not be done given the traditional classroom setting. For example, Smith (2002) and Gruenewald (2003) state that place based education should include not just the ecological elements of place, but the history of that place as well. The museum portion of the visitor center included many exceptional displays discussing the historical economic and societal development of the Great Lakes Bay region. However, this portion was not structured or facilitated, and students were allowed to wander the exhibit. It is unknown to what extent their concept of "place" was enhanced by this module on the field trip. Additionally, Gahl Cole (2007) states that place-based education needs to contain a sociological element as well, one that identifies and respects indigenous ways of knowing. This sociological element was not as apparent in this unit, particularly concerning how the natives of Michigan utilized the land.

One of the strengths of this unit was the role-played case study approach to solving an environmental problem and the subsequent town hall meeting. Students commented that they enjoyed the debate that occurred as they struggled to find solutions to complex ecological and economic issues. One student wrote in his written reflection on the meeting that "I liked how we could practice on being adults and maturely discuss the problems that we have in the Saginaw watershed." Indeed, the students as a whole did an outstanding job. What would further strengthen this component and more accurately follow the model of place-based education would be if students did not simply role-play this issue, but became involved real city discourse about environmental issues facing our region. Opportunities for this likely exist in many regions in the United States. For example, in the Great Lakes Bay Region, Dow Chemical holds quarterly town hall meetings regarding cleanup efforts of the Tittabawassee River.

Citizens who live within this watershed share concerns with Dow representatives, and community input has helped direct the cleanup of chemical contamination. This would allow students to not just "act like real adults" as one student commented, but actually participate in community discourse. As Smith (2002) states, "We do not ask children to pitch and catch and run by asking them to read books or watch video tapes… real learning comes from involvement in the actual game."

After attempting to utilize placed-based education in the secondary classroom, the researcher concludes that in order to truly study in "place", and for this method to work in a traditional school setting, the lessons would have to be cross-curricular, with many teachers and core subjects involved. It is not practical or fair for students to be out of other classes for multiple days for a science class, even if they are gathering vital information and gaining a sense of place. An ideal model of placed-based education utilizing this same unit would include spending more time at the place itself and multiple teachers interacting with students in their various academic disciplines. This would provide a more holistic approach to place-based education, and students would develop a complete sense of the place in which they live. Knapp (2000) warns that this style could serve to water down the environmental education component. However, if done correctly and the school and teachers have all the support they need to truly implement place-based learning, students would not only become more environmentally literate, but develop a strong sense of place as well while growing in multi-disciplinary knowledge. This can only be practical in a school district that has the funds to put its students in "place" as well as the buy-in from the school board as well as its teachers that this teaching philosophy is effective for teaching all academic disciplines effectively.

Despite these concerns about whether or not this study truly utilized place-based learning, the literature resoundingly supports the educational practices of this study to be in line with sound environmental education. Each of the three major components of this unit, the hands-on science investigations, the field trip, and the role-played case study utilized strong practice that can increase not only environmental knowledge, but provide opportunities to foster environmental literacy. Hands-on science opportunities allowed students to better quantitatively describe environmental issues, which is critical in the formation of environmental literacy (Coyle, 2005; Knapp, 2000). Students who participated in this research study were better able to describe environmental issues using scientific reasoning as opposed to emotional argumentation, which is consistent with strong environmental education (Knapp, 2000; Van Weelie & Wals, 2002). The field trip to Bay City State Recreation Area included both a great deal of hands-on science investigation that occurred in "place". The trip allowed for deeper connections to the place in which one lives, necessary for both environmental education and place-based education (Sobel, 2004). In addition, the authority of park staff added to the authenticity of science knowledge during an outdoor education experience (Slattery & Lugg, 2003). The role-played case study involving a local environmental issue was an effective pedagogical method for teaching environmental issues (Cook & Deaton, 2012).

The researcher will use each of the three basic components of the unit in future years, modifying them as needed, given the makeup of the class as well as the environmental issues that are ongoing in the Saginaw Bay region. In addition, the supporting activities such as the photo scavenger hunt and the Lake Macatawa videos provided students an opportunity to interact with material in different ways and will also be utilized again.

Teacher Recommendations

This study contributes to and expands the knowledge base in the areas of science education, environmental education, and place-based education. The first recommendation is that environmental science should be taught throughout science curriculum. Additionally, when teaching environmental science, it should be grounded in hands-on science activities, data collections and principles of science. Science teachers should strive to find real-world applications when teaching traditional basic science. Environmental issues are certainly relevant, and as pointed out previously, students concern for environmental issues is rising even as interest in traditional science wanes (Gough, 2002). This provides the perfect opportunity to harness student interest in environmental issues to teach basic science principals that will provide the foundation for interest in science. Throughout the course of this unit, science topics and techniques, including ecology, making solutions, collecting data, classification, and many more were taught in direct connection with environmental issues that impact students. Students were immediately aware of the application, and there was no question as to why the topic was being studied or the lab was being done. This is consistent with what Knapp (2000) states about environmental education; it must be grounded in basic science. Gough (2002) also says that both science education and environmental education are strengthened when they are used in conjunction with one another. In addition, grounding environmental education in basic science promotes true environmental literacy in which students can rationally and scientifically describe their environment instead of emotionally (Knapp, 2000).

The second recommendation is that field trips should be included whenever logistically possible. Preferably, these trips should occur locally, to help students develop a sense of place for the area in which they live. While place-based education may not be entirely possible due to scheduling and other logistics of traditional schools, onsite field trips are still authentic and valid experiences that can expand student understanding of place. Science professionals, including Department of Natural Resources staff and park interpreters should be included in these trips whenever possible. Students respond to the authenticity and authority of these professionals (Slattery & Lugg, 2003). In addition, by participating in field trips outdoors, a student who either purposely averts nature or simply has limited exposure to nature in a structured setting may begin to develop the confidence to explore nature themselves (Louv, 2005). Science teachers should get connected with local nature centers or the Department of Natural Resources as the purpose for existence of many of these centers is community outreach. These nature centers work with teachers to design the most effective lessons and workshops that will be developmentally appropriate. The field trip in this study, which was conducted in the state of Michigan, was completely free of charge, making it very accessible. Many educators cite lack of time, resources, and planning as excuses for not taking their classes on field trips (Bennett & Heafner, 2004). However, because of effective, professional, well planned and managed programs, such as those at the Saginaw Bay Visitor Center at Bay City State Recreation Area, this is clearly an empty excuse. The planning and logistics are indeed time consuming, as this researcher discovered, but the benefit of this type of experience for students made it extremely worthwhile.

The third recommendation is that teachers incorporate local environmental phenomena into their lessons. It has also been shown that role-played case studies involving these local issues are effective in engaging student interest, developing a student's sense of place, and ultimately increase environmental literacy (Cook & Deaton, 2012). Allowing students to research a particular role or interest group in a case study promotes empathy and understanding. By allowing students to work together to solve environmental issues, students discover in an authentic way that environmental issues are complex, and that there is no one correct answer that satisfies every stakeholder. If at all possible, students should be provided with the opportunity to engage in real community discourse, not just role-play, to begin to participate in their community (Smith, 2002).

An additional contribution of this study to science and environmental education is that even though a great deal of literature condemns the practice of merely teaching environmental knowledge to students and instead promotes educating for social action, the student subjects in this study made it clear that they were not able to act for the environment without a knowledge of issues and a rationale for acting (Coyle, 2005). This confirms what Knapp (2000) says when he identifies that students need grounded scientific information before they are asked to take up a cause. Rather, as students grow in knowledge, they will identify actions and solutions on their own without being coerced to participate. Educators should be wary of asking students to engage in solving environmental issues when they do not have a strong scientific and environmental knowledge foundation upon which to build environmental literacy. It should be reiterated that this foundation of environmental knowledge upon which environmental literacy is built cannot be done so without being grounded in basic science.

CONCLUSION

The data collected for the pretest and posttest indicate that the hypothesis stating that the teaching methods utilized in this unit would increase student knowledge was supported. The average pretest score of 4.809/16 (30.0%) compared to the average posttest score of 11.26/16 (70.3%) shows that student understanding increased significantly. With a t value of -25.5, the probability of this result, assuming the null hypothesis that the unit would have no effect, is 0.000. It has also been supported through conversations with students and observations from student writing that student environmental literacy has increased throughout this unit. That being said, this study recommends that environmental literacy is a lifelong journey, one that begins at a young age and continues through adulthood. Science educators should incorporate local environmental phenomena whenever possible through the use of field trips, role-played case studies, and hands-on science labs to help foster environmental literacy among students.

APPENDICES

APPENDIX A - Forms

PARENTAL CONSENT AND STUDENT ASSENT FORM

Dear Students and Parents/Guardians:

I would like to take this opportunity to welcome you back to school and invite you to participate in a research project, Increasing Environmental Literacy: An Integrated Lab and Case Study Approach, that I will conduct as part of Biology class this semester. My name is Mr. Benjamin Cooper. I am your science teacher this year and I am also a master's degree student at Michigan State University. Researchers are required to provide a consent form like this to inform you about the study, to convey that participation is voluntary, to explain risks and benefits of participation, and to empower you to make an informed decision. You should feel free to ask the researchers any questions you may have.

What is the purpose of this research? I have been working on effective ways to teach ecological topics with an emphasis on human impacts, and I plan to study the results of this teaching approach on student comprehension and retention of the material. The results of this research will contribute to teachers' understandings about the best way to teach about science topics. Completion of this research project will also help me to earn my master's degree in Michigan State University's Department of Natural Science.

What will students do? You will participate in the instructional unit about ecology. You will complete the usual assignments, laboratory experiments and activities, class discussions, class demonstrations, and pretests/posttests just as you do for any other unit of instruction. There are no unique research activities – participation in this study will not increase or decrease the amount of work that students do. I will simply make copies of students' work for my research purposes, and may use in my research video taken from class discussion as well as debate during the case study. This project will continue from September 1st, 2012 to June 5th, 2013. I am asking for permission from both students and parents/guardians (one parent/guardian is sufficient) to use copies of student work for my research purposes.

What are the potential benefits? My reason for doing this research is to learn more about improving the quality of science instruction. I won't know about the effectiveness of my teaching methods until I analyze my research results. If the results are positive, I can apply the same teaching methods to other science topics taught in this course, and you will benefit by better learning and remembering of course content. I will report the results in my master's thesis so that other teachers and their students can benefit from my research.

What are the potential risks? There are no foreseeable risks associated with completing course assignments, laboratory experiments and activities, class discussions, class demonstrations, and pretests/posttests. In fact, completing course work should be very beneficial to students. Another person will store the consent forms (where you say "yes" or "no") in a locked file cabinet that will not be opened until after I have assigned the grades for this unit of instruction. That way I will not know who agrees to participate in the research until after grades are issued. In the meantime, I will save all of your written work. Later I will analyze the written work only for students who have agreed to participate in the study and whose parents/guardians have consented.

How will privacy and confidentiality be protected? Information about you will be protected to the maximum extent allowable by law. Students' names will not be reported in my master's thesis or in any other dissemination of the results of this research. Instead, the data will consist

of class averages and samples of student work that do not include names. After I analyze the data to determine class averages and choose samples of student work for presentation in the thesis, I will destroy the copies of student's original assignments, tests, etc. The only people who will have access to the data are me, my thesis committee at MSU, and the Institutional Review Board at MSU. The data will be stored on password-protected computers (during the study) and in a locked file cabinet in Dr. Heidemann's locked office at MSU (after the study) for at least three years after the completion of the study.

What are your rights to participate, say no, or withdraw? Participation in this research is completely voluntary. You have the right to say "no". You may change your mind at any time and withdraw. If either the student or parent/guardian requests to withdraw, the student's information will not be used in this study. There are no penalties for saying "no" or choosing to withdraw.

Who can you contact with questions and concerns? If you have concerns or questions about this study, such as scientific issues, how to do any part of it, or to report an injury, please contact the researcher Benjamin Cooper: 3560 McCarty Road, Saginaw, MI 48603; bcooper@vlhs.com; 989-790-1676 and /or Dr. Merle Heidemann: 118 North Kedzie Lab , Michigan State University, East Lansing, MI 48824; heidema2@msu.edu; 517-432-2152 x 107. If you have questions or concerns about your role and rights as a research participant, would like to obtain information or offer input, or would like to register a complaint about this study, you may contact, anonymously if you wish, the Michigan State University's Human Research Protection Program at 517-355-2180, Fax 517-432-4503, or e-mail irb@msu.edu or regular mail at 207 Olds Hall, MSU, East Lansing, MI 48824.

How should I submit this consent form? If you agree to participate in this study, please complete the attached form. Both the student and parent/guardian must sign the form. Return the form Dr. Lisa Myers by September 1st, 2012.

Benjamin Cooper
Science Teacher
Valley Lutheran High School

Parents/guardians should complete this following consent information:

I voluntarily agree to have _____ participate in this study.
(print student name)

Please check all that apply:
Data:
_____ I give Mr. Benjamin Cooper permission to use data generated from my child's work in this class for her thesis project. All data from my child shall remain confidential.
_____ I do not wish to have my child's work used in this thesis project. I acknowledge that my child's work will be graded in the same manner regardless of their participation in this research.
Photography, audiotaping, or videotaping:
_____ I give Mr. Benjamin Cooper permission to use photos, audiotapes, or videotapes of my child in the class room doing work related to this thesis project. I understand that my child will not be identified.
_____ I do not wish to have my child's images used at any time during this thesis project.

Signatures:

_____

_____
(Parent/Guardian Signature) (Date)

I voluntarily agree to participate in this thesis project.

_____

_____
(Student Signature) (Date)

******Important******
Return this form to Dr. Lisa Meyers in the front office.

APPENDIX B - Assessment

Directions: Read the paragraph below. After carefully reading the text, answer the questions as thoroughly as possible. Use information from this text, as well as your current knowledge and understanding of environmental issues to answer the questions. Please answer using complete sentences and complete thoughts.

In recent years, pollution in the Great Lakes-Bay region has become a major problem. Bay City State Park often has a smelly muck consisting of cyanobacteria and thick clumps of green algae washing onto its beaches. Not only is this unsightly at the state park, but it has affected the ecosystem of the entire region at an ecosystem level. Mayfly nymphs (baby mayflies that develop in water) were once in abundance in the Saginaw Bay, but are now almost gone (see Figure 1). Recent efforts to improve environmental conditions have been partly successful, with most point sources of pollution identified and regulated. However, nonpoint source pollution is still a major problem. Local and federal government officials are working on solutions to this environmental problem, and yet, each citizen also plays an important role in this solution.

1) What is pollution?

_____

_____

_____

_____

_____

2) What is the difference between point source and nonpoint source pollution?

_____

_____

_____

_____

_____

3) How could the water of Saginaw Bay be considered polluted if there are so many living things (cyanobacteria and algae) in it?

_____

_____

_____

_____

4) Do all types of pollution affect organisms the same way? Explain.

_____

_____

_____

_____

5) How could you tell scientifically (using a controlled experiment) what level of pollution is dangerous to organisms?

_____

_____

_____

_____

6) What is a food web? How do you think the death of so many mayflies disrupted the food web of the Saginaw Bay region? Draw a hypothetical food web that contains mayflies (space on the next page).

_____

_____

_____

(Draw food web here…)

7) What are some practical strategies that local and federal governments could use that would help curb pollution in our region? In other words, what could be done to ensure that the recovery efforts of Saginaw Bay continue to be successful?

_____

_____

_____

_____

8) What could individual citizens do to ensure that these solutions are accomplished?

_____

_____

_____

_____

Table 4: Rubric used to assess the pretests and posttests.

Question	**Weak 0**	**Developing 1**	**Mastery 2**
1	No coherent explanation is given by the student	Student demonstrates a basic understanding of pollution (common litter, air pollution, dumping sewage, etc).	Student defines a wide variety of pollutants, including residential, industrial, and agricultural.
2	No coherent explanation is given by the student.	Student identifies a difference based on the words themselves, but cannot provide thorough explanation.	Student correctly identifies point source pollution as from a factory, etc., while nonpoint sources are not as easy to pinpoint (residential, farm).
3	No coherent explanation is given by the student.	Student identifies that something in the pollution must be good for the algae. It may not always be "bad" for all organisms.	Student identifies that excess amounts of nitrogen and phosphorus, nutrients are being added.
4	No coherent explanation is given by the student (i.e. – it hurts them)	Student identifies in a general way that pollutants may affect metabolism and general cell processes. Also, students identify that pollution can affect organisms differently.	Student identifies a specific physiological function that is affected by a pollutant. Also, students provide an example of how pollution affects organisms differently.
5	No coherent explanation is given by the student.	Student describes a noncontrolled method to determine the effect of a pollutant on an organism.	Student describes a controlled bioassay to determine the tolerance of the LD 50 of a pollutant on an organism.

Table 4 (cont'd)

6	No coherent explanation is given by the student. Food web is incoherent.	Student identifies a food web and attempt to logically explain how *Hexegenia* loss would alter food web. Food web is attempted, but energy flow is wrong.	Student explains a food web correctly and what would happen was it to be disrupted. In addition, food web correctly follows energy flow.
7	No coherent explanation is given by the student.	Student mentions methods not relevant to problem (stop throwing garbage in the river, littering, etc.) but attempt to solve problem.	Student mentions at least two of the following: legislation, bioremediation, personal choices regarding fertilizers, pesticides and other chemicals,
8	No coherent explanation is given by the student	Student mentions methods not relevant to problem (stop throwing garbage in the river, littering, etc.) but attempt to solve problem.	Student mentions specific things like purchasing from environmentally aware companies, voting for legislation that protects the environment, using chemical products responsibly, etc.

APPENDIX C – Handouts, Labs, and Assignments

Appendix C1
Photo Scavenger Hunt

As we begin our study of *ecology*, there is a great amount of vocabulary and terms which will help us describe the observations we make. Your job is to learn about these terms, and go on a 'photo scavenger' hunt to capture these concepts. Each photograph should represent the concept or term that you have chosen.

Planning is important – before you go to take pictures, you should discuss how you want to represent the picture with your table group. This project will be started in class but after this class time is over, you are on your own. Table groups may continue to share ideas and collaborate to find picture ideas.

After photos have been taken, you will incorporate them into a presentation (PowerPoint, Keynote, Prezi) that includes the pictures with captions that *label the picture* and *describe why the concept or term matches with the picture* in your own words.

Guidelines:

- You must use a different picture for each term – no repeats.
- Table group members may collaborate and share pictures.
- Come up with a way to *identify each picture as your own*. (Some people put an action figure or their phone or keys in each picture).
- The final presentation must have *labeled pictures* with a *brief description of why the concept or term matches with the picture*.

Terms:

Set 1
Organism
Population
Community
Ecosystem
Habitat
Niche
Autotroph
Heterotroph
Biotic factors (at least 2 pics/examples)
Abiotic factors (at least 3 pics/examples)

Set 2
Predation
Mutualism
Parasitism
Competition
Producer
Consumer
Herbivore
Carnivore
Omnivore
Decomposer
Plant adaptation
Animal adaptation

Set 3
Habitat loss
Biodiversity
Runoff
Erosion
Pollution (at least 2 pics/examples)
Invasive species
Monoculture

Set 4 – a few pics that represent each cycle
Water cycle
Carbon cycle
Nitrogen cycle
Phosphorus cycle

This is an ongoing assignment that will take place throughout the unit. To keep track of progress, there will be four checkpoints. The presentation files should be saved to the Student Drive in the 'Biology' folder in the appropriate class hour folder. Files should be named with your last name followed by your first name.

Set 1 Checkpoint: _____

Set 2 Checkpoint: _____

Set 3 Checkpoint: _____

Set 4 Checkpoint: _____

Final Due Date: _____

Appendix C2
Unit 2 Notes – What is Pollution? How is Pollution Harmful?

_____ is the introduction of contaminants into the natural environment that causes _____ change to an organism. Pollution can take the form of _____ substances *or* energy, such as noise, heat or light. Pollutants, the components of pollution, can be either **_____ substances** *or* **_____ occurring contaminants**.

Would you rather drink a cup of caffeine or a cup of trichloroethylene?

- Trichloroethylene is in glues, paint, and other products – but _____ is more toxic!

_____ is vital – we need it to survive. But in large amounts, it becomes a _____ chemical!

The _____ makes the poison – all substances can be _____ (even water!) – the difference between the poison and the remedy is the amount.

Humans can eat many _____ bars – but to dogs, just a few chocolate bars can be fatal because they lack the ability to _____ and break down the chemicals in chocolate.

One chemical, _____ (Dow is famous for it), is 5,000 times more deadly for _____ _____ than _____! Why? How a chemical is **_____** by the body is important. Is it stored? Where? In the _____, kidneys or _____? Additionally, the body can change a harmless chemical into another.

Also – some pollutants can lead to **_____ poisoning** – it happens quickly! Other poisons build up over time, and dangerous levels can be reached after many exposures – this is called **_____ poisoning**. _____ poisoning and _____ poisoning are examples.

_____ is the term for when organisms start showing effects of exposure to chemical.

A **_____** uses living things to determine chemical toxicity.

_____ source pollution – Pollution is entering an area at an identifiable source – such as a _____ from a factory or a hole in an oil tanker.

_____ source pollution – Pollution is entering an area, but the exact location can't be pinpointed.

Pollution affects **_____ webs.** Food webs show "_____ eats _____" in an ecosystem. Food webs show how _____ flows through an ecosystem. Arrows _____ *the flow of*

energy – sun energy is captured by **_____** and converted to chemical energy. Then it is eaten by **_____**.

Consider these organisms: ***grass, mouse, sunflower, owl, grasshopper, snake, fox***.
Think about the flow of energy, and draw a food web on the back of this notes page…

Appendix C3
Unit 2 Notes – Teacher Copy

Pollution is the introduction of contaminants into the natural environment that cause adverse change to an organism. Pollution can take the form of *chemical substances* or energy, such as noise, heat or light. Pollutants, the components of pollution, can be either **foreign substances**/energies or **naturally occurring contaminants**.

Would you rather drink a cup of caffeine or a cup of trichloroethylene?

- Trichloroethylene is in glues, paint, and other products – but caffeine is more toxic!

Vitamin D is vital – we need it to survive. But in large amounts, it becomes a deadly chemical!

The **dose** makes the poison – all substances can be **toxic** (even water!) – the difference between the poison and the remedy is the amount.

Humans can eat many chocolate bars – but to dogs, just a few chocolate bars can be fatal because they lack the ability to digest and break down the chemicals in chocolate.

One chemical, dioxin (Dow is famous for it), is 5,000 times more deadly for guinea pigs than hamsters! Why? How a chemical is **metabolized** by the body is important. Is it stored? Where? In the liver, kidneys or fat? Additionally, the body can change a harmless chemical into another.

Also – some pollutants can lead to **acute poisoning** – it happens quickly! Other poisons build up over time, and dangerous levels can be reached after many exposures – this is called **chronic poisoning**. Lead poisoning and alcohol poisoning as examples.

Response is the term for when organisms start showing effects of exposure to chemical.

A **bioassay** uses living things to determine chemical toxicity.

Point source pollution – Pollution is entering an area at an identifiable source – such as a pipe from a factory or a hole in an oil tanker.

Nonpoint source pollution – Pollution is entering an area, but the exact location can't be pinpointed. It could be from

Pollution affects **food webs.** Food webs show "who eats who" in an ecosystem. Food webs show how energy flows through an ecosystem. Arrows *follow the flow of energy* – sun energy is captured by **producers** and converted to chemical energy. Then it is eaten by **consumers**.

Consider these organisms: ***grass, mouse, sunflower, owl, grasshopper, snake, fox***.

Think about the flow of energy, and draw a food web on the back of this notes page…

APPENDIX C4
Bioassays: How Does Pollution Affect Organisms?

The dilution of chemical waste by adding it to rivers, streams and other bodies of water was a very common way of disposing of hazardous chemical waste during the 20th century, and it is still a method used to this day. Many years ago, the long term effect of harmful chemicals was not known, nor was it known how long they would persist in the environment. Because of this, companies would dump this waste directly into the watershed (review – do you remember what type of pollution this is?). It was assumed that with enough water, you could dilute any chemical to harmless levels that would have not impact the environment. Many communities, including our own, are paying the long term consequences of this irresponsible practice.

We all know that pollutants are harmful, but to what extent? What levels are fatal, and at what levels can organisms tolerate? We can safely assume that a gold fish dropped in a bucket of bleach would die immediately (there is no need to try this!). But would a gallon of bleach accidentally spilled into a medium sized pond produce the same effects?

It is worth noting that organisms respond differently to different levels of pollution. Some species have extremely low **tolerance** and others extremely high tolerance. For example the tamarisk tree, an invasive species encroaching upon many habitats in the United States, not only loves salty soil, it continues to make the soil salty until other species cannot live there. Pollution in the Great Lakes has been a limiting factor for many native species of fish, while invasive species such as the round goby have thrived in these poor conditions.

A **bioassay** is a technique that uses living organisms, such as radish seeds or *Daphnia*, to determine the toxicity of a pollutant. Let's say that you know that a bottle of weed killer will harm aquatic organisms because it says so on the bottle. In order to determine what levels are harmful or fatal, the pollutant would be diluted to a certain concentration, and then further diluted using either **serial dilutions***,* or simply modifying the percent. Then, organisms are placed in different solutions and observed for a set period of time (30 minutes, 1 hour, 4 hours, 24 hours are common times). During the time period, observations are recorded, and at the end of the time period, data is collected (number living, number dead). The results will give you a general idea of which concentrations are harmful. The concentration at which half of the specimens are dead after the set time has expired is known as the **L.D. 50,** or **lethal dosage 50%.** If specimens only died at one concentration, you would know to narrow your test around that value.

The decisions we make about the products we purchase and what we do with our waste has a direct impact on the ecological community in which we live. In order to experience a bioassay first hand, and to make a connection with how our pollution has a direct impact on the organisms in our community, we will conduct a bioassay.

How to Make a Serial Dilution:

1. Take your stock solution. Pour 100 mL into a beaker. Label this beaker "100%"
2. Fill 4 beakers with 90 mL of water – label them 10%, 1%, 0.1%, and 0.01%
3. Pipette 10 mL of 100% solution, and combine it with the water in the 10% beaker.
4. Pipette 10 mL of the 10% solution, and combine it with the water in the 1% beaker.
5. Pipette 10 mL of the 1% solution, and combine it with the water in the 0.1% beaker.
6. Pipette 10 mL of the 0.1% solution, and combine it with the water in the 0.01% beaker.

You now have a very wide range of concentrations with which to perform a bioassay.

How to Make Different % Concentrations:

Let's say you've narrowed down the range of toxicity. Now you can make different percent solutions using that concentration. Use the table below as a guide for making the solutions.

Table 5: Making Solutions of Different % Concentrations

Solution Concentration	0.2 M KI (mL) (example)	Distilled Water (mL)
100%	100	0
50%	50.0	50.0
37.5%	37.5	62.5
25%	25.0	75.0
12.5%	12.5	87.5
Control	0	100

Now you can better determine the toxicity within the range in which you first noticed the effect.

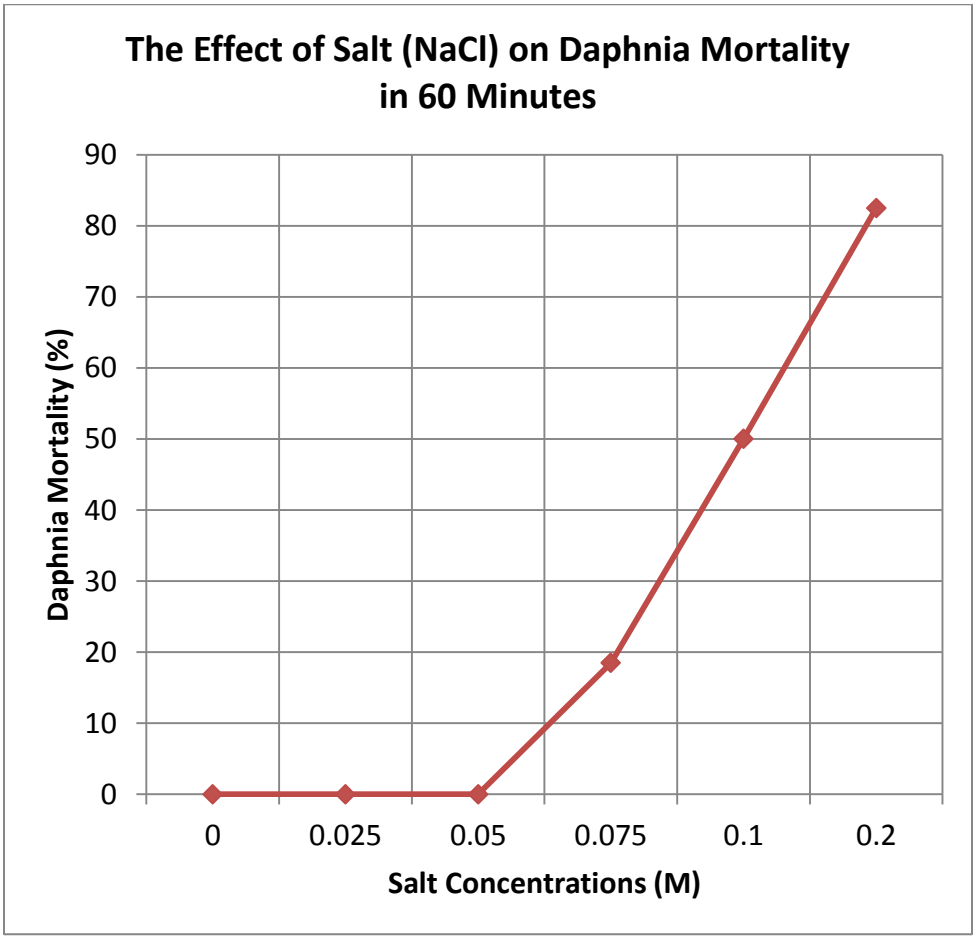
Appendix C5

Bioassay: The Effect of Salt on *Daphnia* Mortality in 60 Minutes

Daphnia magna, commonly called the water flea, is a small aquatic crustacean. *Daphnia* can be found in nearly all freshwater ecosystems, and they are a valuable **indicator species**. An indicator species is one that is susceptible to toxins in the environment. When an indicator species begins to decrease in number, ecologists realize that the ecosystem is in danger, even if there are no other warning signs.

The following experiment was performed in order to determine how tolerant to salt *Daphnia* are. Six molar concentrations of salt were prepared. A simple understanding of molar concentrations is that the higher the molar concentration, the more molecules of salt are present. The concentrations were 0, 0.025 M, 0.05 M, 0.075 M, 0.1 M, and 0.2 M of salt (NaCl). Six healthy *Daphnia* were placed in Petri dishes containing each solution. A scientist observed the *Daphnia* and recorded observations during a 60 minute time period. When the 60 minutes were over, the scientist recorded how many *Daphnia* had been killed. The graph below shows the data for his experiment.

Figure 1: The Effect of Salt (NaCl) on *Daphnia* Mortality in 60 Minutes



Analysis and Conclusion:

1) Based on the graph, what are acceptable levels of salt pollution in an ecosystem? Explain your answer.

_____

_____

_____

2) At what salt concentration is the L.D. 50 in 60 minutes? Draw a horizontal line through this point on the graph, and label it 'L.D. 50.'

_____

_____

_____

3) The scientist's journal includes this note: "0.075 – most are still alive – but they are sluggish and only move in halting, jerky motions." Predict the L.D. 50 if this study had been conducted for 4 hours instead of 1 hour.

_____

_____

_____

4) The humble *Daphnia* is an important part of the aquatic food chain. Collectively, they consume great amounts of aquatic algae, and are themselves an important food source for fish. Predict what could occur in a polluted ecosystem where *Daphnia* are no longer present.

_____

_____

_____

Appendix C6

Bioassay: The Effect of Salt Concentrations on Radish Germination

Radishes are easy to germinate in classrooms and are therefore a great "model organism" to study plant growth. Even though salts are naturally occurring chemicals, humans impact the amount of salts that enters ecosystems. Therefore, salts can be pollutants. This bioassay will help us to determine the level of salts that affect radish seed germination. We can then apply this understanding to other plants, keeping in mind that some species are more salt tolerant than others.

Question: What levels of salt can radishes tolerate?

Hypothesis: *Based on what you already know about pollution, propose a hypothesis that answers the question above.*

_____

_____

Materials

Paper towels - 16
Zip-Loc bags - 8
Radish seeds - 80
Distilled water
Salt – noniodized

1. Make salt solutions in the following concentrations: 0.5%, 1.0%, 1.5%, 2.0%, 2.5%, 3.0%, 4.0%, and 5.0% - use the following info to help – 1 g / 100 mL is a 1% solution.

2. Stir the solutions until the salt has dissolved.

3. Label each Zip-Loc bag with the appropriate %. Label one bag 'Control.' This bag will contain distilled water.

4. Take two paper towels and place 10 radish seeds in a line along the crease. You may need to wet the crease using distilled water before placing the seeds so they stay in place.

5. Fold the towels into a square and place them into a Zip-Loc bag, being careful not to jostle the seeds.

6. Using a 25 mL pipette, transfer 20 mL of solution so that the paper towel is thoroughly saturated.

7. Repeat these steps until you have filled all of your bags with the different solutions and radish seeds.

8. Each day for three days, observe your bags with your group and record your data. (# germinated / # ungerminated)

Construct a data table and record your data:

Graphing: On graph paper, tell the "story" of the data collected from this investigation.

Analysis and Discussion

1. Research the following question: Why does salt effect seed germination? ("It kills them" is not an acceptable answer.)

_____

_____

_____

2. What is a salt? Is table salt the only type of salt? What are some common pollutants that contain salts? (hint: ask chemistry student or ask to use their book!)

_____

_____

_____

3. Look at the labels of various household cleaning products or lawn care products. Based on your answer for number three, do these items contain salts? Write down the three products you examined and list the type of salt contained in each product.

_____

_____

_____

4. What could happen if these chemicals were accidentally or purposefully released into the ecosystem?

_____

_____

_____

5. Based on your understanding of the affect of salt on plants, how does the annual salting of roads affect our local ecosystem?

_____

_____

_____

6. What human activities, other than road salting, add salts to the environment?

_____

_____

_____

7. Research the tamarisk tree. How does it take over a community?

_____

_____

_____

8. List at least 2 questions that could be investigated as an extension this bioassay plant lab.

_____

_____

_____

Appendix C7
Eutrophication in a Bowl

Questions: What is eutrophication? What are the physical and biological factors that influence eutrophication? What are the effects of eutrophication?

Hypothesis: Read the procedure so you are aware of what will be added to each tank. Based on what you know about eutrophication, write a hypothesis that ranks each bowl from least to greatest regarding the amount of eutrophication.

_____

_____

Materials:
5 small clear plastic 1-liter aquariums – "microcosms"
Phosphate testing strips
Nitrate testing strips
Dissolved oxygen testing tablets
Liquid plant fertilizer containing nitrogen and phosphorus
Masking tape
Marker
Graduated cylinder

Procedure:

1. Fill five containers with pond water or water from some other natural source, such as a lake or a stream.
2. Label the containers 1-5.
3. Test and record the concentrations of dissolved oxygen, nitrate, phosphate, and pH.
4. Tank 1 is the control tank and no fertilizer will be added.
5. In Tank 2, add 5 mL of fertilizer and mix well.
6. In Tank 3, add 10 mL of fertilizer and mix well.
7. In Tank 4, add 20 mL of fertilizer and mix well.
8. In Tank 5, add 40 mL of fertilizer and mix well.
9. Retest and record the concentrations of dissolved oxygen, nitrate, phosphate, and pH.
10. Place the tanks in a location that receives a lot of sunlight or on a plant table.
11. Allow phytoplankton to grow in the tanks for 3 days.

Data Recording: Construct a data table and record data as it is collected.

Graphing: On graph paper, tell the "story" of the data collected from this investigation.

Analysis and Conclusion:
1) List at least three sources of nitrogen to aquatic environments. List at least three sources of phosphorus to aquatic environments.

_____

_____

_____

2) Which is a more important limiting factor in freshwater ecosystems, nitrogen or phosphorus? Why? Which is a more important limiting factor in marine (ocean) ecosystems, nitrogen or phosphorus? Why?

_____

_____

_____

3) Explain how dissolved oxygen becomes an issue in a highly eutrophic environment.

_____

_____

_____

4) Why does dissolved oxygen begin to decrease when the amount of oxygen producing algae is increasing?

_____

_____

_____

5) State the hypothesis developed by your group. Explain the reasoning behind how the group hypothesis was developed. Was your hypothesis supported? Explain.

_____

_____

_____

6) Explain how urbanization and the population size of a city can influence eutrophication.

_____

_____

_____

7) Explain the relationship between your observations and results during the course of the experiment. Use the following terms in your explanation: dissolved oxygen, eutrophic,

hypereutrophic, light attenuation, mesotrophic, nutrients, nitrogen, oligotrophic, phytoplankton

_____

_____

_____

_____

_____

8) List at least two questions that could be investigated as an extension using these eutrophication models.

_____

_____

_____

Appendix C8

Into the Watershed: Understanding the Importance of a Healthy Watershed, and What We Can Do To Maintain It

Understanding the importance of a healthy watershed, and knowing how to maintain it is essential in an ecological education. The following videos will help develop your understanding of what a watershed is, why it is important, and how to maintain, preserve and restore them.

Watch the videos (they are short – and goofy!) and answer the following questions about watersheds.

Intro: What are Watersheds?
http://www.youtube.com/watch?v=xUYWb8XTo58
http://www.youtube.com/watch?v=f63pwrMXkV4&feature=related

Part 1 – Into the Watershed – Intro
http://www.youtube.com/watch?v=yyvOGq4iA-s&feature=relmfu

Part 2 – Into the Watershed – Wetlands
http://www.youtube.com/watch?v=U-LtpEf1D2c&feature=relmfu

Part 3 – Into the Watershed – Stormwater
http://www.youtube.com/watch?v=CExPKYBGrbM&feature=relmfu

Part 4 – Into the Watershed – Agriculture
http://www.youtube.com/watch?v=eb6heh0inqw&feature=relmfu

Part 5 – Into the Watershed – Land Use
http://www.youtube.com/watch?v=gW4dBAKdHdo&feature=channel&list=UL

Intro: What are Watersheds?
http://www.youtube.com/watch?v=xUYWb8XTo58
http://www.youtube.com/watch?v=f63pwrMXkV4&feature=related

1. What is a watershed?

_____

_____

_____

Part 1 – Into the Watershed – Intro
http://www.youtube.com/watch?v=yyvOGq4iA-s&feature=relmfu

2. What is in Lake Macatawa? Why is this a problem?

_____

_____

_____

3. What does Lake Macatawa suffer from? What causes this?

_____

_____

_____

4. Why is it a problem for a lake to have too much algae?

_____

_____

_____

5. What happened when the rain drop hit the cow patty?

_____

_____

_____

Part 2 – Into the Watershed – Wetlands

http://www.youtube.com/watch?v=U-LtpEf1D2c&feature=relmfu

6. What percent of wetlands have been lost?

_____

_____

_____

7. What are different types of wetlands?

_____

_____

_____

8. Why are they being destroyed?

_____

_____

_____

9. In addition to protecting the wetlands that remain, what else must be done?

_____

_____

_____

10. What role do wetlands play in maintaining a healthy ecosystem?

_____

_____

_____

11. Briefly describe the purpose of each part of a wetland:
Upland

_____

Riparian zone

_____

Aquatic area

_____

12. How do wetlands accomplish this purpose?

_____

_____

_____

13. What are the benefits of wetlands?

_____

_____

_____

Part 3 – Into the Watershed – Stormwater

http://www.youtube.com/watch?v=CExPKYBGrbM&feature=relmfu

14. What is stormwater? How does it move?

_____

_____

_____

15. What types of surfaces make runoff move quickly? Provide examples of these surfaces?

_____

_____

_____

16. What types of things can be contained in runoff?

_____

_____

_____

17. Where does runoff, and the things contained in runoff, go?

_____

_____

_____

18. What percentage of phosphorus in lakes enters via runoff from storm drains?

_____

_____

_____

19. How can citizens help keep stormwater clean?

_____

_____

_____

Part 4 – Into the Watershed – Agriculture

http://www.youtube.com/watch?v=eb6heh0inqw&feature=relmfu

20. What are sources of phosphorus that enter the watershed from the farm?

_____

_____

_____

21. What are buffer strips? How do they work? What materials do they work with?

_____

_____

_____

22. What problems can be caused by too much rain on the farm?

_____

_____

_____

23. How is manure managed?

_____

_____

_____

Part 5 – Into the Watershed – Land Use

http://www.youtube.com/watch?v=gW4dBAKdHdo&feature=channel&list=UL

24. What does land use mean and what does it include?

_____

_____

_____

25. What does it mean by the following quote: “We try to balance the economic needs of the community with community values and the natural world.”

_____

_____

_____

26. What are watershed friendly land use ideas?

_____

_____

_____

27. Based on this video clip, what should city planners consider when they are determining how land should be use?

_____

_____

_____

Conclusion

28. How do you think the issues of the Lake Macatawa watershed relate to the watershed in which we live?

_____

_____

_____

Appendix C9

JUNGLES – Video Review

Ecology Review – Planet Earth: Jungles – Watch the videos and reflect on what you have seen by applying your knowledge of ecological concepts. And enjoy the show!

What is an example of an organism in the video?

_____

What is an example of a population in the video?

_____

What is an example of a community in the video?

_____

What is an example of an ecosystem in the video?

_____

What are 3 abiotic factors that determine what organisms will be present in the tropical rainforest?

What are 3 biotic factors that determine what organisms will be present in the tropical rainforest?

What are two examples of producers in the video?

What are two examples of primary consumers in the video?

What is one example of a secondary consumer in the video?

What is one example of competition in the video?

What is one example of parasitism in the video?

What is one example of a decomposer in the video?

What is one example of mutualism in the video?

What are two animal adaptations and two plant adaptations that help organisms survive in the jungle?

Appendix C10

Life or Death Food Chain Decision

The Question

A small group of people are stranded on a barren desert island. They have 500 bushels of wheat and one cow. What should they do to survive the greatest length of time?

A. Eat the cow and then eat the wheat
B. Drink the cow's milk, eat the cow, and then eat the wheat
C. Don't feed the cow, drink the milk, eat the cow when milk production ceases, and then eat the wheat
D. Feed the wheat to the cow and drink the milk
E. Feed the wheat to the cow, drink the milk, and then eat the cow
F. Eat the wheat and then the cow

1)First, think about the question by yourself. Which answers do you think are the best ones? Which make the most sense? *Why?*

_____

_____

_____

2)When your teacher indicates, get into a discussion group and exchange/debate ideas to the question. Try to rank the responses from best to worst. Your group will be called on to *explain* or *justify* your choices. Summarize your group's thinking below.

_____

_____

_____

3)Next, there will be a class wide discussion wherein each group will share its ideas on the question to the class.

4)After the class wide discussion, write a reflection on the following: How was your thinking on the question changed after the group and class discussions? What new connections and understandings have you developed? Explain.

_____

_____

_____

APPENDIX D – Field Trip

APPENDIX D1

Water Watchers: Permission Slilp

What: **Freshman Field Trip to Bay City State Park**
When: **Monday, October 8th, from 8:30-2:30**
Where: **Bay City State Park**

The goal of this fieldtrip is to obtain hands on experience in a limnological study of Tobico Lagoon at Bay City State. Students will have an opportunity to practice what they have been learning in class about ecology and human impacts on our environment.

The freshman class will be divided up into 8 small groups. These groups will rotate through four activities. The four labs which they participate in are: Macro Invertebrate Survey, where they will use nets to sift through bottom sediments for bug larva, snails and worms; Turbidity and Temperature Survey where determine the depth of the photic zone of the Tobico Lagoon and rate the turbidity of the water. This station will also include Water Tests, where students will work with a partner to determine the Dissolved Oxygen, the pH, Nutrients, Silica, and hardness of the pond water; Shoreline Assessment will be conducted along the perimeter of the pond where students look at the plant make-up, erosion potential, area land use and other factors to determine risk factors for poor water quality. In conclusion, students will be led through a discussion focusing on how wetlands act as nature's water filter. Finally, students will learn about healthy watersheds at the Saginaw Bay visitor's museum.

Schedule
8:00 – Leave Valley for Bay City State Park

8:30 – Arrive at Bay City State Park

8 groups of students will rotate through different lab stations. There will be a *30 minute lunch break* at some point during the lab stations.

- Macroinvertebrate Survey
- Shoreline Assessment
- Combined Turbidity and Water Testing
- Saginaw Bay Museum

2:30 – Leave Bay City State Park for Valley

3:00 – Arrive at Valley

Students should bring a sack lunch that does not need refrigeration, as no refrigerators will be available.

Each student should be dressed for weather conditions, which are generally 10 degrees cooler near the Bay. Wind can be much harsher and a jacket or coat should be worn regardless of weather conditions at school. Shoes should be selected for outdoor exploration and boots worn when weather is snowy or muddy. Wear clothes that you don't mind getting dirty!

Field Trip
PERMISSION FORM

DATE: Monday, October 8th

TIME: Depart Valley Lutheran High School: 8:00

Return to Valley Lutheran: 3:00

Event: Ecology at Bay City State Recreation Area
Cost: $6 – checks made payable to Valley Lutheran High School
- ***Please turn in money to Mr. Cooper***

I hereby give my permission for my son/daughter_____ (insert full name) to attend the Biology field trip to Bay City State Recreation Area on Monday, October 8th. I understand that my son/daughter needs this signed permission form and the parental consent signed to be able to attend this activity.

Furthermore, I agree to absolve, release, and hold blameless Valley Lutheran High School, any teacher, VLHS students who may be driving, and/or any adult chaperones from any financial liability or claim arising out of this activity. I realize that any field trip has certain risks involved, but that every attempt will be made to safeguard the students.

The buses will leave Valley at 8:00AM, and will return at 3:00 PM
Please return this permission slip and fee by Wednesday, October 3rd.

_____ _____
Signature of parent/guardian Date

_____ _____
Address Telephone number

PARENTAL CONSENT FOR TREATING A MINOR:
I hereby give my permission for such necessary and emergency care to be given to my son/ daughter at the nearest medical facility.

_____ _____ _____
Student signature Date Parent/guardian signature Date

APPENDIX D2

Department of Natural Resources: Activities and Labs Packet

The Activities and Labs Packet includes worksheets in the following areas:

Macroinvertebrate Survey

Macroinvertebrate Habitat and Identification

Water Testing

Water Temperature Survey

Pond Habitat Survey

Turbidity Inventory

For a copy of this activity and lab packet, contact the Saginaw Bay Visitors Center at

989-667-0717

APPENDIX D3

Water Watchers Field Trip Assignment

"With all of the pollution in our area, is Tobico Marsh a healthy ecosystem, or a damaged ecosystem?"

This is the question that all of the lab modules we performed on our field trip were attempting to answer. The *Turbidity* and *Temperature Tests*, the *Macroinvertebrate Survey*, the *Shoreline Assessment Hike*, and the *Water Quality Testing* all provided valuable data to answer this question. If the chemical and physical tests we performed add up and support each other, we should be able to answer our question confidently.

Your job is to write a report that summarizes what you learned during our field trip to Bay City State Recreation Area and what we found out about the Tobico Marsh.

Your report should include these sections…

Introduction

An introduction paragraph should include:

- Information about Tobico Marsh (from field trip, internet sources)
- The question (listed above)

Methods

A description of the activities/tests performed during the trip that answers our original question and how the test will determine if an ecosystem is healthy or not. Each activity should be described in a short paragraph. Sometimes, drawings or sketches may be helpful to add to your descriptions of what we did.

Results

Written results for each activity are shared here. This is where you describe the *data* and what you found out in the four activities – again, a brief paragraph for each test.

Discussion of Results

This is where you explain what your results mean and ultimately answer the question: "With all of the pollution in our area, is Tobico Marsh a healthy ecosystem, or a damaged ecosystem?"

Conclusion

Why is Tobico Marsh an important area? What can people do to make sure that Tobico Marsh can be enjoyed for years to come?

Formatting Guidelines:

- 12 point font, Times New Roman
- Double-spaced
- Proper heading on first page
- Papers less than 3 pages long will not be accepted. You did a ton of stuff on the trip. Show me what you've learned!

Table 6: Field Trip Report Rubric

Category	Weak –1	2	Developing - 3	4	Mastery –5
Paper was turned in on time (all or nothing)	--	--	--	--	Paper was turned in on time
Introduction	Does not include background on Marsh or question	--	Includes some background – includes question	--	Includes background on Marsh, includes question
Description of activities	Activities are not described – purpose is not explained	--	Some activities are described – purposes are either not included or are vague	--	Activities are described well – purpose of each is explained
Inclusion of data	Data is not included at all to support answers	--	Data is sometimes included to support answers	--	Data from all activities is explained and supports answers
Paper answers main question: Conclusion explains how to preserve Marsh	Paper does not answer question. No ways/reasons are provided	--	Paper answers question. Reasons to preserve are included	--	Paper answers question. Ways and reasons to preserve marsh are included
Spelling, grammar and punctuation	*Many* spelling, grammar and punctuation mistakes	5+ spelling, grammar and punctuation mistakes	3-4 spelling, grammar and punctuation mistakes	1-2 spelling, grammar and punctuation mistakes	No spelling, grammar and punctuation mistakes
3 Pages	Less than 3				3 pages long

Total Score: _____ / _____

Comments:

APPENDIX D4

Field Trip Discussion

Discuss the following questions with your table group and record your answers.

What was your favorite activity yesterday? Why?

What was your least favorite activity yesterday? Why?

What were two things you heard/saw that you already knew?

What were three things you learned that you didn't know before?

What are three questions you still have about the things you did and saw on the field trip?

What class information was reinforced from the watershed demonstration?

At your table group, review the data for the following labs (get out your packet – if you don't have this, you're going to have to find someone who does!)

- Turbidity and water temperature:
- Water testing: pH, hardness, D.O., nitrates, phosphates
- Shoreline assessment
- Macroinvertebrate survey

APPENDIX E – Case Study

APPENDIX E1

Page 1 – Introduction: Can the Saginaw Bay be restored?

Background Information

Before European settlement of the Great Lakes Bay Region, the Saginaw area was approximately 25% wetland and 75% forest. As the area became settled, the timber industry exploded. Saginaw Bay was an important harbor during the logging days. When much of the region's virgin forests were cut down, the deforested area within the watershed was converted to agricultural land. Because of the glacial history of Michigan, the soil in the region is primarily clay, and the topography is mostly flat. These make for poor farming conditions because of poor drainage and susceptibility to flooding. A complex network of drainage ditches was constructed to prevent soil loss and flooding, which allowed the Great Lakes-Bay Region to become an important producer of corn, soy beans, and sugar beets. Michigan is the third largest producer of sugar beets in the United States, processing nearly one billion pounds of sugar per year from the beets. Farming is still a huge part of the economy within the Saginaw area; however industry has also influenced our region. During the auto boom in the late 20^{th} century, Saginaw and Flint were important producers of automotive parts. However, as this industry declined, many urban centers, including those of Saginaw and Flint became economically depressed. The economy adapted by focusing on education, science, technology and health care training, as well as an increased focus on tourism. In recent years, manufacturing jobs have returned to some extent, and most recently, the region has focused on 'green jobs' and the manufacturing of alternative energy devices such as wind turbines.

The Saginaw Bay watershed is the largest drainage basin in Michigan, draining approximately 15% of the entire state. The watershed area is 8,709 square miles (22,556 km^2) and includes 22 counties within its drainage basin. This means that if you pour a cup of water within this region it will end up in the Saginaw Bay. The main outlet to the Saginaw Bay is the Saginaw River. The Saginaw River is fed by many rivers and streams, but its four main tributaries are the Tittabawassee, the Cass, the Flint, and the Shiawassee rivers. Each of these rivers is fed by many streams, creeks, and drainage ditches. They all come together to make the Saginaw Bay watershed. The Saginaw Bay watershed is one of Michigan's most diverse areas and its rich resources support agriculture, manufacturing, tourism, outdoor recreation, and are the home to a vast variety of wildlife. The watershed contains the largest contiguous wetland system in North America. These wetlands provide permanent habitat as well as migration rest stops for over 260 species of bird. They provide other wildlife, including two endangered species, the Eastern fox snake and Blanding's turtle, important habitat space. Wetlands are vital for preserving the biodiversity in the Great Lakes Bay Region.

As the human population within the Saginaw Bay watershed (currently home to over 1.4 million people) has increased, decisions have been made regarding land use and industry that have not considered the Saginaw Bay watershed. Because of this, the watershed is significantly degraded with pollution. Any pollutant that enters a river, creek, or ditch within the watershed will either contaminate the waterways leading to the Saginaw Bay, or will end up in the bay itself. This pollution has also affected the important wetlands and other natural areas in our region.

Decisions about how to rectify the pollution problem are often controversial. Programs that prevent flooding and erosion need to be paid for with taxpayer contributions, and those who are not directly protected are often unwilling to contribute to these proposals. Bay City, the largest urban center near Saginaw Bay, has to deal most directly with problems that are the result of water contamination from other communities within the watershed. Bay City, and other towns that surround Saginaw Bay, have to witness the end product directly – a filthy, mucky bay filled with algae and bacteria. A degraded and polluted watershed is bad for all interest groups within the region. It harms tourism, industry, property values, agriculture, and could permanently alter the biodiversity within our region.

APPENDIX E2
Page 2 – The Case: Can the Saginaw Bay be restored?

A town hall meeting has been called to discuss the pollution problems that are contributing to the degradation of Saginaw Bay. It has been a record year for the thick, black muck of algae and bacteria that residents are used to seeing from time to time. The muck is smelly and unsightly, choking out wildlife and providing a breeding ground for potentially dangerous bacteria, such as *E. coli.* The effect that this environmental problem could have on the recovering economy of the Great Lakes Bay Region reaches all areas: agriculture, tourism, services, industry, and more.

The issue is more complex that most citizens understand it to be. A certain writer for the Saginaw News has written a series of finger pointing editorials, and virtually every interested party, from the CEO of the large Midland chemical company to the typical Saginaw resident has been implicated as the root of the problem. Those who live closest to Saginaw Bay are quick to blame the problem on those that live in other areas the watershed. And of course, there are some citizens who don't know anything about the problem, let alone what a watershed is in the first place. The purpose of this meeting is threefold. The first goal is to educate citizens about the importance of a healthy watershed and unite them in the common goal of restoring the health of the Saginaw Bay and its watershed. The second goal is to determine the various sources from which the pollution is originating. The third goal of the meeting is to propose sustainable, cost effective solutions that benefit both the environment as well as the local economy.

If solutions cannot be found, the situation will only get worse. Past generations started many of these problems – they weren't thinking ahead to a sustainable future – but it is up to the next generation to find solutions that will keep the Great Lakes Bay region beautiful and productive for generations to come!

The town hall meeting will be moderated by a respected city official noted for his neutrality and fairness, and assisted by an advisory board. During the meeting, each interested party that is represented will be given a chance to voice concerns as well as contribute to community understanding of how our watershed is currently protected. A special emphasis will be placed on constructive ideas and solutions, while finger pointing will be discouraged. In addition, representatives from organizations such as the Department of Natural Resources and the Environmental Protection Agency will be on hand to offer their expertise. It is the job of the town moderator and advisory board to compile a list of suggestions and take them to local governments for implementation. Everyone must work together to come up with a plan of action – the entire region is at stake!

APPENDIX E3

Case Study ROLES

Traditional farmer

You have farmed corn and soybeans outside Unionville for many years. It's a quiet community, and when you can get away, you enjoy taking the boat out to get in some fishing. As a fourth generation farmer, you know things have really changed in agriculture over the past 60 years. Your great-grandfather used to grow a wide variety of fruits and vegetables, as well as raise all sorts of livestock. He wasn't able to do much more than feed his family, but it was a good, honest living and you are proud of your heritage. Today, you can grow more than 150 bushels of corn per acre! In fact, you have to in order to keep up with rising expenses. You have also had to increase the use of petroleum based fertilizer and pesticides to make sure your yields bring a profit. Even though it is difficult to make ends meet, you take pride in the work you do, because the crops you grow feed people all over the world. What would your great-grandfather say if he could see the farm today?

Your Role

- Research the impact that farming has on watersheds – be ready to educate the public about this and explain what farmers can do to have a minimal impact and a productive farm

Feedlot Operator

You own a feedlot in Hemlock that finishes beef for slaughter. On the whole, feedlots have taken a lot of flak for environmental issues, so you are concerned that your business could be partly responsible for the water quality problems in Saginaw Bay. You would feel bad if this were true. You want to have a productive business – after all, how would Americans get their Big Macs if it weren't for feed lots like yours? But you also want to do what you can to be environmentally sustainable.

Your Role

- You have a hunch that your feedlot could be to blame
- You should be prepared to provide solutions for dealing with excess manure and making sure it doesn't end up into the watershed

Resident

As a Bay City resident, you are furious that this problem has escalated. You know that water quality issues in this area are nothing new – you still remember how bad the water smelled when you were a kid in the 1970's! You feel that large companies are to blame and the local government should be doing more to solve this issue. It is important to you that Bay City State Park is restored. You signed your kids up for the new archery classes and they are having a blast. In addition, you realize the money that is generated through tourism. Your personal hobby is restoring cars, and you can't wait for the Be Cool car show that's coming up in July! You wash your cars constantly to keep them show-ready! Recently, one of your eco-crazy

neighbors told you that you should wash your car in the lawn instead of on the driveway… what a weirdo!

Your Role

- Find out what that person was talking about…
- You are willing to help as long as it doesn't mean big changes for you
- During the meeting, challenge anything that requires work/money of citizens – you have to be convinced!

Resident

You just purchased your first home in Saginaw Township in the Lawndale Farms neighborhood. You've had some of the typical first time home buyer problems, but it's been very difficult to "keep up with the Jones-es" when it comes to lawn care. Everyone has such a nice, thick green lawn, and yours is so… dead. You've been using lots of chemical fertilizer products to feed the lawn, and it has greened up quite a bit. You were a bit concerned when a lot of the fertilizer ended up on the sidewalks and curbside, but after the rain it was gone. You believe that it probably entered the stormwater drains, and you wonder with so many homes just how much fertilizer ends up in the stormwater drains. And where do stormwater drains lead to anyways? To the treatment plant, right?

Your Role

- You are new to the area and don't know much about the problem – research the effect of fertilizers runoff
- During the meeting, challenge anything that requires work/money of citizens – you have to be convinced!

Resident

You have fished in the Saginaw River and Saginaw Bay for as long as you can remember. You've started taking your grandson, just like your grandfather took you when you were a boy. Being an old timer, you've seen the water quality fluctuate throughout the years. But lately, it has been very bad. There have been very few fish lately, and you haven't seen many mayflies and other aquatic invertebrates in the water that the fish eat. What could be happening? You are concerned that the fishery is damaged beyond repair and future generations will not be able to connect with nature.

Your Role

- You want to help solve the problem, and you are willing to help in any way that you can – research the effect of pollution on aquatic food webs
- You are concerned that if we lose our natural environment, kids will be even more disconnected with nature than they already are

Vacationer

As a resident of Chicago and a successful lawyer, you love to escape to scenic Michigan. While most of the Chicagoans head to packed resorts on Lake Michigan to fight over beach space, you have found a few gems on the Lake Huron side, a lot of them on or around Saginaw Bay. Your

family loves to relax at Tawas Point State Park, and you haven't missed the Cheeseburger Festival in Caseville since it started. But most of all, your family loves the dining and shopping in historic downtown Bay City. When the kids get tired, you head out to Bay City State Park to unwind on the beach, while the kids play in the water. The muck on the beach is very unsettling. Is it even safe for the children to play near it? You are concerned about the future of this family getaway and unless something is done to fix this problem, you may go somewhere else next year...

Your Role…

- To convince the board that this is a serious problem that will keep tourist money out of the Saginaw Bay region
- If anything is mentioned about taxing out-of-state guests to raise funds, throw a fit
- If the meeting doesn't produce any plans or solutions, you will not be vacationing in this area any more.

Saginaw City Councilman

It is a stressful time to be active in local politics! As part of local government in the area, you and many other city, village, and township representatives have been taking a lot of flak from those in Bay City. Tensions have been very high as much of the blame has been placed on your city, particular the sewage treatment plants. You are hoping that this meeting fosters unity among the local governments, and that everyone can see the common good. You also want to represent your city well, and show them what you are already doing to prevent pollution into the watershed.

Your Role

- Establish peaceful relations with other groups represented at the meeting
- You see yourself as a diplomat – you want to find fair compromises whenever possible
- Educate others about what Saginaw is doing to keep the watershed clean
- During the meeting, challenge anything that requires government spending – you have to be convinced!

Bay City Councilman

You aren't too confident that this meeting will accomplish anything. You don't want to be a pessimist, but how many meetings like this have been held in the past? How many ended in fights and hard feelings? Most of them! People just aren't willing to consider that their actions could have negative effects in other communities. People generally consider what benefits their community, and not the region and its environment. You feel that Bay City could have the most to lose if this problem continues, and you worry that the city will stand alone in recovery efforts. The only way this issue can be fixed is if the meeting can determine the source – we can't just keep treating the symptoms!

Your Role

- Remind others present that the actions of one community can have an effect on another community
- You need to see that others are willing to step up and contribute to this effort
- During the meeting, challenge anything that requires government spending – you have to be convinced!

PR Manager of local Chemical Company

You've had an enjoyable and successful career working for the large chemical company in Midland, where you have had an opportunity to be part of the planning stage for several highly successful products. In the past, you know that your company has made mistakes with the storage and disposal of dangerous chemical waste products. These problems were neither intentional nor malicious; the knowledge about the long-term effects of these chemicals simply didn't exist. Your company is doing the best they can to rectify the long-term consequences of these mistakes. This new problem concerns you, and while you suspect pollution is definitely a factor, you do not believe your company is responsible this time. You are genuinely concerned with helping to solve this problem

Your Role

- To convince people that your company is being responsible with its chemical waste – find evidence that shows this is not caused by chemical waste
- Defend your company against unjust accusations
- To help find the solution to this problem

Developer of housing units

This is just another one of those eco-freak doomsday stories. You are tired of all the expensive and time consuming hoops you have to jump through when planning a development and when building homes. Whenever your company starts a new project, there is so much paperwork and meetings with county officials. That being said, you always make sure your employees follow the letter of the law when it comes to construction sites – you've been fined before and it wasn't pretty for the workers who were responsible… You live in Freeland so you are concerned with this problem because it affects your area – however, you are more concerned with making a living and protecting your reputation.

Your Role

- Defend your business at all costs – do not take any responsibility – this isn't your fault!
- Explain the practices your company uses to ensure that construction waste does not enter the watershed
- You are genuinely concerned about this problem, but mostly because your livelihood is at stake – you will fight against ideas that will affect small business owners – you have to be convinced!

Hotel owner

You've worked hard to get to where you are, and you don't want this water quality problem to disrupt tourism in your area – you need tourists to feed your family! You own a newly renovated hotel in downtown Bay City. You recently updated many of your rooms with new A/C units and flatscreen TV's, and boy, do the tourists enjoy them. You weren't quite sure what to do with the electronic waste, so you disposed of them at the curbside. Was there a better way to dispose of them? Could harmful contaminants in these electronics harm the watershed?

Your Role

- You are willing to help as long as it doesn't mean big changes for you – the bottom line is what matters most!
- Research how electronic waste can be disposed of safely and effectively – identify whether this type of waste could harm the ecosystem
- You are genuinely concerned about this problem, but mostly because your livelihood is at stake – you will fight against ideas that will affect small business owners – you have to be convinced!

Auto Shop Owner

You have owned your own auto shop for ten years now. You pride yourself on being honest with customers, and because of this you have a large customer base and a thriving business. Dealing with hazardous waste responsibly is a part of your business, but it is expensive and time consuming. You know that some of your employees have disposed of used oil and other fluids in the dumpster instead of storing it for treatment. You take care of the waste responsibly… most of the time. You want to defend your business, but deep down you have a feeling that the hazardous waste could be a problem.

Your Role

- Share with the community what you do to make sure that used motor oil and other pollutants do not enter our watershed – and explain what happens when they do enter the watershed.
- You are genuinely concerned about this problem, but mostly because your livelihood is at stake – you will fight against ideas that will affect small business owners – you have to be convinced!

Biology Professor from University

You have taught at the local University in Saginaw for a few years and you enjoy your job. You especially enjoy teaching students about ecology, and the impact that humans can have upon the ecosystems in which we live. Generally, you are discouraged by the general public's unwillingness to educate themselves about the environment. There are many pollution problems in our region, but based on what you have heard and studied this water quality issue is related to eutrophication. Now how are you going to explain eutrophication to the ignorant public in terms they can understand at the town hall meeting next week? You are worried that people don't care and won't be willing to help if it involves personal decisions

Your Role

- Explain the reasons that algae may be growing at such a rapid rate
- To explain the situation clearly in a way that citizens can understand

SASWA Representative

You got involved in SASWA a few years ago. It has been a fulfilling job making sure that our storm water and wastewater has a minimal impact on the Great Lakes Bay region. You didn't realize before working here all of the planning, engineering, and expense that went into protecting our water. You have a passion for sharing this knowledge with others so that they can see the impact that each citizen can have upon our ecosystem, but you feel that citizens view environmental problems as too abstract, and they do not feel they can impact the environment directly. You have an idea of what is causing the muck problems in the Bay, but you should probably review the basics of eutrophication. You are worried that people don't care and won't be willing to help if it involves personal decisions

Your Role

- To educate the public about the watershed and storm water
- Educate citizens about how they can ensure that storm water is pollution free
- To explain the situation clearly in a way that citizens can understand

Primary Sewage Treatment Plant Employee

You work for the Saginaw Township sewage treatment plant. Due to the environmental issues, your boss has asked you to represent the plant at the town hall meeting. Most likely, the sewage treatment plant will be implicated in some way for the poor water quality issues. You want to "save face" and explain to the general public how wastewater is treated before safely being released into the watershed. It would be helpful to explain how and where this happens. You are a bit nervous that people will point fingers at you, but you know that policies are tightly followed at the treatment plant and that when done correctly, sewage treatment will not cause this type of environmental problem. You should probably mention the problem of CSO's, and what you can do to prevent them. You are genuinely concerned about the problem and want to help.

Your Role

- To educate the public about how sewage is treated. Also, explain what CSO's are and what can be done about them
- To defend the sewage treatment plant

Town Moderator

Because of your active support of the community, your involvement in affairs of city and state, and you reputation for listening to all sides of an argument, you have been chosen to preside over the town hall meeting. This issue concerns you because you live within the Saginaw Bay

watershed. You want to find a sustainable solution quickly, one that benefits the economy and environment of the region. You know that this is a delicate issue. You must listen carefully to all arguments and sides, and encourage community members to find a compromise.

Your Role

- Summarize the problem at the beginning of the town hall meeting
- To keep the meeting running smoothly – stop interruptions, and make sure people don't talk for too long
- To keep the meeting on task – only topics that are relevant to the issue should be discussed (no mudslinging!)
- Provide a series of recommendations to solving the problem – also, propose means of raising funds towards the solution

Representative from the EPA (Environmental Protection Agency)

You have an important job at the EPA, and state and local governments often seek your expertise when environmental issues arise. You don't live in the area, but you do have a professional concern that a safe solution can be found. From the notes you have read, you can tell that it could be a complicated issue that involves more than just point source pollution. The EPA budget is stretched pretty thin, however, you are able to provide some federal funds as long as state and city governments will commit funding to worthwhile solutions.

Your Role

- To provide financial support for effective solutions
- To advise effective solutions that benefit the economy and environment

Board Member (1)

You have served on many advisory boards in the past, and your colleagues value your ability to ask good questions, be fair and balanced, and provide sound advice and counsel. People with whom you interact perceive you to be very compassionate. Because you live in Bay City, you are concerned about the problem and would like to see a solution. An avid bird watcher, you have noticed that the numbers and varieties of species that migrate through the wetlands have been decreasing. You are sure that it has something to do with the degradation of the water quality which in turn has degraded the ecosystems in our community. You are more likely to listen to personal appeals than your other board members.

Your Role

- To assist the town moderator in asking questions and help get to the bottom of this issue
- To help identify solutions to the problem
- To help the town moderator keep order

Board Member (2)

You have been selected to the advisory board due to your knowledge of business and economics. Your fellow board members appreciate your ability to make hard decisions. You know that the environmental problem is big issue… but the most important thing is making sure that any solution is financially feasible. If the problem is caused by industry, we can't shut down our factories. That would ruin the economy! You see your role as to identify a logical balance between economy and environment. You are less likely to listen to personal appeals than your other board members – you would rather hear facts that could solve the problem

Your Role

- To assist the town moderator in asking questions and getting to the bottom of this issue
- To help identify solutions to the problem
- To help the town moderator keep order

Beat Writer for the Saginaw News

You can tell that the latest water quality problem is going to be a big story. You do know that there is a pollution problem that is ending up in the Saginaw Bay – but no one is sure from where the problem is originating. You have already written several stories implicating a number of companies and individuals, which hasn't made many friends. But hey, that's what makes a good story and sells papers, right? You are attending the meeting to get notes for your next story, ask a few questions (or make some accusations), and speak with those at the meeting to ensure that the cause is found and solutions are developed. If this story goes well, maybe your dream of writing for the New York Times will come true.

Your Role

- To report to the citizens of the Great Lakes Bay region the 'who, what, when, where, and why' of the meeting
- To ask questions of those who attend the town hall meeting

Resident

You have recently retired from a long career with the police fighting crime in the Tri-Cities. It's time to relax! You've taken a few trips in your RV and your plan is to spend the summer RV'ing all over Michigan and the country. One inconvenience with RV's is dumping waste. Usually you dump water into the storm drain, but you are wondering if this activity is contributing to the problem. Where can this waste be properly disposed of? As a resident of Saginaw, you are concerned that this water quality problem could affect your recreational activity in the state. You are genuinely concerned with this problem and want to help find a solution.

Your Role

- Find out more about RV dumping and how it could be influencing the problem
- Find out how/where to safely dispose of RV waste
- You are willing to help as long as it doesn't mean big changes and fees for you – throw a fit if these become outrageous

DNR Officer

You work for the DNR and you love your job. You get to experience nature and our natural resources in ways that most citizens will never experience. You wish that people noticed our natural areas more, and you encourage people to spend more time outside. If people spend more time in these areas, then they will care more about them. The environmental problem is extremely disturbing. You know it is a complex problem, but you have a few ideas about what is causing it and what can be done to begin solving it.

Your Role

- Educate the public about how poor water quality affects aquatic ecosystems
- Educate the public about the endangered species that live in our watershed
- Offer your advice and expertise about water quality, and provide suggestions for solutions.

Lawn Care Company Owner

Your company, Pure-Green, is a lawn care company that guarantees a "thick, lush, green lawn by the end of summer or your money back". You have access to powerful fertilizers that the general public doesn't have access to, which increases your results. Your company grows each year, and you currently have 30 employees. In a way, you find it ironic – why do people have lawns if they don't want to take care of them? But hey, their laziness is your livelihood! You are concerned with the problem because you live in Kawkawlin Township. Because you have had to defend your company from similar environmental allegations, you know a lot about fertilizer and how organisms use it.

Your Role

- Defend your company from allegations
- Educate the public about fertilizers and how organisms use them
- Explain recent changes in the fertilizer industry that will help to solve this problem

APPENDIX E4

Email to Town Moderator
Subject: TOWN HALL MEETING ATTENDEES

To: Town Moderator
CC: Board Member 1; Board Member 2

From: the_best_secretary@vlhs.com

Esteemed Moderator and Board Members,

Please find attached a list of people, along with brief descriptions, who will be in attendance at the Town Hall Meeting…

Beat writer for the Saginaw News – this is the guy who caused so much trouble with his colorful reporting – we'd better keep an eye on this one!

Biology professor from SVSU – this person would be a good source for help on identifying the problem and its cause, as well as finding a solution. We just better make sure he keeps it in English!!

Primary sewage treatment employee – this person can explain how waste is treated to ensure that our waters stay safe.

SASWA representative – Rep for the Saginaw Area Storm Water Authority – will be able to tell us what happens to storm water after a rain

DNR officer – will be able to tell us how this problem is affecting our native wildlife and endangered species. Will also be able to help us identify the source of our problem.

Representative from the EPA – this guy is a fed! Very well known throughout the country for dealing with environmental catastrophes. Will be very professional and helpful towards solving the problem.

Lawn care company owner – runs a successful business. Is pretty much an expert when it comes to fertilizers.

Public Relations guy from Midland chemical company – will most likely want to save face and explain why his company is not responsible – which is okay if it helps us get to the bottom of this

Saginaw City Councilman – representing local government

Bay City Councilman – representing local government

Farmer – owns a large and productive farm

Feedlot operator – runs a large feedlot in Hemlock.

Home developer – large developer of homes and condos in the Great Lakes Bay Region

Auto shop owner – owns an auto shop in Saginaw – good honest ,business – we get our cars fixed at his shop

Hotel owner – owns hotel on waterfront in Bay City. Recently updated all appliances in hotel.

Resident of Bay City – an avid car show attendee. Owns several hot rods.

Resident of Saginaw – retired – avid fisher and outdoorsman

Resident of Saginaw 2 – new homeowner

Resident of Saginaw 3 – retired cop and avid RV'er

Vacationer – big shot lawyer from Chicago. Spends lots of $$$ when his family is in town

Here are a few notes from our last meeting that will remind the board of our goals:

1. Determine the cause of the problem
2. Keep the meeting running smoothly – stop interruptions, but don't let people have the floor forever.
3. Determine solutions to the problem – including ways of raising funds for these solution

Please let me know if there is any more paperwork I need to prepare for the meeting.

Thank you!

The Secretary

APPENDIX E5

Research Check for Town Hall Meeting

Teacher Initials: 1. _____ 2. _____ 3 . _____

Research facts/Information:	**Sources/Websites:**

APPENDIX E6

Table 7: Town Hall Meeting Participation Evaluation

Student Scores	**Poor (1)**	**Good (2)**	**Great (3)**	**Comment:**
Student Name:				
Participation				
Mastery of Material				
Relation to environmental problem				

APPENDIX E7

Solving an Environmental Problem – Reflection Paper Assignment

Solving an environmental problem is a complicated task. Each person brings a different perspective to the discussion, as well as different priorities, both professional and personal. Because of this, reaching long term solutions that benefit the environment as well as every stake holder involved is extremely difficult. You have taken part in a Town Hall Meeting and have played a role in solving the problem of eutrophication in the Saginaw Bay. You were assigned a specific role, and therefore had to approach the debate from a certain point of view. Now is the time to reflect on how the Town Hall Meeting went, what you learned from this process about solving environmental problems, writing about our problem and potential solutions, and sharing any questions that remain.

Reflection Paper Requirements:

- A minimum of 5 paragraphs – an intro paragraph, body paragraphs, and a conclusion paragraph
- Double spaced
- Must include – thoughts about debate, what you learned about solving environmental problems, specifics about our problems, and any remaining questions
- A proper heading and a title

Prewriting Activities

- Make a mindmap that organizes the problem
- Make a traditional outline
- Examine rubric to see how the reflection paper will be assess.

Postwriting Activites

- Proofread your own essay
- Read your work – does it make sense? One of the best ways to tell is to *read it aloud*.
- Have someone else proofread for spelling, grammar, awkward sentences, etc.

Reflection Paper Due Date: _____

Table 8: Rubric for Case Study Reflection Paper

Criteria	Weak (1)	Developing (2)	Developing (3)	Strong (4)
Analysis and Interpretation	Shows limited understanding and analysis of topic Provides little evidence to support reflections Makes limited connections to outside world Makes illogical or incorrect interpretations of concepts	Shows some understanding and analysis of topic Provides some evidence to support reflections Makes some connections to outside world Makes some logical interpretations of concepts	Shows considerable understanding and analysis of topic Provides considerable evidence to support reflections Makes considerable connections to outside world Makes logical interpretations of concepts	Shows a high degree of analysis of topic Provides thorough evidence to support reflection with supporting details and examples Makes thorough connections to outside world Makes logical and thorough interpretations of concepts
Communication	Information is communicated with limited effectiveness (grammar, spelling, etc.) Essay demonstrates limited clarity – it does not flow well	Information is communicated with some effectiveness (some grammar, spelling, etc.) Essay demonstrates some clarity – reflection flows well in most cases	Information is communicated with considerable effectiveness (one or two spelling/grammar) Essay demonstrates considerable clarity – reflection flows nearly all the time	Information is communicated with a high degree of effectiveness (no spelling or grammar errors) Essay demonstrates thorough clarity – reflection consistently flows

Table 8 (cont'd)

Organization	Reflection paper shows limited organization, with no clear intro, body, and conclusion Paragraphs and arguments are illogically organized	Reflection paper shows some organization (clear intro, body, and conclusion) Paragraphs and arguments show some logical organized	Reflection paper shows considerable organization, with clear intro, body, and conclusion Paragraphs and arguments are logically organized	Reflection paper shows a high degree of organization (intro, body, conclusion, and includes a title) Paragraphs and arguments are thoroughly organized

Comments/Suggestions:

Score: _____%

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