ENGINEERING STEWARDSHIP FOR THE INLAND NORTHWEST

by

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DEDICATION

MSSE faculty, advisors, and collaborators: Thank you for the suggestions, critiques, and advice throughout this entire process.

To my students and co-workers at Spokane Public Schools: I am so grateful for your insight and inspiration.

From the nine-year old Reen collecting horse chestnuts and leaves in the backyard, canoeing and swimming in Mica Bay, and hiking trails while singing with her camp counselors: This is for the Lorax, who speaks for the trees, which they seem to be chopping as fast as they please.

For Shane and our trio of little Savages: Thank you for the love and support. I could not have done any of this without you. (Plus, thanks for managing the craziness while I buried myself under homework, research, and data.)

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ABSTRACT

This investigation analyzed utilization of an environmental engineering challenge to increase perceptions of stewardship. Integration of place-based natural resources allowing for personalization and connection was included in the research strategy. Additionally, computer coding and other technologies were incorporated to support a multi-faceted, human-centered design, socio-scientific project. Data collected in this study suggests increased environmental awareness and responsibility for natural resources within the test group of ninth grade students.

INTRODUCTION AND BACKGROUND

Project Background

I give my pledge as an American to save and faithfully to defend from waste, the natural resources of my country - its air, soil and minerals, forests, waters, and wildlife.
(Outdoor Life Magazine, 1946)

The Conservation Pledge is posted in the Nature Hut at Camp Sweyolakan, along the shorelines of North Idaho's Lake Coeur d'Alene. Generations of campers have learned this version of the pledge, along with accompanying hand gestures and body motions. Interaction with "air, soil and minerals, forests, waters, and wildlife," has been integral to daily activities for the camp's nearly 100-year history.

Problem Identification

Apathy. Dis-engagement. Indifference. Each of these terms is a notable topic of concern for high school teachers just as much as it is for ecologists. Educators of environmentally related science disciplines often encounter and battle the perceived meaninglessness of these topics in tandem within their classrooms. How do we support student progress if they are interested in neither classes nor conservation? How can we encourage ownership of both their learning and their environment? How can we help tie students' advancing technological experiences to advancing responsibility of natural resources?

Inspiration

I have always loved nature. Perhaps it is due to extensive time outdoors as a child or a youthful love of plants and animals. Perhaps is due to a scientific intrigue of planetary development, the uniqueness of water molecule and the matrices of molecular interactions, or evolutionary and geologic changes through time. Perhaps it is the juxtaposition of science disciplines within the natural world. Regardless, I acknowledge there is a strong personal interest in conservation.

My own justifications and opinions aside, scientific research is continuing to reveal the importance of personal experiences with nature, particularly as it applies to environmental education. Scientists, social justice personnel, educators, parents, and even psychologists and medical doctors are all conducting research into humanity's connection to outdoor spaces and place-based education. The introduction of *Your Brain on Nature*, written Harvard Medical School professors Selhub and Logan, states

> Less contact with nature, particularly in one's young years, appears to remove a layer of protection against psychological stress… In the big picture, our turn away from nature is associated with less empathy and attraction to nature and, in turn, less interest in environmental efforts related to nature…. Sustainability of the planet is not merely about being a good citizen and recycling; it is ultimately about maintaining an intimate relationship with nature. Research shows that in order to truly care about 'being green,' one must actually have meaningful exposure to nature (p. 3).

Interest in activities involving student data collection of nearby water sources guided my initial plans. I had hoped use students' personal attachments to bodies of water frequented for recreational activities. Information from early interviews showed an extremely limited understanding of hydrology. Raw data collected from water and soil quality sampling would not likely be of high interest or value, as the individuals interviewed did not enough background knowledge for understanding the consequential information. Topics of local geology, water quality, hydrology and limnology, and watershed resources would need significant attention prior to student investigation and data collection. Additionally, contrary to my initial assumptions, students' care for and even awareness about our natural resources were not remotely guaranteed.

Teaching Experience

For the majority of my classroom experience, I have been involved with the Math, Engineering, Science Achievement (MESA) program. This national organization partners with classroom teachers and other school district personnel to provide additional opportunities in science, technology, engineering, and math (STEM) to student populations traditionally underrepresented in these fields. Designed by national coordinators, the program periodically transitions from a pilot year, a full implementation cycle, and a phase-out period. I have taught eighth, ninth, and tenth grade MESA classes and have observed varying success of student engagement. One complication of full program incorporation is a lack of coordination with district-mandated curriculum. Students' grade level science discipline frequently does not correspond to the nation-wide project's theme. Often times, this disconnect increases the challenge of engaging students' full participation in these "extra" projects, as they are still required to cover the same content and at the same pace as their counterparts not involved in the MESA program.

During the 2012-2013 academic cycle, the pilot year of a new topic, I gave my eighth grade students a choice. This class, which was studying physics first semester and earth science during the second semester, was offered the possibility of two different engineering projects. Groups could elect to participate in the official MESA activity, including designing and engineering a prosthetic arm, writing a scientific paper, creating a presentation of results, and participating in the city-wide competition. The alternative was to design their own project, which included identifying a local problem, conducting informational research, contacting a regional expert for assistance finding a nearby location where the "issue" could be observed, creating or participating in a hands-on volunteer project, and communicating the results at an evening symposium.

While most students elected to participate in the pre-planned engineering challenge, several teams selected the alternative activity. One team, a group of young women, was particularly interested in ecology. In addition to researching invasive plant species in our region, coordinating with conservation agencies, and receiving donations of native Ponderosa Pine seedlings, they asked me to help them find somewhere safe for the saplings and assisting in organizing a "planting day." Luckily, with my day camp contacts within Camp Fire's Inland Northwest Council, I was able to arrange an onsite planting and invasive vegetation removal event. Five years later, the saplings and the arborists are growing strong. Most of the young women from this group were recently enrolled in Advanced Placement Environmental Science or had taken the course previously. Within this cohort of newly-graduated seniors, a couple are looking into colleges with ecology programs.

My students' excitement was contagious. I attended the Geo Literacy Summer Leadership Institute in Seattle over that following summer. The GeoLitAlliance and the Institute for Science and Math Education developed this program in partnership with National Geographic (NatGeo) and the University of Washington (UW) for supporting place-based science education. Like-minded teachers from every Washington State region convened to share potential conservation ideas and projects using neighborhood woodland and wetland locations. I learned about fantastic educational resources such as the Pacific Education Institute and Project Learning Tree, complete with direct professional support by NatGeo researchers and UW professors. As part of the Eastern Washington team, I helped develop lessons to be incorporated into urban ecology classes. We started making connections between our students' attitudes, experiences, and skills to prospective yearlong plans. Data collection and interpretation problems were identified and sustainable design solution outlines diagrammed. Spokane area teachers analyzed the "Washington State K-12 Integrated Environmental and Sustainability Learning Standards" and coordinated best-fit relationships to each of our individual districts' expectations. We addressed foreseeable timing, seasonal, and funding challenges. We coordinated our personal schedules and planned quarterly collaboration meetings. Yet, unfortunately, we all discovered major implementation hurdles as we returned to our respective classrooms.

Several years, school sites, grade level assignments, and science disciplines since, we have since entered a new cycle of the MESA program. The proposed project was to design a water-quality or usage sensor running off the Arduino computer-coding platform. The ninth graders' science discipline is biology, with a strong molecular component. This immediately posed a challenge, as the grade level's topic did not correlate highly to the engineering project. Additionally, as this group of students was the point of adjustment for a district-wide rearrangement of disciplines and vertical alignment, they did not have experience in potentially related earth science, hydrology, or chemistry topics. Limited familiarity with the subject matter likely decreased the initial value attached to the proposed project. Further, past experiences using the Arduino program suggested the lack of coding fluency increased perceived hurdles for students. One student remarked about her frustration with the project's coding aspect, "I am thinking about dropping [this class] because I just don't think my brain works like this."

I hoped increasing background knowledge and "buy-in" would add value to the individual engineering challenge tasks. Using the success of this pilot group, the treatment could continue for the rest of the project's three-year sequence. Beyond my individual classroom, these methods could increase success and perceived value in other MESA classes regionally and throughout the nation. The approach could be applied at multiple levels of the program and support future cycles with differing foci. Finally, a plan to integrate the Next Generation Science Standard's (NGSS) goal of sustainability, conservation, and engineering could be utilized by the school and school district following the phase-out period of the current program challenge, as this is an area of identified content deficiency.

Classroom Environment

Selection of the MESA biology class relied upon several factors making this course section unique to the others I teach. The majority these students attended the bulk of individual class meeting times, presumably putting students at the same advantage for learning targets and providing common experience during the school year. This class also had a lower number of students with documented behavioral issues compared to other sections of the course, in addition to having a greater number of students who met standard in the most recent state-level reading and math checkpoints.

Until this year, completion of a biology course was a Washington State high school graduation requirement. Interested students had the option of taking this specific class to fulfill the biology course requirement, but with the supplementary benefits of participating in an engineering challenge, attending off-campus field trips, visiting colleges and universities, and attending guest speaker presentations. Qualifications for this program included identification within a group having historically low representation in STEM careers. Gender, racial background, socio-economic status, disability, familial housing stability, sexual orientation, gender identity, and even living in a rural location qualify a student for MESA participation. For my class, this results in proportionally larger numbers of female students and students reporting inclusion in racial minority groups than is seen in typical classes for our region. Approximately 90% of students in this class are female, with 2 male students completing the class total (N = 22). Students qualifying for free/ reduced lunches account for nearly 45% of the class. In regards to racial and ethnic backgrounds, this group of learners reports approximately 40.9% Caucasian, 13.6% Asian, 13.6% Latino/a, 9.1% African-American, 9.1% Native American/ Alaska Native, 4.5% Pacific Islander, with the final 9.1% of students representing 2 or more identifiable groups. Unlike statistics for the school at large, 100% of students chose to anonymously disclose this information directly to the instructor without concerns about undocumented citizen status (T. Meyers, personal communication, October 07, 2017).

The number of students from minority groups in the MESA class section contrasts with the overall demographic of the nearly 2,000 students of this inner-city school. Located in Spokane, Washington, Lewis and Clark High School is identified as a traditional, comprehensive 9th -12th grade option of the large, eastern Washington school district. Spokane Public Schools, of which Lewis and Clark is one of the oldest sites, also offers alternatives such as online programs, project-based learning opportunities, English-Spanish language immersion, and targeted-interest magnet institutes. This neighborhood school's nearly equal gender percentages include an annually increasing number of students qualifying for free/reduced lunch, with data from the 2017-2018 academic year above the 34% mark. The centralized location of this urban school includes students reporting 68.8% Caucasian, 10.7% two or more identified racial or ethnic backgrounds, 4.7% Asian ancestry, 4.5% African American, 2.1% Native Hawai'ian/ Pacific Island descent, and 1.1% Native American/Alaska Native. The final 8.1% choose not to disclose this information, as reported by the Washington State Office of the Superintendent of Public Instruction (Washington State Office of the Superintendent of Public Instruction, Spokane Public Schools - Lewis and Clark High School, 2018).

Connections

My research project offered an opportunity to help students step beyond a traditional classroom experience. Support by organizations outside the school district provided a unique chance to extend learning and support meaningful connections to industry, business, and community leaders. By including student-created, place-based environmental engineering projects for engagement and assessment of ninth graders' natural resource stewardship, relationships and experiences more easily crossed the perceived school/ real-world barrier. In this way, battling apathy, dis-engagement, and indifference became a natural connection between the classroom and conservation.

CONCEPTUAL FRAMEWORK

We teach earth, ecological, and environmental sciences
in and about places imbued with meaning by human experience.
(Semken & Freeman, 2008)

Directional Research

Setting the Context: History and Ecosystems of the Inland Northwest

I began this endeavor with moderate background knowledge in our area's geologic history, as well as some of the region's historic economic drivers. Located adjacent to the coastal Pacific Northwest and including the Idaho Panhandle, the Inland Northwest and the Spokane-Rathdrum Prairie-Coeur d'Alene area is a relatively continuous sequence, in urban planning, as well as for the region's geology and hydrology. This zone has a five-staged geologic history. The area's true bedrock is argillite rock, the metamorphosed result of clay, silt, and calcium carbonate layers. This region, once the bottom of a shallow sea, results from ocean islands intermittently crashing into and merging with the early North American continent. Above this is the Kaniksu Batholith, a granitic formation caused by magma intruding upward due to a highly pressurized environment. Fissures formed later, and the entire area experienced low-viscosity lava flooding. Afterward, along with trademark evidence of Glacial Lake Missoula, the cataclysmic outburst floods and deposition of sediment ranging in size from boulders to sand formed the Spokane Valley - Rathdrum Prairie (SVRP) aquifer. At the surface, the area is covered in loose sediment from water movement, wind erosion, and landslide material deposits.

The intimate ties of the aquifer's development and our existing geologic features define much of the area's past economic growth and current commercial entities. Known for the picturesque Lake Coeur d'Alene and the connective river ways, including the interstate Spokane River, waters in the Inland Northwest have endured long-term damage. Mining operations inundated the water basin with heavy metals, pollution from railways, deposition from factories, fertilizer and pesticide assault from agricultural operations and land owners, and even surficial contamination from recreational users (Spokane Valley- Rathdrum Prairie Aquifer Atlas, 2015).

As I researched local environmental topics, it became apparent grassroots efforts may be key to the watershed's recovery, rather than awaiting federally designated dollars. Limnologists monitoring Lake Coeur d'Alene's water chemistry have been charting trends in quality for 25 years, after the mining operations ceased to be of substantial economic value. Soil sampling and tracking of migratory birds, particularly bald eagles looking for land-locked spawning salmon, have received scientific attention for the last several decades.

The Inland Northwest includes a section of the Idaho Panhandle's mountainous area known as the "Silver Valley." Starting in the 1880s, reported gold discovery was a catalyst to mining operations. Economically, other metals were significantly more important. Not surprising given the nickname, silver became the most profitable mineral, with mines producing over a billion ounces and providing nearly half of the nation's silver during the 1970s. With three million tons of zinc and eight million tons of lead also mined from the Silver Valley, this small region ranks among the world's top ten mining districts.

Unfortunately, economically successful mining came at a huge environmental cost. Mining waste contaminated local lakes, rivers along with tributary streams, wetlands and riparian zones, plus other spaces of exposed soil. Sediment polluted with arsenic, cadmium, lead, and zinc covers the area in amounts measured in millions of tons. In 1983, the Environmental Protection Agency (EPA) identified a 21-square-mile zone in the Silver Valley as one of the largest, most polluted places in the United States. Later, the contamination range was expanded to include the entire Coeur d'Alene area, including more than 1,500 square miles. Pollution from the "Bunker Hill Superfund" site, affects health of vegetation, wildlife populations, and human inhabitants. Lead, the same contaminant found in Flint, Michigan's water system, exists in high levels at the bottom of Lake Coeur d'Alene.

Natural events complicate efforts to stabilize the polluted soils. The Spokane-Coeur d'Alene area experienced a storm during which rain fell on top of heavy snow layers in late 1996. The "Ice Storm" triggered lake and river flooding, washed out roadways, caused widespread power outages, and collapsed both commercial and residential buildings. Saturated ground material resulted in landslides continuing for months, further removing trees, slope-stabilizing vegetation, and additional topsoil. Geologists calculated more than one million pounds of lead rushed into Lake Coeur d'Alene in a single day. A similar weather event in 2011 resulted in another series of flooding with an estimated 352,000 pounds of lead, and the polluted soil carrying it, washing directly into the lake in less than 24 hours.

However, reductions in lower depth oxygen levels during the summer and fall months are a more pressing issue for Inland Northwest waterways. This decrease is the result of increased fertilizer run-off from local users. Fertilizer used by homeowners and farmers has the same effect on aquatic plant life as it does for the intended use in domestic gardens and commercial farms. Later, as the additional vegetation dies and decays, oxygen is removed from water as organic matter decomposes. Oxygen is vital to this water system, acting as a “cap” for heavy metals deposited in the lake while mining operations were running at full capacity.

The lake’s specific geology includes a depth allowing for water column stratification. Although density-based layering is typically considered a sign of increased pollution or a result of aging processes, in this case, stratified levels provide a benefit. The oxygen layer prevents toxic heavy metals from mixing with upper portions of the water column. Near the surface, these metals would contact fish, migratory bird populations, invertebrates, native wildlife species, and humans. Division of contaminated versus uncontaminated water will only remain intact if dissolved oxygen levels do not drop any further. According to Dr. Craig Cooper, a limnologist who speaks at inland waterways and environmental health events regularly, “Dissolved oxygen levels are going in a direction we don’t want to see them go… This is not opinion. This is fact” (Kootenai Environmental Alliance, 2016).

Coho salmon, a native of Northern Pacific waters, is promoted as not only a keystone species, but as a “canary of the water,” referencing the use of canaries to act as early indicators of air quality issues for miners. The salmon’s sensitivity to urban run-off has been marked as a major cause behind rapidly reducing viable fry numbers and the growing count of pre-spawn adult deaths. Public awareness, improving the “greening” of local infrastructures, and clean technologies have been suggested by various agencies, including National Geographic researchers and the EPA. Accordingly, federal mandates recently started requiring “environmentally acceptable lubricants” for all vessels in US marine waterways to help encourage regulating motor oil pollution (Reisewitz and Martin, 2015).

The Inland Northwest’s land-locked lakes are well known for the Chinook and Kokanee salmon population in residence. Beyond the sport fishing value of these and other fish, salmon here spawn as bald eagles are migrating from Alaska. Successful recovery efforts from pesticide-caused eagle reproductive issues have produced an increasing raptor population density during annual December and January counts. Rising eagle numbers balance precariously on the prey salmon’s health. Surges of dead fish have been found in local waterways. Microplastics are being detected, along with alarming levels of biologically magnified toxins, in the digestive tracts of upper trophic level predatory animals.

Education and Stewardship

High school Next Generation Science Standards (NGSS) for human sustainability reflect the integral status of the Inland Northwest’s ecological health. Standards, such as

High School Earth and Space Science 3-1 (HS-ESS3-1), state students who demonstrate understanding can “Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.” These nature-human influences include access to fresh water, such as rivers, lakes, and groundwater, and regions of fertile soils near river deltas. This sentiment continues in NGSS HS-ESS3-2, as students are expected to:

> Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources... [with emphasis] on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Science knowledge indicates what can happen in natural systems—not what should happen.

NGSS-provided examples include agricultural soil use, mining for coal or other resources, along with pumping petroleum and natural gas. Economic, societal, environmental, and ethical considerations are supported, in conjunction with attention to potential cultural impacts. Conversely, constraints must also be calculated into design solutions, including cost, safety, reliability, and aesthetics (NGSS).

The Inland Northwest is an area rich in geologic treasures, natural biological beauty, and location of a world-renowned, designated sole-source aquifer. It is concerning resident students are neither equipped to evaluate their environmental surroundings nor to appraise personal ecological responsibilities. Early in my career, basic rock and water cycles were introduced in elementary school. Later, students learned about water quality, our local aquifer, and pollutant remediation in seventh grade, with major earth science and regional geologic history instruction during eighth grade. Additional physical science concepts and Earth-based applications were addressed at the ninth-grade level.

Unfortunately, the prevalence of these topics has been greatly reduced during the last decade. At this point, natural resource education is limited to pre-packaged kits entitled “Water” for third grade students, “Earth Materials” for fourth graders, a small geology section with the once-a-week science specialist in sixth grade, and, if time allows, a unit on ecology within a ninth or tenth grade biology class. Although Advanced Placement (AP) Environmental Science is offered, overall environmental education has significantly limited student exposure and engagement with natural resources (SPS Curriculum Connection, 2018).

The importance of student recognition of localized resources is becoming more apparent as I delve further into the literature. I value connecting students to familiar areas and locations, but I was not aware this was as an educational arena. “Place-based” science is appearing more frequently in documented research. Investigators are identifying science understanding can grant increased value to a site, as individuals develop emotional attachment to “meaningful places.”

Supporting these attachments allows students and teachers to focus on local environments. Attachment encourages advocacy. Researchers Semken and Freeman established the importance of emotional connection, suggesting teachers and researchers should be exploring place-based science as both an educational engagement opportunity and as an assessment technique. Further, they observed increases in attachment to the locations used for the place-base scientific inquiry (Semken & Freeman, 2008).

The idea of place-based science provided an easy segue into “community-based” science. Connecting not just places, but entire communities, supported regional stewardship. While British Columbia is a few hours' drive north of the Spokane - Coeur d'Alene area, results from a study done in the Canadian province could easily have been applied to the Inland Northwest. The collected data resulted in three suggestions for rethinking science education.

First, researchers advocated science literacy should develop as a collective and with a collaborative effort. Making a comparison to society's division of labor, not every citizen needs an identical skill set for beneficial community contribution. While striving to provide basic science proficiency and scientific thinking to all students, where should the line between functional ability and practical expertise be drawn? This idea was significant, as successful completion of a biology class and coordinating end-of-course test was required for all Washington State high school graduates. This requirement came at a cost of basic science literacy across all scientific disciplines. Second, the report continued with a discussion supporting a community's ability to make contributions affecting their natural resources. British Columbian researchers were alarmed about public perception scientific knowledge is limited to "privileged" decision makers, particularly as this may come at a cost to citizens unaware of local environmental conditions. Third, including multiple avenues supported ownership and stewardship of resources, while at the same time, preparing students for socio-scientific, community concern participation. The authors anticipated increasing life-long conservation awareness and efforts by rethinking science education (Roth & Lee, 2003).

Similarly, the five practices of "Emotionally and Socially Engaged Ecoliteracy," as explained by the Center for Ecoliteracy, included overarching themes and benefits.

These guidelines included students *developing empathy for all forms of life* and *embracing sustainability as a community practice*. Movement towards sustainability was supported by *making the invisible visible*, highlighting the far-reaching implications of human actions, and *anticipating unintended consequences* to dually acknowledge the vastly underexposed interconnectedness of ecology. Finally, *understanding how nature sustains life* expressed a necessity for applicable strategies when designing human sustainability activities (Goleman, Bennet, & Barlow, 2012). Although not created by the Center for Ecoliteracy or Goleman et al., Figure 1 provides a visual depiction of the integrated ecoliteracy practices.

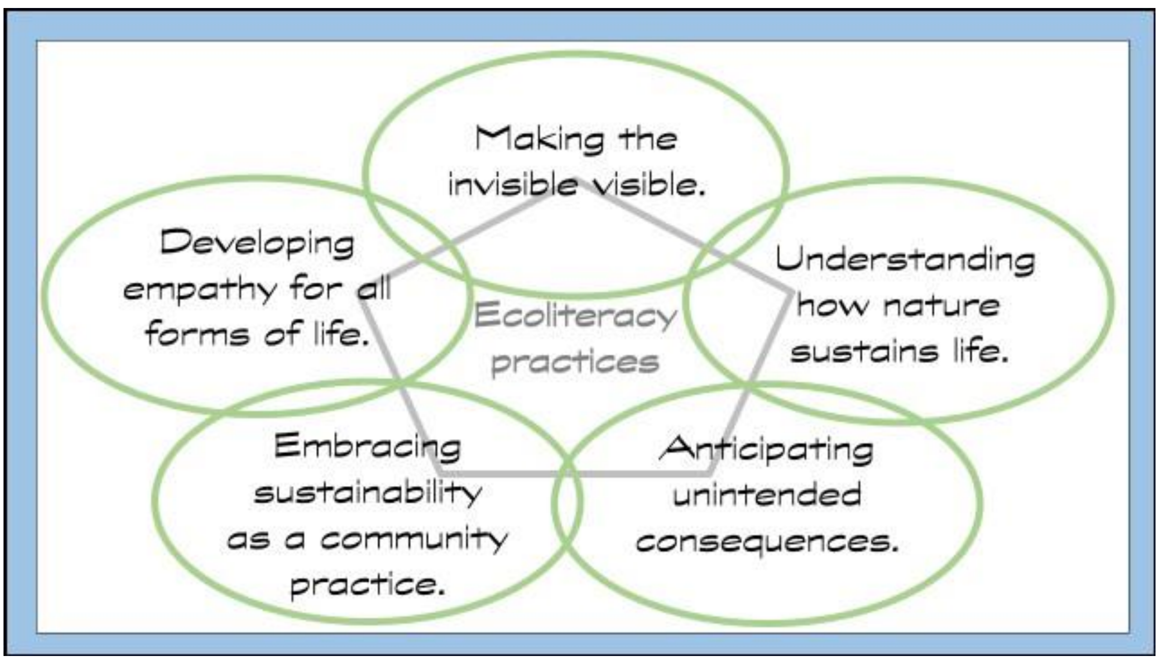


Figure 1. Graphic depiction of the five practices of "Emotionally and Socially Engaged Ecoliteracy."

By supporting the connection between science, community, and local resources, students were encouraged to think of classroom learning as complementary to non-academic life. Both the British Columbian and the Center of Ecoliteracy research teams discussed the links between community and conservation. Roth and Lee described this model by saying,

> Children's activities are continuous with those of adults concerned about environmental health. In this way, rather than preparing for life after school, science education allows students to participate in legitimate ways in community life (Roth & Lee, 2003, para. 1).

Environmental education initiates integration discussions. Incorporating social justice issues, interdisciplinary sciences, and engineering solutions to local problems provides meaningful opportunities. Projects, such as building a soil moisture sensor to prevent oversaturation or a hydroponic garden to allow for urban farming, gave students a chance to integrate scientific understanding, technology applications, and guidance on personal ability to affect the region's environmental health. Inclusion of social justice aspects further supported natural resources' perceived value (Finio, 2017).

A growing number of grassroots efforts are employing the ideal "People will care for what they love." A San Francisco agency developed a unique introduction to careers in environmental and social activism. Teens involved in the program develop a knowledge base to address conservation issues directly affecting their lives and their neighborhoods. Through early childhood outdoor experiences and future employment opportunities in areas such as wetland restoration and renewable energy advocacy, students acquire first-hand involvement with attainable change. Ecological information complements social justice, addressing concerns about food security and positive role models. These students are taking an active part in solution-focused, place-based projects designed to help their communities. The agency, Literacy for Environmental Justice, offers a powerful lesson in deeds, rather than in discussion. Their programs utilize a learning model incorporating tasks, visibly demonstrating student have the ability to mediate social, scientific, and public problems (Lanza, 2005).

Just as natural networks intertwine within ecology, applying a "systems" approach could lead to a shift in environmental education. According to Stone and Barlow (2005), the problems of overspecialization is relevant to place-based learning, reflecting the isolation of not just education or of individuals, but also as it applies to the disconnect between sustainable levels of change. Their research included hands-on, integrated learning locations. The value of interconnectivity described the sites pursued for testing their ideas. Specifically, they looked for educational settings and opportunities meeting four guidelines. To support innovation, the selected sites:

a) Function as whole communities,
b) Expressed the spirit of systemic school reform,
c) Showed committed to teaching ecological knowledge through project-based learning linked to particular places, and
d) Desired to integrate their curriculum through school gardens, habitat restoration, or work with energy, shelter, or environmental justice programs (Stone & Barlow, 2005, p.3).

Current community understanding and traditional ecological knowledge are juxtaposed within my classroom research. The MESA program, as it encourages involvement in historically under-represented groups in STEM careers, includes students with Pacific Northwest Native American/ Native Canadian tribal identification. The Coeur d'Alene and Spokane tribes are represented and well respected in the Inland Northwest. Traditional beliefs and honoring the environment typically coincide with nature-focused organizations. The phrase "traditional ecological knowledge" was used to reference connecting native communities with modern science. Examiners noted the isolation of students when traditional knowledge was overlooked. In addition to alienation caused by ignoring indigenous information, dismissing generations of experience in a local area limits access to valuable data. All sources of science understanding, mainstream and multicultural, is needed to solve our major socio-scientific and environmental problems (Snively & Corsiglia, as cited by Van Eijck & Roth, 2007).

The First Nations' research and support of resident environmental groups promotes the link between environmental preservation and a sense of community. This connectivity is particularly piqued by the cultural importance of the salmon run and migration patterns. These ideas reflect back to Marzano's suggestions to relate with pupils by providing students an opportunity to talk about themselves and backgrounds, while supporting understanding of students' interests and existing knowledge (Marzano, 2012).

Our regional history includes our environment and our experiences. The meaningful places to which we gravitate are our homes, just as much as the four walls and the roof below which we reside. There are no cleaning services when it comes to local natural resources. Now is the time to help students learn to clean house.

METHODOLOGY

> *We usually think of children connecting with cute and cuddly animals…or charismatic megafauna… [Instead, these students have] become ardent protectors of a species of California freshwater shrimp, about as uncuddly and uncharismatic an animal as you can find. But, because it's in their backyard and it needs their help, they become its ally.*
> (Sobel, 2008)

Problem and Purpose

Applying environmental education, ecological literacy, and related skills encourages place-based student interactions with natural resources. Connection to students' surroundings is the final component linking science to stewardship. Discussing the necessity for children to become acquainted with nature and assist in combating the "nature deficit" prevalent with school-aged children is particularly applicable. Engaging in outdoor activities relates classroom lessons and academic information to real-life opportunities for change (White, 2004).

Richard Louv, the often-cited author of multiple books on the importance of reintroducing outdoor studies during childhood writes,

> If educators are to help heal the broken bond between the young and the natural world, they and the rest of us must confront the unintended educational consequences of an overly abstract science education: ecophobia and the death of natural history studies. Equally important, the wave of test-based education reform that became dominant in the 1990s leaves little room for hands-on experience in nature (Louv, 2005, p. 134).

Similar to the distance between grocery store consumers and actual food industry farms and ranches, so too have students been separated from the natural world about which they study within the classroom.

Early interviews provided material evidence for students' and community members' local resources awareness levels. Discovering the extremely limited comprehension of this information drastically altered my intended approach and project design. I sampled class of AP Environmental Science students with a short formative assessment. Although these volunteers were not in my classes, they were entering a unit of water quality resources, so data collected provided key pre-assessment information to their teacher as well. This survey revealed limited local resource knowledge was not restricted to the small initial sample size and led to an even more thorough evaluative question set.

Science-Technology-Society (STS) refers to an older concept and research of the science-society connection. A modern version, termed *socio-scientific issues*, "focuses on empowering students to consider how science-based issues reflect, in part, moral principles and elements of virtue that encompass their own lives, as well as the physical and social world around them" (Zeidler, Sadler, Simmons, & Howes, 2005).

This team's data supported the interaction of current information and the identified practices or factors vital to "real life" science education's success. Particularly significant for the study was the association of scientific reasoning to specific social issues. The authors provided a working model to demonstrate both theoretical and conceptual links, allowing teachers to engage in appropriate psychological, sociological, and developmental factors. Matching student reasoning ability with skill progression increased successful connections between classroom and community concerns (Zeidler, et. al., 2005).

Incorporating socio-scientific issues, or the similar concept of STS, supported applications of student-designed solutions and possibilities within environmental engineering discovery. While jokes abound regarding to the sharp learning curve of young people and the most modern devices, integrating technology in the classroom is too often reduced to internet accessibility or science content gamification. References to Nye's *Technology Matters: Lessons to Live With* appeared frequently throughout my research. The necessity of understanding the science behind our technological society, especially from a historian's viewpoint rather than educational researcher or science instructor's perspective, provided further insight into effective technology integration (Nye, 2006).

Again, the NGSS fully supports cooperative measures. High school Earth and Space Science (ESS) standard ESS3-4 asks students to "evaluate or refine a technological solution that reduces the impacts of human activities on natural systems," with clarification statements including pollutant quantities and types, while limiting future impacts through local efforts and geoengineering design solutions. This, and other environmental engineering projects, may provide significant insight to best practices involving student engagement and environmental stewardship, while still accomplishing educational goals (NGSS).

Study Sample Description

Within my current MESA students, a variety of historic academic success levels are represented ($N = 22$). English / Language Arts assessments reveal 50% of students met grade-level standards, 29% attained an above standard score, and 21% were nearing proficiency. Math standardized assessments showed wider variation. Above standard scores (a level 4 rating) were earned by 25% of students, at standard (level 3) students totaled 29%, nearing standard (level 2) included 25% of students, with the final 21% of students earning a below-standard score (level 1). The science assessment administered to all eighth grade students showed 44% of students in this class section reached an above standard/ level 4 rank, 42% met standard/ level 3 score, and the last 17% did not meet standard prior to high school promotion.

An additional 20-minute block was added to this class period once a week. While other teachers opted to use this time for study hall, we used this extension for MESA-specific items. Students would regularly utilize this block of time for researching environmental issues, listening to guest presentation, identifying engineering practices, project design and development, or working on associated topics. Regular attendance was particularly important due to activities beyond required biology content. Of the group with satisfactory attendance, only three students missed reaching standard in the combined testing scores, one of whom is on a special education plan. While one student listed as being "at risk/ chronic absenteeism" did not meet overall standards, the three other students with attendance concerns just barely reached passing scores on standardized tests.

<u>Research Questions</u>

I used a variety of investigative methods during my classroom research project. Survey results in the formative and summative assessment periods provided the majority of data points for comparison over time. Lab journals, interest evaluations, *Muddiest Point*/ *Stickiest Point* classroom assessment techniques, and informal interviews offered additional insight to student progress. Engineering concepts were further examined using *One-sentence Summary* plans, prototype design/ development/ display, and invented dialogues in the form of an advertising "pitch" for each group's environmental engineering project. Throughout the duration of my research, I made observations and documented qualitative information, as well as making appropriate treatment plan adjustments.

My classroom research questions were as follows:

1. How does the use of place-based environmental engineering challenges influence student perceptions of stewardship for natural resources? (Major classroom research question.)
2. What is the impact of using residential resources in supporting students' perceived value of ecological awareness? (Investigative sub-question.)
3. How will incorporating localized water and soil science content and concepts affect student attitudes toward environmental responsibility? (Investigative sub-question.)
4. Does the integration of computer technology and human-centered engineering projects support socio-scientific issues of preserving the health of natural resources? (Investigative sub-question.)

<u>Triangulation Matrix</u>

Table 1 provides a question matrix and the corresponding data collection methods.

Table 1
Data Collection Methods and Research Questions and Sub-questions.

	Data Collection Methods										
Major Action Research Question and Sub-questions	Concept / content formative & summative assessments	"Care-level" survey (before and after)	Lab Journals (includes response, related content)	Interest evaluations	One-sentence summary of enviro engineering plan	Classroom Observations	Prototype Development and design display	Field-trip Muddiest Point and informal interviews	Student Work (engineering design and construction)	Prototype Pitch (Invented Dialogues)	Reflective Journaling (teacher)
Question #1	X	X	X	X	X	X	X	X	X	X	X
Question #2	X	X	X	X	X	X		X		X	X
Question #3	X	X	X	X	X	X		X			X
Question #4	X	X	X	X	X	X	X		X	X	X

Treatment Description

My treatment plan involved creating and collecting informational readings, inquiry activities, and natural resource learning modules to support identifying potential student interest areas. These hydrology, geology, and pollution lessons were used in preparation for the final environmental engineering project design. Instructional elements included topics of water and soil quality, usage and resources, plus historic and current challenges. Guest speakers and local field trips helped support student connections to places, to science, and to the community. As well as my overall intent to assess student natural resource stewardship, incorporating engineering/ technology components provided an opportunity for human-centered applications or social justice awareness and involvement.

I hoped by including background information and providing a real-life, place-based connection to the engineering project, students with be better equipped to address both ecological and human needs. Modifications to my practices and the additions of supplementary lessons were selected to benefit developing authentic reasons for students' time and effort investments. Incorporating computer coding, electrical wiring, project selection, concept model design, solution development, and public communication all offered opportunities for influencing student perceptions of environmental stewardship, value, and responsibility.

Instrument Description

Environmental engineering project design and development commenced in January and concluded in March. However, pre-assessment surveys were administered in October, with investigation, inquiry, and exploration beginning in November. Initial survey replies were recorded. These were later compared to responses following whole-class research and the onset of team project design, and again to the final survey results following prototype display and demonstration. Journaling, both students' and my own, continued throughout the treatment duration. Incremental checkpoints, such as the *Muddiest Point* and *One-sentence Summary* plan occurred in time-spaced periods from November through the end of March.

Instrument Analysis

Evaluation Details/ Presentation - Instrument 1: Concept/ Content Formative Assessment

I grouped responses to the *Concept/ Content Formative Assessment* (Appendix A) into related subject matter and displayed these in "stacked column" graphs. Columns constituted Likert-style answers to questions using *Nope*, *Not likely*, *Sort of / maybe*, *Probably*, and *For sure/ yes*. These responses were translated to relative scoring of one, two, three, four, and five, with one as the low agreement response and five as the highest level of agreement. Columns in graphs represented percentages of students providing the corresponding response

Subject groupings included five topics. Topic A, *Water Quality Questions*, evaluated the strength of agreement or disagreement to statements such as "I can describe the ecological benefits of clean water." Using the same measurement scale, Topic B, *Community Interaction*, was comprised of ideas along the lines of "I could explain to a community member a few ways to conserve water in our area." Statements about *Local Watershed Knowledge*, designated as Topic C, contained concepts like "I can describe from where water in the Spokane River originates and to where it flows." Topic D, the questions grouped into *Personal Responsibility*, addressed reflection on behaviors such as "If I personally caused pollution or contamination of a lake or river, I would clean it up." Finally, Topic E helped students evaluate their *Computer Coding Confidence* levels through agreement to statements such as, "With the right equipment, I could code a sensor to alert for too much or too little water."

Graphed columns denoted the amalgamation of individual questions within the larger subject divisions. The same questions were utilized in October before treatment began, in January as groups transitioned from whole-class learning activities to team-specific foci, and in April after treatment concluded.

Evaluation Details / Presentation - Instrument 2: Care-Level Survey

Care-Level Survey (Appendix B) results were analyzed in a similar fashion to the *Concept/ Content Formative Assessment*. As such, the options of *Totally Agree* / *Mostly Agree* / *Sort of Agree* / *Kind of Disagree* / *Mostly Disagree / Totally Disagree* coordinated to Likert levels of agreement. In particular, I concentrated on questions 12 through 17 of the *Care-Level Survey* instrument as queries applied to each individual. Questions emphasized connections between the students' projects and their personal life and their community, other peoples' lives and other communities, society, and the environment.

Graphic display of information appeared in a pie chart format, with a three-tiered display of focal question class responses. This time-line provided an opportunity to watch changes in the entire group's agreement levels over the treatment period.

Evaluation Details / Presentation - Instrument 3: Lab Journals

Student *Lab Journals* were a separate entity from the interactive notebooks used for biology course content. Journal entries included technical information, such written reports and computer coding rubrics, as well as notes from supplementary materials selected for my classroom research project. Data from documentaries on local geology, newspaper and magazine articles on current environmental events, and short peer research presentations were included in *Lab Journals*. Official notes were taken on the "right side" of a two-page notebook spread; transcribed student comments and reflections about the notes appeared on the facing "left side."

I periodically collected the *Lab Journals* to oversee prototype development and monitor appropriate time management. Journal evaluations also provided the opportunity to observe changes in student perceptions toward natural resource stewardship. As part of the design and development practice, I annotated initial ideas and developing plans. Students were familiar with this model and regularly performed peer-reviews and provided feedback to classmates. I documented images of student commentary, tracking changes for later evaluation.

Evaluation Details / Presentation - Instrument 4: Interest Evaluation

The *Interest Evaluation* (Appendix C) instrument was administered to the test group for assisting the environmental engineering project design and development. I evaluated responses for qualitative progress data. The *Interest Evaluation*'s final application was to support planning students' prototype design *One-Sentence Summary* plan (Appendix D).

Evaluation Details / Presentation - Instrument 5: Classroom Observations

Classroom Observations were documented as anecdotal evidence in a dated journal. I wanted format flexibility and allowances for necessary and situationally determined changes. My observation journal included students' actions and comments within our classroom, as well as on field trips. Interactions with guest speakers were documented and incorporated into *Classroom Observations.* These accompanied notes on students' practice speeches at the MESA Family Presentation Night and the final engineering competition.

Evaluation Details / Presentation - Instrument 6: Muddiest Point

The *Muddiest Point*, a published classroom assessment technique and rapid data-collection tool, was used each time we attended an off-site event (Appendix E). This method asks students to designate one point of confusion on provided *Muddiest Point* cards. I complemented these by also probing students to identify the most shocking, surprising, or insightful portion of the day. In relative terms, I asked students to think about what issue was going to "stick" and to describe this item on the coordinating *Stickiest Point* card.

I collected both cards at the conclusion of each event to gather qualitative evidence. I evaluated, captured images, and documented responses prior to returning cards for installation into student *Lab Journals*. Comments and further discussion about the *Muddiest Point* and *Stickiest Point* card topics occurred as students progressed through project design and development phases.

Evaluation Details / Presentation - Instrument 7: Prototypes and Presentations

Official judging panels evaluated the student teams' written reports, prototype design and development, advertising "pitch," and oral presentations. However, my interest focused on students' changing view and values, as stated in the classroom research question, "*How does the use of place-based environmental engineering challenges influence student perceptions of stewardship for natural resources*?" I used anecdotal recorded evidence to document visible or auditory student reactions. I scored a secondary *Care Survey* evaluation to watch for altered student attitudes towards projects, related social issues, and associated environmental topics. Individual team members were evaluated on observable indicators, such as building material interaction, group discussion engagement, ability to answer questions about projects, and self-driven completion of tasks.

IRB Exemption

Prior to beginning research, data collection techniques received exemption by the Institutional Review Board (Appendix F). Methods were approved by a building administrator. Consent forms were not necessary for research because my capstone does "not contain any names or personal information identifying [students]." Additionally, as I worked with my own students, techniques were considered "normal educational practices." The school district's Director of Assessment and Program Evaluation verified all details.

DATA AND ANALYSIS

Pass on the knowledge and skills you have, and mentor other educators so that they can benefit from studying their practice.
(Hendricks, 2017)

Practices of Ecoliteracy

The full treatment of my classroom research project spanned from late autumn until mid-spring. Data collection avenues covered student self-assessments, teacher observations, peer feedback, and design/ development/ display of an integrated environmental engineering prototype. As introduced under Conceptual Framework, the Center for Ecoliteracy describes *making the invisible visible*, *understanding how nature sustains life*, *anticipating unintended consequences*, *embracing sustainability as a community practice*, and *developing empathy for all forms of life* as the five key ecoliteracy practices (Goleman et al., 2012). Treatment design and collected data supported the development of key ecoliteracy practice. Further, each was applicable to my focus question, "*How does the use of place-based environmental engineering challenges influence student perceptions of stewardship for natural resources*?"

Making the Invisible Visible

The practice of *making the invisible visible* highlighted the far-reaching implications of human actions. Students completed the *Concept/Content Formative and Summative Assessment* to assess progress periodically. Trends observed in Topic A: *Water Quality Questions* indicate increased student agreement levels during the October/ January/ April treatment sequence, as shown in Figure 2.

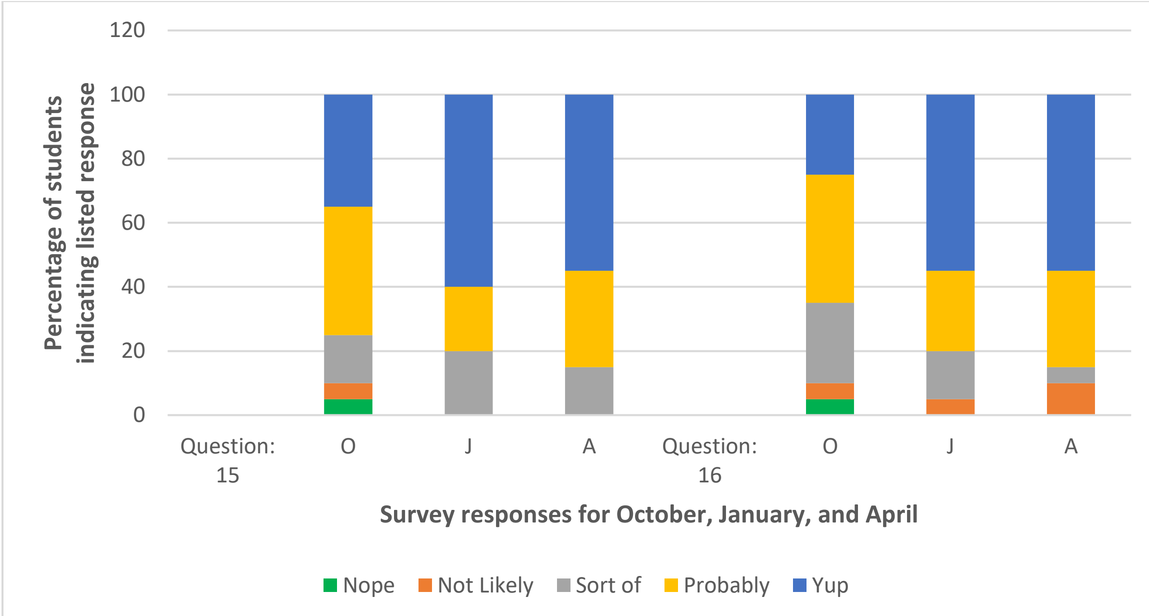


Figure 2. Student responses to Concept/ Content Topic A: Water Quality Questions, (*N* = 22).

Sectional survey questions included specific water quality traits. Selection of question 15, *I can describe the benefits of clean water for my community*, emphasizes how water quality affects human usage. As a support for the thematic focus of *making the invisible visible*, the counterpart bypasses effects beyond human populations and concentrates on benefits for nature as a whole; question 16 asks for agreement level to the statement *I can describe the ecological benefits of clean water*.

Increased concern echoed lab journal responses, displayed in Figure 3. After watching a video highlighting improper water management, one student wrote, “Although we have a lot of good water it can’t last forever [and] we shouldn’t wait for a disaster to start conserving water.”

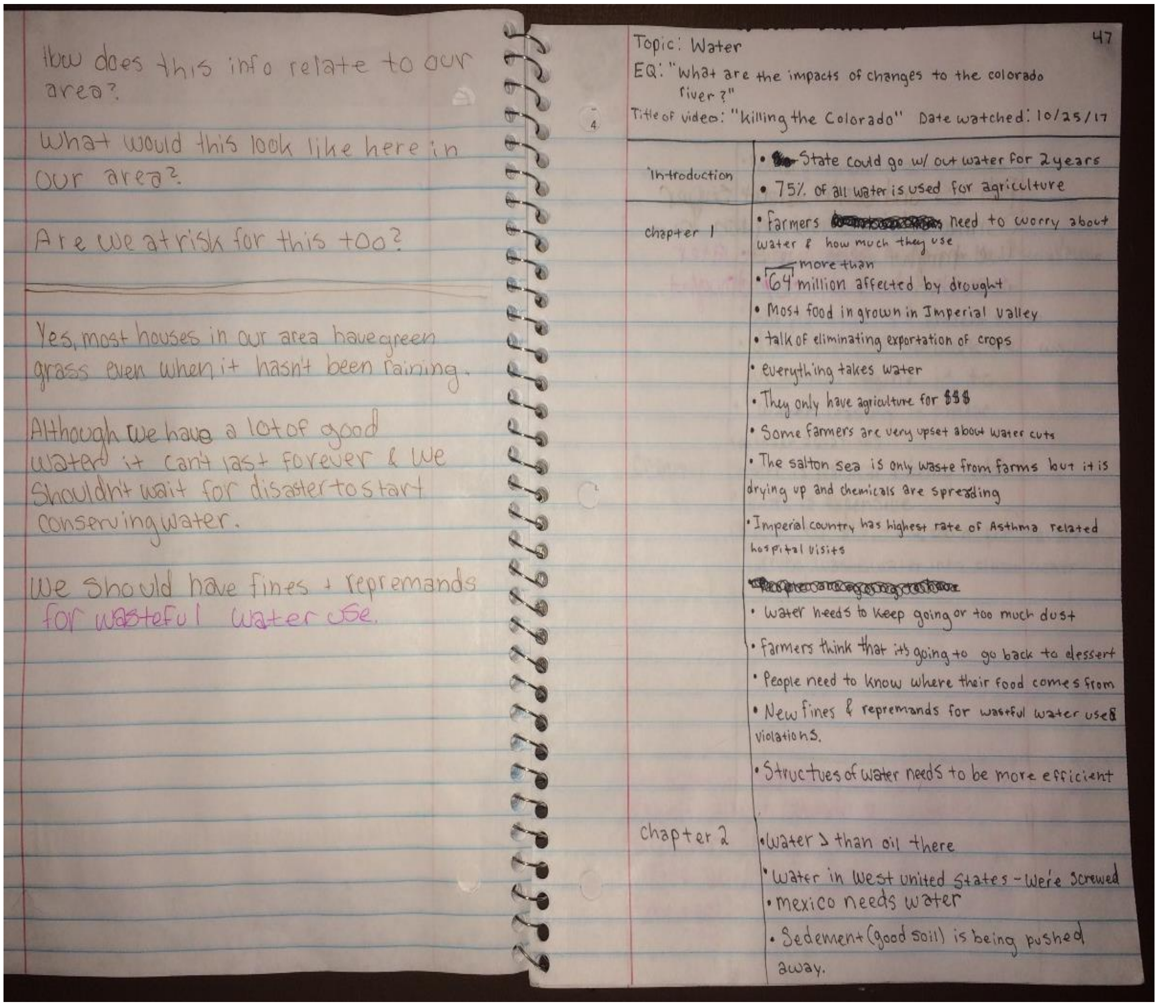


Figure 3. Student response to "What would this look like here in our area?" for evaluating *Making the Invisible Visible*.

Making the invisible visible continued into topics B and C, *Community Interaction* and *Local Watershed Knowledge*. Table 2 identifies specific questions from these portions of the *Concept/ Content Survey*.

Table 2

Community Interaction and Local Watershed Knowledge Question Identification

Topic Letter: Descriptor	Number	Question for Student Response
Topic B: *Community Interaction*	23	I could explain to a community member how an aquifer works.
	24	I could explain to a community member special features of how our local aquifer works.
	43	I could explain to a community member a few ways to help improve water quality in our area.
	45	I could explain to a community member a few ways to help conserve water in our area.
Topic C: *Local Watershed Knowledge*	27	Besides a general description of the water cycle, I can describe from where the water in Lake Coeur d'Alene originates and to where it flows.
	28	Besides a general description of the water cycle, I can describe from where the water in the Spokane River originates and to where it flows.
	29	Besides a general description of the water cycle, I can describe from where the water in the Spokane Valley-Rathdrum Prairie originates and to where it flows.
	30	Besides a general description of the water cycle, I can describe the interconnectedness of our local water systems.
	31	I am aware of historic water quality issues in our local waterways.
	32	I am aware of current water quality issues within our local waterways.

I invited a guest presenter from the Spokane County Water Resources department into the classroom to provide background information before taking students on a water quality and management field trip. Halfway through the presentation, one high-achieving student remarked, “Oh! I thought the aquifer was just like a bathtub or bowl under the ground!” Surveys taken in October, January, and April indicated significant gains in both content knowledge and confidence in discussing Inland Northwest water quality and the Spokane Valley – Rathdrum Prairie (SVRP) aquifer (Figure 4).

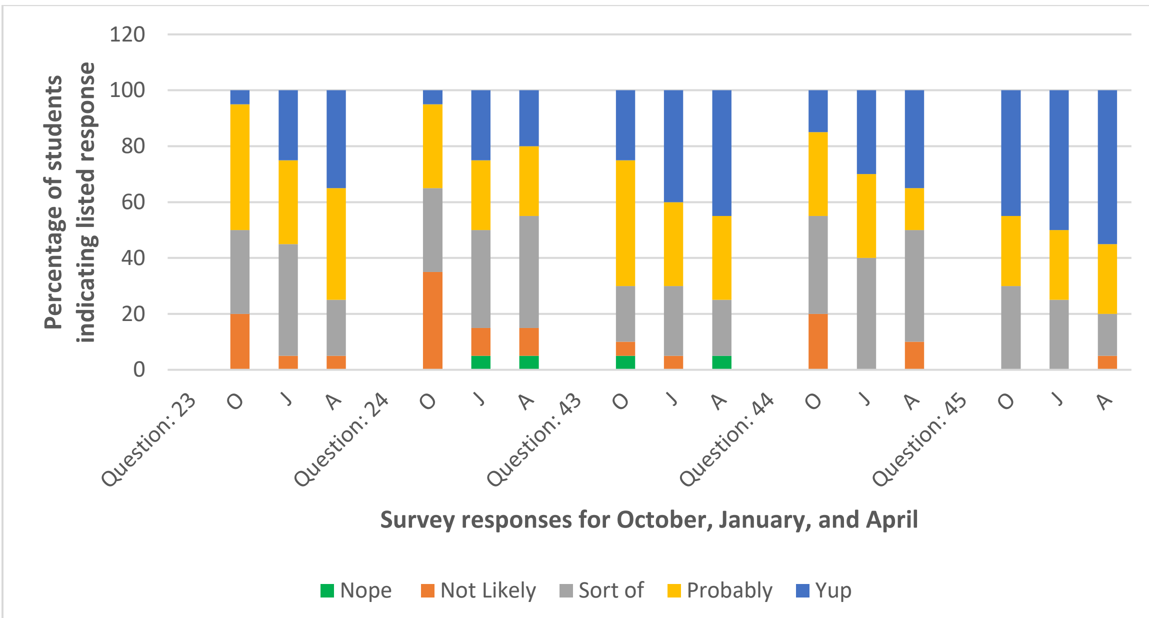


Figure 4. Student responses to Concept/ Content Topic B: Community Interaction, (*N* = 22).

The field trip’s place-based learning created more questions than clarifications. *Muddiest Point* cards indicated confusion and concern (Figure 5). Written commentaries included items such as, “Do our water quality problems effect other cities or places?” Others responses showed growing apprehension in asking, “Why aren’t we learning about this stuff in class?” This particular student verbally added remarks of water quality and local aquifer community knowledge being of greater importance than required molecular biology content.

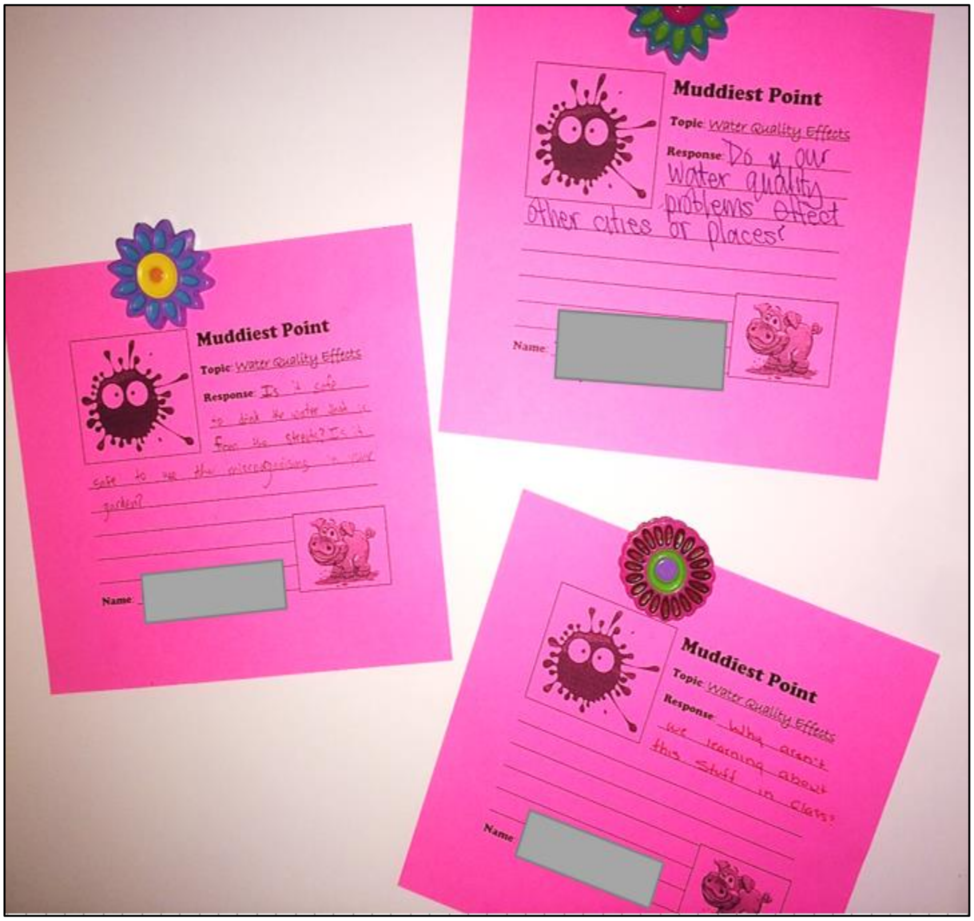


Figure 5. Muddiest Point responses following a water quality and management field trip for evaluating ecoliteracy practice *Making the Invisible Visible*.

Major Spokane and Coeur d'Alene area watersheds are connected to the SVRP aquifer. Initial responses indicated over-confidence in watershed familiarity. While overall treatment period trends showed increased knowledge about local water resources, quantitative progress on individual survey questions varied in agreement levels. As displayed in Figure 6, the highest and lowest values remained relatively limited. However, more moderated levels of gains were observed.

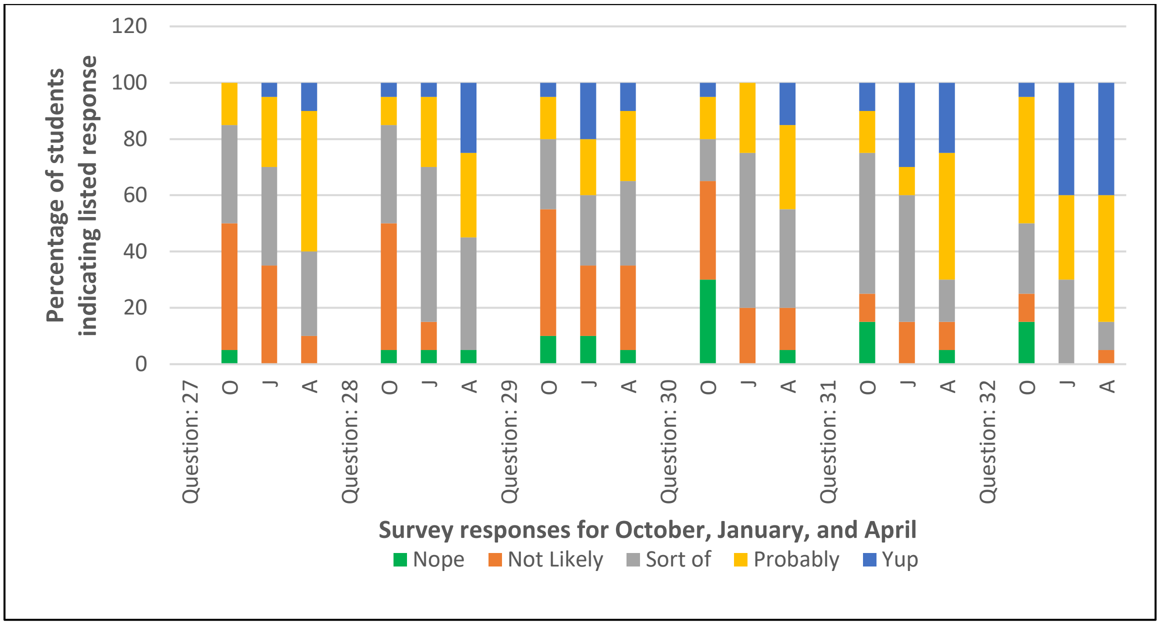


Figure 6. Student responses to Concept/ Content Topic C: Local Watershed Knowledge, (*N* = 22).

Viewing local maps, topographical features, and aerial photographs provided a general overview of the lake's input and output locations. However, watching water flow into the Spokane River from Lake Coeur d'Alene provided a more accessible, clarified understanding of watershed connectivity. Further, physically looking down a 70' well to the aquifer's water-bearing boulders and gravel improved understanding. Conversely, reflecting a student's observation while on the boat trip around the lake she was "learning more and then finding out there's a lot more to learn," *Muddiest Point* cards indicated students' increasing awareness of limited understanding (Figure 7). Four responses and related conversations in particular provided improved cognizance evidence:

1. I still have questions on how the metal at the bottom of the lake doesn't get mixed with the water throughout the entire lake.
2. I was confused about the "point and non point" [pollution sources].
3. I am still unclear on the geology in the CDA lake and how it applies to water pollution.
4. I thought the lead and heavy metals affected the people of CDA [only] when they swam in the lake.

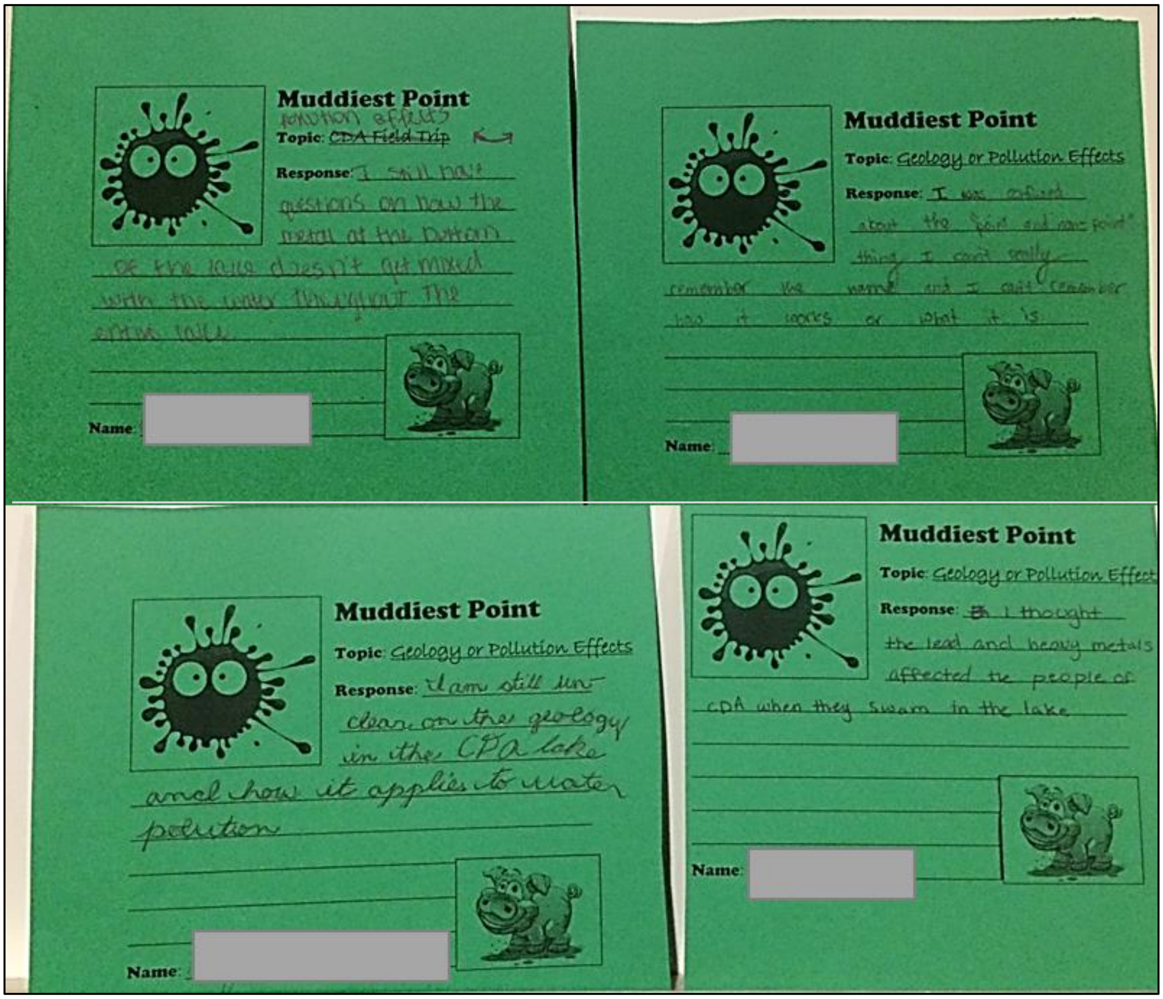


Figure 7. Ecoliteracy practice *Making the Invisible Visible* Muddiest Point responses following the Spokane Valley/ Rathdrum Prairie/ Lake Coeur d'Alene/ Spokane River watershed field trip.

Understanding How Nature Sustains Life

The phrases "matter cycles within systems" and "energy flows through systems" are common matter, energy, and systems teaching tools. These phrases are frequently sequenced with the transfer and transformation of matter and energy in food webs. While the intent is to provide an accessible application and modeling of systems thinking, published examples typically include forest producers and wildlife consumers. The identified trophic levels rarely incorporate human interactions. For example, a simplistic food web image is likely to include organisms such as wild vegetation, a rabbit, and a wolf. I have yet to see a textbook chapter show commercially grown, processed, and concentrated corn, beef cattle herds eating from feedlots, and a person enjoying a flame-broiled steak. While a rather amusing image of energy transfer/ transformation concepts, the overall impression is of marked division between wild and domestic descriptions for *understanding how nature sustains life*.

Bridging the gap between natural resources' provisions for life, both wild and domesticated, was one goal of incorporating technology into student engineering projects. Utilizing students' typically high confidence in using computer-coded resources was selected to interface with hardware wiring and sensors hand-built with manufactured components. Students assessed personal confidence levels in their abilities to code a sensor to alert for (#12) *too much or too little water*, (#13) *chemical pollution,* and (#14) *non-chemical pollution,* such as increased temperatures, when provided appropriate equipment.

Sensor coding was a result of research and prototypes interactions, rather than an engagement driving force. Reported confidence increased throughout the treatment period, but at a significantly lower rate than seen in other data collection devices (Figure 8). Comfort followed computer scripting gender stereotypes. This aspect was not observed through prototype design and construction, trouble-shooting electrical wiring, or during mathematical computations. Several female students remarked "Power tools are so cool!" Observably low enjoyment levels suggests computer coding remained largely less accessible to the test group majority.

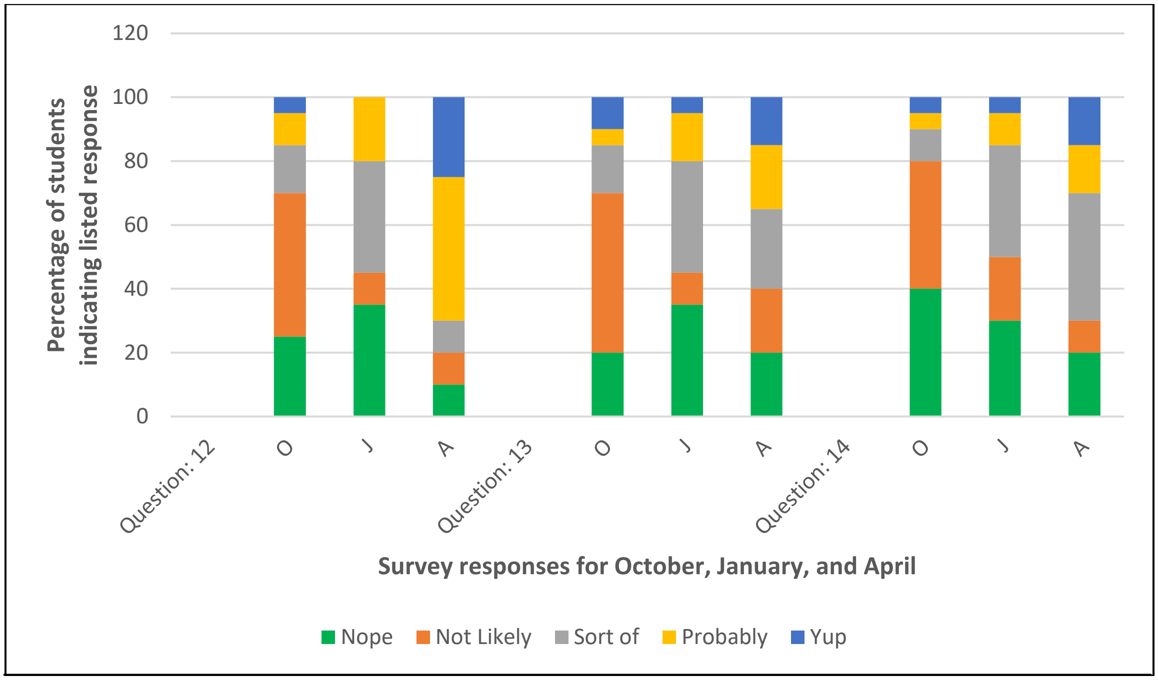


Figure 8. Student responses to Concept/ Content Topic E: Computer Coding Confidence, (*N* = 22).

One team in particular effectively linked multiple aspects of *understanding how nature sustains life*, both literally and figuratively. This team designed an integrated system incorporating aquaponic gardening with socio-scientific interest in senior citizens (Figure 9). Multiple design changes led to successful aquaponic gardening, with mutually beneficial flora-fauna partnerships. The prototype used small, aquarium fish and mixed lettuce greens (Figure 10). However, the team's vision was to include consumable fish and multiple vegetables, improving healthy food accessibility for seniors, particularly those with mobility limitations or reduced intellectual abilities. Their coded sensors detected and visually alerted potential users when the system needed additional water. Proposed subsequent designs included evaluating water pH levels, chemical nutrient threshold detection, as well as adding an auditory alarm. Further, they were interested in the possibility of connecting collected sensor data to cell phones through an app, while acknowledging their current restrictions on related skills and information for effective task accomplishment.

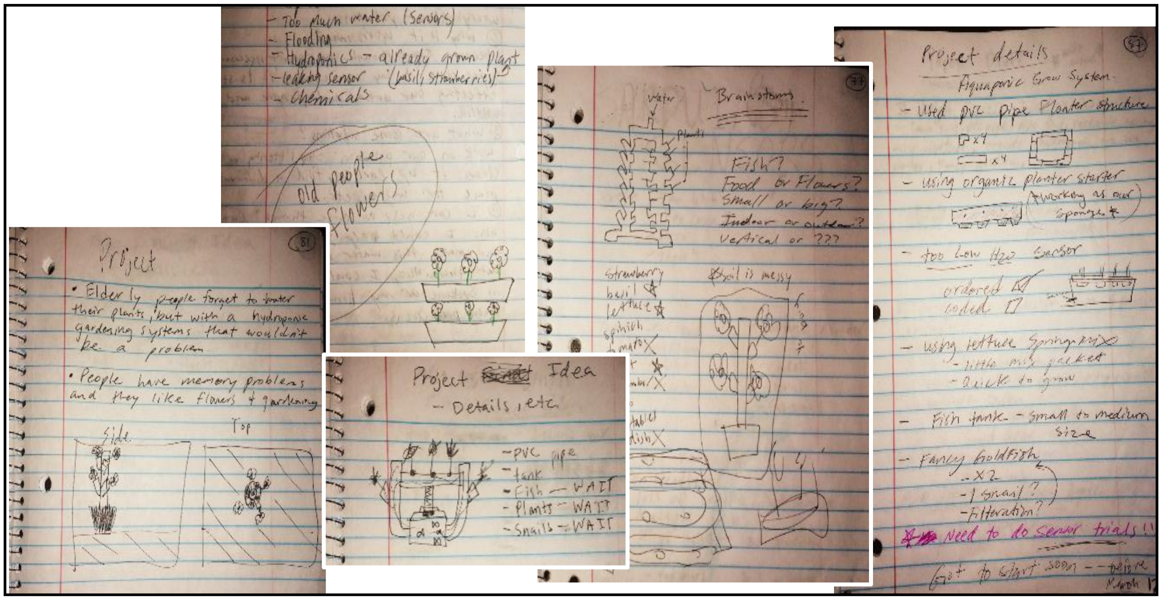


Figure 9. Ecoliteracy practice *Understanding How Nature Sustains Life* "Aquaponics for the Elderly" student initial project planning and research in journal.

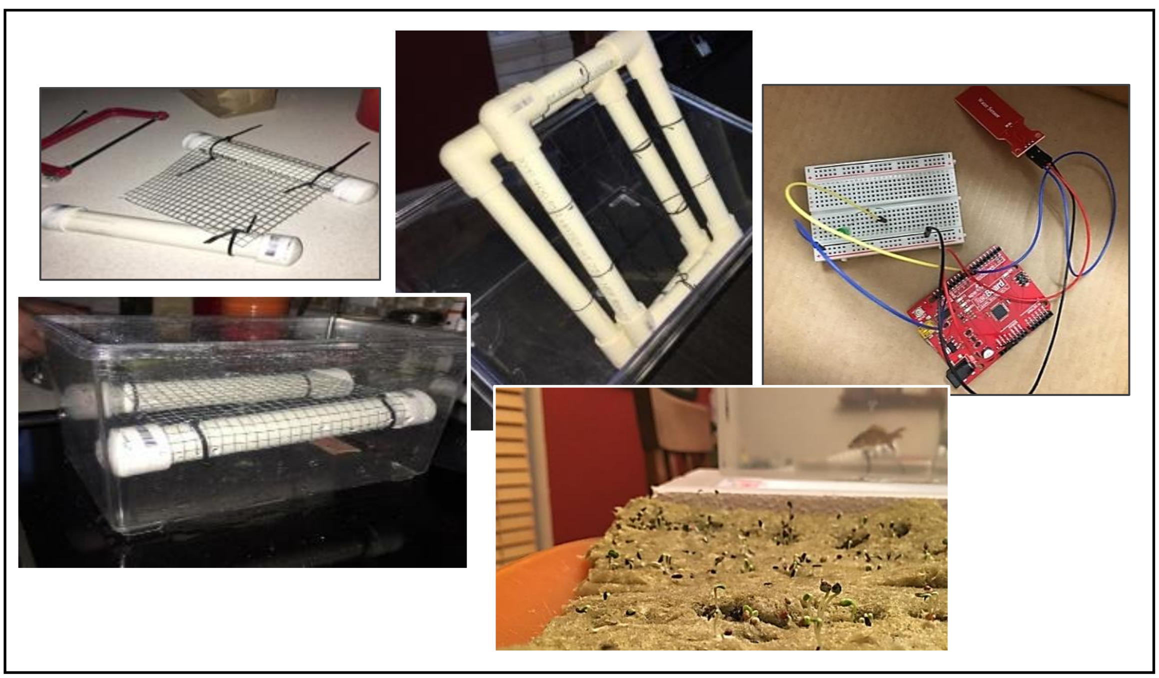


Figure 10. Ecoliteracy practice *Understanding How Nature Sustains Life* "Aquaponics for the Elderly" student project development and re-design.

Beyond environmental benefits of decreasing food transport requirements, indoor air quality improvements, etc., the team identified a secondary meaning for *understanding how nature sustains life*. They discovered the psychologic benefits of watching fish swimming and improving mental health through gardening while researching hydroponic/ aquaponic requirements. We discussed gardening is often used as patient treatment by occupational therapists at long-term rehabilitation centers. Similar to the benefits of outdoor learning seen with children, so too are those observed in other age groups and populations. Increased perceptions of stewardship were highlighted during the prototype project introduction and discussion (Figure 11).

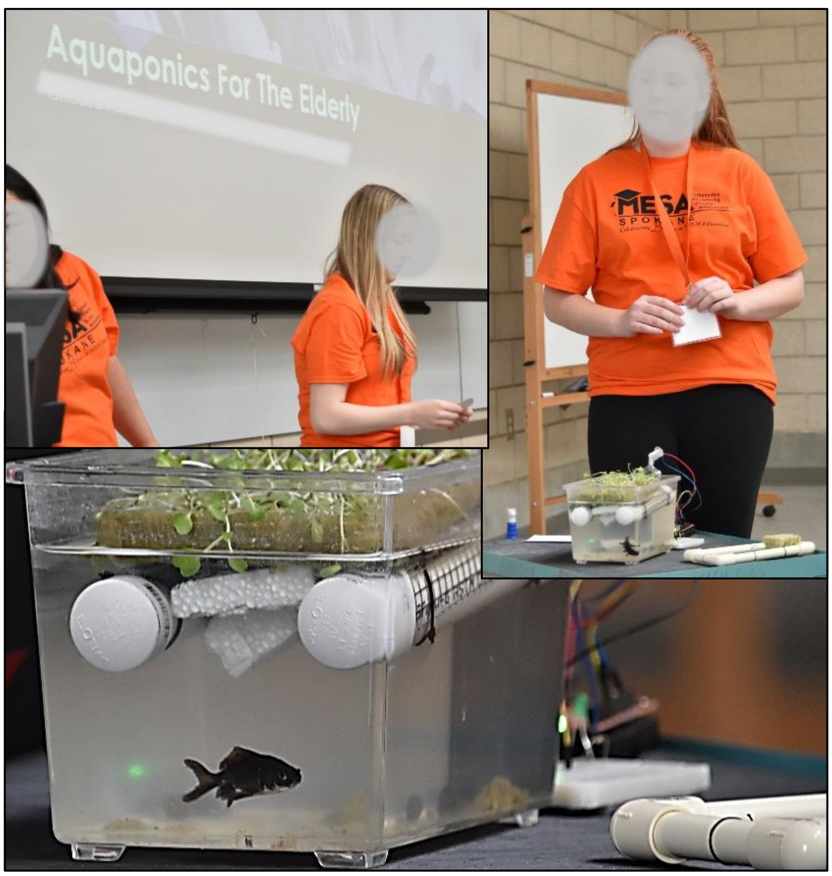


Figure 11. Ecoliteracy practice *Understanding How Nature Sustains Life* "Aquaponics for the Elderly" prototype project and pitch at the MESA Competition.

Embracing Sustainability As A Community Practice

The third ecoliteracy practice is *embracing sustainability as a community practice*. Movement toward sustainability was a key factor in researching *How does the use of place-based environmental engineering challenges influence student perceptions of stewardship for natural resources?* Component progression evaluation included the digital *Care-level* survey, *Concept/ Content* formative assessment, *Stickiest Point* cards, and *Lab Journal* responses, in addition to observations and anecdotes.

The *Care-level* survey specifically looked for changes in agreement of connections between students' environmental engineering projects and to other aspects of the students' lives. Questions 12 through 15 inquired about student agreement to statements *I feel like there is a clear connection between my MESA project and* (12) *my local community*, (13) *me and my life*, (14) *society*, and (15) *the environment*. *Care-level* survey charting displays qualitative changes before, mid-way through, and at completion of treatment (Figures 12 – 15).

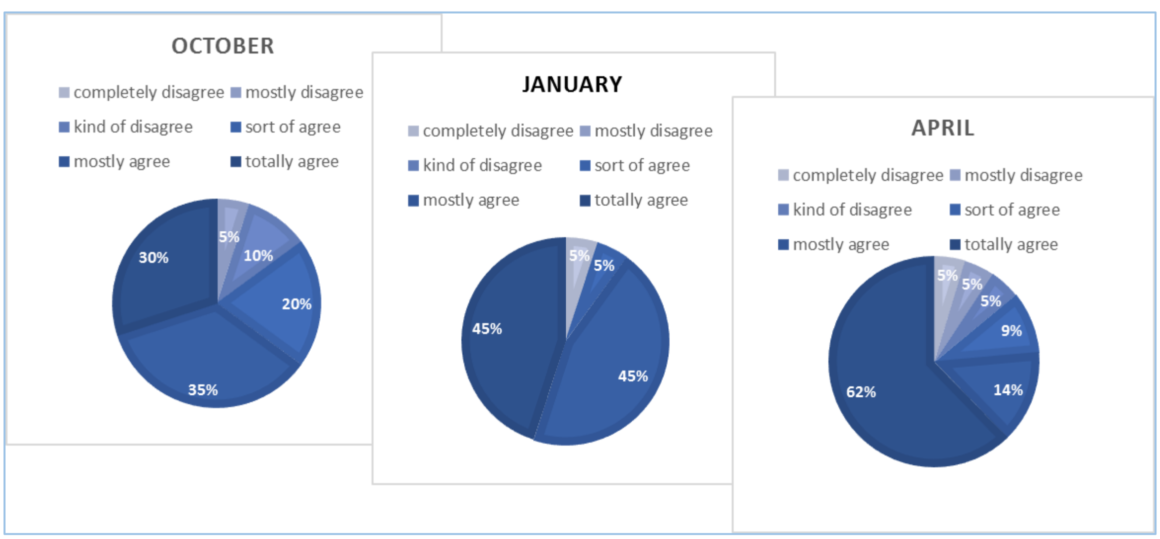


Figure 12. Student responses to Care survey Question 12 *I feel like there is a clear connection between my MESA project and my local community*, (*N* = 18).

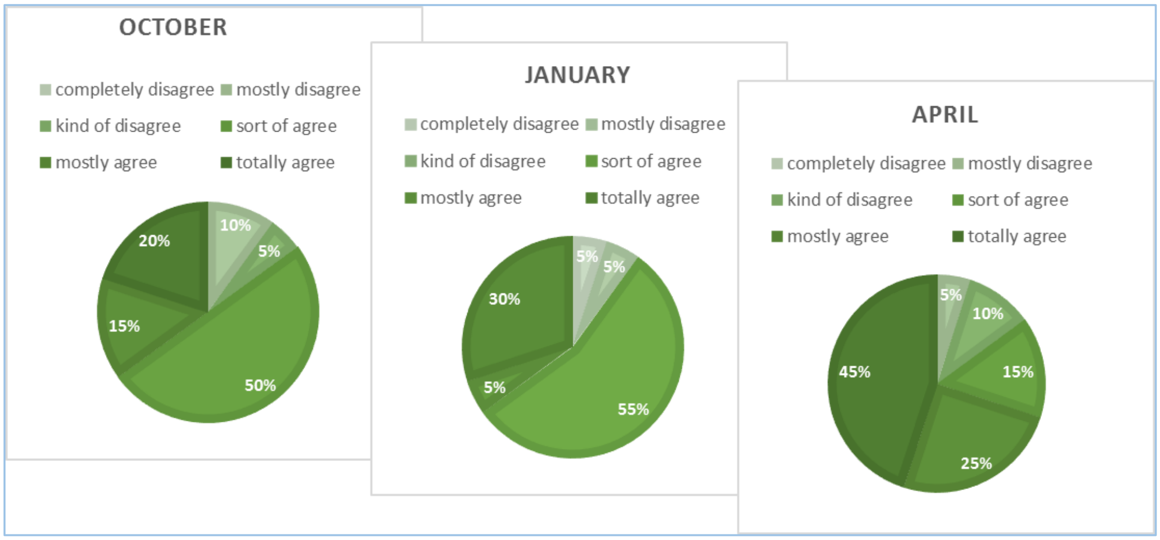


Figure 13. Student responses to Care survey Question 13 *I feel like there is a clear connection between my MESA project and me and my life*, (*N* = 18).

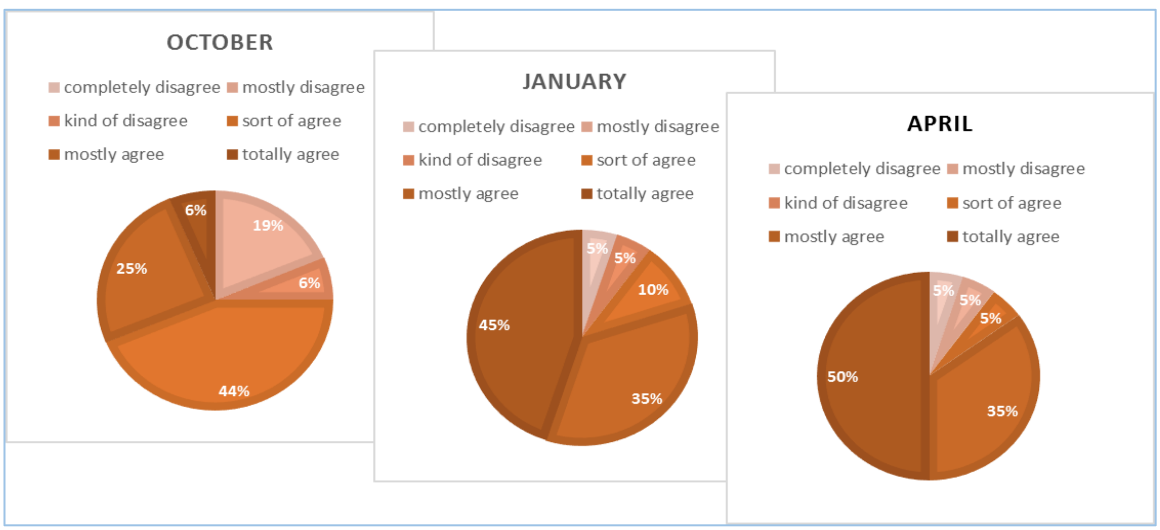


Figure 14. Student responses to Care survey Question 14 *I feel like there is a clear connection between my MESA project and society*, (*N* = 18).

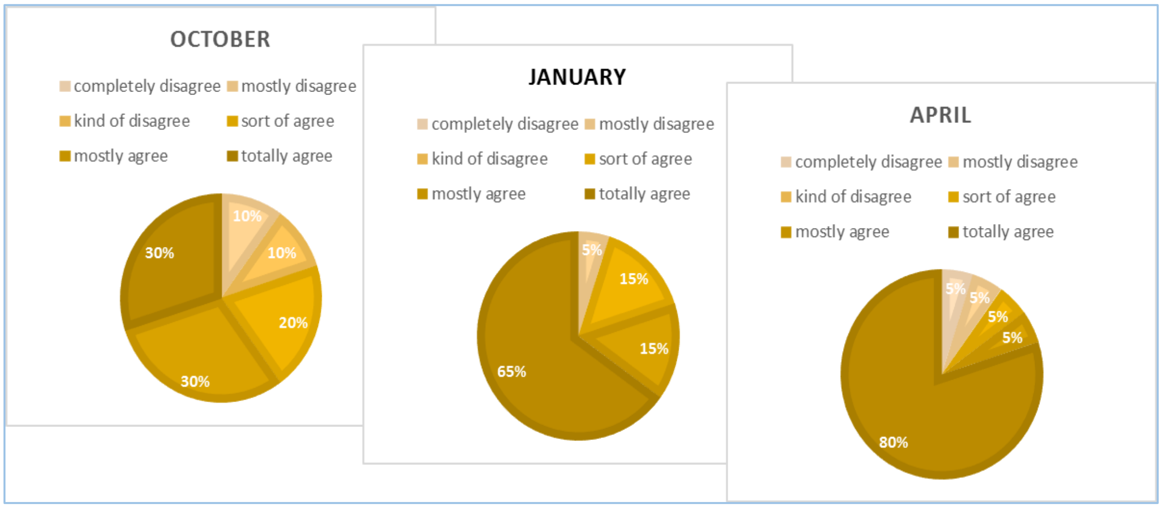


Figure 15. Student responses to Care survey Question 15 *I feel like there is a clear connection between my MESA project and the environment*, (*N* = 18).

Measureable changes were also reported for (16) *I feel like my MESA project could help other people* and (17) *I feel like my MESA project could help other communities (Figure 16).*

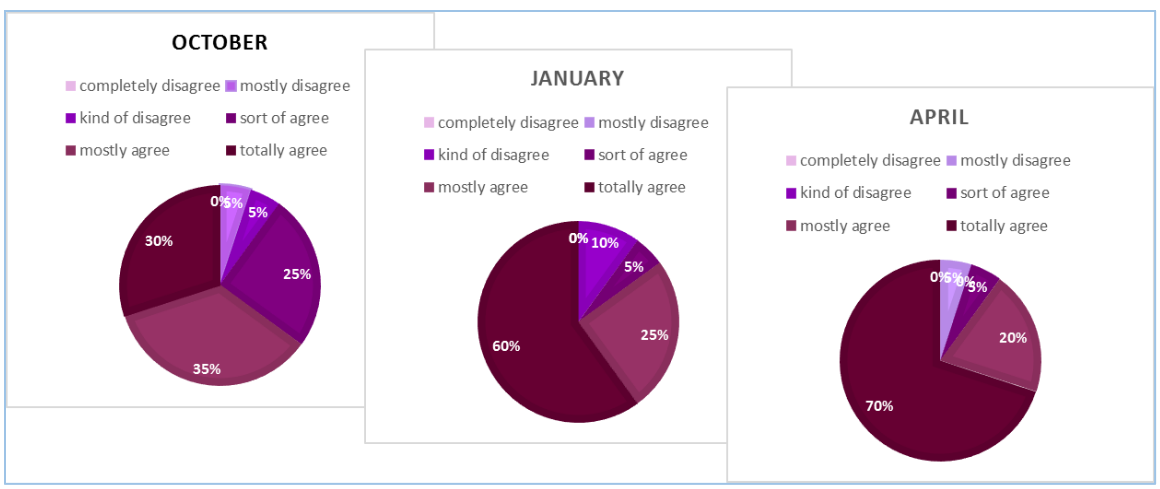


Figure 16. Student responses to Care survey Question 16 *I feel like my MESA project could help other people*, (*N* = 18).

Although scores suggest positive effects on perceived benefits, naïve understanding of the actual project may have resulted in lower initial scores, skewing the appearance of increased gains (Figure 17). Additionally, extensive work on the environmental engineering projects occurred during February and March.

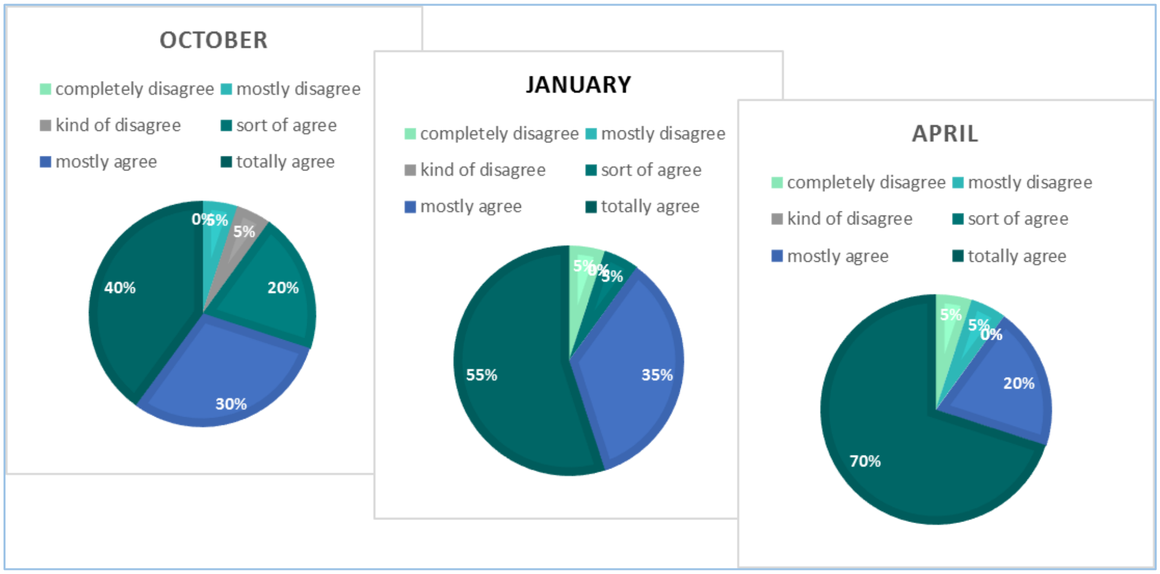


Figure 17. Student responses to Care survey Question 17 *I feel like my MESA project could help other communities*, (*N* = 18).

<u>Anticipating Unintended Consequences</u>

Anticipating unintended consequences is an engineering and design practice just as much as it is an ecoliteracy practice. Acknowledging underexposed and under-researched ecological connections is necessary for envisioning potential ramifications. Expecting complications further encourages creativity to conceptualize and propose conservation approaches. Place-based environmental engineering challenges provided an introduction to interconnected ecological components.

Initial responses to *Concept/ Content* survey questions showed high confidence and statement agreement levels regarding student knowledge and willingness to mediate limnological water quality. Beginning with the phrase “If I personally caused pollution or contamination of a lake or river,” the test group was asked if they knew *how* to clean up pollution and contaminants. In a later question, students were asked if they *would* clean up the waste. Nearly unanimously, student October *Concept/ Content* responses supported personal responsibility and willingness to remediate water quality issues. Only 10% of respondents indicated they would only be *Sort of likely* to take action or *Not likely* to do so (Figure 18).

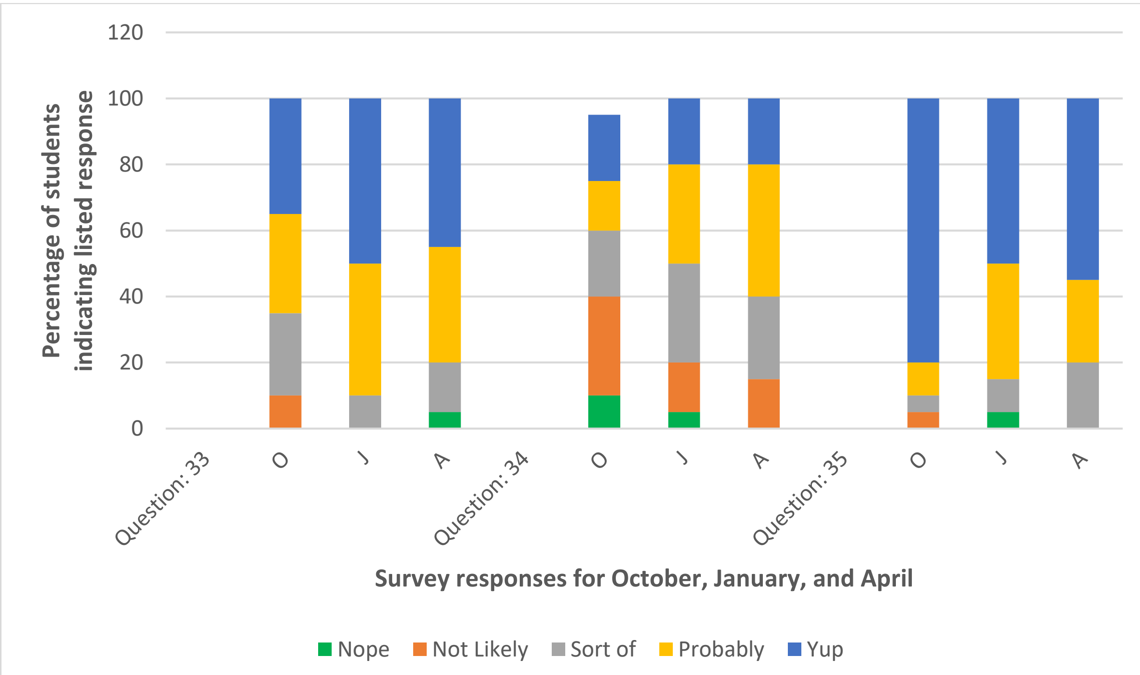


Figure 18. Student responses to Concept/ Content Topic D: Personal Responsibility, (*N* = 22).

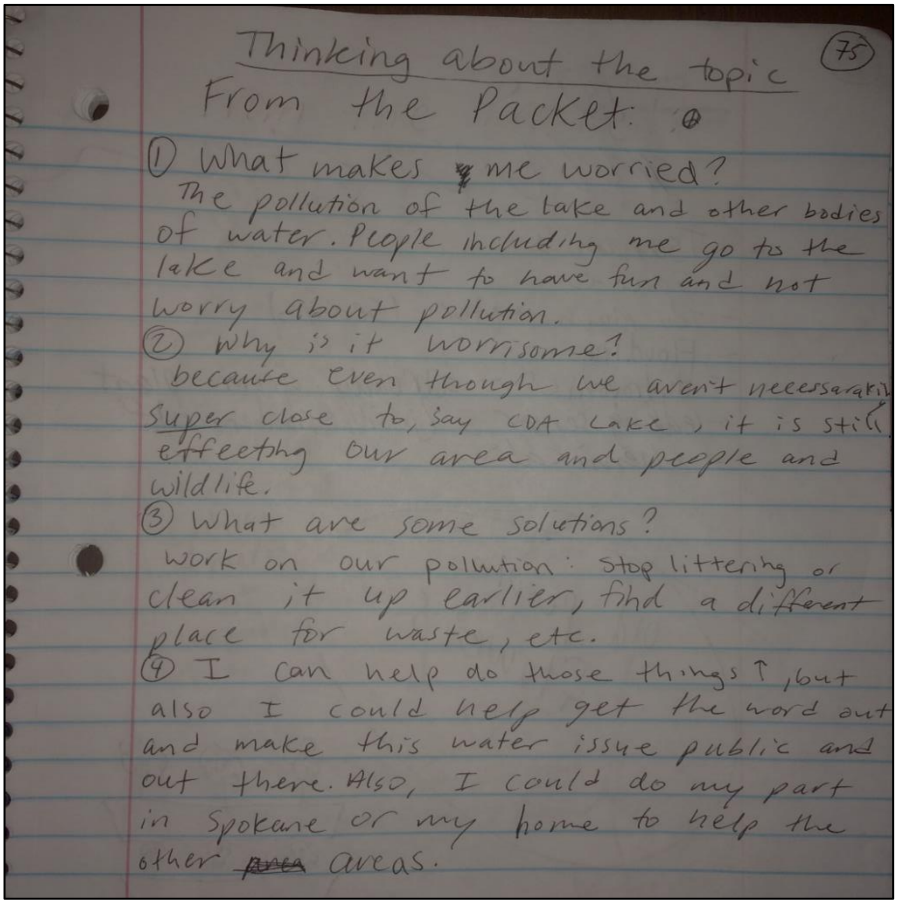
However, positive responses were documented prior to instruction on watershed health or the challenges of cleaning contaminants from water and shorelines. The water reclamation center's hands-on activities provided awareness to innate challenges of water resource management. One student's *Stickiest Point* was, "The water cleaning (hands-on one) we realized that it is very hard to clean the water [sic], so its' good that we have special systems to do it for us." Another card included the comment, "It was cool learning about how our water gets filtered for us, because us [sic] trying to do it was hard." This practical learning experience likely influenced the decreased agreement levels observed in January.

An agreement rebound was observed on final responses to *If I personally caused pollution or contamination of a lake or river, I would clean it up*. Timing suggests teams exploring residential water resources were more likely to address this issue as related skills and knowledge increased. Deeper understanding about local, large remediation techniques provided a model for these students' small-scale prototypes (Figure 19).

Figure 19. Hands-on water filtration system learning opportunities and prototype design development for ecoliteracy practice *Anticipating Unintended Consequences*.

Embracing Sustainability as a Community Practice

The struggle to find water quality and management solutions is a challenging model for *embracing sustainability as a community practice*. Classroom discussions and additional small-group research furthered student interest and concern. I asked a student to explain how dirty dishes were cleaned. His response was, “When we wash dishes, water cleans them and goes down drain, and the soap helps carry the dirt and oily stuff away.” I probed his thinking about how the water, with which he cleaned the dishes, itself was cleaned. While he was able to summarize natural and commercial filtration systems and processes, he added the realization “Bodies of water have no wash ‘away’ place.” He explained his clarity about the situation in his *Lab Journal*, along with worries about water conditions. More importantly, he was able to identify attainable solutions including support for *embracing sustainability as a community practice* in his response, “I could help get the word out and make this water issue public and out there (sic)” (Figure 20).



Thinking about the topic From the Packet: (75)

① What makes me worried?
The pollution of the lake and other bodies of water. People including me go to the lake and want to have fun and not worry about pollution.

② Why is it worrisome?
because even though we aren't neccesarily super close to, say CDA Lake, it is still effecting our area and people and wildlife.

③ What are some solutions?
work on our pollution: stop littering or clean it up earlier, find a different place for waste, etc.

④ I can help do those things ↑, but also I could help get the word out and make this water issue public and out there. Also, I could do my part in Spokane or my home to help the other ~~area~~ areas.

Figure 20. Lab Journal response to overall environmental health analysis of the Inland Northwest for ecoliteracy practice *Embracing Sustainability as a Community Practice*.

Realization there is no "perfect" solution to ecological concerns increased perceived stewardship value. Several students even challenged their own abilities to act as caregivers for environmental resources upon discovering their everyday activities had unknowingly already negatively affected local water quality. One student wrote, "Littering could eventually lead to our water" and her partner added, "Even when you are washing your car or fertilizing your lawns it can get into our aquifer" (Figure 21).

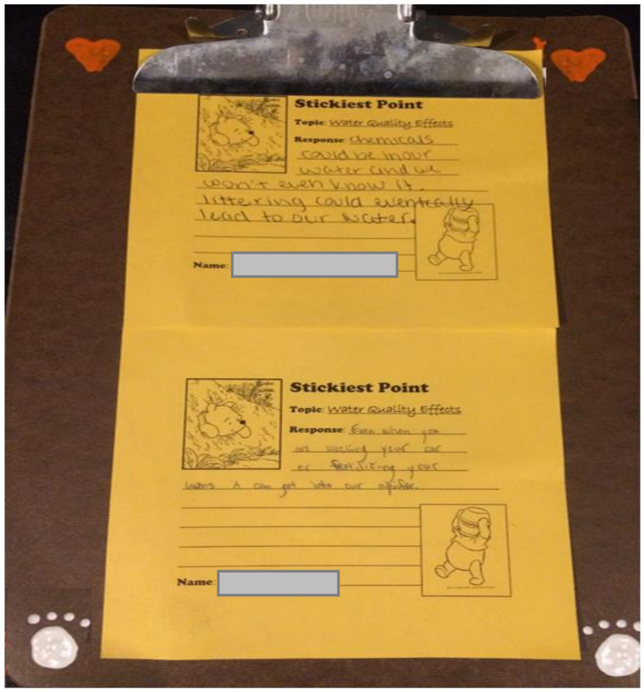
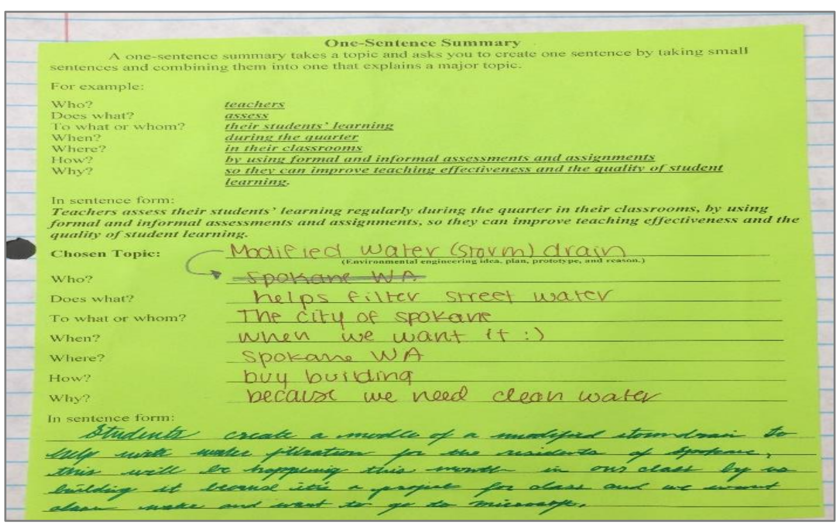


Figure 21. Ecoliteracy practice *Embracing Sustainability as a Community Practice* Stickiest Point responses following SVRP aquifer/ Lake Coeur d'Alene/ Spokane River field trip.

Student thinking on these *Stickiest Point* cards directly influenced this team's eventual engineering problem identification and project selection (Figure 22).



One-Sentence Summary

A one-sentence summary takes a topic and asks you to create one sentence by taking small sentences and combining them into one that explains a major topic.

For example:

Who? *teachers*
Does what? *assess*
To what or whom? *their students' learning*
When? *during the quarter*
Where? *in their classrooms*
How? *by using formal and informal assessments and assignments*
Why? *so they can improve teaching effectiveness and the quality of student learning.*

In sentence form:
Teachers assess their students' learning regularly during the quarter in their classrooms, by using formal and informal assessments and assignments, so they can improve teaching effectiveness and the quality of student learning.

Chosen Topic: Modified water (storm) drain
(Environmental engineering idea, plan, prototype, and reason.)

Who? ~~Spokane WA~~
Does what? helps filter street water
To what or whom? The city of spokane
When? when we want it :)
Where? Spokane WA
How? buy building
Why? because we need clean water

In sentence form:
Students create a modle of a modified storm drain to help with water filtration for the residents of Spokane, this will be happening this month in our class by us building it because it's a project for class and we want clean water and want to go to microsoft.

Figure 22. Ecoliteracy practice *Embracing Sustainability as a Community Practice* solution idea and prototype explanation on the *One-sentence Summary* data collection device.

Developing Empathy For All Forms Of Life

The fifth and final key practice of ecoliteracy is *developing empathy for all forms of life*. This ideal summarizes *why* the four other practices influence perceptions of natural resource stewardship and are a research focal point. Initial classroom discussions invoked memories of viewing pictures near crude oil spills, reading horrific animal abuse cases on social media, and seeing graphic images of highly toxic environments. Early in the treatment, students did not realize "invisible" pollutants were as responsible for environmental contamination as those creating marketable photographs. Dead Canada goose, including those in our local Silver Valley "killing fields," instantly caused empathic reactions. However, the task of deciding which species has a higher ecological value than another was significantly more challenging.

One team in particular exemplified empathic stewardship. They selected a nearby wetland area as a focus location. This team researched the regional necessity for healthy wetlands, including as a breeding location, refuge for migratory birds, buffer zone for small stream flooding, and even researched wetlands' importance as natural air and water filtration systems.

Research on preservation efforts introduced these students to *Myocastor coypus*, or "Nutria," an Inland Northwest invasive species. Although originally brought from South America for pelt production, nutria are classified as a "Prohibited Aquatic Animal Species." By law, all species with this designation must not be returned to the wild, but euthanized.

After significant research on wetlands' importance to entire watersheds, learning about nutria-caused destruction raised concern and became the deciding factor in selecting an environmental engineering project. However, this team was conflicted about how to accomplish removal. Typical trapping and descriptions of how to efficiently euthanize an animal were rapidly dismissed. Poisoning methods were provided in various sources. This team quickly identified the complications of introducing pollutants to a wetland area, noting chemical toxins would be presented to all species and water sources, not simply the targeted nutria.

These students struggled with reconciliation there is no ideal solution. They adamantly wanted to ensure the entrapped animal would not be caged for a length of time during which it could become dehydrated, hypothermic, injure itself from fear or stress, or, due to the nutria's high reproductive rate, leave newborn pups to starve. They designed a modification for commercially available, live-trap wire cages (Figure 23). Their prototype solution included various features indicating environmental concern and familiarity with the specific invasive organism. The trigger required 10 to 20 pounds of pressure, the typical weight of an adult nutria, to close the cage door. If an animal entered the trap, blinking lights would alert the user since the species is most active at dusk. These adaptations would verify a humane death rather than extended suffering. They wrote in the final presentation of their environmental engineering project:

> [Knowing] nutria are harmful to the environment we know that it is in the best interest for people in the area to deal with the problem. Connecting our prior research to things we know now, there is a better understanding of why some states have just put a bounty on the nutria to incentivize people to lower the population. Although we do believe that it would be best to not have kill the animal it would also be the best decision for the area, especially before the problem spreads more.

By being able to go through the process finding the best way, we still believe that traps would be a good option for both the humans and the environment.

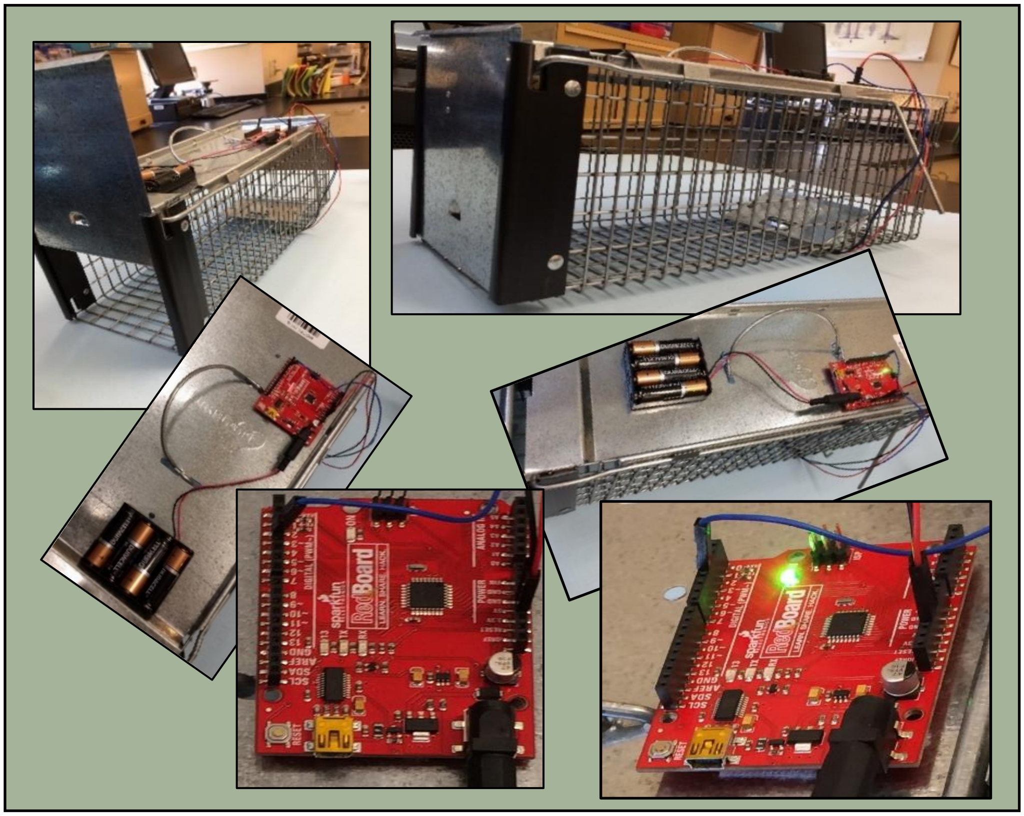


Figure 23. Ecoliteracy practice *Developing Empathy For All Forms Of Life* environmental engineering prototype and presentation on the invasive species, nutria.

INTERPRETATION AND CONCLUSION

"The more slowly trees grow at first, the sounder they are at the core, and I think the same is true of human beings.

(Henry David Thoreau)

Typifying scientific inquiry, additional answers gave rise to additional questions. Themes aligned with key practices of ecoliteracy provided complementary evaluation of the classroom research question as well as the designed sub-questions. Final data interpretation was organized under individual research questions.

Engineering and Stewardship

How does the use of place-based environmental engineering challenges influence student perceptions of stewardship for natural resources?

Student perceptions of stewardship did improve, as evidenced by both quantitative and qualitative data. Multiple data collection devices and measurements suggested the same results indicated in student responses and in teacher observations. Beyond quantifiable statistics, students appeared to fluctuate between pride in personal solution design ability and frustration with prototypes not appearing as aesthetically pleasing as commercially produced items. This common characteristic was dually noted outside of treatment activities and beyond the classroom. The student test group showed similar tendencies in other arenas, such as sports and artistic endeavors. Comparisons to “hacks,” seen on various social media outlets, appeared to have reduced the conflict of pride versus frustration.

Student-designed engineering projects provided an opportunity for engagement and ownership. While the project included competitive elements, this feature was rarely a point of student discussion or questioning. Disregard of point-value alignment during the research, design, and development stages suggested increased fundamental value was granted to natural resource stewardship.

Residential Resources and Ecological Awareness

What is the impact of using residential resources in supporting students' perceived value of ecological awareness?

The Colorado River was used as a preliminary water resource case study. Students exhibited mild interest and concern but became increasingly alarmed as the same principles were shown within our local watershed. Comparison to the Spokane River, which is located only six blocks from the school's front door, initiated more questions and analysis than created by the non-local case study. Integrating Lake Coeur d'Alene and the SVRP aquifer furthered student inquiry and investigation into local water resources. Early-treatment field trips likely contributed to a vested interest, increased attention, and consequential ecological awareness.

Soil resource concern did not increase at the same rate observed for water quality and management. However, student perception of value changed following the prescribed treatment period. Observed early spring mass wasting events, such landslides and mudslides, re-ignited soil resources conversation. Importance of consistent soil moisture levels and overall soil health analysis received more student attention after the data collection period had ended. Students appeared to have had a delayed realization of the strong correlation between water and soil. This connection's timing further supports the impact of using residential environmental resources for perceived significance.

Localized Content and Student Attitudes

How will incorporating localized water and soil science content and concepts affect student attitudes toward environmental responsibility?

Awareness of local ecological concerns strongly aligned to more frequently observed pro-environment behaviors, suggesting increased responsibility. Using the design, development, and display of student projects as indicators, teams became more invested when their prototypes' benefits were directly applied to Inland Northwest locations. Progress on team projects further increased specialized research and awareness, particularly as applied to details and finer points of regional application. This key aspect was especially apparent as teams presented their research to classmates and families.

Computer Technology and Human-centered Design

Does the integration of computer technology and human-centered engineering projects support socio-scientific issues of preserving the health of natural resources?

Counter to initial predictions, integrating computer technology had a negative effect on student perceptions of natural resource health preservation. Although students typically displayed comfort in using highly technical devices and applications, confidence in creating the coding for integrating sensors did not support increased environmental value or responsibility. Computer technology integration was a deterrent for student participation and interest.

In contrast, human-centered design did support socio-scientific issues related to environmental conditions. Connections to family and community were a strong driver in interest and value placed on the research and design components inherently necessary for an environmental engineering project. Classmates' interest in identified problems and solution prototypes likely promoted teams' own perceived importance of natural resource health preservation.

VALUE

Do we teach biology, chemistry, physics, mathematics, [geology, and engineering] or do we teach young people to cope with their own world?

(Fourez, n.d.)

Using emotional attachments to local hydrologic and geologic features, natural resource information, and hands-on engineering activities, students designed solutions to local environmental quality concerns. Social connections encouraged the importance of their ideas and provided an opportunity to make positive community changes. Together, these supported students' perceived value of ecological stewardship.

On-going, extensive investigation and theoretical framework continued to provide new exploration avenues and innovative inquiries. Professional research and explanations channeled students' interest-guided, small-scale modeling and solutions. New conceptions in socio-scientific issues and technological subjects integrated as examination continued. Combining these into my students' classroom experience perhaps inspired the next generation of limnologists, naturalists, soil scientists, ecology scholars, sustainability specialists, conservation engineers, and environmental educators.

My classroom research supports the instructional benefits of three-dimensional science. Described within NGSS, each identified component holds equal importance for cohesive science understanding. Crosscutting Concepts (CCs), Science and Engineering Practices (SEPs), and Disciplinary Core Ideas (DCIs) highlight science as a way of knowing and understanding, rather than as a collection of data or facts. Whether alongside a stream in a national park or at the base of school's solitary tree, the CC-SEP-DCI connections imbed easily within a locally designed environmental education project (Appendix G).

Science content continues to be segmented as physical science, life science, Earth and space science, and engineering. The divisions may assist with student scheduling, but it does beg the question as how these partitions create gaps in overall science understanding. “Scientific literacy is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity," as described the United States National Center for Education Statistics. General scientific literacy can be further examined as ecological literacy. Through environmental education, students gain scientific knowledge, engineering design skills, and stewardship values, each vital for addressing urgent social and sustainability challenges. If our goals include an empowered, ecologically literate society, could environmental engineering projects be key?

Recombining science disciplines furthers conversations of incorporating other academic areas. I will be teaching a different course next year, transitioning from ninth to tenth grade students. Lately, I have been working with a fellow science department member and a tenth grade English/ Language Arts (ELA) teacher to evaluate the possibility of cross-curricular instruction.

As an introduction to this proposed inter-disciplinary approach, the ELA teacher and I are reading Richard Louv’s other books over the summer, plus various other outdoor education and ecoliteracy publications. My preparations will also include increasing familiarity with the tenth grade ELA content and learning targets. “SpringBoard” is the published curriculum currently used at Lewis and Clark High School. Instructional sections include the empowering "Dramatic Justice" unit, which leads into "Building Cultural Bridges."

The latter unit's readings are posed to support addressing socio-scientific issues within our local region. The foundational article, published by the Humane Society of the United States (HSUS), exemplifies the viability of integrating the ELA department's "Building Cultural Bridges" unit into my upcoming course's environmental education directive. This article, "The HSUS and Wild Fish Conservancy File Suit to Stop Sea Lion Killing at Bonneville Dam," is the students' introduction to a local socio-scientific debate. The Bonneville Dam, located only a few hours from Spokane, continues as a source of division for conservation efforts. The text includes auxiliary salmon migration data, watershed interaction documentation, urban development issues, habitat encroachment commentary, river damming complications, invasive species predation statistics, and information on salmon population recovery. Published responses from a variety of groups and from a range of standpoints further encourages student consideration of stewardship's innate challenges. Finally, the SpringBoard program's imbedded assessment, "Presenting a Solution to an Environmental Conflict," provides opportunities for designing and developing a remediation plan, essentially creating a "verbal" environmental engineering project.

Our team recently selected "Solving Economic Inequalities" as the pilot topic in coordinating project-based, locally focused, socially implicative, cross-curricular learning opportunities for our students. This integration directly supports an educated population, including each of the language, social, and scientific uses of the term "literate." Citizen literacy is an indicator of a country's success and a provision for social equality. Ecological literacy not only enhances socio-scientific ties to the local natural environment, but also allows science to become a tool for students and their community.

Utilization of science as a tool is not limited to student populations. Overwhelmingly, I have been distracted from the art of teaching. Union contract discussions, district-wide directives, NGSS curriculum adaptations combined with the ever-increasing needs and numbers of students in trauma continue requiring deserved time and attention. Social issues, mental health concerns, physical safety, and the pressure placed upon our kids continue mounting the stress that we, as trusted adults, must address.

However, the description of science as a tool also relates to individual applications. Mirroring the way I push my students' thinking by repeatedly asking, "But, why?" in response to their answers, I have also been questioning myself. Throughout my classroom research project, I have pondered my personal and professional "why." Why do I want to continue teaching? Why do I want to teach science? Why is all of this so vital? Why do I feel such a sense of urgency?

I do not believe my research and results have altered how I describe myself or drastically changed me as a teacher. Rather, this experience has helped me return to the original trailhead from where I commenced my journey. This beginning comprises not simply my role as a science instructor, teacher researcher, or "green" citizen, but as a caregiver. This includes stewardship of my students and our community, plus the natural resources upon which we rely. Further, this desire extends to supporting education and care for the environment not only to students in my assigned classes, but to those with whom they interact as well.

I began "Problem Identification" with three words: apathy, dis-engagement, and indifference. I will close with only two: empowerment and ecoliteracy. I am hopeful my students will continue working to improve our environment's health and our community's wellbeing. Yet, empowerment and ecoliteracy apply to my teaching practices and to myself as well. Continued investigation of published studies, coupled with my own classroom research, have intensified the significance of advocating for place-based, outdoor environmental, integrated curriculum, real-world learning opportunities. Following the sentiment of Fourez, I am not simply teaching science, but, rather, I am teaching stewardship.

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APPENDICES

APPENDIX A

CONCEPT/ CONTENT FORMATIVE ASSESSMENT

Thank you for participating in this formative assessment. Consider this a non-graded check of what you know already and what you are still learning. No grades for this, but please read carefully and answer honestly. Remember, just because you may not be able to do these things today does not mean you will not be able to do so soon.

1 - Nope **2 - Not likely** **3 -"Sort of" or maybe** **4 - Probably** **5 - For sure, yes**

1. I can tell if the water I am drinking is safe for human consumption ("potable").
2. Not including dangers such as undertows, rocks, and other objects hidden under the surface, I know if the water in a nearby lake or river is safe to swim in, eat fish from, etc.
3. I can thoroughly explain the properties of water to a younger student, including density, crystallization, etc.
4. I can thoroughly explain geology ideas such as porosity, permeability, etc. to a younger student.
5. I can thoroughly explain the geology ideas of erosion and deposition to a younger student, as well as describe solutions for these issues.
6. I can thoroughly explain the hydrology ideas of point and non-point source pollution to a younger student, as well as describe solutions for these issues.
7. I learned about water resources, water quality, and water quality testing in my science class.
8. I learned about water resources, water quality, and water quality testing outside of my science class.
9. If given the appropriate tools, I could accurately perform a ground surface test for too much or too little water.
10. If given the appropriate tools, I could accurately perform a water quality test for chemical pollutants.
11. If given the appropriate tools, I could accurately perform a water quality test for non-chemical pollutants.
12. With the right equipment, I could code a sensor to alert for too much or too little water.
13. With the right equipment, I could code a sensor to alert for chemical pollution.
14. With the right equipment, I could code a sensor to alert for non-chemical pollution.
15. I can describe the benefits of clean water for my community (human usage).
16. I can describe the ecological benefits of clean water (out in nature).
17. I can explain the dangers of too much/ too little water for the human population.
18. I can explain the dangers of too much/ too little water for the food chain.
19. I can explain the dangers of polluted/ contaminated water for the human population.
20. I can explain the dangers of polluted/ contaminated water in the food chain.
21. I can explain the dangers of water-related issues on a small scale or local region.

22. I can explain the dangers of water-related issues on a large scale, such as within or on the shoreline of an ocean.
23. I could explain to a community member how an aquifer works.
24. I could explain to a community member special features of how our local aquifer works.
25. I could explain to a younger student happens to the water we drain down the sink or flush down the toilet.
26. I could explain to an incoming science student what happens to storm water in our area.
27. Besides a general description of the water cycle, I can describe from where the water in Lake Coeur d'Alene originates and to where it flows.
28. Besides a general description of the water cycle, I can describe from where the water in the Spokane River originates and to where it flows.
29. Besides a general description of the water cycle, I can describe from where the water in the Spokane Valley-Rathdrum Prairie originates and to where it flows.
30. Besides a general description of the water cycle, I can describe the interconnectedness of our local water systems.
31. I am aware of historic water quality issues in our local waterways.
32. I am aware of current water quality issues within our local waterways.
33. If I personally caused pollution or contamination of a lake or river, such as physical garbage, "trash," etc., I know how to clean it up.
34. If I personally caused pollution or contamination of a lake or river, such as gasoline, fertilizer, or other chemicals, I know how to clean it up.
35. If I personally caused pollution or contamination of a lake or river, I would clean it up.
36. I could explain to a classmate how the geology or rocks in an area can affect how water moves.
37. I could explain to a classmate how the geology or rocks in an area can affect how water acts.
38. I could explain to a classmate how the geology or rocks in our area were affected by floods during the Ice Age.
39. I could explain to a classmate how the water in soil affects plant growth.
40. I could explain to a classmate how the water affects plant growth when the plant is not grown in soil.
41. I could explain to a classmate how plant growth may affect soil.
42. I could explain to a classmate how plant growth may affect water.
43. I could explain to a community member a few ways to help improve water quality in our area.
44. I could explain to a community member a few ways to help solve issues or damage caused by too much and too little water in our area.
45. I could explain to a community member a few ways to help conserve water in our area.

APPENDIX B

CARE-LEVEL SURVEY

I would like to make some comparisons throughout the year about your MESA project. This year's project is completely new, from the goal, the design and build, to how the competition will run. This is just for you and me. Please read each question carefully and think about how strongly you agree or disagree with the statement. If you have any thoughts about the topic, please add your thinking at the end of the survey. Thanks!

Totally Agree / Mostly Agree / Sort of Agree / Kind of Disagree / Mostly Disagree / Totally Disagree

1. I feel like I thoroughly understand the goal of this year's overall MESA project.
2. I feel like I thoroughly understand the goal of my personal MESA project.
3. I feel like I thoroughly understand the engineering and design (planning) part of my MESA project.
4. I feel like I thoroughly understand the construction and build (making the prototype) part of my MESA project.
5. I feel like I thoroughly understand the electrical ("bread board" and wiring) part of my MESA project.
6. I feel like I thoroughly understand the computer programming (Arduino) part of my MESA project.
7. I feel like I thoroughly understand the written paper part of my MESA project.
8. I feel like I thoroughly understand the presentation part of my MESA project.
9. I feel like I thoroughly understand the prototype part of my MESA project.
10. I feel like there is a clear connection between my MESA project and my class (biology).
11. I feel like there is a clear connection between my MESA project and my school.
12. I feel like there is a clear connection between my MESA project and my local community.
13. I feel like there is a clear connection between my MESA project and me and my life.
14. I feel like there is a clear connection between my MESA project and society.
15. I feel like there is a clear connection between my MESA project and the environment.
16. I feel like my MESA project could help other people.
17. I feel like my MESA project could help other communities.
18. I feel the provided resources (like the MESA notebooks and rubrics) will be helpful to my progress on the project.
19. I feel the Saturday Academies will be helpful to my progress on my project.
20. I feel like I will be able to organize the activities for my MESA project in a sensible way.
21. I feel like my MESA project will flow easily from one week to the next.

22. I feel like I know what I am supposed to be doing from one session to the next.

23. I feel like the classroom time reserved for my MESA project will be time well spent for my personal development.

24. I feel like the classroom time reserved for my MESA project will be time well spent for my academic development.

25. I feel like the classroom time reserved for my MESA project will be time well spent for my future goals.

26. I feel like the sensors I will be using on my MESA project will benefit my MESA project.

27. I feel like the computers and coding programs for the MESA project will benefit my MESA project.

28. I feel like the other technology (red boards/ breadboards/ wires) to I will use on the MESA project will benefit my MESA project.

29. I feel like the other, general materials I will use on the MESA project will benefit my MESA project.

Any last thoughts today about your MESA project?

Questions about your MESA project?

Make a list of things you think you will need to know.

APPENDIX C

INTEREST EVALUATION

Interest Evaluation

These questions are to help you start thinking about water. There are no right or wrong answers and your thoughtful responses cannot hurt your grade. The important thing is to consider what you know, how you feel, and how these questions apply to you. Everyone's answers will be different and this is a very good thing. I am not an answer machine for these, but feel free to ask me to clarify a question you do not understand.

1. How do you know if the water you are drinking is safe?
2. How do you know if the water in the lake or river nearby is safe to swim in? Eat fish from…. etc.?
3. Tell me what you may have already learned (in school or outside of school) about the properties of water.
4. Tell me what you may have already learned (in school or outside of school) about water quality and water quality testing.
5. What are some of the <u>indoor</u> benefits of having clean water or what are some uses of clean water?
6. What are some of the <u>outdoor</u> benefits of having clean water or what are some uses of clean water?
7. What would happen if the water used for these things was not clean/ safe?
8. Where does our drinking local water comes from naturally?
9. Where does our drinking local water come if you are using man-made objects?
10. What happens to the water we drain down the sink or flush down the toilet?
11. In our area, what are some problems that occur if too much water appears?
    a. Any ideas of how to fix that?
12. What about too little?
    a. Any ideas of how to fix that?
13. How might your answers for the last several questions be different depending upon whether it is winter, spring, summer, or fall?
14. Local water:
    a. Lake CDA – Where does this water come from? Where does it go?
    b. Spokane River - Where does this water come from? Where does it go?
    c. Spokane Valley-Rathdrum Prairie Aquifer - Where does this water come from? Where does it go?
    d. Little Spokane River Where does this water come from? Where does it go?
    e. Hangman Valley / Latah Creek - Where does this water come from? Where does it go?

f. What other bodies of water do you know about? Do you know where does this water come from and where it goes?

15. What do you know about the <u>history</u> of water quality safety in these systems or in our area?

16. Do you know about any <u>current</u> water quality issues with these waterways?

17. What are some "big" / industrial causes of pollution in CDA / Spokane area waterways?

18. Any ideas of how to solve these?

19. What are some "small" / recreational causes of pollution in CDA / Spokane area waterways?

20. Any suggestions of how to fix this?

21. If you personally caused pollution in a lake or river (gasoline, physical garbage, etc.), how could you fix it or clean it up?

22. Would you? Why? Why not?

23. Places
    a. What are some important places to you in the Inland Northwest? (This includes our part of Washington State, the Idaho "Panhandle," and along the western border on Montana.)

    b. What are some important places to you in Spokane/ CDA area?

    c. What are some important places to you in the city of Spokane?

    d. What are some important places to you in the neighborhood where you live?

    e. What are some important places to you in the buildings or sports fields of Lewis and Clark High School?

24. What other water-related things you were thinking about while working on this?

APPENDIX D

ONE-SENTENCE SUMMARY

Name: ____ Period: _____

One-Sentence Summary

A one-sentence summary takes a topic and asks you to create one sentence by taking small sentences and combining them into one that explains a major topic. For example:

Who?	***teachers***
Does what?	***assess***
To what or whom?	***their students' learning***
When?	***during the quarter***
Where?	***in their classrooms***
How?	***by using formal and informal assessments and assignments***
Why?	***so they can improve teaching effectiveness and the quality of student learning.***

In sentence form:

Teachers assess their students' learning regularly during the quarter in their classrooms, by using formal and informal assessments and assignments, so they can improve teaching effectiveness and the quality of student learning.

Chosen Topic:

____

(Environmental engineering idea, plan, prototype, and reason.)

Who?

____

Does what?

____

To what or whom?

____

When?

____

Where?

____

How?

____

Why?

____

In sentence form:

____

____

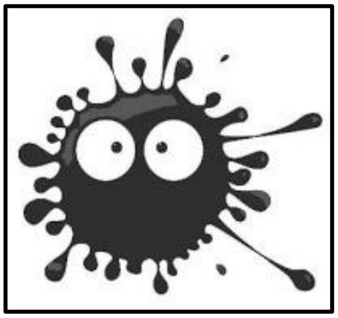
____

____

____

APPENDIX E

MUDDIEST POINT AND STICKIEST POINT CARDS



Muddiest Point

Topic: CDA Field Trip

Response: ______________________

____

____

____

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Name: ______________________________

Stickiest Point

Topic: CDA Field Trip

Response: ______________________

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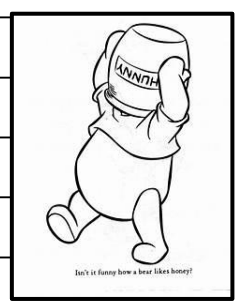

Name: ______________________________

APPENDIX F

INSTITUTIONAL REVIEW BOARD EXEMPTION

INSTITUTIONAL REVIEW BOARD

For the Protection of Human Subjects
FWA 00000165

MONTANA STATE UNIVERSITY

960 Technology Blvd. Room 127
c/o Microbiology & Immunology
Montana State University
Bozeman, MT 59718
Telephone: 406-994-6783
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Chair: Mark Quinn
406-994-4707
mquinn@montana.edu
Administrator:
Cheryl Johnson
406-994-4706
cherylj@montana.edu

MEMORANDUM

TO: Laureen Savage and Marcie Reuer

FROM: Mark Quinn *Mark Quinn CJ*
Chair, Institutional Review Board for the Protection of Human Subjects

DATE: November 8, 2017

RE: *"Engineering Stewardship for the Inland Northwest"* [LS110817-EX]

The above research, described in your submission of November 8, 2017, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

_X_ (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

_X_ (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

___ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

___ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

___ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

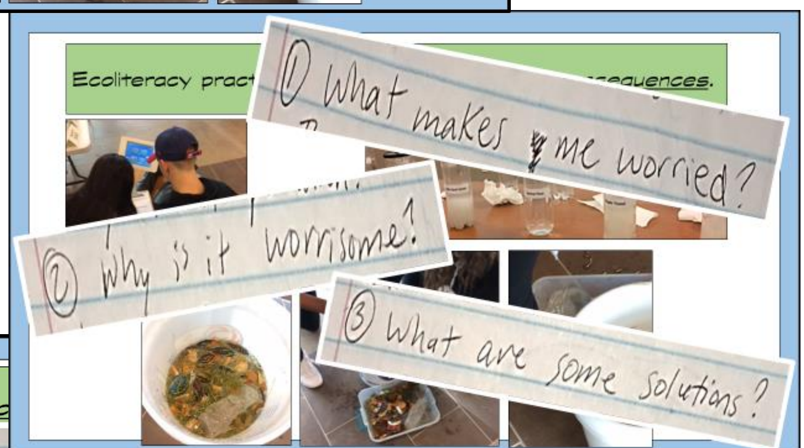
___ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

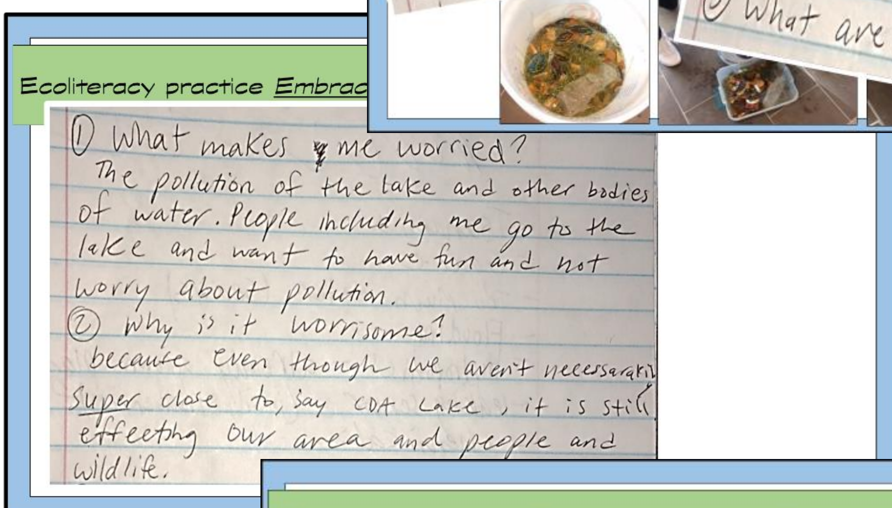
Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

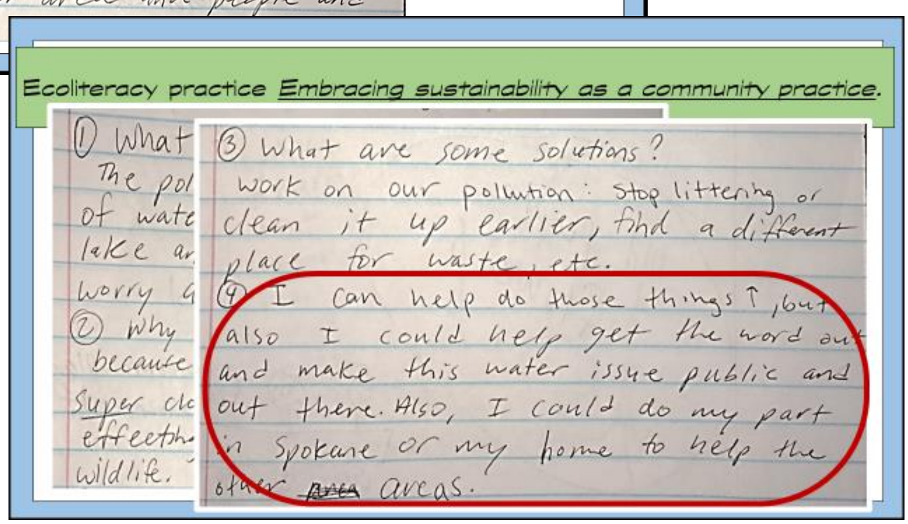
APPENDIX G

STUDENT PROJECT RESEARCH, DESIGN / DEVELOPMENT, AND PRESENTATION IMAGES


Ecoliteracy practice Anticipating unintended consequences.


Ecoliteracy pract
equences.
① What makes me worried?
② Why is it worrisome?
③ What are some solutions?


Ecoliteracy practice Embrac
① What makes me worried?
The pollution of the lake and other bodies
of water. People including me go to the
lake and want to have fun and not
worry about pollution.
② why is it worrisome?
because even though we aren't necessarily
Super close to, say CDA Lake, it is still
effecting our area and people and
wildlife.


Ecoliteracy practice Embracing sustainability as a community practice.
③ What are some solutions?
work on our pollution: Stop littering or
clean it up earlier, find a different
place for waste, etc.
④ I can help do those things ↑, but
also I could help get the word out
and make this water issue public and
out there. Also, I could do my part
in Spokane or my home to help the
other areas.

What words appeared in our responses?

Hi Laureen,

I love everything about this! Fabulous idea. I put it on my calendar and plan to be there.

Kudos,
Sarah

Subject: Special invitation MESA presentation night

Hi, everyone,

I have planned a practice presentation night for my MESA students as we prepare to head to competition. This is designed to give our kiddos a chance to practice discussing their research, prototypes, and projects. Talking to adults is still intimidating for many of my students and discussing something they have created is both exciting and scary. I think practicing this skill prior to presenting to judges will help combat nerves.

Parents and guardians are really enthusiastic to see the projects, especially since most have only seen small snippets of their students' overall environmental engineering creation. I would love to have a few "special guests" and extra important people within our MESA and school community attend the mini-event. We will be meeting on Wednesday, March 21st. Adults are invited to the gallery-style walk-through event from 7:30 to 8:30. I am still verifying the location, but we will be somewhere in the basement/ ground floor. There is also a choir concert the same night, so it is like a two-for-one event of the arts and sciences. Plus, we'll have cookies!

Thank you for considering this invitation. Feel free to invite other interested "special guests," as I am hoping this will become an annual event.

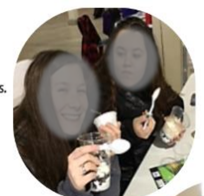
Hope to see you there.
-Laureen

Hi, everyone!

Thank you to everyone who responded. It only took a half stack of sticky notes to arrange the time and date. Adults, I am so glad you are excited about this opportunity. I think this will really help combat pre-presentation nerves.

The best date and time is this Wednesday, March 21st. Most likely, we will be in the basement library, but our activities director is verifying availability. If she discovers something needs to be held there that is not currently on the official calendar, we will keep the date and move to another location.

The schedule will be as follows:
7:00 - Students meet me to set up projects, open PowerPoints and posters, and discuss how gallery-style presentations work.
7:30 - Adults join us and begin viewing and discussing students' environmental engineering projects.
8:30 - Wrap up conversations and re-pack projects, poster boards, and computers.
8:45 - Leave to enjoy the rest of your evening. (Or go home and do homework...)



Important Notes for Students:
1. If your brother has a varsity basketball game that night, join us as soon as it wraps up.
2. I am not asking anyone to dress up. Wear whatever style helps you feel confident.
3. Drill team members, make sure to pack ahead of time so you can go right to bed afterwards.
4. If there is something about your project that is not quite done by Wednesday, please do not panic or stay up all night finishing it. This is a practice round. As long as everything is completed by the competition date, you are all good.
5. Yes, attendance is expected and participation is a huge part of your grade this quarter. If something unavoidable comes up, please have an adult email me. We will find another teacher or a vice principal to hear your presentation so you can earn your participation points and get credit.
6. I am really proud of you!!!!
7. You can despise me a little for making you do this, but just don't let the adults see it! ;)