

THE EFFECT OF PLACE-BASED EXPERIENCES ON SCIENCE IDENTITY, ATTITUDE,
AND ACHIEVEMENT IN A REMOTE LEARNING ADVANCED PLACEMENT
ENVIRONMENTAL SCIENCE CLASSROOM

by

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DEDICATION

This paper is dedicated to all the science teachers who have taught me, inspired me, and pushed me to do better, most notably John Mullenix, Patti Pattison, and Paul Verrell. John and Patti, you were my first experience with field science and I still use what I learned to this day. You both were my inspiration for this paper and my role models as an environmental science teacher. I will never forget my very first hike on Langille Ridge and water testing in the creek in Lewis county. Thank you for devoting your summer (and your career) to helping students realize their full potential – you have reached way more students than you taught! Paul, toxicology lives on! Who would have known that the project you helped me design at WSU would morph into this! Thanks for all your help throughout college and after – you are a true champion for first generation college students.

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ABSTRACT

Students in science courses are routinely consumers of science and are less often producers of scientific work. In this action research project, Advanced Placement Environmental Science students engaged in place-based lessons remotely while asynchronously developing authentic research projects that impacted their local ecosystems. This work was delivered to stakeholders within the community. Scientific questioning, graphing, and explanations, as well as surveys and interviews were used as data collection instruments throughout remote learning. The results suggested that place-based learning experiences helped students increase their skills in scientific questioning and explanations, their science identity, and their attitudes towards science. Students' sense of place was minimally changed. Results indicate the need for place-based and hands-on learning to increase students' attitude, aptitude, and identity, especially during stressful pandemic remote learning situations.

INTRODUCTION AND BACKGROUND

Context of the Study

My strongest memory of science happened in the summer between my seventh and eighth grade year. Instead of babysitting or working behind the counter at my parents' hardware store in rural Washington, I was part of a program that would get me outside to do science. I did not quite know what that meant when I first started, but I knew I liked the outdoors, even though I did not get to be outside very frequently. The program was through a local community college and targeted students who were low-income and/or first-generation college-bound students who were interested in science fields. The course had us inside for an hour a day to receive instruction and then outside the rest of the day. This two-week program had such an impact on me that I returned the following summer. During this time, I learned how to take water samples, sample macroinvertebrates, write a hypothesis, collect data, and keep a field journal. I also learned outdoor skills for the first time, like identifying plants and pressing them, determining how much water to carry on an overnight hike, and setting up a tent. I learned to persevere when things got tough and most importantly to my future, I learned to love outdoor environmental education.

My love of this program led me to become a science educator. Today, I teach at Bremerton High School in Bremerton, Washington. Bremerton is a small city (population 41,405) an hour away from Seattle via ferry. Because of this, we have an urban feel, surrounded by suburban and rural communities. Bremerton's biggest employer is Puget Sound Naval Shipyard, and there is also a large population employed by Naval Base -

Kitsap. Many families have some connection to one or both of these employers. The median family income in Bremerton is \$52,716. The living expenses for Bremerton, as a suburb, are higher than one would expect, based on the interaction and ease of travel to and from the metropolitan area of Seattle. The five largest racial groups represented in Bremerton are white (68%), Hispanic or Latinx (11%), two or more races (9%), Black (6%), and Asian (6%). The city itself is compact (28.5 square miles), but it is surrounded by the marine waterways of Puget Sound and Hood Canal, as well as protected forested areas (United States Census Bureau, 2019).

Bremerton High School is a traditional 9-12th grade public school with a population of approximately 1100 students. The students that I work with are a lot like the population of students that were in my own childhood summer scientist program. Sixty-two percent of students at the high school I serve are free or reduced lunch (OSPI, 2019) and many that are interested in college will be the first in their families to attend.

In the 2020 – 2021 academic year, my teaching assignment consisted of teaching Advanced Placement Environmental Science. I was responsible for bringing this course to our school 11 years ago and have taught it since that point. This course is open to ninth through twelfth grade students, so students come with a wide background of science experiences. Our district is committed to removing barriers for students, so this course is open enrollment. It is recommended that the students complete Algebra prior to joining the course, but it is not required. This means a student can opt into the class without being in any prior honors or Advanced Placement track. This is a great way to expose more students to rigorous science content, but also makes the class vary greatly from one

year to the next. The course usually is freshmen-heavy, since they can opt to take the course as a replacement for the on-level freshmen science class.

I see a disconnect between my students and the natural world. Some of this comes up with activities or assignments and it creates a teachable moment that is a quick misconception to fix, such as what types of trees live in this area, why it is so rainy here, and why certain animals can live in marine versus freshwater (and some both!). Much of the questions and misconceptions students have relate to their sense of place. When I teach, I try to pull in as many examples as possible from our local community, so they have a way to connect what they are learning to the place that they live. Some of the most successful lessons in my class involve me bringing in the outside local world to our classroom: raising “mystery” tadpoles from my pond in the classroom, using lichens from my house to discuss succession, and observing decomposers in the compost we have started in the classroom. Many students only experience outdoor education during their fifth-grade year when they do a one-week residential camp. When students get to me at the ninth-grade level, they all remember the fun and the science they learned at their fifth-grade retreat and want to be counselors for the group that would be going that year. In prior years, I have taken students to do overnight camps through Mount Rainier Institute and at Olympic Park Institute, now known as NatureBridge. The years I am able to implement this type of program always seem like the best years in terms of student participation and attitude about science. However, because these locations are some distance away, these programs cost a lot since we have to pay for transportation. Other years I have implemented trips to a local nature preserve. This is a lot more frugal in

terms of travel costs, plus it is a place that the students do not know about but is within their community. In addition, we can maximize our time on site since it is so close. However, these sites do not include trained outdoor environmental educators. One year the students were able to work with undergraduate ecology student researchers from University of Washington - Tacoma to set up and run some field studies, which really helped students see fieldwork in action.

Since I know that connecting students to their local outdoors creates memorable moments for my students, and memorable moments connect to learning moments, place-based experiences and outdoor education are vital to help students be successful in science, especially those who may not have access to these opportunities, such as low-income families. Place-based education in science teaching and learning is a pedagogy that involves the student's location in conjunction with their content learning. This type of teaching can be especially important for members of communities that are traditionally underrepresented in science fields, which include many of the students I serve daily.

Focus Statement/Question

In my past Advanced Placement Environmental Science classes, I observed that outdoor education and fieldwork is crucial to science inquiry, but students do not come to the high school with extensive experience in doing so. COVID-19 and remote learning for this school year exacerbated this issue and removed the possibility of doing a field trip. These concerns led me to find alternative ways to still help immerse students in this critical skill. My focus question was, how do place-based learning experiences utilizing

natural resources in our local region support scientific engagement and achievement in the Advanced Placement Environmental Science classroom?

My sub-questions include the following:

1. How do place-based learning experiences impact students' ability to generate scientifically oriented questions?
2. How do place-based learning experiences impact students' ability to formulate evidence-based explanations?
3. How do place-based learning experiences impact students' science identity?
4. How do place-based learning experiences impact students' sense of place?
5. What effect does remote learning have on students' attitudes about place-based learning experiences?

If place-based education increases students' science attitudes and abilities, then it is a pedagogy that should be implemented in every science class as much as possible.

This would be especially important in schools that serve students from low-income regions, where outdoor educational opportunities may not be the norm for family enrichment. Outdoor and place-based education could be a way for schools to help narrow the achievement gap, which is usually not because of achievement *per se*. By giving low-income students some of the same experiences as their middle- and high-income peers, the opportunity gap is narrowed. Place-based education could be seen as one such opportunity.

CONCEPTUAL FRAMEWORK

Place-based and hands-on education has its roots in the very beginnings of learning. Before entering formal education, children learn about their surroundings by observing situations around them and responding. Likewise, education around the world started with the need to teach offspring how to interact with their environment and each other in order to survive. Education in our current times has become more and more removed from these beginnings and sense of place, inquiry, and attitudes about science, as well as connections with the community, suffer when this type of learning is not in place.

Rationale & Implementation

In order to truly understand the power of a place-based education, we first have to think about what a place is. A place can be defined as a location, either real or imaginary, that is saturated with meaning; this meaning could be culturally, ecologically, historically, or recreationally important to the people who value this place (Semken, 2020). Our brains categorize places in order to make sense of our local communities and the world. These places could be a natural landscape (such as Mount Rainier) or it could be a cultural landscape (such as a building or park that is not natural). The connection to a place is usually intellectual or emotionally based. Human beings' sense of place is then "the set of all meanings and attachments held by an individual or group for any given place" (Brandenburg & Carroll, 1995).

Place-based education and outdoor education are not easy to get started in science classrooms at any level. They involve a lot of connections with the community as well as adequate funding to make these experiences happen consistently. In addition, educators need to learn a new way of teaching their curriculum and that takes time that is hard to find (Powers, 2004). With the shift to the Next Generation Science Standards (NGSS) in 2013, the focus on only content and vocabulary is gone, replaced by the application and critical thinking within science (NGSS Lead States, 2013). Likewise, with the new Advanced Placement Environmental Science practices rolled out from College Board in 2019, students are required “to spend a minimum of twenty-five percent of their instructional time on hands-on, inquiry-based laboratory and/or fieldwork investigations” (College Board, 2019). Both of these sets of standards that govern the Advanced Placement Environmental Science classroom point to getting students outside to really stretch and strengthen their scientific abilities.

According to Semken et al. (2017), there are five main design elements when it comes to place-based education (Figure 1). Science educators must include all five of the elements when designing effective place-based education, as opposed to the more traditional approach of using only science content.



Figure 1. Five main design elements to place-based education and photos of author's past environmental classes (Semken et al., 2017).

Content should tie in with the natural attributes of the specific place of study. This may mean teaching content out of order from the textbook or standards, but the content would have relevance for the students learning it. Students should be given time and space in the place to form their own emotional or intellectual connections to the specific place. This could be seen as scientific research, nature journaling, or even meditation. They should be allowed to determine if this place is important and carries meaning for them.

Authentic experiences should drive the teaching in the specific place. These experiences could be in-person but could also be virtual. Cultural connections and attributes about a place should be integrated and celebrated. This not only values students from various backgrounds, but also educates students and gives context and relevance. Finally, ecological, environmental, and cultural resiliency should be specifically noted as well as sustainable practices that protect the place of study for all to enjoy. For example, this could be shown by discussing the necessity of wildfire in a community, connecting the

cultural importance of wildfire to the local indigenous people, and looking at how an ecological community goes through secondary succession after a fire. By connecting these pieces, it shows the importance of sustainability of the place of study for both nature but also for humankind.

Inquiry Opportunities

In science classrooms, inquiry is the practice in which students drive the learning through questions and wonderings. Usually such inquiry-based units are framed around a phenomenon or a problem. Many science classrooms use inquiry as a driver for learning content, however this inquiry is almost always extremely scaffolded or guided.

According to Coulter (2014), there is a process of scaffolding for inquiry where each level decreases some guidance from the teacher and instead relies more and more on the student. This starts with manipulation by the teacher, which is where a teacher directs a student to do an assignment for a grade and usually involves regurgitation of content without a connection to any explanation. In the mid-levels of inquiry, the teacher is the scientist in charge, while the students are more like the assistants, gathering data and material, waiting to be told why it is relevant. At the highest levels of inquiry, we have the students initiating the project, whether it is a directed assignment or a spontaneous assignment. These projects rely the most on students to make the connections to the relevance of the science for their community. When done correctly and with minimal guidance, inquiry increases a student's science literacy, which can lead to conceptual change (Chamberlain & Crane, 2009). With place-based education, students can practice their inquiry skills to identify problems that can be researched and that are important to

them. Not surprisingly, the more that students are personally involved in inquiry, the more impactful the experience on their science learning. Students who practice inquiry show large gains in scientific literacy, research, and science confidence (Gormally et al., 2009). In place-based education setting, teachers are more like instructional coaches, collaborating with the students how to utilize different pieces of equipment to answer specific questions, rather than telling the students how to make a question that fits a specific piece of equipment.

Research service learning, a type of hands-on and place-based education, can also be utilized. Reynolds and Ahern-Dodson (2010) discuss the process, merits, and drawbacks of Research Service-Learning (RSL), which could be coupled with place-based education. RSL has students working in partnership with local community groups, but connects this service learning to the content being learned in the classroom. For example, students would be learning about biodiversity in the classroom, would then help a local park document invasive species in the park, and then use this task to “learn basic research skills such as conducting literature reviews, identifying research questions, [and] taking field notes...” Students would be responsible for producing products for their intended audience, such as community members or other stakeholders. By doing RSL in courses, students are more active learners rather than passive participators, they are required to strengthen their knowledge about the science content, and they are challenged to connect their content knowledge to real-world situations in their own communities. Every student will be applying their knowledge, generating questions, collecting and analyzing data, and drawing conclusions. In this action research project, the students

participated in research service learning which required them to hone the above-mentioned skills. This also had the added benefit of sharing their work with our community stakeholders.

Community Connection

This idea of place-based education is not solely a Western construct, it is also being practiced in countries all over the world. Lee and Chiang (2016) looked at place-based education of Taiwanese students, especially since many of these students are marginalized when using the typical Westernized textbooks. They looked at many indicators, including the sense of place survey. Their argument was that if the students were studying more place-based concepts, the students themselves would be more connected to their communities. They also found that the student's gender and race did not have an impact on the student's levels of sense of place, the only difference between students with a high score and those with a lower score were those students who had place-based education. Semken and Freeman (2008) had similar findings in the United States when looking at place-based education increasing a student's sense of place and deep attachment to a community. Likewise, Reynolds and Ahern-Dodson (2010) found that students who completed a community-based research service-learning outdoor education program had more of a community bond and the students were able to have an impact on locations that they may not otherwise. Students were offered paid and unpaid internship positions with their community connections only based on their research service learning and outdoor education.

In our community, there are many opportunities for place-based education, especially in the environmental science field. However, these opportunities are not fully developed for secondary students and most focus on elementary students. Even if an elementary student feels a sense of place or connection to their community, that does not necessarily transfer throughout their secondary schooling years when they may be making decisions about career choices. Any chance to develop connections between secondary students and the community will lead to the student making more positive environmental choices and will hopefully be a good investment for the future of our environmental community. Place-based education invites students to become active citizens and local environmental stewards and gives students power to help positively influence change (Coulter, 2014). Our relationship to place influences how we “interrogate places, learn from them, understand them, and teach in and about them” (Semken, 2020), so if we want our community to be better, we need to do better with our connections to the students.

Science Identities and Equity

Youth in urban and low-income areas face numerous educational disadvantages, especially including inequities in science education. Giving students the opportunity to learn science within their local communities can be seen as a form of social justice and thus removing this opportunity is inequitable. While there are studies and programs that show great academic gains with summer and weekend camps (Leonard et al., 2016), it is also important to use this action research in the traditional classroom. Inequity is amplified among high school students, relative to elementary students, and access to

place-based and field science education. This can even be driven by unspoken social norms where females, especially those of color, are not seen as fit to take Advanced Placement science courses according to traditional and outdated roles. Cannon and Carr (2020) argue that place-based education not only allows students to see themselves as scientists and owners of the information they are consuming and creating, but students that would normally be left on the sidelines are cognitively diverse and have unique ways of thinking about scientific problems. By making the problems meaningful to the students, students who may have been disadvantaged in the past become more powerful.

The research article by DeFelice et al. (2014), is the publication most aligned with my own action research plan. It studied the impact of place-based outdoor education on students in New York City who had limited outdoor experiences. The target population of this study was students who come from populations underrepresented in science, technology, engineering, and math (STEM) careers, such as students of color and of low socioeconomic status. The students joined an enrichment program that was outside of school hours. In this program, the students worked with local scientists for a week in a community park to discuss environmental issues, and complete authentic research projects. The researchers found positive correlations between place-based education experiences and performance and attitudes around learning science outdoors. This article discusses some ways to collect data that I will want to emulate in my own work, such as student journaling, especially asking students to finish the prompt, “Today I felt like a scientist when...”

A newer idea in the field of science education is that of science identity, and it seems to be researched with a hodgepodge of different approaches instead of one streamlined way. Because of this, there seems to be many accepted ways to do this data collection. Vincent-Ruz and Schunn (2018) attempt to quantitatively research science identity in 7th grade and 9th grade, and more specifically, to see if it can predict science choices overall. They were also looking to see if gender and race/ethnicity plays into the science identity of students. The researchers did a survey of students in a longitudinal study, keeping track of gender and race/ethnicity breakdown with the answers provided. They did not see a separation of science identity factors from boys to girls, or along racial lines. However, one of the biggest indicators of if a student continued into sciences later in life was the student's sense of science identity. The researchers contend that the time from 7th to 9th grade is crucial in building girls' science identity. Therefore, girls with a strong connection to science through place-based learning in secondary school should be more likely to continue in science courses throughout their formal education.

A formidable concern for science educators is how to determine the efficacy of field experiences for all students, as it should be since many of these experiences also have a significant cost and take students out of their other classrooms. There are two related concepts to assess for field experiences. One, how does it promote science achievement and inquiry, and two, how do these field experiences and hands-on work promote science identity and well-being for students? Both are equally as important and together, lead to competent and passionate scientists. While the Next Generation Science Standards (NGSS) do not condemn place-based education and field experiences, there is

not explicit promotion of them either. Semken and García (2021) found that “learning by observation in the surroundings was found to be especially scarce in the middle-school and high-school grade bands and strangely wholly absent from [performance expectations] for studies of ecosystems and anthropogenic impacts on ecosystems”. This could lead to science educators undervaluing the impact of place-based education and field experiences in favor of easier and more economical choices. On the other hand, if educators feel empowered to design their own curriculum or framework for their courses, many elements of place-based education can be embedded within the existing standards.

Most field experiences use student surveys to determine if a field experience was effective in increasing science identity (Cannon & Carr, 2020; DeFelice et al., 2014; Leonard et al., 2016), as science identity is not a concept a student can express in an assessment format. These student surveys can also take the format of journals, which also build students’ inquiry skills through observations and sense-making (Laws & Lygren, 2020). However, it is much simpler for educators to quantify gains made in scientific reasoning and processing if students are given a similar situation or set of data to see if they are able to analyze it effectively. This can be difficult to do while in the field, but can be approximated through the use of Data Nuggets, which are data sets from real field scientists. These assessments have been used as pre- and post-assessments for in-classroom units about the nature of science (Schultheis & Kjølvik, 2015), but lend themselves to this situation as well. For the Data Nuggets, there is a common rubric so that the results can be compared one against another. These data sets force students to realize that science is messy and the process will not always conform to expectations. In

addition, the use of authentic data in the classroom has been shown to help students analyze data more deeply, as well as promote trust in science and show how the process of science is not a straightforward process (Schultheis & Kjelvik, 2020).

Equity is very important to me and a focus of most of my educational research as a teacher. As a course for upperclassmen, Advanced Placement Environmental Science attracted equal amounts of males and females. However, as a course for honors-level freshmen, it has more females, but they are split on the question of whether they feel represented in science. This is especially true for my students of color. Another issue is that the free-reduced lunch percentage of the course is much higher in our school than in my class as a sample. This is an issue of concern. I hope that by incorporating more of a focus on authentic placed-based education, it will help students understand the cultural as well as scientific relevance of the course and increase the diversity of students taking the course.

METHODOLOGY

Demographics

The demographics of my course during the 2020-21 treatment period were very similar to previous years. There were 21 students in my section, all freshmen. For second semester, there were 19 students. Their previous science experience was eighth grade science. They only had about 6 months in person, and four months of remote learning during the 2019-20 school year. All students spoke English, but 15% ($n=3$) spoke an additional language at home (Spanish, Tagalog). A majority of my students considered themselves White (67%), followed by 19% identifying as Asian or Pacific Islander, two students declining to answer, and one student identifying as Latinx. Fifty-five percent of the students are first-generation college bound students, as 100% said they are headed to college after high school. Females dominated the class, at 75% of the population, followed by 20% of the class male and 5% nonbinary. Only one student reported having taken a science class that got them outside prior to this course, and only 30% reported taking a class in the past that focused on the local environment. This course had a 38% free or reduced lunch rate, which connects to the socioeconomic status of the students. These demographics are similar to most of the Advanced Placement courses at Bremerton High School. However, our school's demographics are different from this population of students, with a population at a 60% free and reduced lunch rate and slightly over half of the population is male. Ethnicity make-up of this class mirrored that of the larger school population.

The 2020-21 school year was projected to be in person but was changed to an entirely remote format in August 2020 for a start in September. Due to continued COVID-19 cases in our county, we stayed fully remote until the start of April 2021. All students had access to Chromebook computers at a rate of one-to-one; our district made that shift in September 2019. Students without access to internet were provided hotspots provided by the district. While remote, courses were held synchronously two days a week for 45 minutes over Google Meet, with additional asynchronous work assigned to total up to 5 hours a week per class. Throughout this time, students had to balance their own schedule of work and family life, and many students struggled with being distracted by other temptations (cell phones and video games) or responsibilities (babysitting, chores, or assisting younger siblings with online work). In addition, as a school we learned that most of our students were dependent learners instead of independent learners, which added to the difficulty of doing remote teaching. My district chose a hybrid plan for reopening, which meant that students had the option of staying fully remote or having one of their class sessions face-to-face and the other remotely. This was implemented in April 2021. In this class, seven students decided to remain remote, while the remaining 12 students were split into cohort A (five students) and cohort B (seven students). Students who were back in the building for one class period a week were not allowed to share work or work closely together, due to six feet distancing protocols, so any collaborative work had to be completed during our virtual class time.

Treatment

For my action research project, throughout the course we focused on hyperlocal examples and discussed ways to extend many of our studies to our own community (table 1). I embedded local examples into each unit so that students could connect their learning back to their homes or a location that was familiar to them.

Table 1. Activities, laboratory experiments, and discussions focusing on local examples, by unit, for the 2020-2021 school year.

AP Environmental Science Topics	Local Community Examples & Activities
<i>Ecosystems</i>	<ul style="list-style-type: none"> • Olympic National Park ecosystems and graphing
<i>Biodiversity</i>	<ul style="list-style-type: none"> • Biodiversity survey of your community
<i>Populations</i>	<ul style="list-style-type: none"> • Population growth of Kitsap County
<i>Earth Systems and Resources</i>	<ul style="list-style-type: none"> • Landforms of the Pacific Northwest • El Nino and its effect on the Pacific Northwest
<i>Land and Water Use</i>	<ul style="list-style-type: none"> • Local soil texture and sampling • Farms in Kitsap County • Water Quality testing
<i>Energy Resources</i>	<ul style="list-style-type: none"> • Analysis of Puget Sound Energy resources
<i>Atmospheric Pollution</i>	<ul style="list-style-type: none"> • Particulate matter and air quality • Orcas and naval noise pollution/traffic
<i>Aquatic and Terrestrial Pollution</i>	<ul style="list-style-type: none"> • LD₅₀ testing of a common substance
<i>Global Change</i>	<ul style="list-style-type: none"> • Tree size and history local resources • Tonewood and Olympic National Forest

This varied from what I did in previous years, where local situations and data was more of the exception rather than the rule. In addition, the 2020-2021 school year focused on the process of science and scientific skills, whereas in previous years I chose to focus my instructional time on solely on understanding content (figure 2).

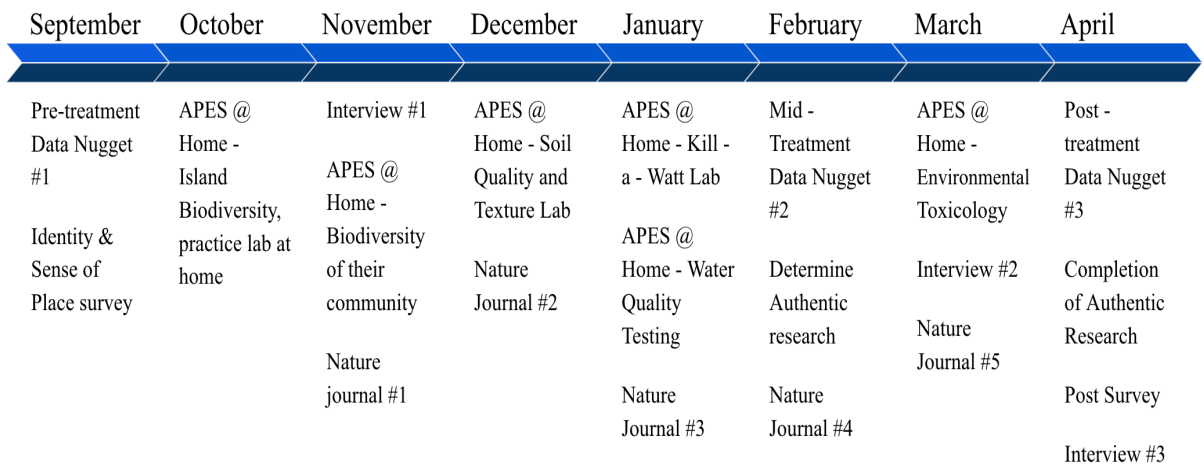


Figure 2. Timeline of treatment for place-based learning, 2020-21 school year.

Students were challenged to design their own authentic place-based research and experiment from their experiences in the class. In order to do this, students needed to learn all the elements of doing science, as well as feel comfortable being scientists. It was also necessary to understand the needs of their community. After students completed their research, these research learning presentations were given to stakeholders throughout the community.

After students did their scaffolded versions of each of their projects and learned about community needs and impacts, they developed their scientific question for their final project. Students developed their research, and these fell into one of the following themes: environmental toxicology, soil health, or water quality analysis. Laboratory

equipment was purchased by our local Kiwanis organization and school district and mailed directly to students so they could design and collect the appropriate data without worrying about the cost of the equipment. For many students, this was the first time they were asked to design their own procedure, let alone do it at their own homes and communities, without a teacher's direct supervision. Therefore, purposeful scaffolding was built into the curriculum about the equipment and procedures prior to students beginning their experimental data collection. Each of the three topics had a linked required assignment that everyone completed for the class. This allowed students to understand how the equipment and basic procedure worked, so they could do their research with confidence.

The research methodology for this project received an exemption by Montana State University's Institutional Review Board (IRB) and compliance for working with human subjects was maintained (Appendix A).

For each subquestion, I used triangulation to increase reliability among emergent themes (Table 2). These data collection efforts were a mixture of qualitative and quantitative methods. Each subquestion had a minimum of three sources of data which increased trustworthiness in the results of this action research.

Table 2. Data triangulation matrix for place-based learning data sources.

Focus Questions	Source 1	Source 2	Source 3
<i>1. How do place-based learning experiences impact students' ability to generate scientifically oriented questions?</i>	Performance on Data Nuggets	Original lab or fieldwork designs	Direct teacher observations
<i>2. How do place-based learning experiences impact students' ability to formulate evidence-based explanations?</i>	Performance on Data Nuggets	Original lab or fieldwork designs	Direct teacher observations
<i>3. How do place-based learning experiences impact students' science identity?</i>	Student survey data	Student interviews and digital responses	Individual journal responses
<i>4. How do place-based learning experiences impact students' sense of place?</i>	Student survey data	Student interviews and digital responses	Individual journal responses
<i>5. What effect does remote learning have on students' attitudes about place-based learning experiences?</i>	Direct teacher observation	Student interviews and digital responses	Individual journal responses

Data Collection #1: Performance on Data Nugget Assessments

I used free response questions to ask students to graph a given set of field data, and then interpret that graph to draw clear conclusions. Students were asked to cite evidence from the data to support their conclusions and explain why that evidence is important for the scientific question. For this assessment, I used a tool called Data Nuggets (Appendix B) by Arismendi, Gregory, and Boyle (2019), Charles (2020), and Hawn and Curry (2021), which is a collection of fieldwork experiences that are authentic

and written for upper middle school and high school students. Data Nuggets have been used by researchers in the past to gather information about students' abilities to analyze scientific data (Schulthesis & Kjellvik, 2015, 2020).

For each of these, I chose to use a fieldwork topic that would be connected to something had discussed, but they would not need to be knowledgeable in the process in order to do the analysis. I assigned the first Data Nugget as a summer assignment for AP Environmental Science, and all of the students submitted it. Since we were in a remote setting, I made it an assignment in early August for them to complete by the second week of school. The second Data Nugget was assigned in early February 2021, and the final Data Nugget was assigned in April 2021. For the last Data Nugget, I chose a topic that would reflect our local region, using scientific content that many students chose as their authentic research topic.

I followed up with similar fieldwork questions on exams. These questions are connected to our local area and look similar to the Data Nugget they already completed as a pre-test. They were created with the help of local scientists and data they collected, as well as resources from Otto et al. (2015). These happened approximately monthly in the course. This information was used informally and as a way to help teach and discuss scientific questioning and scientific reasoning and explanations between the Data Nugget assessments.

I used a rubric in order to appropriately evaluate all Data Nugget assessments (Appendix C). For each student, I evaluated their answers and scored them using standards-based assessment practices, where 4 is exceeding standard, 3 is meeting

standard, 2 is approaching standard, and 1 is not proficient. Students who made no attempt earned a separate notation. This gave me quantitative data. In addition, I indicated any specific results if they were not captured sufficiently using this rubric. I analyzed the frequency of the scores for the class, as well as student individual progress.

Because students are learning environmental science while they are also learning how to do fieldwork, it is difficult to discern their familiarity with the content from their ability to apply it to field work. Therefore, I assigned field work exercises as a data collection instrument after the students have shown mastery of the content expressed in the fieldwork topic if it appeared they would need the science content to feel competent with the data. This means going over the background information with them ahead of time and discussing any confusing scientific terms and allowing them to ask questions as needed.

I chose to have all students in my AP Environmental Science course complete this data collection tool. This reasoning is twofold. First, I wanted to get a sense of the ability of the entire class. This would help me decide where to start when discussing fieldwork and data analysis. Normally, I would use science test scores and grades from their previous science classes. However, because of COVID-19 precautions, the normal state testing was canceled and their grades from their previous class did not accurately reflect their science abilities. Second, helped determine students for the interview portion of my action research project. In addition, normalized gains were calculated from the pre-assessment to the post assessment, as well as paired t-tests.

Data Collection #2: Likert Survey and Sense of Place Survey

This survey (Appendix D) was used to look at attitudes about the environmental science class. It was delivered to all students in September of 2020 and then again in April 2021 to see how attitudes have changed or stayed the same. I used a similar Likert survey that is a combination of DeFelice et al. (2014) and Vincent-Ruz and Schunn (2018).

In this survey, students were asked to reflect upon their interests as science students, their past science classes, and how they learn best. I connected it with the sense of place questionnaire for time concerns, which asked them about the region in which they live. I used the ordinal categorical variables of strongly agree, agree, neutral, disagree, and strongly disagree. Because we were doing remote learning, this Likert survey was administered through digitally through Google Forms, even when we went back to face-to-face learning. My entire class completed this survey in September 2020 and then again at the end of April 2021. I analyzed the frequency of each category, percentiles, and trends in either direction for both the pre and post class survey. These questions were grouped into themes in order to analyze.

Data Collection #3: Original Fieldwork Design, Application, and Analysis

Original and authentic fieldwork design, application, and analysis was the main deliverable for the students in the second semester, from February to June 2021. All students conducted the original fieldwork design, application, and analysis. Students were instructed to choose an investigation topic and then develop, conduct, analyze, and share

their findings. This project was scaffolded throughout the school year, with an emphasis during second semester. Students picked their topic, developed their scientific question, and discussed how to minimize sources of error while collecting data. They also discussed who their audience would be for their final results, and the most appropriate way to share them (i.e., a paper, presentation, letter to the editor, video, or scientific poster).

All students completed this data collection tool. This was an effective way for them to learn how to develop an experiment with minimal scaffolding from me. The students would be asked to do this same skill later on the national Advanced Placement Environmental Science exam from College Board. In the past we would discuss experimental design concepts in hypothetical ways, instead opting for more extreme guided lab experiences.

Based on the students' progress through their project, I was able to extrapolate if the students were able to generate scientifically testable questions in addition to if they could think critically about their collected data and generate scientific explanations. While this data collection tool was not set to collect sense of place or science identity data, the scientific attitudes the students displayed throughout the process was noted.

Data Collection #4: Student Interviews

Student interview questions (Appendix E) were developed to assess how students viewed their science identity, their sense of place, and the impact of remote instruction on their science learning. The interviews were conducted in November 2020, March 2021, and April 2021. The interview in March 2021 was prior to the beginning of their

authentic work and the interview in April 2021 was following the conclusion of their authentic work. All interviews were conducted remotely through video conferencing software and outside of our class time.

I chose a sub-set of students to interview based on their initial responses to their survey and their performance on the first free-response question they completed during their summer assignment (high, medium, and low, two of each category). I also included one more student since their science identity score (low) did not match with their science performance (high) like the other students. This gave me a group of seven students to interview.

In order to analyze the interview transcripts, I looked for emerging themes in their answers. Even though the interviews were conducted separately to help promote uniqueness of their answers, there were themes that appeared throughout the interviews. Because the group was small, I looked for themes shared by three or more students, or 42%. These were used to support the answers that were also given in the identity and sense of place survey, as well as the journal responses.

Data Collection #5: Direct Teacher Observations

Direct teacher observations were utilized to capture participation in class, including clarification emails, and attendance in our virtual classes and optional office hours. Participation in class looked different than in a traditional classroom and was a lot more difficult to quantify, so these were tallied into categories of types of participation with notes about the topics they were covering. Students could participate in various ways, including turning on their camera, answering questions either on microphone or in

the chat function either privately or to the class, answering entry tasks and exit slips, and working on assignments collaboratively in breakout rooms.

Attendance was used as another form of direct teacher observation. While our virtual meets were completely optional, it along with the student participation in class allowed me to determine how working remotely was impacting their learning in environmental science and their general feelings about distance learning.

Data Collection #6: Individual Journal Responses

In order to hear from all students about various different topics regarding environmental science and their local communities, I utilized prompts into a series of assignments called Science and Nature Journals (Appendix F). The questions were a combination of my own work, as well as questions inspired by DeFelice et al. (2014), Laws and Lygeren (2020), and Semken et al. (2020). We used a variety of software for these responses, including Google Forms (for typed answers), Google Canvas (for created images), Google Slides (for collaborative owned answers), and Google Jamboard (for collaborative anonymous answers), as well as handwritten and hand-drawn responses and photographs.

This data collection instrument was completed by all students in the virtual meet for that specific day, as we would do it during our meeting time. Many times, this tool would be used as students joined the meet for the day, and would include questions that all students could do, no matter their understanding of the current content within class. Each of the journaling topics was categorized by focus question. The student answers

helped define their authentic work, as well as helped me with discussions in class about what places mattered to them in our community.

In order to analyze the journal responses, I looked for emerging themes in their answers. Even though these journal responses were conducted separately to help promote uniqueness of their answers, there were themes that appeared throughout the interviews. If a topic was reported more than three times (16%) in journal responses, it was considered an emergent theme.

DATA ANALYSIS

ResultsSub Question #1: Scientific Questioning

For the free-response methods of data collection, all students turned the assignments. One student earned nearly a perfect score of four (exceeding standard) in all categories. Three students earned zeros in all categories, and when asked about their blank document, stated that they did not know how to do any of it. One student commented, “I never learned how to do this last year”. Six students did not complete the entire assignment, and when asked, said they completed all the parts they knew how to complete with confidence, with two students writing “I don’t know” in place of the sections of work. The part left blank or incomplete was most often the future questions section, but it was also the section with the highest number of students meeting standard, as seen in Table 3 ($n=6$). One student commented in this section that they would just “rerun the experiment to make sure it was right.” For this sub question about scientific questioning, the focus is on the sections about future questions and about variables, as both of these lead to building the scientific questioning skills of students.

Table 3. Frequency of scores ($N=21$) for scientific questioning sections of the pre-assessment Data Nugget, September 2020.

Frequency of score ($N= 21$)						
<i>Section</i>	0	1	2	3	4	Average Score for Section
<i>Variables</i>	5	9	4	2	1	1.28
<i>Future Questions</i>	10	2	3	4	2	1.33

In February 2021 students looked at a Data Nugget of similar difficulty, but of different content (Table 4). This Data Nugget was based in the Pacific Northwest, in an ecosystem similar to our local region, using familiar animals and situations. Both Data Nuggets asked the students to do the same scientific analysis. For this data collection, all students completed the work ($N=19$) and only one student left one category blank. One student (5%) earned a perfect score of four in all the categories. One hundred percent of students increased their score from the first assessment to the second assessment.

Table 4. Frequency of scores ($N=19$) for scientific questioning sections of the second Data Nugget, February 2021.

Frequency of score ($N=19$)						
<i>Section</i>	0	1	2	3	4	Average Score for Section
<i>Variables</i>	0	2	1	4	12	3.37
<i>Future Questions</i>	0	0	4	3	12	3.42

The last Data Nugget was completed in April 2021, while working on and completing their authentic research. This topic was also something linked to our local community and was also connected to work that many students were doing for their authentic research. Four students (21%) earned a perfect score of four in every category. One hundred percent of students raised their score from the second to the third assessment.

Table 5. Frequency of scores ($N=19$) for scientific questioning sections of the post-assessment Data Nugget, April 2021.

Frequency of score ($N=19$)						
<i>Section</i>	0	1	2	3	4	Average Score for Section
<i>Variables</i>	0	0	0	2	17	3.89
<i>Future Questions</i>	0	0	4	3	12	3.42

For the variables section, the average of the class increased from not proficient to meeting standard, an increase of 2.61. They also increased their median, from one in the first assessment, to four in the second and third assessments. Likewise, in the future questions section, the class average increased from not proficient to meeting standard, also an increase of 2.09 or two scoring categories. They increased their median, from zero in the first assessment, to four in the second and third assessments. Four students (21%) earned scores of approaching standard. This data strongly suggests that students became proficient at identifying variables, while some students continued to struggle at designing future scientifically testable questions when given a case study.

In September, students were asked to develop a scientifically testable question. This was in the form of a Science and Nature journal prompt (Appendix F). The only requirement was their question needed to test something related to environmental science in our local community. Responses fell into three different categories, based on Costa's Levels of Questioning: 1) Level 1 questions (example: "Why is Hood Canal salty?"), 2) Level 2 questions (example: "How do the Canada geese impact Lions Park?"), and 3) Level 3 questions (example: "Is recycling worth it, and how do we get people to do it

more?”). Level 2 and level 3 questions are seen as scientifically testable. Sixty-two percent of students asked level 1 questions, 14% asked level 2 questions, while 23% asked level 3 questions.

Throughout the month of February, the students were focused on developing scientifically testable questions for their authentic work. Through direct teacher observation, students developed a question and shared these questions in our virtual class. Students then worked with each other virtually and revised their questions for clarity. Ninety-four percent of students participated in this feedback process, with 88% of those students creating a level 2 or 3 scientifically testable question and 12% creating a level 1 question. Students then used these questions to develop their original fieldwork projects. In the process of this, the 12% of students without testable questions developed them further so they could do their work after they found they could not run fieldwork or an experiment with the question they had.

Sub Question #2: Evidence-based Explanations

To see if students changed in their knowledge of how to generate evidence-based explanations, I looked at their Data Nugget assessments in their entirety, including the sections of scientific questioning, graphing, and developing claims, evidence, and reasoning surrounding a case study. The first study was purposely not based in our local region but had scientific concepts that the students were familiar with so that they could still make a claim, provide evidence, and explain their reasoning behind what they found.

Table 6. Frequency of scores ($N=21$) for all sections of the pre-assessment Data Nugget, September 2020.

Frequency of score ($N=21$)						
<i>Section</i>	0	1	2	3	4	Average Score for Section
<i>Variables</i>	5	9	4	2	1	1.28
<i>Graph</i>	4	4	10	3	0	1.57
<i>Claim</i>	4	6	9	1	1	1.48
<i>Evidence</i>	5	7	7	1	1	1.33
<i>Reasoning</i>	5	8	4	3	1	1.38
<i>Future Questions</i>	10	2	3	4	2	1.33

The section about claims and the section about evidence had the lowest number of students meeting standard (for both, $n=2$) for the first assessment (Table 6). For the graph, claim, and evidence section, the median was a score of 2, or approaching standard. The reasoning section had a median of 1, or below standard. All sections in this first assessment scored an average of below standard.

Only one student left one section blank (Table 7). For the graph, claim, evidence, and reasoning sections, the median was increased to a 3, or meeting standard, while the average of the graph, claim, and reasoning section was approaching standard while the mean for the evidence section was meeting standard.

Table 7. Frequency of scores ($N=19$) for scientific questioning sections of the second Data Nugget, February 2021.

Frequency of score ($N=19$)						
<i>Section</i>	0	1	2	3	4	Average Score for Section
<i>Variables</i>	0	2	1	4	12	3.37
<i>Graph</i>	0	1	3	11	4	2.95
<i>Claim</i>	1	0	8	4	6	2.74
<i>Evidence</i>	0	0	6	6	7	3.05
<i>Reasoning</i>	0	0	7	8	4	2.84
<i>Future Questions</i>	0	0	4	3	12	3.42

In the third and final assessment, there were no sections left blank by any students. The graph and evidence section had a median of 3, or meeting standard, while the claim and reasoning section had a median of 4, or exceeding standard. The claim section had an average of 4 or exceeding standard, as all students showed mastery of this topic in the final assessment.

Table 8. Frequency of scores ($N=19$) for scientific questioning sections of the post-assessment Data Nugget, April 2021.

Frequency of score ($N=19$)						
<i>Section</i>	0	1	2	3	4	Average Score for Section
<i>Variables</i>	0	0	0	2	17	3.89
<i>Graph</i>	0	1	0	9	9	3.36
<i>Claim</i>	0	0	0	0	19	4
<i>Evidence</i>	0	0	1	12	6	3.26
<i>Reasoning</i>	0	0	3	3	13	3.52
<i>Future Questions</i>	0	0	4	3	12	3.42

As seen in tables 6, 7, and 8, students as a class performed better as the school year went on. In addition, every student increased their overall score, with the biggest gains being seen in the sections of variables and claims. However, every section did go up at least two graded categories, from below standard to meeting standard. Likewise, as seen in figure 3, individual student scores went up for each assessment. Fifteen (79%) students had normalized gains of high, with the remaining students (21%) having gains of medium. The average normalized gain was $g = 0.86$ (high). A paired-samples t-test was conducted to compare the Data Nugget scores by students before treatment and after treatment. There was a significant difference in the scores between the beginning of the treatment and the end of the treatment. In addition, the range of the scores for the mid- and post-assessment are much narrower than the pre-assessment. This suggests that the students who were struggling the most were able to drastically increase their scores from the pre- to the mid- and post-assessments. However, this does not account for students

who may have scored low on the pre-assessment who dropped the course at the semester break, prior to the mid-assessment and any learning that may have happened for those particular students.

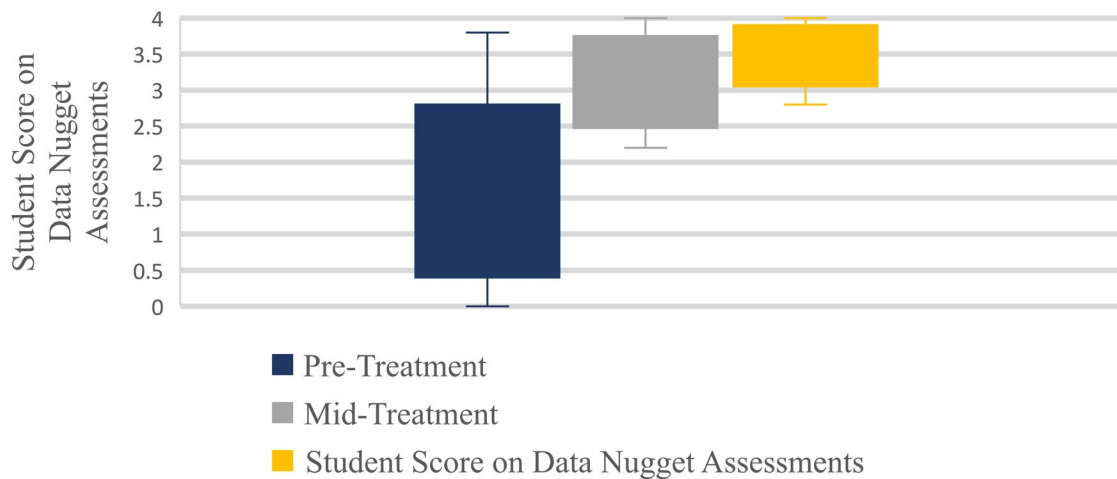


Figure 3. Individual student scores on Data Nuggets throughout the study period, ($N=19$).

Student journaling responses were also used as a data collection tool to observe students' perception of their ability to generate and apply scientific explanations. The questions for their journal were open-ended and themes were identified after submission, as seen in figure 4. When asked to name a skill they gained through doing their authentic work, 57% of students reported a skill they learned was how to analyze their own science results. One student replied, "A skill I learned was how to make my own science project. I think you had us do this so it would give us the experience of having our own procedure and getting our own results from something we wanted to do." Another replied, "I learned how to independently perform more complicated science procedures, and what the information means when I am done." In addition, 21% of students said they learned time management from this project.

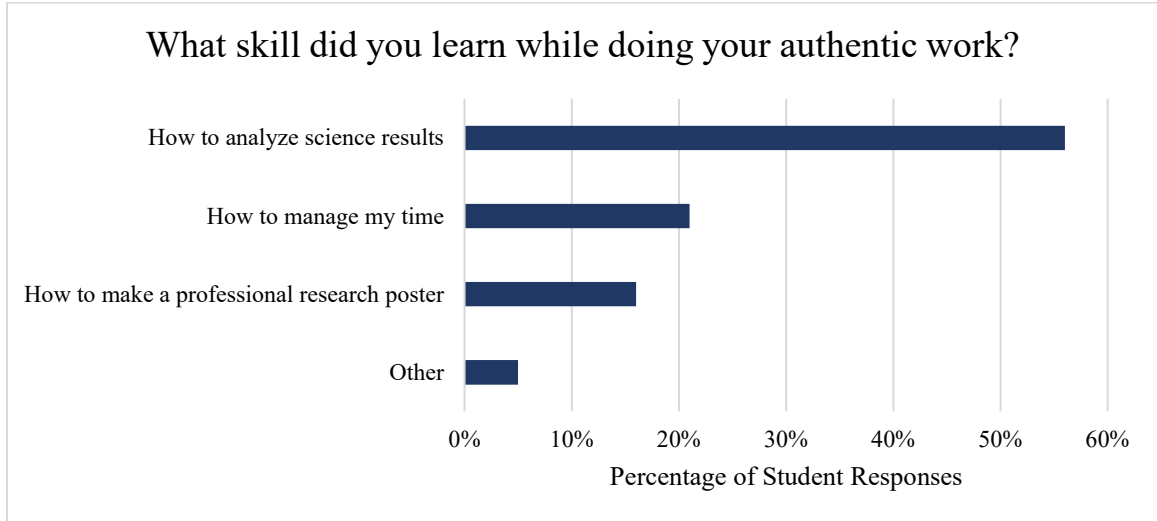


Figure 4. Science and Nature journal prompt focusing on skills gained during their authentic research projects, ($N=19$).

Authentic research projects were also analyzed to determine if students were able to use their own results to generate scientific explanations. Of 19 students, 18 students conducted research and submitted their findings. Their claims, evidence, and reasoning were evaluated using the same rubric as for the Data Nugget assessments, for continuity.

Table 9. Frequency of scores for authentic research project, ($N=18$).

Frequency of score ($N= 18$)						
<i>Section</i>	0	1	2	3	4	Average Score for Section
<i>Graph</i>	0	0	1	11	6	3.28
<i>Claim</i>	0	0	0	0	18	4.0
<i>Evidence</i>	0	0	0	12	6	3.33
<i>Reasoning</i>	0	0	1	5	12	3.61

Overall, the scores for their authentic research project were similar to the last Data Nugget assessment. The lowest score was in the graph section, which also was slightly lower than the last Data Nugget Assessment. Claim, evidence, and reasoning were all very similar in scores. Only one student scored approaching standard and this was in the graph section and in the reasoning section. Students continued to score high in the claim section.

Sub Question #3: Science Identity

Science identity was determined through the evaluation of data collected through surveys, student interviews, and individual journal responses. Questions from the survey that fit into the science identity theme are shown in figure 5 in the diverging stacked bar chart. The middle of the neutral category is lined up so that differences in the answers are easy to identify. Answers that are linked to a more positive science identity are shown to the right of the chart, and answers linked to a more negative science identity are shown to the left. The surveys were given two times, once in September 2020, prior to treatment and then again in April 2021, after treatment.

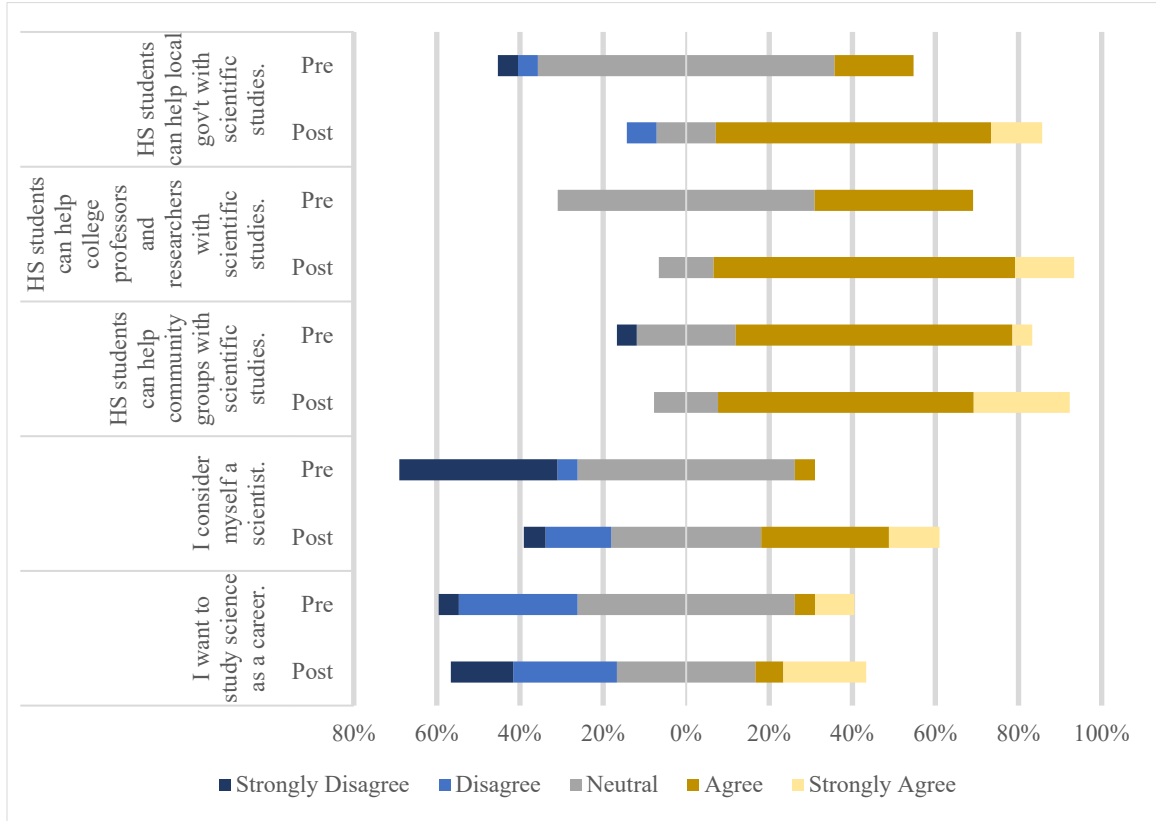


Figure 5. Science identity indicators, as collected in the pre- and post-treatment Science Identity Survey, (N=19). Neutral responses are split as a baseline for comparison.

Prior to treatment, most students either disagreed or had neutral opinions about becoming a scientist in the future (86%). Only 14% of students responded favorably about a future in science. In the post-treatment survey, the number of students strongly disagreeing about a future in science increased, as did students strongly agreeing about a future in science. Seventy-three students either disagreed or had neutral opinions about a future in science. However, there was a larger shift when talking about if they currently thought of themselves as a scientist. For this question, in the pre-treatment survey 95% of students responded that they either did not consider themselves a scientist or they were

neutral on this topic. In the post-treatment survey, students agreeing with the statement greatly increased, from 5% to 55%.

Students were also asked if high school students could assist college professors and scientists, community groups, and governmental agencies when researching scientific studies within their community. In general, students were mostly neutral or positive about these questions in the pre-treatment survey. However, after treatment, the neutral responses narrowed while the agree and strongly agree responses increased.

Student interviews were conducted prior to treatment and then mid-treatment. When students were asked about their authentic work project that they developed, they were able to identify the question they were testing, why they were testing it, and how they would test it. One student explained that they were inspired to do a toxicology bioassay after she saw a video in class showing how chemicals can affect living things. Another student explained they were testing how car soap impacted seed germination and was doing that because she had done a carwash before in our community and wanted to know if there was a safer type of soap to use so she did not harm her city's environment. She was also going to make her results available to local carwash businesses and city hall. When asked if the students felt like they were scientists, one student replied, "I feel cool! Honestly, I feel so important when I'm doing the work when it is going somewhere else and going to help people and not just an assignment." Another replied, "I feel very smart being able to say that I can run this experiment on my own." Yet another said, "When we do science with the equipment you sent us in our box, I feel like a scientist." When asked if this had changed from previous experiences in science, one student

replied, “The labs I’ve done [in middle school] were not like this, I feel like I can say I’m an environmental scientist.”

Individual student journal responses followed this trend. Students were asked to discuss a time when they felt like an environmental scientist. Answers were analyzed and grouped into themes and shown in figure 6.

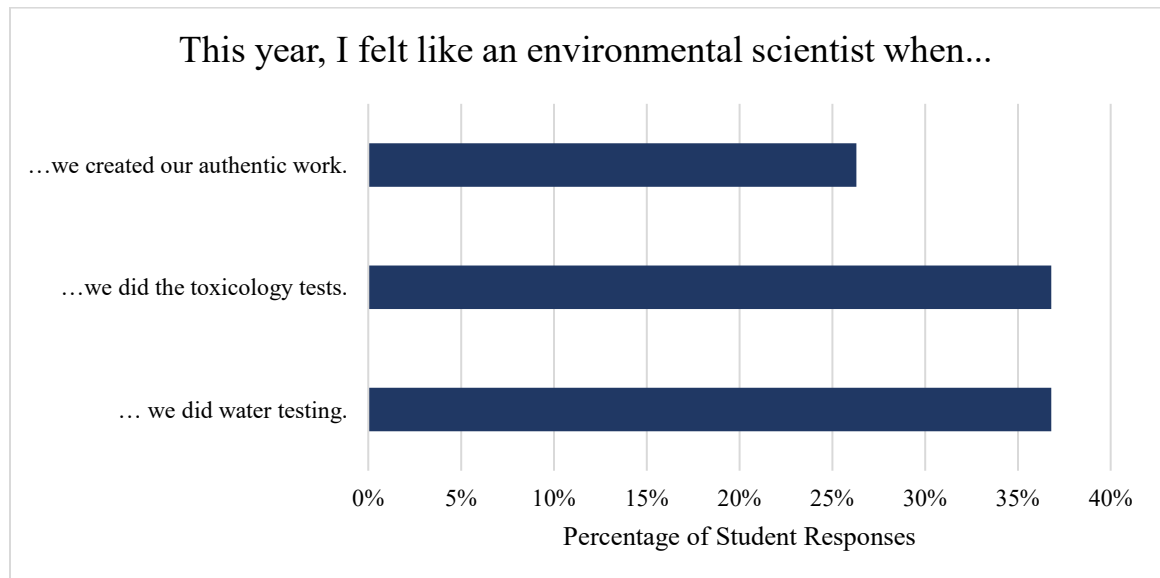


Figure 6. Science and Nature journal prompt focusing on science identity, ($N=19$).

Thirty-seven percent of students felt like an environmental scientist when they did water testing as well as when they did the toxicology tests. Twenty-six percent of students felt like an environmental scientist as they created their authentic work. One student wrote, “This year, I felt like an environmental scientist when we started doing labs, whether it be the hands-on ones like water testing or the ones where we just learned about certain local topics.” All students reported they felt like an environmental scientist at some point in this course.

Sub Question #4: Sense of Place

Students’ sense of place was studied through the use of Likert survey data, student interviews, and individual journal responses. Questions from the Likert survey that were sense of place indicators are shown as a diverging bar graph in figure 7. More positive responses are shown on the right of the graph, while more negative responses are shown on the left. Neutral responses are seen as a baseline and centered around zero.

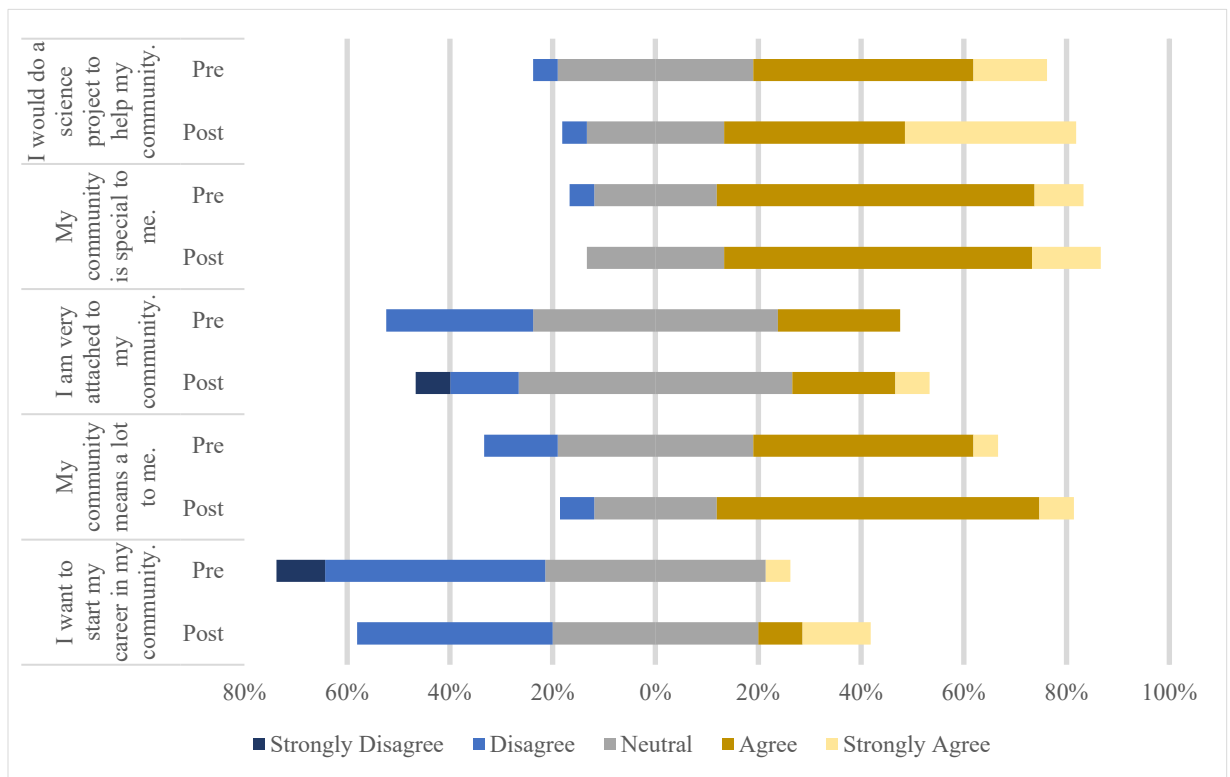


Figure 7. Sense of place indicators, as collected in the pre- and post-treatment Sense of Place Survey. Neutral responses are split as a baseline for comparison, (N=19).

All questions were around the topic of our local community. Students answered the most positively when asked about their feelings about helping their community. In the post-treatment survey, the percentage of students responding strongly agree more than doubled, from 14% to 33%. Students also greatly increased their positive responses when

asked if their community means a lot to them, from 47% to 70%. The other questions in this set did not shift appreciably.

Student interviewees were asked about how this class has impacted their day-to-day thoughts about their local community. One student remarked that they noticed concepts we discussed in class when driving around town. Another said it was difficult to apply the ideas we discussed since she was not allowed to leave her neighborhood. Another said they did not notice their thoughts change, but that they felt more informed about global environmental concepts. When asked if this course made them want to do more service to their community, all students interviewed replied positively. One student said she would like to help “teach kids about the Junior Ranger program in the Olympic National Park, so they can get a badge like [she] did.” Another remarked that she would like to help organize some student clubs to pick up litter near the school. Another student discussed helping with trail building in our local parks or helping to build a community garden so people could get fresh food.

Individual journal responses were more varied and difficult to narrow to a few themes. When asked to draw a local outdoor place that was special to them, answers varied from a local campground to waterfall hikes to specific places that are places to think (figure 8). Students drew them in their digital notebooks. Some students then used these exact places they drew about as subjects for future field experiences.

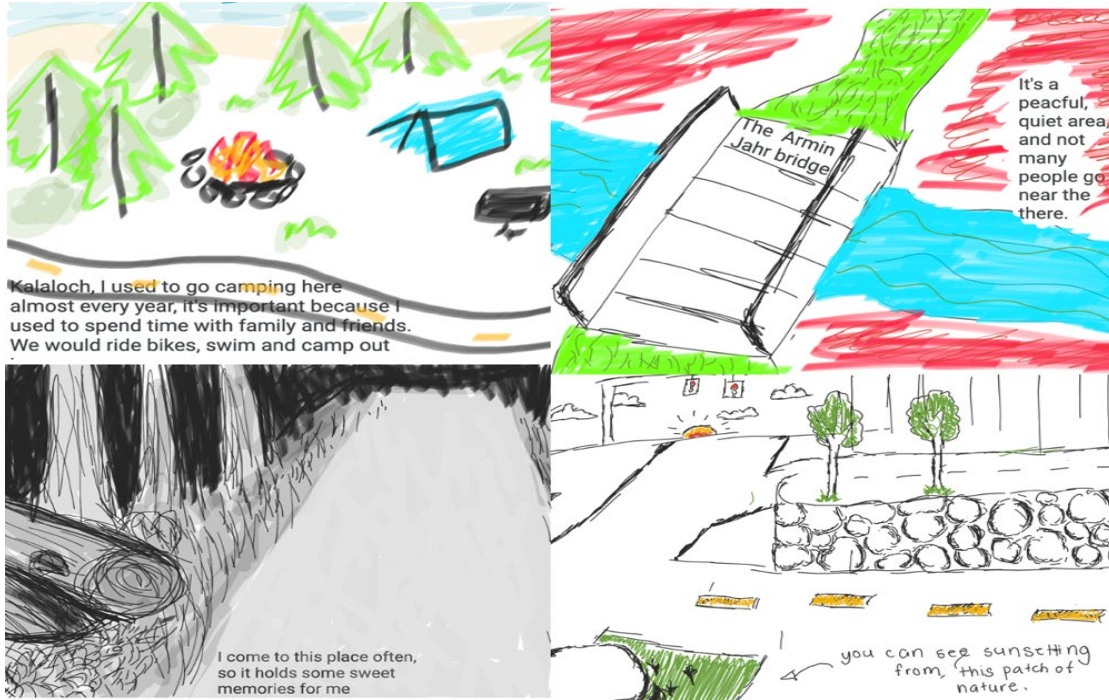


Figure 8. Example images digitally drawn by AP students, representing a place in nature that is special to them.

In another journal prompt, students were asked to find something that was part of nature, anything, and sketch it, and then ask wondering questions about it, to tie in with our focus on scientific questioning (Figure 9).

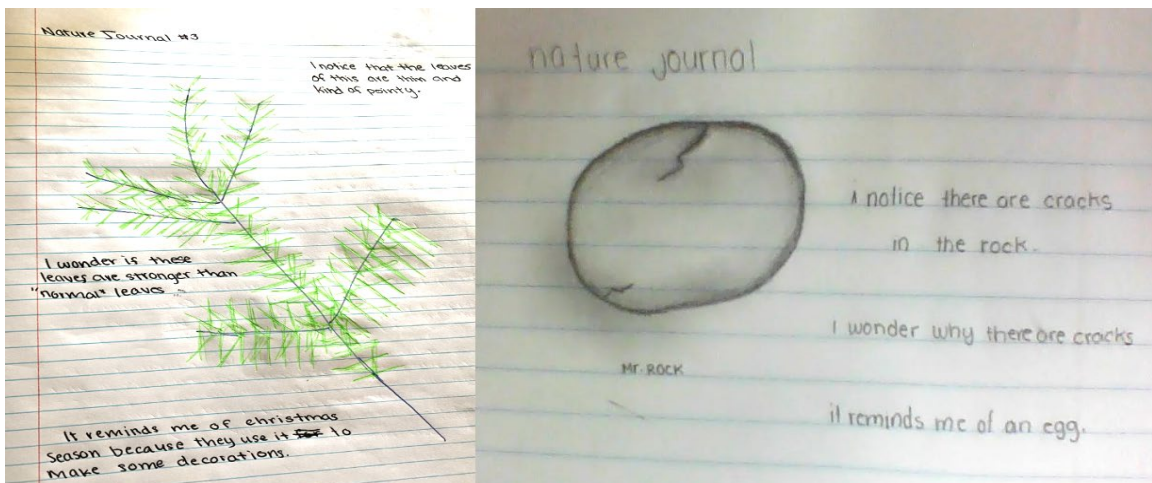


Figure 9. Example images hand-drawn by AP students when they were prompted to find an object outside and write down what they notice, what they wonder, and what it reminds them of, in their nature journal.

Students drew rocks, trees, leaves, and shells. One student pondered, “I wonder why the branches on this tree go in all different directions.” Another asked, “What type of tree is this? It is outside my house.” After students shared their drawings and discussed their questions, other students helped this student identify the tree as a ginkgo.

Sub Question #5: Attitude and Remote Learning

Student attitude towards science while doing remote learning was analyzed through direct teacher observation and attendance records, student interviews, and individual journal responses. Direct teacher observation was difficult since we were meeting via Google Meet and not face-to-face. However, on the days when we would be learning or setting up a place-based field experience or a hands-on lab, I noticed that 32% of students in the class would turn on their cameras so we would be doing the set-up together and I could see what they were doing. I had a lot more participation and feedback during this time as well, through the chat feature and through students unmuting and asking their questions out loud. This was unprompted. On days when we would be doing mathematics problems or a lecture, all students would have their cameras off and only a few students, if any, would ask questions or answer my prompts vocally. They would only answer my questions in the chat function.

Another direct teacher observation was class attendance. We were only able to meet twice a week in class, and students were supposed to work on asynchronous work the other three days of the week. This meant that we were only able to meet approximately 66 times from September 2020 to April 2021, while in a normal year we would meet approximately 170 times from September to April. During this time, my

class had a 98.6% attendance rate. This is compared to 92.9% for my class in the fall of 2019 when in person during a normal non-pandemic school year, and an attendance rate of 86.2% for all ninth-grade students at Bremerton High School for the 2020-2021 pandemic-affected school year.

Student interviews helped qualify how students were feeling about remote learning. In November, when asked about remote learning and how it was impacting them, all students reported that it was impacting them in a negative way. Many students in the interview sample group said that because there was no hands-on science, they had a more difficult time understanding the content because they could not do the science. This was prior to our treatment of hands-on and place-based lab experiences. One student said overall her experience was negatively impacting her understanding of science, but her social and emotional health was better since she did not have to deal with anxiety and bullying while at school.

Students also answered attitude about remote learning questions via their Science and Nature journals. At the end of the treatment cycle, students were asked about their attitudes towards remote learning during this class in particular. This was framed as an open-ended question and responses were grouped into emergent themes discussed (figure 10).

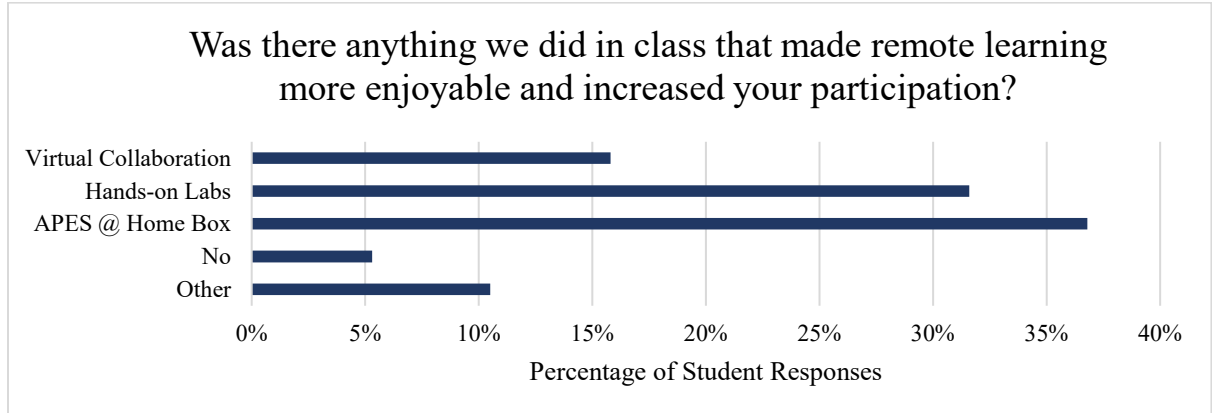


Figure 10. Individual student journal responses about what aspects of the course increased their attitude about the course after treatment was completed.

Many students (68%) discussed the hands-on labs and the lab equipment that was sent to their homes (the APES @ Home Box) as something that increased their participation and enjoyment in the course. One student replied, “I really enjoyed getting the mail package for hands on activities. Online learning is harder when it isn’t hands-on so that made it easier to have a little lab kit.” Students also discussed that they appreciated the collaboration through various activities (15%), games, and just the content in general (other – 11%). One student reported that there was nothing in the course that made remote learning enjoyable.

Students were also asked in a separate journaling prompt about what their favorite lesson, activity, or lab was during the treatment cycle. This question was also framed as an open-ended question, with results grouped into themes as they appeared (figure 11).

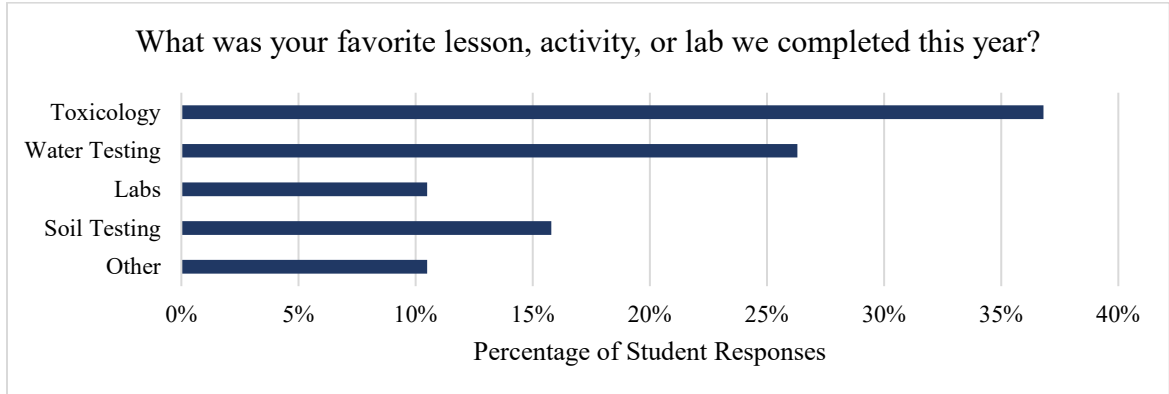


Figure 11. Individual student journal responses about the students' favorite experience in class, ($N=19$).

Seventy-nine percent of students reported that their authentic work project topic was their favorite activity they did this year. One student replied, “My favorite was the water testing lab. I had my huge sweatshirt on because it was snowing, and stuck my hand in the freezing cold water for data. But the challenge was really fun. I felt very professional.” Other students agreed through their comments about water testing and toxicology.

Overall, both the qualitative and quantitative data that was collected throughout the research period pointed to significant gains in achievement, identity, and attitude. The students reported the most important parts of this class were the hands-on and field-based opportunities. These opportunities made the students feel not only like they were in school but also that they were scientists making a real contribution to their communities. Sense of place was more difficult to directly impact, but students still reported that they were excited about their citizen science authentic projects.

CLAIM, EVIDENCE, AND REASONING

Claims From the Study

The goal of this action research project was to increase the students' science achievement, identity, sense of place, and attitude while remote learning by using aspects of place-based learning and experiences. While teaching remotely presented many challenges, some were negated by focusing on hands-on place-based education when appropriate. As a result, students made gains in their abilities to ask scientific questions and design appropriate field and laboratory experiments to answer their questions, as well as analyze case studies done by other field researchers. When doing hands-on and place-based experiences, students noticeably changed in their science identity. Sense of place, arguably the most difficult to influence remotely, had a slight increase, but probably less than learning face to face in a location. Place-based hands-on education was for many students the highlight of their remote learning experience, increasing to the overall value of the class when taught at a distance.

Increase in Scientific Questioning and Sense-Making

In this action research project, students made gains in every aspect of scientific questioning and sense-making, especially when analyzing other researchers' work, as seen in the Data Nugget assessments. When starting the course, many students noted that they had never done assignments like this before, so there may have been some unfamiliarity with the process when they first started, which could be seen in the pre-treatment surveys and assessments. This contributed to their pre-treatment having a wide

range, from a score of zero to a score of 3.8. As the course went on, every student's score increased and the range narrowed. In mid-treatment, the assessment range had a low score of 2.2 to a maximum score of a four, and the range narrowed even further with the post-treatment assessment with the range 2.8 to four. Their paired t-test also indicated significance between their pre- and post-treatment assessments. By the end of the treatment, students were able to analyze case study data easily, especially if it pertained to a concept they already knew or were studying, so the high normalized gains ($g = 0.86$) supported having students do more place-based case study work in class. This is in line with the findings from Schulthesis and Kjølvik (2015, 2020). However, I was not able to discern between students being uncomfortable with remote learning or computer files versus being uncomfortable with the science process, and in the year being more comfortable with that process.

Students also worked on scientific questioning and sense-making through their authentic work project. While in this process, I noticed that many students did not start off with confidence in their skills as scientists. As the project went on, and they continued to give feedback to each other in a peer review format, their confidence grew.

Increase in Science Identity

In this study, I wanted to positively influence science identity. I did this in many different ways. For the Data Nugget assessments, I chose scientists that represented scientists of color and scientists in the LGBTQ+ community. We read science I had done as a student researcher during class and discussed research I had done throughout my undergraduate studies, as well as ones done through my current studies. I made sure to

refer to myself as a scientist, a student, and an educator so students would not think they were mutually exclusive. In addition, students were challenged to complete a Junior Ranger packet from a national park of their choice, which then sent them a badge upon accurate completion. Students sent me images of themselves wearing their badge when they received them in the mail. One student commented, “In general I do not feel represented in science, except this year when I was able to earn my Junior Ranger badge and learn about a national park in Hawaii.” While the student identity survey did not show large shifts in thinking about going into science as a career, it did show that students realize that as a high school student, they can do meaningful scientific work. My students are definitely learners who rely on being able to discuss and collaborate to learn, and this was not as readily available to them as it had been in prior years. While this impacted their confidence levels in what they were doing, it allowed me to see a clearer picture of what each student was able to do.

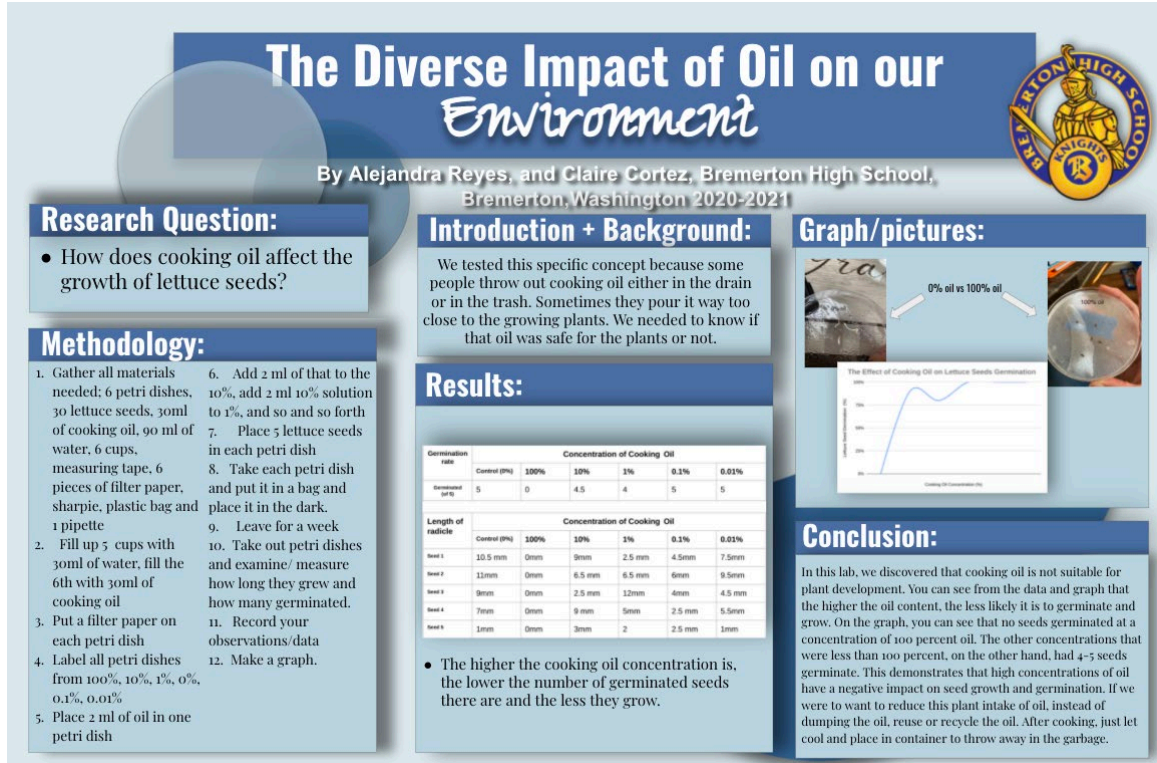


Figure 12. Example student authentic research poster.

As hands-on work was increased, it also increased students' science identity. This is because many of comments from students about science identity also tied with doing hands-on experiences from their equipment box and their general attitude about the course, with over 60% of the students reporting that their favorite parts of the class were the hands-on experiences. The culmination of their skills and science identity was demonstrated when they saw their authentic work in its deliverable form. An example of student work is shown in figure 12. When students who chose to do scientific posters saw their printed work, they were so excited and wanted to show everyone. To this end, the new home of these posters will be Bremerton City Hall. While this experience did not focus solely on females and the change in their science identity, the females in my class were the most excited about their work and their finished product, much as Cannon and

Carr (2020) found in their publication. Even though my course has a lot of females electing to take it, it is work like this that impacts students' science identity long term.

Sense of Place Difficult to Influence Remotely

Of all the sub questions, sense of place was the most difficult to influence. While it may seem that since students are staying home in their neighborhoods, it would be simple for them to learn to value these places, that was not the case. Students did value the places they already knew in our local community, but they did not get to see anything new that would impact them thinking the community was special. Some may have even been bored of their community since many were not allowed to leave their home. Even though their field exercises, such as water testing, got them out to another place than their home, they picked places that were already familiar as would anyone in that situation. A big part about increasing sense of place is the student connection (Semken et al., 2020; Hoke et al., 2020; Coulter, 2014). They would need to have a reason to remember and protect a specific spot, and have a peak moment – that is, one that would not be recreated. Many times, that is with a group of their peers around a single goal. This was hard to recreate, so I did not see the same gains in sense of place as in the publications I reviewed. However, there were students who said they would want to help their community through cleaning up litter or volunteering at a community garden. It seemed like these ideas were more because the students were altruistic rather than impacted by the science we learned, but I did not ask this as a pre-treatment question.

Hands-on Positively Impacts Remote Learning

Perhaps the timeliest aspect of this action research was the study of attitude towards science while remote learning. In this research, I was hoping to positively affect students' attitudes about my class. According to my students, learning about local environmental issues was not what made them enjoy the course, it was mostly the fact that we did hands-on experiments rather than everything being digital. The APES @ Home box that I sent out greatly impacted my students' willingness to keep going in the course. This box contained all the materials the students would need to do all the hands-on labs and manipulatives for some activities, as well as some fun extras such as modeling dough, a vinyl sticker for their Chromebook, and a stress relieving earth ball. Students enjoyed the box so much that it was even a box opening video shared on our associated student body social media account. This was unexpected. While the box was just to get supplies to students, it ended up symbolizing much more than that for the students in the class. It symbolized that school was an actual construct and not just a face on a screen. Because of this action, students were more invested in the course and willing to try to do work they had never done before.

Value of the Study and Consideration for Future Research

Student scientific questioning and sense-making are one of the most important transferable skills that I can help students develop in my course. Not only can this skill be transferred to future science classes, but it can also be applied outside of formal education. These skills can be used when studying a science claim but can likewise be used when deciding the validity of a social media claim. This is a skill that many younger

children use to learn about our world. However, it is a skill that appears to be lost as students get older. At the same time, the opportunities afforded to students to explore their world through place-based education and field experiences shrinks as students get older in the K-12 education system (Semken & García, 2021). Place-based and hands-on learning experiences help students rediscover this skill. In addition, it helps students enjoy the science content they are learning. While doing this remotely did impact their science abilities, it would be valuable to see if the results are more or less impactful than doing the same treatment in person.

Science identity and attitude are important, but often overlooked, components of science education. They are also closely connected to science equity. Seeing a strong role model in a science field is important, even if that role model is in the pages of a case study. It is difficult for students to see themselves as scientists when they have never seen or heard of a scientist who presents like them, and it is difficult to want to do science if it is not a course you enjoy. Luckily, environmental science is a younger science than many other science fields and it lends itself well to finding a wide variety of scientists making changes in their communities. They are also researching very engaging topics that discuss the wider topic of environmental studies, such as environmental education, environmental justice, and environmental legislation. A future direction of research involving science identity could focus on bringing in scientists from varied backgrounds into the classroom, either via the computer or face-to-face, to see if that has an effect on science identity and attitude of the students who also identify with that background.

A sense of place is crucial for communities that are trying to grow their own leaders. Students who value their community are more likely to stay in that community, and for communities trying to increase the education level of their residents it is important that the students feel compelled to come back after leaving for post-secondary training and schooling. Semken et. al., (2017) states that the five main elements to place-based education are science content, student connections, authentic experiences, cultural attributes, and resiliency of place, and when these pieces are all strong, it impacts a student's sense of place. These elements also value students' experiences as human beings and stakeholders in our community. Even though I was not able to leverage all of these elements remotely, I was able to make small changes in students' sense of place. These should be pieces of every science classroom if a district and a community is serious about retaining residents who value their region. The Bremerton community is a location that does value increasing sense of place with its young people, as seen through the substantial volunteer work with our students and the funding provided for projects that emphasize sense of place.

Impact of Action Research on the Author

I would look forward to the class periods where we would be doing hands-on work because it meant that it would be more like being in class. Imagine this: teaching to a computer, while outside, in early December. Our soil testing lab had me teaching outside in the cold while the neighbor's chickens were walking around in the background, and students were very involved on that day, asking questions about our lab and also about chickens and my surroundings. It was the first day of us utilizing our APES @

Home boxes and there was a chance I could be attacked by chickens or need to run inside if it started to rain. It was one of my favorite days of the school year. Even though this could sound like a nightmare to some teachers, this is the part I missed most of all as I would sit on the other side of a computer screen, looking at blank screens with just names. Environmental science, even in the classroom, is messy, loud, and unpredictable. Spontaneous questions and learning that comes from that was missing in the remote classroom. That is, until we decided to start doing hands-on experiences from home, involving the places near their neighborhood. Suddenly, students had stories they wanted to tell or questions they had about specific places. I never realized how much I relied on that aspect of environmental science to help my students make connections and learn content and skills.

This action research helped me in my time of need. Remote teaching is very difficult for both students and educators. Educators feel that students are not putting in the time needed to understand and complete topics, while students feel that they have no boundaries between home life and school life, making it impossible to either start or stop working on classwork. Our school saw this as engagement fell off across many classes and subject areas. This project forced me to reimagine how my action research would look if it was not done face-to-face, but remotely instead, something neither my students nor I had ever done. By conducting this research and continuing to connect the science back to familiar topics, as well as giving opportunities for hands-on and field experiences, I avoided a lot of the fall off of engagement that I saw in other courses I was instructing. It was exciting for me to teach and was exciting for the students to learn. If

our next year starts off even partially remote, I know that I can help students stay engaged through hands-on activities involving their neighborhood communities.

Students in this course were challenged to design, develop, and run their own authentic research project. Of my 19 students in the course, 18 of them completed an environmental research project that is destined for various places in the county. Some of the projects will be going to stakeholders within our school. Some will be going to specific businesses and government agencies. Some will be displayed in city hall to have a wider audience. While some people may view the work and think it is a simple project, I am amazed. My students, who have never done a completely unscaffolded science research project, were able to do this. They had made the switch from completely dependent science learners to independent scientists. Not only that, but they did this project under the pressures of a pandemic and uncertainty about the future of their education. This is a good reminder for me that environmental science is not solely about the content of the course, but more about the scientist that comes out of the course.

This action research helped me get back to my roots in environmental education and my reasons for teaching in the first place. It forced me to take a step back and let my class discover their own love for science, hands-on learning, and the community, albeit remotely. I hope that some of what we were able to accomplish were considered peak moments for my students and will drive them to continue thinking, questioning, wondering, and exploring their local environment, much like my childhood field experience did long ago.

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APPENDICES

APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 0000165

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MEMORANDUM

TO: Briana Faxon and Marcie Reuer
FROM: Mark Quinn [Signature]
Chair, Institutional Review Board for the Protection of Human Subjects
DATE: November 30, 2020
RE: 'The Effect of Place-Based Fieldwork on Science Identity, attitude, and Achievement in the Advanced Placement Environmental Science Classroom' [BF113020-EX]

The above research, described in your submission of November 19, 2020, 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; and (iii) the information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by section 16.111(a)(7).
(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 B

SAMPLE DATA NUGGET ASSESSMENT

Name _____

DATA *Nugget*

Spiders under the influence

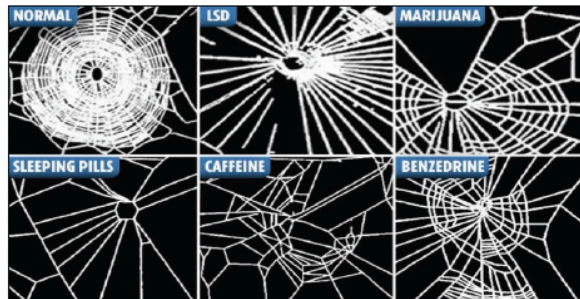
Featured scientists: Chris Hawn from University of Maryland Baltimore County and Aaron Curry from Baltimore Ecosystem Study LTER

Research Background:

People use pharmaceutical drugs, personal care products, and other chemicals on a daily basis. For example, we take medicine when we are sick to feel better, and use perfumes and cologne to make ourselves smell good. After we use these chemicals, where do they go? Often, they get washed down our drains and end up in local waterways. Even our trash can contain these harmful chemicals. For example, when coffee grounds are thrown into the trash, caffeine gets washed into our waterways.

Animals in waterways, like insects, live with these chemicals every day. Many insects are born and grow in the water, absorbing the drugs over their lifetime. As predators eat the insects, the chemicals are passed on, working their way through the food web. For example, spiders living along riverbanks feed off aquatic insects and absorb the drugs from their prey.

Just as chemicals change human behavior, they change spider behavior as well! Effects of drugs on spiders have been studied since the 1940s. Dr. Peter Witt first discovered that chemicals change spider web construction. Peter gave caffeine, and a few other drugs, to spiders to see if they would build their webs during the day instead of at night, which is when they



Drugs significantly impaired spiders' ability to make webs.
Retrieved from 1995 NASA report.

usually work. After giving his test spiders some of the drugs, the spiders still created their webs at night. However, he noticed something unexpected – the web structure of spiders on drugs was completely different from normal webs. The webs were different sizes and had more spacing between each thread. Normal webs help spiders to easily catch prey. Irregularly shaped webs were not good at catching prey because insects could fly right through the large spaces. After his study, Peter knew that drugs were bad for spiders.

Name _____

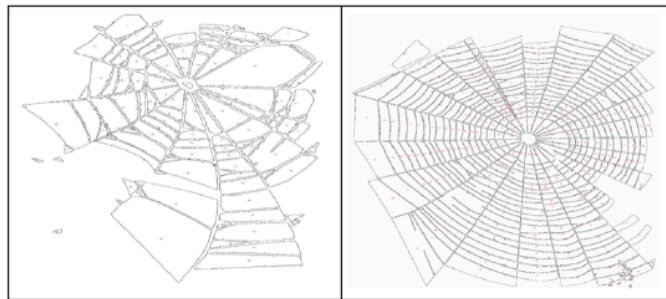
Chris (they/them), a current resident of Baltimore and a spider enthusiast, lives in a watershed that is affected by chemical pollution. They wanted to build on Peter's research by looking at spider webs in the wild instead of in the lab. Chris knew that many types of spiders live near streams and are exposed to toxins through the prey they eat. Chris wanted to compare effects of the chemicals on spiders in rural and urban environments. By comparing spider webs in these two habitats, they could see how changed the webs are and infer how many chemicals are in the waterways.

Chris worked with Aaron, a local high school teacher, to do this research. They collected images of spiderwebs in areas around Baltimore. They chose two sites: Baisman Run, a rural site far from the city, and Gwynns Run, an urban site close to the city. Chris traveled to the sites and took pictures of eight spiderwebs at each location. Chris and Aaron expected that urban streams would have higher concentrations of chemicals than rural areas because more people live in cities.



Field picture of an urban web using dark paper to make the web more visible for data collection.

When they got back to the lab, Aaron took the pictures and used a computer program to count the number of cells and calculate the total area of each web. These data offer a glimpse into whether spiders near Baltimore are exposed to harmful pharmaceutical chemicals and personal care products. If spiders are exposed to these chemicals, the webs will have fewer, but larger cells than a normal web. The cells will also have irregular shapes.



A computer program was used to measure web properties such as the number of cells, web area, and cell area. The web on the left is from Baisman Run. The web on the right is from Gwynns Run.

Name _____

Scientific Question: Does the habitat where a spider lives affect their exposure level to chemicals?

What is the hypothesis? Find the hypothesis in the Research Background and underline it. A hypothesis is a proposed explanation for an observation, which can then be tested with experimentation or other types of studies.

Scientific Data:

Use the data below to answer the scientific question:

Location	Habitat type	Area of web (mm ²)	Number of cells in web	Cell area (mm ²)
Baisman Run	rural	28939	153	69
Baisman Run	rural	14135	108	60
Baisman Run	rural	35807	76	153
Baisman Run	rural	55714	203	122
Baisman Run	rural	27450	191	47
Baisman Run	rural	35491	213	44
Baisman Run	rural	23174	145	73
Gwynns Run	urban	34933	342	66
Gwynns Run	urban	32898	893	11
Gwynns Run	urban	37128	471	54
Gwynns Run	urban	42826	489	58
Gwynns Run	urban	10821	41	75
Gwynns Run	urban	24728	319	17
Gwynns Run	urban	26453	829	21
Gwynns Run	urban	46892	544	30

Location	Habitat type	Average area of web (mm ²)	Average number of cells in web	Average cell area (mm ²)
Baisman Run	rural			
Gwynns Run	urban			

Data Nuggets developed by Michigan State University fellows in the NSF BEACON and GK-12 programs

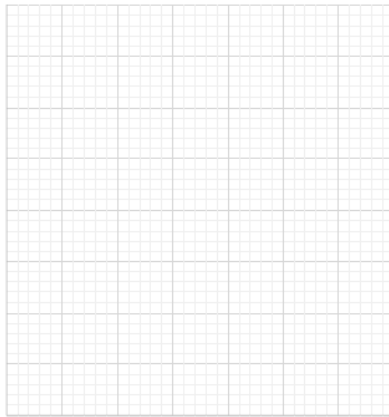
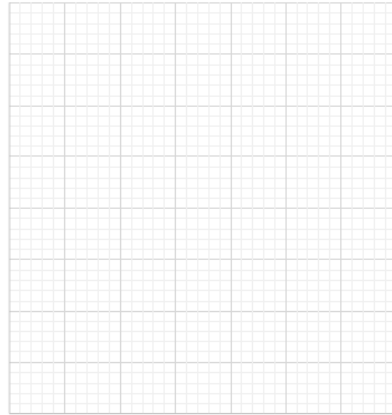
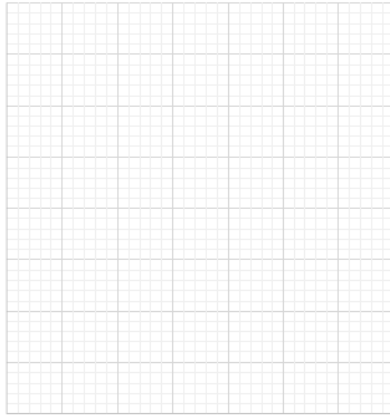
Name _____

Which data will you graph to answer the question?

Independent variable: _____

Dependent variables: _____

Draw your graphs below: Identify any changes, trends, or differences you see in your graph. Draw arrows pointing out what you see and write one sentence describing what you see next to each arrow.



Name _____

Interpret the data:

Make a claim that answers the scientific question.

What evidence was used to write your claim? Reference specific parts of the tables or graphs.

Explain your reasoning and why the evidence supports your claim. Connect the data back to what you learned about how spider web structures change when exposed to various drugs.

Name _____

Did the data support Chris' hypothesis? Use evidence to explain why or why not. If you feel the data are inconclusive, explain why.

Your next steps as a scientist: Science is an ongoing process. What new question(s) should be investigated to build on Chris' research? How do your questions build on the research that has already been done?

APPENDIX C

RUBRIC FOR SCIENTIFIC QUESTIONING AND EXPLANATIONS

Section	1	2	3	4
Variables	Neither variable identified is correct, or no attempt is made.	Multiple variables listed for both, OR unnecessary variables are listed.	Only one variable is correct.	Both independent and dependent variables are correctly and clearly identified.
Graph	No attempt to graph, or graph is missing five or more graph components from score 4.	Chose incorrect type of graph AND missing 3-4 graph components from score 4.	Chose correct type of graph, AND missing 1-2 components from score 4.	Chose correct type of graph, includes all the following: <ul style="list-style-type: none"> • Axes labeled correctly • Units included • Scale is correct • Data graphed correctly • Includes key/legend • Trend line or error bars included • Title included
Claim	No claim written OR claim is missing 4 of the criteria listed in score 4	Claim is missing 2-3 of the criteria listed in score 4	Claim is missing 1 of the criteria in score 4	Claim meets all of the following criteria: <ul style="list-style-type: none"> • Correctly answers question (based on graph) • Mentions relevant variables • Does not include extra info (such as evidence) • Clearly stated as a complete sentence
Evidence	Provides no evidence to support claim, or is missing 4-5 of the criteria under score 4	Evidence is missing 2 - 3 of the criteria in score 4	Evidence is missing one of the criteria in score 4	Evidence meets all of the following: <ul style="list-style-type: none"> • Provides necessary and appropriate evidence to support the claim • Does not include extra evidence • Mentions a comparison, trend, or relationship between the variables • References specific data OR refers back to table/graph • Clearly stated using complete sentences
Reasoning	Does not provide reasoning, OR only provides inappropriate reasoning.	Reasoning is missing both of the criteria listed in score 4.	Reasoning is missing one of the criteria listed under score 4.	Reasoning includes both components below: <ul style="list-style-type: none"> • Explains why the evidence supports the claim • Identifies underlying science concepts
Future Questions	Did not attempt to identify questions, or questions are not scientific.	Identified at least one question, but it is missing 2-3 of the criteria listed under score 4.	Identified at least one question, but is missing one of the criteria listed under score 4.	Identified one or more questions that meet all of the following: <ul style="list-style-type: none"> • Phrased as a question • Can be addressed with research • Related to relevant science concepts • Can not be answered with yes/no • Clearly stated using complete sentences

APPENDIX D

STUDENT SURVEY QUESTIONS

APES Science Interest Survey

Thank you for your participation completing this survey. This survey will take about 20 minutes to complete. Participation in this survey is voluntary and the information you provide will not impact your grade in any way in this course.

The purposes of this survey are to: determine students' interests in science and the environment and improve science learning experiences for high school students.

This survey is administered by Briana Faxon to complete action research through Montana State University's Master of Science in Science Education.

Thank you for your time!

Please choose for each question:

Strongly agree, agree, neutral, disagree, or strongly disagree

1. I care about the environment.
2. In a typical school year, I would rather learn about science in the park than in a classroom at school.
3. I want to one day study science as a career.
4. I have taken a science class that is/was primarily held outside.
5. I learn from completing lab experiments.
6. I plan to go to college.
7. I consider myself a scientist.
8. It is my responsibility to take care of the environment.
9. I enjoy going to outdoor parks, forested areas, or other "nature spots" during nice weather.
10. I like science more when it is studying about an area where I live.
11. I think high school students are able to work with community groups on scientific studies.

12. I think high school students are able to work with college professors and researchers on scientific studies.
13. I think high school students are able to work with local government on scientific studies.
14. I think high school students can do science that impacts communities.
15. I like doing passive work (notes, listening to lectures) in science.
16. I like doing hands-on activities (labs) in science.
17. I enjoy learning outdoors.
18. I have taken a science class that studies the local environment around me.
19. I like learning about how people impact the environment.
20. I am considering majoring in science in college.
21. I understand science better when it is related to my life.
22. If I had the opportunity, I would do a science project that would help my community.
23. I took this course because of its difficulty (because it is AP).
24. I feel my community is a part of who I am.
25. My community is the best place for what I like to do.
26. My community is very special to me.
27. No other place can compare to my community.
28. I am very attached to my community.
29. My community means a lot to me.
30. When I start my career, I want to live in my community.

31. If I can do something to protect the environment around my community, I will.
32. I know how to help the environment around my community, even if it is small impact.

APPENDIX E

STUDENT INTERVIEW QUESTIONS

Interview #1

1. What have you enjoyed most about your previous science classes?
 - Why was that memorable for you?
 - What have you not enjoyed about previous science classes?
 - What is something you've enjoyed in our class so far?
 - Why?
 - What have you not enjoyed? Why is that?
 2. Remote learning is different from learning in person. What has been the biggest impact on your science learning experience?
 - Has it been a positive or negative experience?
 - Why is that?
 3. Have you found yourself thinking about the environment outside of class?
 - Can you please give an example?
 4. Have you ever done an authentic science project (one that has meaning for people outside of your science class)?
 - We will be doing an authentic science project in this class. What are your feelings about this?
-

Interview #2

1. What authentic work are you doing for this project?
 - Why did you choose that topic?
 - If toxicology, why did you choose that chemical?
2. Do you feel like you are a scientist?
 - Why/why not?
 - Has that changed throughout the year?
3. How has this class changed your outlook on your local community?
4. What other ideas do you have for testing about your local community related to environmental science?
5. Do you have any ideas of ways to reach out to your community to make it a better place?

APPENDIX F

SCIENCE AND NATURE JOURNAL PROMPTS

Science and Nature Journal Prompts:

- Develop a scientifically testable question about something in our local community. You can use any environmental topic.
- Do you feel represented in science fields? Do you feel your culture is represented in science fields? Why or why not?
- Answer the prompt: “This year, I felt like an environmental scientist when...”
- Draw a picture of a local place in nature that you value.
- Find a piece of nature that you can bring in from outside. Sketch it. Write down observations (I notice) and questions (I wonder).
- What is your favorite memory about the snow? You can sketch, write, or sculpt (with modeling dough!)
- What was your favorite lesson/lab/activity we did this year?
- What is one skill or concept you learned as a result of your authentic research project?
- From this class, is there anything we did to make remote learning more enjoyable?