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Title: Democratizing the Data Stream: Creating an Equitable Transfer of Research Vessel Data from Scientists to Students

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With the emergence of big data and the Open Data Movement, and the wide availability to the public of large databases, Data Literacy is a necessary learning goal for students. Understanding the data process in its entirety is now a vital skillset required across industry, government, and scientific disciplines. The newest ships in the U.S. Academic Research Fleet, the Regional Class Research Vessels (RCRVs), are being built with the aim to support data literacy through a forthcoming real-time data portal that is intended to foster outreach and engagement. Research for understanding how the new RCRVs may support data literacy occurred in two phases. The first phase research investigated the transfer of real-time oceanographic data from researcher to K-12 classrooms and "The Data Stream" was identified. The second phase research, explained here, expanded upon the first phase through interviewing experts in the field of data literacy and shipboard education. In addition, specialists in diversity, equity, and inclusion in the geosciences were interviewed. The objective was to determine promising practices in data literacy education and shipboard outreach that are also culturally responsive.

The expert interviews illuminated numerous educational strategies which may facilitate building a student's data literacy. One prominent strategy is student-driven community action research, in which students collect and evaluate data to create local change. An eight-week afterschool program, Mar Adentro, was developed where students could examine the presence of microplastics in their local watershed. The pilot program was tested with seven students from Oregon's Latina/o community. Students ultimately emerged from the program with a deeper understanding of the data process. The program also demonstrated the value of providing second-language students informal learning spaces where they can comfortably utilize linguistic capital and engage with one another in their first language.

Democratizing the Data Stream: Creating an Equitable Transfer of Research Vessel Data
from Scientist to Student

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

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Hannah Nolan, Author

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Chapter 1

Introduction

1.1 The Fourth Paradigm & The Ocean Technoscape

Science has entered the "fourth paradigm", in which experts project most scientific discovery will be generated through large databases (Hey et al., 2009). Oceanographic science in particular is moving toward generating information through technological systems, collecting and streaming data in real-time or near real-time. Ocean scientists predict many of their future discoveries will come from a large network of data systems (Hey et al., 2009).

The ocean is being transformed each day by scientists into a "technoscape," as an increasing number of scientific instruments are placed into the sea or atmosphere to collect data on ocean phenomena. Examples of these instruments include buoy arrays, Argo floats, and satellites (Figure 1.1). Remote instrumentation allows for ocean scientists to collect continuous data, as well as data on previously unexplored areas of the ocean. A significant amount of oceanographic information has been generated in the past thirty years as a result of the modern ocean technoscape. Alongside the constant data collection lies a hope that this data may be used in advancing public engagement with the global ocean (Benway et al., 2019).

Prior to the development of remote instrumentation, ocean scientists gathered most data during expeditions aboard research vessels. In an examination of the history of ocean-going research, Adler reported that the research vessel has evolved in the past three centuries from an instrument to a laboratory, and finally in the last thirty years to an "invisible

technician" (2014). The research vessel (or its complement of crew and scientists) deploys, fixes, and retrieves technology from the vast ocean technoscape. The vessel also serves to provide more contextual data in specific swaths of the sea in order to frame and refine the constant stream from the technoscape (Adler, 2014). While the transformation of the research vessel is certainly interesting, there is a crucial backstory in the development of ocean-going science which is necessary to comprehend in order to examine the current state of diversity in the geosciences.

Surrounding the history of the research vessel and oceanography is a history of imperialism, warfare, and colonization. Kucklick and Kohler state:

"Even more than geology and geography, oceanography was created by imperialism and the global travel associated with it. Developed by Anglo-American scientists, it was intended to provide navies and commercial fleets with vital intelligence in areas of national interest. Seagoing scientists were often accommodated on the vessels of their nations' navies and were obliged to fashion physical niches within the distinctive maritime culture of the ships. They appropriated both the instruments and the work organization of naval operations.[…] Oceanography exemplifies the formative linkage between knowledge and power. It is an offspring of Western expansionism, could hardly have existed without it, and persists in large part thanks to military patronage (1996, pg 9)."

Understanding the development and history of research vessels, why they exist, and the industries which historically support them is imperative for understanding how oceanography was originally shaped by dominion, white supremacy, and colonization. Oceanographers must

comprehend the history of science at sea, as we move forward into re-imagining oceanography

and research vessels as an inclusive and equitable space for exploring and learning about the

global ocean.
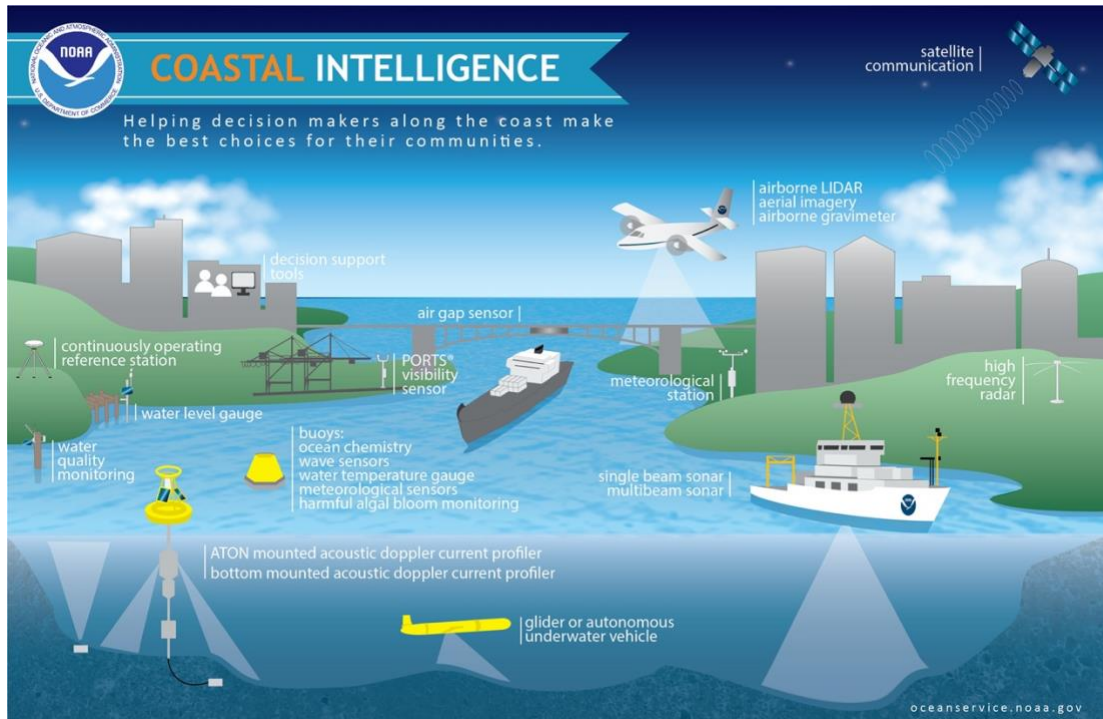
Figure 1.1: NOAA Open Resource Graphic of the Ocean Technoscape

1.2 RCRV: A New Tool in the Technoscape

In 2013 the National Science Foundation (NSF) selected Oregon State University (OSU)

to lead the construction of three new Regional Class Research Vessels (RCRV) for the United

States (US) Academic Research Fleet. RCRVs are vessels designated to operate in coastal

regions of the United States (Reimers & White, 2020). One vessel will have its home port on the

west coast and be operated through OSU. Another RCRV will go to the east coast and be

operated through the University of Rhode Island (URI) and the final vessel will be operated

within the Gulf of Mexico through the Louisiana Universities Marine Consortium (LUMCON) and the University of Southern Mississippi.

The new RCRVs are part of a concentrated effort to revitalize the United States Academic Research Fleet which is coordinated through the University-National Oceanographic Laboratory System (UNOLS). The RCRVs will have advanced technological capabilities, are designed to be environmentally conscious, and will produce reduced levels of underwater radiated noise. In September of 2018, OSU announced they had named their vessel the R/V Taani. Taani is the Native American Siletz word for "offshore" (Reimers & White, 2020).

Arguably one of the most exciting features of the RCRVs will be their capability to directly stream oceanographic data to shore in real-time as the data is collected by a host of ship sensors. Until recently, ocean-going researchers in the US had to wait until ships returned to the dock before sending data to the lab due to limited technology and band-width. The RCRVs will allow ocean-going and land-based scientists to interact in real-time. Scientists will be able to visualize data collection in real-time and thus collaboratively determine when and where to focus data collection in order to learn more about the world's oceans (Reimers & White, 2020).

In addition, this data will be made publicly available throughout the world via internet connectivity. Ideally, anyone interested in ocean science, both professionals and the general public, should be able to access data streaming from sea so long as their internet access is unimpeded. The RCRV open resource data may be used for collaborative research and outreach in the United States as well as globally. This is an exciting new development in ocean science, as it will foster participation and engagement between shore-based researchers and ocean-going scientists, as well as students and the general public.

While the operations plan for the RCRVs is to improve and advance scientific understanding through advanced technologies and data sharing, a broader goal is for these facilities to support education and outreach. During the spin up of the RCRV Project an outreach and education team was assembled to develop an ambitious plan to research how to best engage the general public with the vessel and its data portal. The goals of this research team were to promote the vessel and to research best practices in the design and use of real-time data from RCRVs in K-12 education. The original thought was this data portal may be useful in helping build student's data literacy.

The first phase of the research examined the transfer of data from researcher to teacher to student, labeling this information flow as "The Data Stream." This research examined the current status of oceanographic real-time data use in the classroom and barriers that exist between researchers and teachers and their students. In addition, several strategies for addressing the barriers were tested (Miller, 2019). This phase suggested that further research was needed to investigate how to effectively facilitate transfer of data from researcher to teacher, and teacher to student. One of the suggestions was to inquire as to how this data transfer could be done equitably, in order to better facilitate the engagement of minoritized students in oceanographic science.

Through outreach and education, the R/V Taani could work to build a space in the ocean technoscape for diversity, equity, and inclusion (DEI), thereby working to address oceanography's discriminatory past. However, in order to do so, we must be knowledgeable of the current status of DEI in ocean-going research, public data portals, and geosciences as development of protocols, portals, and programming continues.

1.3 A Critique of the Current Status of DEI in the Geosciences and Democratized Data

1.3.1 DEI in the Geosciences

It has been reported that the geosciences have some of the least diverse leadership across academic STEM programs in the US (Dutt, 2020). Only 3.8% of tenure or tenure-track faculty in the top 100 geoscience programs in the US identify as non-white (Dutt, 2020). In 2016 only 6% of PhDs awarded in the earth, ocean, and atmospheric sciences for permanent US residents were conferred to people who identify as Black, Latinx, or Native American (Bernard & Cooperdock, 2018).

The geosciences are reported to have one of the lowest proportions of doctoral degrees awarded to minority groups of all academic STEM programs in the US (Bernard & Cooperdock, 2018). While the geosciences may not be intentionally racist, the absence of growth in diversity points to systemic issues which result in poor recruitment and retainment of people of color within geoscience institutions (Dutt, 2020). The geosciences may participate in "colorblind" practices, which effectively erase the experiences of people of color (Dutt, 2020). In her paper on racism in the geosciences, Dutt reports that white people often view race as merely incidental, whereas people of color view race as inherent to their identity. This disconnect is tacitly dismissive of people of color, functionally excluding their unique identities and counter to their inclusion in the dominant culture (Dutt, 2020). By ignoring race and culture as a part of identity and experience of our non-white colleagues, we effectively erase their experiences and struggles within the greater society. Reporting of racial injustices within academia may turn defensive,

with white people weaponizing the conversation to victimize themselves and the institution, as opposed to listening and responding to the concerns of non-white academics.

Due to the identification of systemic racism in the geosciences, there has been an encouraging effort to reform and highlight research on DEI in the discipline. The 2019 American Geophysical Union Fall Meeting dedicated an entire program to talks on DEI in the field throughout the six-day conference. However, the identification and highlighting of research is just the prelude to an ongoing process requiring the involvement of all university programs, geoscientists, and education initiatives to abolish identified systemic racism (Bernard & Cooperdock, 2018, Dutt, 2020, Miriti, 2020).

1.3.2 Democratized Data

New data tools will be critical to better engage a diverse public with the global sea. However, enthusiasm must be tempered and based upon lessons learned in open data engagement from other disciplines. A common critique of the fourth paradigm is that it will further the divide between the "data haves" and the "data have nots" (D'Ignazio, 2017). Data literacy theorists such as Catherine D'Ignazio, Rahul Bharghava, Lauren Klein, and Erica Deahl report data collected on marginalized communities is typically used against the community rather than for the empowerment of the community. These theorists urge that as the fourth paradigm progresses it is critical that communities are empowered to utilize data so they may be participants in research rather than purely the subjects of it (Deahl 2014, D'Ignazio & Bharghava, 2017, D'Ignazio & Klein, 2020).

An aspect of empowering marginalized communities through data literacy is in the design of learner-centric open data portals. Open source data portals are being created and placed online at an increasing rate, yet there is no unanimous consensus on how to make the platforms user-friendly (D'Ignazio & Bharghava, 2017). Scientists tasked with creating a public data portal frequently design the end product for the scientifically adept rather than the layperson. A critique of open source data platforms is that their design is for experts, resulting in impractical programs for learners (Bharghava & D'Ignazio, 2017). In addition, one study reports while open-source platforms are designed with the intention of democratizing technology, they are more often utilized by affluent schools as opposed to low-income schools due to their lack of usability for people without proper training (Kimmons, 2015). Low-income schools rarely have the budget for providing professional development opportunities for their staff in order to train them on more technical open-resource platforms (Kimmons, 2015). Data literacy theorists urge developers to create open data platforms for learners as opposed to experts in order to democratize the data stream. In addition, developing educational resources is vital for building data literacy in K-12 students (D'Ignazio & Bharghava, 2017).

1.4 The Need for Data Literacy

A common definition of data literacy is the ability to "collect, evaluate, analyze and interpret data, present derived results, and take ethically sound action based on them" (Dichev & Dicheva, 2017, pg. 2153). Data literacy emerged in the past fifteen years as a necessary skill in the wake of big data and the Open Data Movement. Large quantities of data are collected and placed in large databases by multiple actors including scientists, governments, and corporations.

As a result, many more careers in the US require some data literacy beyond the field of science. (Manyika et. al, 2011).

Many professions require employees to work with big data. Among these are data science, engineering, statistics, and computer science, all generally understood to regularly work with data. However, scientists across a spectrum of disciplines now require the skills to work with big data as the fourth paradigm progresses, including oceanographers, environmental scientists, ecologists, epidemiologists, and social scientists. Data specialists routinely make recommendations based on big data to governments, academic institutions, and corporations (D'Ignazio & Klein, 2020). Jobs requiring knowledge of large datasets are projected to grow by 27-33% over the next decade (US Dept. of Labor, 2019). Interpreting large databases is an essential skill for understanding the new ocean technoscape.

 Beyond the need for data experts, it is projected at least 1.5 million jobs in management and analysis require high-level data literacy in the US. The US currently exists as a "data economy," where numerous quantities of data are collected yet sit unanalyzed. Data specialists call for more data training so society may shift to a "knowledge" or "innovation" economy wherein data generates actionable decision-making (Manyika et. al, 2011).

According to the US Bureau of Labor Statistics only 8% of data scientists identify as Black and 7% identify as Latino. There are currently no statistics on indigenous people working in data science. Forty-five percent of data scientists are white (US Dept. of Labor, 2019) and 16% of data scientists are women (Harnham, 2019). This skewed demographic of data scientists has social consequences because many data scientists develop the algorithms for analyzing large databases. The lack of diversity plays an important role in deciding which questions to ask,

which data to collect and evaluate, how to analyze data, and interpret what the results mean (Klein & D'Ignazio, 2020).

Beyond workforce needs, data literacy is now a necessary literacy for participatory democracy. The intention of the Open Data Movement was to increase public participation in decision-making processes through freely available data (Deahl, 2014). The belief was that by making civic data available, governments are more transparent, and the public can participate in local decision-making processes (Deahl, 2014). Communities may be able to use data to address specific needs where the government may be unavailable or unaware (Deahl, 2014). While open ocean data may seem uncoupled from government design and planning, the ocean is a valuable resource both locally and globally. Open ocean data may be used in understanding the impacts of climate change, locating sources of food and medicine, and placement of marine renewable energy facilities (Benway et. al. 2019; Johnson, 2020).

1.5 Purpose of This Study

This research investigates promising educational practices intended to support a more equitable data stream delivery from the new RCRVs and strives to investigate practices which may promote greater diversity and inclusion in the oceanographic workforce of the future. It examines data literacy practices in education through interviews with professionals actively working in the field of data literacy and ship education through a lens of equity and inclusion. The efficacy of identified promising practices was then tested via an eight-week afterschool program for Latina/o youth living in Oregon.

1.6 Thesis Outline

The following thesis identifies and examines promising practices in data literacy education which can be supported by the RCRVs and other research vessels. This research compiles promising practices in data literacy education as informed by interviews with data literacy researchers, ship educators, and DEI specialists in the geosciences (Chapter 2). These best practices are then applied to a curriculum for an eight-week afterschool program for Latina/o youth in Oregon (Chapter 3). The effectiveness of the after-school program is evaluated in Chapter 4. The thesis concludes with Chapter 5 in which the overall findings are discussed as well as the challenges of the study. Subsequent ideas are then presented for prospective research in the field of equitable data literacy and research vessel outreach.

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Chapter 2

Making Big Oceanographic Data Useable for Everyone: Perspectives from DEI Professional Development Specialists, Data Literacy Theorists & Shipboard Educators

2.1 Introduction

Chapter One detailed plans for the National Science Foundation's new Regional Class Research Vessels (RCRVs), and the intention to develop data-presence systems that directly stream data from ship to shore as it is collected. The data will broadcast in real-time from a web-based portal, adding to the growing number of open source data platforms in ocean science.

As they traverse their dedicated coastal regions, the RCRVs will be coordinated systems equipped to collect and share crucial data to aid better understanding of the global ocean. The data portal will allow shore-based and ocean-going scientists to analyze data and collaborate with one another in real-time. The data portal is also intended to be available as an educational resource for students as they develop data literacy. The designers of this system are planning an outreach effort to better engage the public in oceanography. Those who work on the outreach and education initiative desire the outreach to be equitable and inclusive, in the hopes of fostering diversity within oceanography.

To determine the best path forward in developing the vessel's education plan, Phase One (Miller, 2019) research was conducted to examine the flow of oceanographic data from researcher, to teacher, to student. The term "The Data Stream" was developed in order to describe the movement of data from scientists to classrooms (Miller, 2019). Teachers,

oceanographic researchers, and a handful of professional development specialists were interviewed in order to identify barriers and examine promising practices during the first phase of the research. Numerous barriers were identified in Phase One, the most prevalent being a lack of time: researchers have limited time to turn their data into useable products for teachers, and teachers have limited time to turn data into tools for their students. The research presented here – Phase Two – builds upon the previous study.

Phase Two began with a thorough review of the initial report. This was followed with additional interviews conducted with experts in the fields of data literacy, oceanographic data, and ship outreach and education. The goal was to locate experts in these subjects who work to advance diversity, equity, and inclusion within their fields and bring to light systems of oppression within ocean and data science. The geosciences, which oceanographic research is considered a part of, have been recently scrutinized for the lack of diversity within academic institutions (Bernard & Cooperdock, 2018; Dutt, 2020).

Speaking with experts helped illuminate knowledge of best practices that may facilitate how the RCRVs and programs utilizing these facilities may advance equitable data literacy education. Expert interviews are best utilized when there is a need for timely results and when published research is limited, as is the case for data literacy due its status as an emergent field. Expert interviews are also useful for preliminary investigations prior to conducting more in-depth research (Bogner et al., 2009).

This research seeks to answer the following questions:

1. What are promising practices in data literacy education?

2. What are promising practices for making research vessel data equitable and useful in K-12 classrooms?

3. How can the new fleet of research vessels best support diversity, equity, and inclusion (DEI) through education and outreach?

2.2 Background

Data Literacy is an emerging term in education. When, where, and how the term came about is difficult to trace, though may be linked to the book, *The Fourth Paradigm of Science*. Scientists from multiple disciplines came together to report on how big data is revolutionizing their fields (Hey et. al., 2009). Big data can be defined as mass quantities of data collected on a subject, deposited in data repositories for storage, and then analyzed by the appropriate professional(s). Alongside big data came the Open Data Movement, in which governments and research institutions were encouraged to make their data publicly available. The Open Data Movement originally declared big and open data the tool which would drive data literacy education, especially within the ocean sciences (Hey et al., 2009). The Ocean Observatories Initiative (OOI) is one of the first organizations to declare the power of data for oceanographic education. In his essay for *The Fourth Paradigm*, a principal investigator of OOI, John Delaney, states the following about real-time data in oceanography:

"While the cabled observatory will have profound ramifications for the manner in which scientists, engineers, and educators conduct their professional activities, the most far-reaching effects may be a significant shift in public attitudes toward the oceans as well as toward the scientific process. The real-time data and highspeed communications inherent

in cabled remote observing systems will also open entirely new avenues for the public to

interact with the natural world (pg. 36-37, 2009)."

Delaney's idea of the ocean technoscape as a space for furthering the public's attitudes toward

the ocean is certainly stirring and calls to mind an emboldened future for oceanographic

discovery.

Previous research, however, has pointed to the domain expertise of open data as beyond

the limits of the average learner, especially due to user-knowledge and terminology variation

from discipline to discipline (Deahl, 2014; Koltay, 2015; D'Ignazio, 2017). For a person to work

with large, unstructured databases they require expert-level data literacy (Krumhansl, 2015); a

requirement that may not be given consideration in the design or implementation of data portals

and education programs.

This could stem from a lack of clarity as to what data literacy is. Research subsequently

emerged to define "Data Literacy". Several papers have been published attempting to give this

new literacy a definition (Deahl, 2014; Koltay, 2015; ODI, 2015). One consortium of data

scientists and data educators came together and generated the following definition:

"The data-literate individual understands, explains, and documents the utility and

limitations of data by becoming a critical consumer of data, controlling their personal

data trail, finding meaning in data, and taking action based on data. The data-literate

individual can identify, collect, evaluate, analyze, interpret, present, and protect data

(ODI, 2015 pg. 2)."

Data literacy stands apart from scientific and statistical literacy in that is isolates data as a

process. Through understanding the data process, both a student's understanding of the scientific

and statistical process may be solidified (Koltay, 2015). Understanding the where, the why, and the how of data may help develop a student's understanding of how scientific information is collected and evaluated, as well as understand the statistical limitations and explanations within data (Koltay, 2015).

Other researchers suggest that due to the mass collection of social data via the internet, data literacy goes beyond natural, material, and physical science and steps into the realm of social science. In her thesis "Better the Data You Know", Deahl included qualitative data in the definition of data literacy (2014). Deahl states understanding qualitative data is necessary alongside quantitative data in order to highlight individual stories and narratives which may be lost in large, aggregate datasets. Qualitative research can provide rich context to quantitative research (Deahl, 2014).

As data literacy attempts to find a definition and place in education, it is critical researchers be cognizant of the philosophical connotations of "literacy." The data feminist and data literacy theorist, Catherine D'Ignazio, argues that Paulo Frieire's definition of Literacy applies to data (2017). To become literate is emancipatory; it is one thing to teach students skills, it is another to connect those skills to methods of empowerment. In becoming data literate, a student is not just able to understand data, they use data to create a better world.

2.2.1 Current Frameworks in Data Literacy Learning

Due to data literacy being an emergent skill set and field of study within the realm of education, there are currently few applied curricula, evaluations, or standards in place to determine how a person becomes "data literate." This gap has spurned development in recent years.

New standards in computer science are being recommended through the K-12 Computer Science Framework, and strongly support student's development of data literacy. The framework begins with skills like data storage and visually organizing data in kindergarten through 2nd grade. Students then collect, validate, and use data in 3rd through 5th. In 6th through 8th it is recommended students collect and transform data for usability and reliability. By 9th grade students begin to create computational models (K-12 Computer Science Framework, 2016).

In January of 2020, the Oregon Legislature introduced House Bill 4098, which directs the Oregon Department of Education to develop a long-term, strategic plan for computer science education in the State. The bill currently sits in the House and is waiting to be passed to the Senate. Should the bill be signed into law by the governor, the state could potentially adopt the K-12 Computer Science Framework.

The Next Generation Science Standards (NGSS) and the Common Core State Standards are the current curricular and evaluation framework in science education in the US. Oregon adopted the NGSS in 2014. The NGSS is a recent framework with only twenty states having adopted the standards thus far. The NGSS shifts science education from rote memorization to skill-based learning and compels students to understand the inter-connected nature of science across disciplines. While the NGSS covers numerous topics, a recurring standard is the Science and Engineering Practice (SEP) #4: Analyze and Interpret Data. In a white paper published by ODI (Kastens, 2015), it was determined that SEP #4 is more commonly found among elementary and middle school standards. The SEP #4 diminishes at the high school level. The same report determined there are an adequate number of standards to support the data literacy development in students, however the standards are fractured. The steps of the data process exist in isolation

rather than in a cycle in the NGSS (Kastens, 2015). This research seeks to understand how the new fleet of research vessels may create curricular resources and data learning opportunities which support the NGSS and also facilitate data literacy education in a way that is comprehensive to the definitions set out by experts.

In determining effective frameworks for teaching data literacy, Deahl proposed that informal learning spaces may be an optimal place for building the skills necessary to understanding process in its entirety (2014). While informal learning spaces, such as afterschool programs, may be excellent spaces for developing data literacy, Deahl warns they limit access to the students who have the availability and resources to join them. Determining how to support teachers in K-12 classrooms with culturally responsive data literacy curriculum is the next step in supporting *all* students.

2.2.2 Cultural Relevancy in Data Literacy Education

Big data extends across all disciplines from the environmental sciences to the social sciences. Businesses, non-profits, newspapers, academic institutions, and government all call for "data-driven decision making." There are some concerns with regard to social science data use in government and corporations, as many social science data are analyzed by computer algorithms (Deahl, 2014; D'Ignazio & Klein, 2020). These algorithms are typically built by computer scientists, a field predominantly occupied by white men (US Dept. of Labor, 2020). There have been numerous instances of racial and sexual bias being integrated into algorithmic data gathering and analysis, which can affect the lives of marginalized communities.

Racial and sexual bias may affect what data is gathered and examined. For example, Serena Williams mentioned in a post to Instagram about pregnancy complications resulting in a

longer-than-expected stay at the hospital while giving birth to her child. The post brought

childbirth mortality amongst black women to the forefront of the national conversation, exposing

our healthcare system with the statistic that black women are three times more likely to die in

childbirth than white women regardless of their economic status (D'Ignazio & Klein, 2020).

Despite this statistic, data around pregnancy complications and childbirth mortality in the US is

lacking. There is no national data system for tracking these numbers, even though there are

national data systems for hip replacements and heart disease (D'Ignazio & Klein, 2020).

Racial and sexual bias additionally sneaks into data analysis and data-based decision

making through the reinforcement of classification systems and hierarchies which uphold white

supremacy (Ledford, 2019; D'Ignazio & Klein, 2020). An example of this was found in the

algorithm for a software commonly used amongst healthcare providers (Ledford, 2019). The

purpose of the algorithm was to determine if a patient with complex health issues should be

recommended to extended care programs. A critical analysis of the software determined black

patients with complex and long-term health problems were significantly less likely to be

recommended for extended care than white patients (Ledford, 2019). The designers of the

software programmed it to rate black patients as less sick than white patients, even when

experiencing the same health problems (Ledford, 2019).

Due to these issues, many data literacy education experts call for data education to be

framed through feminist and critical race lens (Deahl, 2014; D'Ignazio & Klein, 2020). Critical

race theory and feminist theories are epistemological approaches which illuminate social

hierarchies and histories that disenfranchise women and people of color; especially Black and

Indigenous people of color (BIPOC).

Culturally responsive education pedagogy may be a necessary framework for building data literacy in order to view data through a feminist or critical race lens. In a culturally responsive learning space, students are taught to critically examine systems of oppression and multi-cultural experiences are validated (Gay, 2018). Data literacy education taught through a culturally responsive pedagogy may help students identify and understand power differentials and social hierarchy in the data process, especially within social science data. In being able to recognize and understand these power differentials, students may be inspired to build a more just society.

While ocean science data is not typically thought of as a form of data that may oppress disenfranchised communities, it is still vital data for comprehending climate change and other environmentally pressing issues. Oceanographic data helps experts make decisions around the placement of renewable energy parks, the opening and closing of fishing seasons, and the designation of marine reserves (Benway et. al, 2019; Johnson, 2020). Students should be taught that understanding oceanographic data is necessary for making informed and sustainable decisions for our future.

2.3 Methods

2.3.1 Data Gathering

Interviews were conducted with experts in the fields of data literacy, DEI in oceanography, and shipboard education, in order to examine promising practices for research vessel participation in supporting equitable data literacy (Table 2.1). The intention of the interviews was to expand upon the initial twenty-seven interviews conducted during the Phase

One of the research conducted by a former graduate student. In Phase Two, additional professionals in the field of data literacy, ship outreach and education specialists, and DEI experts in the oceanographic sciences were identified and recruited for interviews. Two interview guides were developed with open-ended questions (Patton, 2002): one for ship outreach and education specialists and another for data literacy professionals. Questions were designed to be open-ended in order to capture the interviewees' thoughts with minimal inserted bias from the researcher (Patton, 2002). The two interviews were blended for the DEI specialist interviews, as the researcher was put into contact with these individuals later in the research (Appendix A).

Interview questions were designed to illicit the experiences of the experts to understand effective strategies and best practices in shipboard education and data literacy. Additionally, questions were asked of both groups to ascertain how to best combine the two fields (oceanography and data literacy) while using real-time data. Several questions were also developed to examine how this work can be done equitably and inclusively.

Interview participants were originally selected purposefully (Yin, 2011) through identifying current experts in both data literacy and ship-based outreach and education. Snowball sampling (Yin, 2011) was then utilized to select participants for subsequent interviews. Sampled candidates were reviewed prior to making contact. Not all of the candidates recommended by the interviewees were ultimately interviewed in order to remain purposeful towards the research (Yin, 2011). Eleven interviews were conducted in total using a semi-structured format (Packer, 2011). Semi-structured interviewing allows the researcher to ask participants to expand upon or elaborate further on their answers. While the experts were broken up into three groups based on

primary job responsibility, many had overlap between the categories. The average interview length was forty-five minutes; the longest interview lasting one hour and six minutes and the shortest lasting thirty minutes (Table 2.1). Interviews were recorded and transcribed to capture the data authentically. Notes were taken during the interviews to reference during analysis and each interview was followed with reflective notes from the researcher.

Table 2.1: Categorization of Expert Interviews

Expert Type	Number Interviewed	Average Interview Length
Shipboard Educator	3	46 minutes
Data Literacy Expert	6	45 minutes
DEI Specialist	2	34 minutes

2.3.2 Positionality

The data was examined through a lens of constructivism in terms of the researcher's position in the research and the positions of her interview subjects. Constructivism allows a researcher to "understand and reconstruct the constructions (including those of the inquirer) initially held" around the research subject (Guba & Lincoln, 1994, pg 113). Through understanding the constructions of the interviewees and self, the researcher can move towards more complex and better-informed interpretations of the research (Guba & Lincoln, 1994).

The researcher of this study identifies as white, cis woman and recognizes this grants her certain privileges in society and a dominant worldview when navigating societal structures in the

US. While analyzing the interview data, the researcher chose to strongly highlight promising practices suggested by participants who identified as being a part of non-white racial groups. These highlights applied especially to recommendations made with regard to engaging students from non-white groups. Emphasizing the recommendations made by non-white interview participants for engaging non-white students was an intentional decision in order to acknowledge these experts had a lived experience of being a non-white student in the United States. However, all interviews were consolidated for thematic analysis.

2.3.3 Analysis

This research falls within the social science realm of grounded theory. Grounded theory is a method of qualitative research best utilized when there is little to no prior research explaining a theory or process (Creswell & Poth, 2018). This approach was employed to create a framework of promising practices for research vessel support of equitable data literacy. Because data literacy is an emergent field in education, grounded theory was chosen as the most appropriate method to approach this research. The literature provided limited examples of research vessel participation, specifically in data literacy education for K-12 students. Further, there are limited studies into the effectiveness of real-time data portals in supporting student learning. Additionally, the lack of diversity, equity, and inclusion in the ocean sciences have come to the forefront of the conversation in the field over the past two years (Bernard & Cooperdock, 2018, Dutt, 2020). Examining data analysis through a constructivist lens allowed the researcher to detect possible practices a research vessel might utilize for increasing diversity in the geosciences.

To employ grounded theory, the researcher did an initial round of open coding of the interviews. Codes utilized verbs and described processes for supporting K-12 classrooms in data literacy and oceanographic research learning (Huberman & Saldana, 2014). Continuous notes were taken throughout the process of interviewing and memos were recorded during the coding process. Memos were written down as they occurred to the researcher and then re-examined to tie parts of the data together (Huberman & Saldana, 2014). The open coding process resulted in over seventy-five codes in the first round. Codes which occurred with little frequency were removed in the second examination of interviews and remaining codes were placed into categories (Table 2.2). For example, the codes "scaffolded learning, building through grade levels, engage deeply with each step, and takes time," transformed into axial codes which were then combined together to create the core phenomena, "Data is a Process." Codes which occurred most regularly across interviews were more closely examined in order to develop themes within the interviews.

Table 2.2: Expert Interview Codebook

Theme	Core Phenomena	Axial Codes
Data Literacy Pedagogy	Relevant and Relatable	• Local, Actionable • Useable in the Classroom • Standard-Aligned • Interesting for Students
	Context	• Storytelling with Data • Understanding Data Origin • Data Biographies

		• Data Dictionaries
	Data Literacy is a Process	• Engage Deeply • Takes Time • Build through Grade Levels • Scaffolded
	Learner-Centered Tools	• Fun and Playful • Easy to Find • Easy to Use • Active Learning
Intentional Community Engagement	Collaboration	• Boundary Spanners • Community Input
	Building Trust	• Takes Time • Takes Effort
	Representation	• Community Mentors • Cohort Models • Multilingual Resources
Institutional Change	Examining Current Beliefs, Practices, and Barriers	• Consult Experts • Provide Opportunity • Constant Work in Progress

2.4 Results and Discussion

Codes which described core phenomena in the interviews were combined to determine the following three themes in regards to how a research vessel may participate in equitable data literacy: Data Literacy Pedagogy, Intentional Community Engagement, and Institutional Change. There are developed pedagogical approaches within data literacy which may be more engaging

for minoritized youth, however raising interest in research vessels through data requires seeking out and engaging with non-dominant communities. This requires more concerted changes in regards to equity and inclusion from within geoscience institutions in order to grow diversity.

2.4.1 Data Literacy Pedagogy

Pedagogy is method and practice in teaching. Because data literacy is a relatively new focus in education, pedagogical practices for teaching it are also relatively new and developing (Deahl, 2014). In interviews with data literacy experts, the following methods were identified as necessary for effective pedagogy and should be kept in mind for future curricular and programmatic designs for the new fleet of research vessels.

2.4.1.1 Data Literacy is a Process

A common theme identified in interviews with data literacy experts is that building data literacy is a process. There are many steps for turning data into information, and understanding each step of the process takes time. Considering the enormity of big data, a standalone intervention may be inadequate to developing a student's data literacy. Just as with language literacy, data literacy should be taught continuously, throughout one's K-12 education.

When working with teachers and students it is imperative to emphasize that each step in the data literacy process is a skill which takes time to develop. While some data literacy experts believed these skills should be developed in isolation, others insisted students should never lose sight of the entire process, stating:

"Designing a research question, collecting the data, cleaning up the data at some level, etc. A lot of the time we start in the middle of the process, and we ignore the fact that

there's all this messy human stuff that came before that…to me, a high-quality data literacy activity introduces the whole process." *-data literacy expert*

In addition, high-quality data literacy learning requires time, said one expert: "Give (the) time and space to do the process well. At each stage of the data process there's really interesting and important questions for students to engage with."

The data literacy process includes developing a research question, creating data collection and storage protocols, collecting data, analyzing data, and presenting data. Learning how to do each of these steps takes time and instruction. As one data literacy expert pointed out: "Kids won't become data literate in one lesson or one unit or even one school year."

Regardless of where a student starts in the process, all experts agreed that data and scientific processes exist in a cycle. It is important that a student contextually understand which step they are learning and become proficient in applying each step.

One method which may be necessary for proficiency is for students to conduct their own research projects where they analyze self-collected data. Several data literacy experts interviewed emphasized the need for student-based research in conjunction with the utilization of public databases.

"Authentic data sets are what makes the most sense when (you're) trying to analyze data. So we want to give the students a chance to collect their own numbers if they have the opportunity, or at least to have it at a really crucial stage... To have them connected to data in some way."

According to the experts, for a student to fully contextualize and relate to the data process, they must learn how research is done. Through working with data that they collect,

some experts believed students will be more excited about analyzing their data when the time comes. By contextualizing the data process through student-led projects, students may be better able to work with large databases later in their education (Krumhansl, 2015). Most of the data literacy experts interviewed for this research agreed that students should know how to work with large open-resource datasets by the time they graduate high school.

2.4.1.2 Contextual, Relatable, and Relevant

Data literacy experts and ship outreach and engagement specialists both brought up that open data is meaningless without context. All of the three expert groups (data literacy experts, ship outreach and education specialists, and DEI experts in the oceanographic sciences) further added that alongside context, data should be relevant and relatable.

For many of the research participants, context meant understanding that people collect data and have protocols for collection. This is partially why student-led research projects are key, because they support student's understanding that the data process is a human enterprise. Each data literacy expert thought a dataset should include information about the people who collected it, why they collected it, and why they chose certain collection protocols.

> "When you publish open data, provide context. (This is important) so that people can first understand the domain from which it came, and also understand some of the limitations of the data, (so that they can) understand the collection process." -*data literacy expert*

Many strategies for providing context were brought up alongside the need for it. This included developing data dictionaries, student friendly protocol guides, and data biographies. If data is to be open resource with the intention of engaging with the general public, experts believe

it should be humanized. Data is ultimately a human construct, which we use to better understand our world. Even big data is based in numbers collected and analyzed through algorithms created by humans.

> "Students need to know protocols are in there for a reason, and what a protocol is. Here's your experience following one (a protocol). Because ultimately, good science is done in service of bigger science around the world. We want to teach our learners that science is not done in isolation, that it is done as a community." *-data literacy expert*

Ultimately, students cannot learn from the data if they do not understand its context. If data seems pointless to a student, without a question or purpose, then the student may lose sight of the reason behind the data collection. Koltay (2015) reports data literacy requires the awareness of exchange between both the data user and data creator. The data creator, typically scientists, create data through scholarly communication and publication of open data. Supporting data literacy requires a consideration for accessibility when creating open data platforms (Koltay, 2015; D'Ignazio, 2017). While context is crucial, so is making sure students are connected to and care about the data.

Experts interviewed also insisted that data used in building data literacy should be relevant and relatable. Relevant data is usually referenced as recent data or data which fit the learning objectives of the teacher. Essentially suggesting that students demonstrate ambivalence toward dated curriculum, one data literacy expert expressed: "Because (the) students think everything in their lessons aren't real, right? Because so often textbooks are like, 'Look at these data from the nineties."

Data literacy experts and ship outreach and education specialists interviewed stated that for educational data to be relevant, it should be easy to adapt to a teacher's needs. Said one shipboard specialist: "the more you can provide guidance and materials that teachers can plug into their existing plans, the better."

Teachers are mandated to teach targeted proficiency goals and standards to students. These goals are shaped by state standards such as the Common Core State Standards and NGSS. Curriculum and resources are traditionally designed around these standards and adopted by school districts.

Phase One of the research, which examined "The Data Stream", determined teachers are unlikely to use data if it does not help them meet a learning goal for their students (Miller, 2019). Teachers who work to build culturally responsive classrooms look to use culturally relatable data for their students. Interviews with data literacy experts, ship outreach and education specialists, and DEI experts in the oceanographic sciences all emphasized that data used for teaching should be relatable and interesting for students. As a DEI expert and oceanographer stated:

> "A lot of people are unaware a lot of medicines are derived from marine organisms. When I do outreach, I'll give a talk about how certain diseases plague communities (of color) and the drugs we use to treat them. Those drugs actually have their origins in the ocean, and ocean acidification will affect drug availability. I'll watch everyone's surprise and interest when I bring this up. So, find (data) examples that connect to and are important for student's communities."

Beyond general relatable data, interviews with data literacy experts illuminated how data study can empower students to solve an issue in their community. This use of data can be highly

pertinent for engaging minoritized populations. (Deahl 2014; D'Ignazio, 2017). Participatory

action research in which students are able to use data to make informed decisions or change

within their communities has been highlighted as necessary within data literacy (Deahl, 2014;

D'Ignazio, 2017). In addition, it is also believed data activities which empower a student to

impact change in their community may be one of the best strategies for building data literacy.

> "Thinking about how we connect, and then connecting people through a whole cycle (of
>
> research is important). If you take people through a data-driven research project, and then
>
> they make a case to their schools to change something that's unjust about their schools, or
>
> change their trash system, that's going to be very compelling. Something like that could
>
> be successful. They used a data-driven project to make a case, to make change, and then
>
> affected that change in the world."
>
> *-data literacy expert*

Data used in the service of positive change-making was a common emphasis in all of the

data literacy expert interviews. Some experts also brought up there is a lot of useful data which

may help affect change in marginalized communities, but it is locked in portals and databases

that are challenging to navigate and understand. Deahl reported that the utility and usability of

open data, especially from government, tends to be poor (2014). Open data portals are rarely

updated or maintained once published and present raw data which require significant education

and technology for manipulation and analysis (Deahl, 2014).

Alongside the need for contextual, relatable, and relevant data, ease of access and use

was the most commonly identified theme across all interviews. Data is meaningless for students

if it is not presented in a user-friendly format.

2.4.1.3 Learner-Centered Tools

"Creating Learner-Centered Tools" was a theme that appeared in almost all interviews conducted. The unanimous consensus is that if data literacy education is to be done well, there must be effective tools and resources in place to support the learner. When a real-time data portal was brought up in the interviews, creating effective learner-centered tools was frequently mentioned. Throughout the interview process, key features were identified by interview subjects to distinguish between useable and unusable data portals (Table 2.2).

Table 2.3: Expert Reported Best and Worst
Practices in Data Portal Design

Features of Useable Data Portals for K-12	Features of Unworkable Data Portals for K-12
Easy to Find *Easy to Use* *Fun and Playful* *Facilitates Active Learning* *Addresses Specific Learning Goals* *Utilizes Relevant and Relatable Data* *Supplementary Resources*	*No Explicit Learning Goals for Teacher* *Passive Learning (Data is given, Student does no work)* *Overly Complicated, Unscaffolded* *Hard to Use* *Hard to Find* *No Explicit Instructions for Use*

In order for a data repository to address all of these identified themes it must be designed intentionally and built to address the need. A data literacy expert who is also an oceanographer summarized the opinions of all of the experts elegantly:

"If we step away from the real time piece and just think about data products first... a lot of what has been done and is still being done is that we're passing data to archives and repositories.…. We're not making the transformation of the whole suite of available data

into integrated data products, and we're not transitioning that into information…. We have to take those extra steps; otherwise it's just data and it doesn't live up to its full potential of informing and educating and connecting with the public."

Data literacy is best developed through tools built for the learner, which help students understand there is a process in understanding data (D'Ignazio & Bharghava, 2016). In addition, students learn best when provided context and when data is relatable and relevant (D'Ignazio, 2017). Helping students understand the data process can help empower underrepresented students, especially if they work with data that can make a positive change in their community. However, many of the experts interviewed forewarned that if we are to truly commit to building minoritized student's data literacy, we must be intentional in our efforts and make changes within our own institutions.

"To create an environment that's representative of the success of underrepresented students of color is special. Obviously, it can be done, (but) it takes, first of all, accepting there's a problem." -*Oceanographer & DEI Expert*

2.4.2 Intentional Community Engagement

Several sub-themes emerged from the data analysis which were grouped into a main theme of "Intentional Community Engagement." This is a form of engagement designed to dismantle structural inequalities created by academic institutions, and it can be especially powerful if implemented by the institution in order to balance the structural inequalities the institution created (Weerts & Sandmann, 2008).

Intentional community engagement seeks to undo this insidious past by recognizing it and working with marginalized communities to balance power. Several tenets for intentional community engagement designed to foster equity and inclusion emerged during the interviews: building trust, collaboration, and cultivating relationships with community mentors and "boundary spanners." Boundary spanners are people with one foot in the community who also hold expertise or interest in the scientific discipline seeking to engage with the community (Weerts & Sandmann, 2008).

> "We talk about these boundary spanners, folks who tend to have a foot of science and a foot in the world of the community you're interested in. Find those individuals, engage with them beforehand, understand who you are working with." *-DEI expert*

In order to build trust in outreach and engagement initiatives one must first acknowledge a lack of trust that might be held by minoritized populations when it comes to academic institutions. Many interviewees stated that building trust begins with families.

> "There's a huge push to make sure you are building trust with families so that they feel like they can trust you to do well with their students. That's a very culturally tied thing. Like brown people do not trust anyone outside of a brown community. We spend time hosting events, like evening events, for the parents to come and talk to us and have face time with us. (We do this so that) they get to know us. They get to know what the program is that we're operating."

-data literacy expert

Research has shown Black, Latina/o, and other non-white communities in the United States demonstrate significantly less trust in white communities and institutions created by white

people. This is due to long histories of racism which have excluded people of color from participation and success (Smith, 2010). Many non-white communities only trust people from within their own community, who comprehend the community's struggles (Smith, 2010). The research participant in the quote is stating families need to be assured the institution purveying to teach their children is genuinely dedicated to the success of their children.

Alongside the need to build trust with families is making sure there is diverse representation among staff in all programmatic activities so that students may see themselves in the role. Representation could look like images in outreach materials, ship-to-shore interactions with a diverse group of people, or spotlighting scientists from minority groups. However, interviewees from all three groups emphasized that the visuals need to be grounded in reality. If mentors from the community are advertised, they must be present in the program. This quote succinctly summarizes the opinions (across disciplines) of a majority of experts interviewed:

> "If you are in a place where you're thinking about how to facilitate programs, how to support communities that have been historically disengaged in science, (then you must consider) representation. Absolutely. And having someone who is able to riff with that culture, and understand where people are coming from when they pose concerns or questions, or when they disagree with anything. I would strive for that for sure."

Institutions striving to undo any biases they have toward minoritized communities must employ members of the community (Williams, 2019; Miriti, 2020). In the case of facilitating relationships between the institution and minoritized communities, employees who are members of the community may serve as boundary spanners, should they be interested and available (Miritri, 2020). Regardless, having faculty and staff from non-dominant communities is a

necessary step for reforming institutional practices which inhibit the success of minoritized students (Williams, 2019; Miriti, 2020). Likewise, when designing programs that seek to involve community mentors, trust must be established to ensure the institution is genuinely committed to diversity, equity, and inclusion.

> "You have to build relationships. You have to build relationships with the advisors and the mentors who are out there. (People) like myself and many others who have the direct access to these students in different spaces and places, and are a part of the network for recruitment. You have to prove to us that this is going to be a culture that is conducive to the success of these students." -*Oceanographer & DEI Expert*

Building relationships with community takes time and effort (Duran et. al, 2014). The institution must genuinely recognize there is a problem and be committed to fixing it. Science, Technology, Engineering, and Mathematics (STEM) outreach and engagement initiatives designed to build relationships and facilitate learning for minoritized students come under scrutiny if they emerge from institutions not already examining and changing their own systemic racism (Miriti, 2020).

2.4.3 Institutional Change

> "Many of the gateway programs (in geoscience) are pretty much inaccessible to students of color, for many reasons. One of the ones I tackled had lots of issues. Lots of barriers to entry, lots of challenges with process, procedure, behavior, perception. A lot of (geoscience) programs have these same problems." -*DEI expert*

Academic institutions, scientific ones in particular, were not historically designed for the success of minorities (Patton, 2004; Yosso et al, 2009; Williams, 2019; Miriti, 2019). Numerous

variables interact to make navigating academia challenging for students from non-dominant populations. These include: microaggressions, scarcity of advising and mentors, "colorblind" practices from white faculty which may ignore unique cultural capital, Eurocentric bias in curricula, and overt racism (Williams, 2020). There is a long history of white supremacy interwoven in most academic spaces which must be undone. Many experts that were interviewed commended research being conducted to identify the problem and then looking into how we, as education researchers and oceanographers, can work to make space for underrepresented students in our efforts.

Data literacy is a necessary skill for all youth in the modern workforce, and creating tools and education materials which facilitate this learning is crucial (D'Ignazio & Bharghava, 2016). Through effective data literacy education support, the new RCRVs may help empower students to make changes within their communities through data, as well as gain skills which will be necessary in their professional pursuits. The RCRVs may spark interest in the geosciences for minoritized youth through intentionally designed education programming. However, this will require intentional community engagement, which in turn requires institutional change (Miriti, 2020).

Institutional change was a theme that emerged across interviews. Methods for institutional change included consulting experts, providing opportunity, and examining current beliefs and practices. The latter was the most prevalent sub-category within this theme. Many experts interviewed stated that there are beliefs held within the field of oceanography which inhibit the success of minoritized students. These beliefs can subsequently create practices which create a barrier to entry for underrepresented students. Before implementing any sort of program

designed for minoritized students, the institution must work to examine their current practices and how they inhibit entry. Many mentioned they were still in the process of undoing oppression at their own institutions.

> "We are thinking about (it). We are in a new stage of proposing our five-year strategic plan. And we wanted to call out equity, diversity, and inclusion in our programs. And we're currently in the stage of doing that work as staff members to understand what that means for us as individuals, and then to reflect on the current programs that we offer." -
> *Data Literacy Expert*

Others mentioned that beyond reflection, examining beliefs also means evaluating what success looks like in the field of oceanography:

> "That (is) one of the challenges. The model for what you need it to be to be a scientist. You need to be a MD, a PhD at Johns Hopkins, (someone) who is going to be a Nobel Laureate. And we know not everyone's going to do that, right? So, there has to be a lot more options for people.…Think of all the different career options you have on a research fleet. You can be the chief scientist, the person who drives the ROV, the person who designs the ROV. There's all kinds of different things that you can do." -
> *Oceanographer & DEI Expert*

Re-adjusting our ideas of what success looks like in science is one aspect of examining current beliefs. The "STEM Pipeline" has been scrutinized because it views the only successful outcome in science is to become an academic. Many people participate in science in some capacity in their careers, but never go on to be full-time researchers and professors at universities (Bevan, Calabrese & Barton, 2018).

Another theme that arose in the research was examining the barriers to entry which may keep a student from pursuing a STEM career. One expert summarized this theme:

"To get to where they got to, a lot of people were weeded out and there were structural barriers.... Every scientist should, and many are, thinking about that now, (including) whatever privilege they had getting to where they are." *-Data Literacy Expert*

The theme of institutional change was so prevalent across interviews that, ultimately, it became clear that if the RCRVs are to genuinely commit to equity through outreach and engagement, we must ensure we are committed to diversity, equity, and inclusion within the operating institutions and aboard the vessels.

2.5 Key Take-Aways

Based on this research, a model emerged as a vision for how research vessels can help facilitate equitable data literacy. The following is a synthesis of findings and applicable recommendations made by experts which could fit into a research vessel outreach and education model. Take-aways which may not fit into research vessel outreach and education were not included in the model.

The first step is creating a data portal that is user-friendly for teachers and students. The data portal should be included on an education website focused on lessons designed around data, not all of which need be exclusively based on oceanographic data. Lessons not involving oceanographic data could explore how to develop a research question or show students different data they can collect at school. The resources should align to NGSS standards and be organized by grade level and by topic.

Each time the research vessel is out at sea, an expedition summary should be written and posted in accessible language supported by images. Scientist biographies may be included for each expedition which emphasize why the scientists are excited about the research they are doing. Biographies of the ship's crew should be included as well to highlight alternative careers aboard research vessels.

The real-time data portal might have a guide attached for how to use it and anomalies to look out for. Many of the interviewed experts stated real-time data is great as a hook for students, but not always the best for teaching phenomena. Canned data should be used in lessons alongside real-time and near real-time data for helping students answer direct questions with data. The canned data utilized should be fairly recent in order to be relevant.

In order to facilitate diversity, equity and inclusion through programming, Outreach and Education teams working with research vessels should strive to cultivate relationships with schools with more diverse populations. This may be through professional development workshops, family science nights, or afterschool programming. All of this programming should be affordable for the school. Through cultivating relationships, the research vessel may inform their partners of "teacher at sea" or "student at sea" programs, should they exist, and potentially develop applications that would not deter students from applying.

Student at sea programs could be vital for diversifying the geosciences, as students get to engage in the data process while at sea. Either intentionally creating our own program or partnering with STEMSEAs is advisable. STEMSEAs is an NSF-funded program which brings underrepresented students in the geosciences aboard UNOLS vessels for a week of learning

about oceanographic research. STEMSEAs programming typically occurs while a vessel is transiting to its next location.

Finally, the research vessel team should consider assembling a group of experts to advise on establishing a culture of diversity, equity, and inclusion across all aspects of the vessel. The experts may examine the application process for going to sea, outreach and education materials, and conduct multiple cultural sensitivity trainings for all employees. All staff members should be encouraged to have open conversations to create a vision for inclusive seagoing culture.

2.6 Conclusion

Data Literacy is a relatively new topic in the field of education and was conceptually designed to support learners in the wake of the big data and the Open Data Movements. It is a crucial literacy in the modern era, necessary for understanding the large waves of data we are exposed to on a near daily basis. Data literacy may also support scientific and statistical literacy through galvanizing a student's understanding of scientific and statistical methods. Beyond needing the skill for the modern workforce, data literacy is useful for empowering communities to insert themselves into the data process. Critical Data Theorists argue data is incredibly compelling for speaking truth to powerful institutions harming disenfranchised populations including ethnic minorities, indigenous people, queer communities, and women (D'Ignazio & Klein, 2017).

The Regional Class Research Vessels are being equipped to support equitable data literacy and the RCRV Project is sponsoring research to develop a better understanding of promising practices in data literacy education. The first phase of the research identified the transfer of data between teachers, students and researchers, known as "The Data Stream." This

first phase, conducted by Danielle Miller, began to examine methods for overcoming these barriers. The second phase of research sought out experts in the field in order to elucidate and cement understanding of promising practices the new regional class outreach and engagement teams may employ for genuinely engaging in equitable data literacy education.

Ultimately the research determined data used for educational purposes should be situated in context, be relevant and relatable for students, and be taught through learner-centered tools. Oceanographic researchers cannot expect to deeply engage students with data platforms designed for experts. Learner-centered tools would be a strong start for imparting knowledge from oceanographic experts to the general public because they may help build trust and interest in ocean science and research vessels. However, in order to genuinely include underrepresented populations through outreach and engagement, research vessel outreach and engagement should also build trust with minoritized communities and their bridge-spanners and develop educational programming in collaboration with these communities.

Creating intentional community engagement requires internal examination from the institution and a concerted effort to shift practices which may inhibit participation from marginalized students. Geoscience programs have been making significant efforts to understand and remediate lack of diversity in recent years with efforts like the STEMSEAs program and the Unpacking Diversity Group at OSU's College of Earth, Ocean, and Atmospheric Sciences (https://unpackingdiversity.wixsite.com/ceoas). However, there is still extensive work to be done, and geoscience programs must continue to examine and reform current practices in order to manifest a more inclusive future.

2.7 Future Research

Future research could examine the application of the identified practices for developing a learner-centered oceanographic tool centered around the research vessel. Research could examine the engagement of students though an intentionally designed website. The website could also be reviewed for its usability by K-12 teachers. Future research may also examine how student and teacher experiences aboard research vessels impact their data literacy and interest in oceanography.

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Chapter 3

Mar Adentro: A Microplastics-focused Afterschool Program for Fostering Data and Environmental Literacy

3.1 Introduction

Mar Adentro is an eight-week afterschool program designed to introduce high school students to the data cycle and to connect them to the ocean through their local watershed by investigating an emergent environmental issue: microplastics.

The program was supported through funding from the National Science Foundation (NSF) Regional Class Research Vessel (RCRVs) Project and Oregon Sea Grant. The pilot program tested promising practices in data literacy education, in order to advance our understanding of educational solutions for building student data literacy. Determining the effectiveness of emergent practices is necessary for aiding in the development of curricular and programmatic resources supporting the use of the RCRV data portal. The pilot program focused on working with students from Oregon's Latina/o community, and examined how to build equitable programming and science learning experiences for Latina/o students. Latina/o students were selected to participate in the program in order to investigate best practices in building culturally responsive materials and programs which may support more diverse participation in the geosciences.

The program was designed in partnership with Oregon Sea Grant and the Juntos Program. The NSF funded RCRV project, Oregon Sea Grant and Juntos programs are all affiliated with Oregon State University (OSU). Oregon Sea Grant is one of 33 national Sea Grant

College Programs and is supported through funds from the National Oceanic and Atmospheric Administration (NOAA) and OSU Extension funds. Oregon Sea Grant supports Oregon's coastal communities and ecosystems through research, education, outreach and engagement. Juntos is a part of OSU's Open Campus, facilitating Latino families' access to college by building relationships with community partners to provide culturally relevant programming.

The Mar Adentro program was designed to lead students through a community action project using the tenets of Creative Data Literacy (CLD). CLD is an educational strategy designed by Catherine D'Ignzaio for teaching data skills to people without expertise and may be especially pertinent for engaging minoritized populations with data (D'Ignazio, 2017). The first tenet of CLD is to work with local, actionable data. In order to apply the first tenet, microplastics were chosen as the topic of study for the Mar Adentro program. Microplastic pollutants are an emergent environmental issue that is both local and actionable for students who do not reside near the ocean, but could still potentially connect them to the ocean through their watershed.

The intention of this project was to facilitate students through both the inquiry cycle and data process while simultaneously connecting students to the ocean through their local watershed (Figure 3.1). Students visited a nearby creek, studied the flow of the creek to the river, and the movement of plastics from neighborhoods, through the watershed and out to the ocean. Following this, students were then introduced to large ocean databases. The thought was that through engaging students with each step of the data process utilizing local data, they may feel more interested and empowered to understand big oceanographic data. Once students are able to comprehend and connect with big oceanographic data, they may feel inspired to become oceanographers themselves (Figure 3.1). Studying the programs intermediate and advanced

impacts would require interviewing the students later in their education. A longer-term study of the program would be required to measure whether or not the intermediate and advanced outcomes occur.

Inputs	Actions	Intended Outcomes

Timeline
- 2019-2020

Resources
- NSF RCRV Grant
- Oregon Sea Grant
- Space + Local School
- Personnel

Personnel
- Bilingual Education Coordinator
- RCRV Grad Student
- Oregon Sea Grant
- Juntos Coordinator

Mar Adentro Pilot
- Curriculum Development
- Form relationships with program partners
- Recruit participants
- Implement 8-week afterschool program
- Move online due to Covid-19 pandemic
- Program assessment

Outputs
- Curriculum
- Program Materials
- New Community Partnerships
- Publications and Presentations

Short Term
Increase student's environmental & data literacy
Indicators
- Knowledge of data collection methods
- Concern for plasics pollution partners
- Desire to use data to make community changes

Data
- Program observations
- Student interviews
- Student surveys
- Student generated materials

Intermediate
Increase student's interest in the geosciences
Indicators
- Curiosity about earth, ocean or atmospheric science
- Understanding of how to use and apply open resource geoscience data
- Participants pursue geoscience at the undergraduate level

Increase student decision making from data
- Students examine data for making well-informed decisions
- Students are able to locate reliable data and anomalies

Advanced
Indicators
- Widespread data literacy in the general population
- Increased diversity in the geosciences

Figure 3.1: Logic Model of the Mar Adentro Program

3.2 Background

3.2.1 Afterschool Programs & Creative Data Literacy

Creative Data Literacy is a framework for developing data-driven educational programming. D'Ignazio outlines five strategies for ensuring data is taught "creatively." The first strategy is working with community-centered data, specifically data that informs the learner about themselves or an issue they are facing. The second strategy is creating biographies for the data, something a data specialist may refer to as "metadata." Data biographies help the learner discern why the data was collected and by whom so they might contemplate the intentions behind the data. Data biographies tie into the third strategy: *make data messy*. Professionals who work with data spend the majority of their time cleaning and organizing it. It is important for students to understand that not all data is useable data (D'Ignazio, 2017).

The fourth strategy is building learner-centered tools. D'Ignazio critiques that large data systems are rarely developed with the end-user in mind. Freemium data analysis tools are being created at a rapid rate with little consideration on how to teach people to use or understand them. D'Ignazio asserts that learner-centered data tools strive to do one thing well, are guided with sample data in order to get the user started, are visually appealing and humorous, and help the student progress onto the next steps of understanding data. D'Ignazio's fifth strategy for creative data literacy is celebrating community-centered creativity in data analysis. How data is utilized may not be what the researcher expects when a non-expert engages with it. (D'Ignazio, 2017).

A recent report released by the National Science Foundation (NSF) states that people living in the US spend 95% of their lives outside of a school setting (Bevan, Barton & Garibay,

2018). The same report attests a large quantity of STEM connections exist outside of the classroom: in museums, science centers, summer camps, and after school programs. Children with clear pathways to STEM, typically middle class and white, have regular access to these informal learning spaces. The report determines there has been success in creating STEM pathways for non-dominant groups when informal learning programs are designed with a specific non-dominant group in mind (Bevan, Barton & Garibay, 2018).

Beyond the NSF report on informal learning settings, there is substantial literature on the capability of afterschool programs for empowering students in their STEM studies. One study found that an eighteen-month afterschool intervention program incorporating technology improved student's confidence in technology use and piqued student interest in STEM careers (Duran et al., 2014). Another study on a long-term STEM afterschool program exclusively serving Black students found participation in the program directly resulted in more students attending college and majoring in a STEM field (Hargrave, 2015).

Key components of both programs consisted of a long-term approach and utilized the expertise of teachers, researchers, STEM professionals, and community members. In addition, parents were engaged every step of the way and considered part of the community. Both studies emphasize the importance of exposing students to professionals within STEM and taking students on experiential field trips to see labs and universities. While these recommendations are salient, the Mar Adentro program was neither long-term nor did comprehensive work to engage with families. Working to engage families was discussed multiple times while the program was in design, but collaborators ultimately determined the effort beyond the scope of the pilot. The pilot program was designed for a shorter period, primarily investigating promising education

practices and examining strategies for later longer-term engagement. Lessons learned from the pilot may be used in future program iterations in which Latina/o families are engaged over a longer period of time.

Beyond the development of science identities, past research also points to these informal learning spaces as having a strong potential for facilitating data literacy education. After-school settings lack the constraints of the traditional classroom and may better support the need for a highly integrated approach for teaching data literacy. One example of a successful data-based informal education experience is the Young Rewired State's Festival of Code, a week long hackathon in the UK where students utilize open data to solve real-world problems. A study of the event revealed students emerged with a better appreciation of open data. While the results of the hackathon were exciting, relying entirely on afterschool programs for teaching data literacy should be approached with caution, as it limits exposure to the students who are able to participate (Deahl, 2014).

3.2.2 Microplastics

The use of plastic has been growing exponentially since the 1940's due to the material's cost-effectiveness, durability, and ease of manipulation. Alongside the growth in plastic manufacturing, is the growth in plastic waste, accounting for over 10% of global human waste. (Cole et al., 2011). Microplastics have emerged recently as an environmental and toxicological concern (Rillig et al., 2017; Gasperi et al., 2018; Koelmans et al., 2019). Plastics do not decompose naturally in the environment, but rather break down into smaller and smaller fragments over time. Microplastics are both the broken-down particles of plastic waste and

plastic that is industrially produced in microscopic size. A plastic is counted as "micro" if it measures less than five millimeters.

Microplastics initially emerged as an environmental concern in the global ocean, but research has recently expanded them to be a worldwide issue concerning all environments. There are spatial areas of the ocean where plastic converges into a visible conglomerate. Ocean gyres are an example. However, evidence points to microplastics being ubiquitous in both the water column and sediments (Cole et al., 2011). Beyond the ocean, microplastics have also been found in air, agricultural soil, and drinking water (Rillig et al., 2017; Gasperi et al.; 2018, Koelmans et al., 2019). There is considerable evidence pointing to marine life consuming microplastics (Wright et al., 2012). Microplastics have potentially detrimental effects on an organism's life after consumption, with variation between species. Detrimental effects include internal abrasions and blockages, as well as observed leaching of polymer-based chemicals into the organism that is likely to cause endocrine disruption and cancer. Microplastics also appear to be bioaccumulating as they move through marine food webs (Wright et al., 2012).

The human health effects of microplastics are relatively unknown at this point in time, despite ample evidence that humans are ingesting plastic. One report claims most people consume the equivalent of a credit card in plastic per week (Dalberg & World Wildlife Fund, 2019). There is evidence pointing to toxic chemicals binding to microplastics. In addition, until recently, many consumer plastics contained known endocrine-disruptors and carcinogens like bisphenol A (BPA), Bis(2-ethylhexyl) phthalate (DEHP), and dibutyl phthalate (DBP) (Manikkam et al., 2013).

3.3 Program and Curriculum

3.3.1 Program Description

The curriculum was tested in a small exploratory study with high-school aged Latina/o youth living in the Willamette Valley region of Oregon. The school and participants were selected with help from the Juntos program who determined which school coordinator would have the capacity and interest for helping facilitate the program. Student feedback provided information on how to improve the program for future iterations. The following descriptions are overviews of the curriculum, for the full curriculum and NGSS standards please see Appendix B.

The Mar Adentro program is designed as a community action project with an inquiry cycle curricular framework. Inquiry-based science instruction emphasizes active participation and students discover knowledge which is new to them (Pedaste et al., 2015). In an inquiry-driven lesson, students explore a phenomenon, develop hypotheses, collect and analyze data, present results, and draw conclusions from their results (Pedaste et al., 2015). The entirety of the lesson or curricula can be viewed as a cycle, commonly referred to as "The Cycle of Inquiry." While there are many iterations describing the Cycle of Inquiry, Pedaste et. al. synthesized and distilled the cycle into five phases: orientation, conceptualization, investigation, conclusion, and discussion (2015).

The Cycle of Inquiry provides a structure for facilitating student's growth in data literacy. According to the Oceans of Data Institute, a data literate person can "identify, collect, evaluate, analyze, interpret, present, and protect data" (2016, pg. 2). The Cycle of Inquiry could potentially be concomitant with data literacy if students are made aware of the steps of the data process

(Figure 1). It is important that students learn about both the power and limitations of data throughout their inquiry, one of the tenets of Creative Data Literacy.
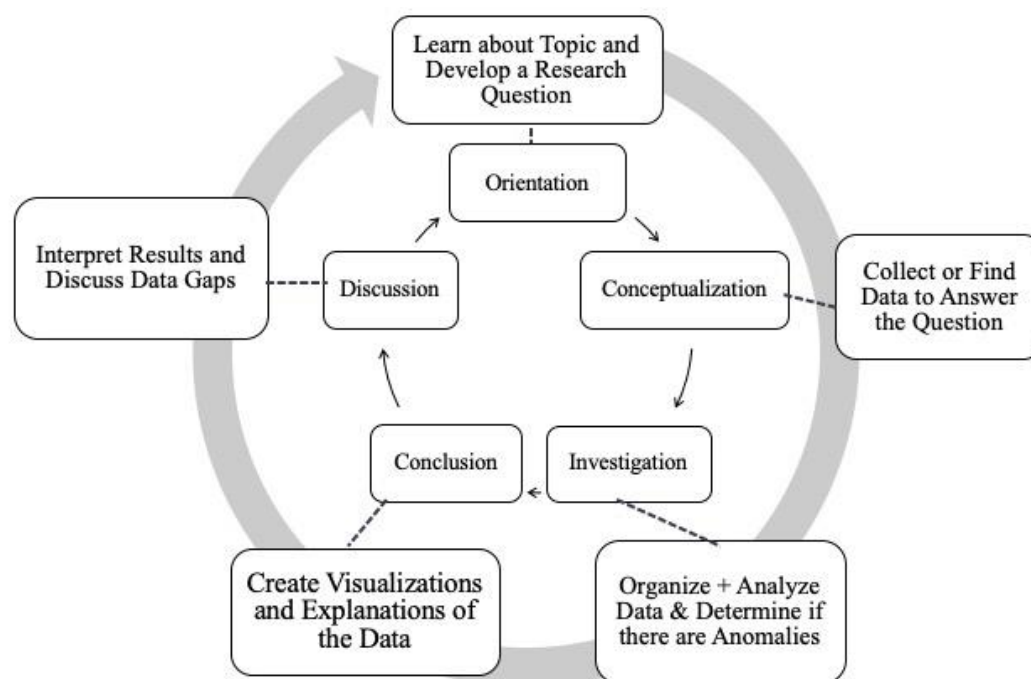
Figure 3.2: The Potential Coordination of the Data and Inquiry Cycles based on Pedase et. al. and the ODI definition of data literacy.

The first few lessons of the 8-week Mar Adentro program introduce students to background information on the issue of microplastics, how to develop research questions, and data protocols through a survey of terrestrial plastic at their school. In subsequent lessons, students build microplastic trawls (Figure 3.3) from scratch using cost efficient materials and collect samples with their self-built trawls in a local stream or river. These lessons touch on NGSS engineering concepts and data collection protocols in order to immerse students in the experience of being scientists and engineers.

Figure 3.3: Student Built Microplastic Trawls Utilizing Low-Cost Materials (Design Source: Testing Our Waters)

In the final three lessons of the program, students sort their data using dissecting scopes, input their data into spreadsheets, and then analyze their data with a user-friendly software such as Google Sheets or TuvaLabs. Students conclude the program by working together to determine their choice in disseminating their results. This may include a scientific poster, an awareness campaign at the school, or the creation of data art. Data art is abstract artistic renditions of data in the form of performance, murals, multimedia, or sculpture.

3.3.2 Curriculum Overview

In the first two lessons of Mar Adentro, the students experience the first phase of the Cycle of Inquiry: "Orientation." Students are oriented first to the program and its learning goals,

and in the second lesson they meet a scientist who further explains the problem of microplastics. The scientist initiates the second phase, "conceptualization," through providing in depth information and mentoring students as they collaboratively develop hypotheses (Table 3.1).

Lessons three through eight focus on the investigation piece of the Cycle of Inquiry. Investigation may be the most time intensive step, as students must explore, experiment, and analyze data. Lesson four takes a brief pause from the Cycle of Inquiry to teach students about community science and building low-cost scientific instruments for environmental monitoring. Lesson eight represents the conclusion piece of the Cycle of Inquiry as students present their findings. Lesson nine is an optional extension in which students re-start the Cycle of Inquiry by presenting their findings to a chosen audience, and creating new testable questions based on their data. Lessons eight and nine are student driven as students determine how they want to present their data and who they want to present it to. The entire program is developed to be aligned with the NGSS.

Table 3.1: Mar Adentro Lesson Summaries

	Lesson	Summary
Orientation	1. Program Introduction	Relationship building between the instructor and the students. Students are introduced to the foundation of data literacy and the course is explained for the next seven weeks of program.
Conceptualization	2. Meet a Scientist	Students meet with a scientist working on microplastics who introduces students to a data set and offers some mentoring. Students work with the scientist to develop their own research questions regarding microplastics in their watershed.
	3. Terrestrial Plastics Survey	Students examine plastics pollution at their school and consider how their school community may or may not be contributing. Students are encouraged to develop initial research questions and learn how data collection protocols are organized and why. A collection protocol designed by a scientist, with accompanying worksheets, is introduced. Students visit a creek to do their own terrestrial plastic survey.
Investigation	4. Build a Microplastics Trawl	Students design and build their own trawl for collecting microplastics in their local watershed. A trawl is a scientific instrument for collecting water and filtering particulates. The trawls are open resource designs created by the Testing Our Waters Projects. Students learn about the design process for scientific equipment and build their own product based on guidelines developed through Testing Our Waters.
	5. Stream Sampling	Students use the microplastic trawls built during the previous class to collect data from a local river or stream. Students work to create a sampling protocol based on research questions, collect data with their self-designed equipment and available technology, and experience field science in a local setting.
	6. Sample Sorting / Categorizing Data	Students work together to sort and categorize the data they collected during the previous class. Students use microscopes and research guides to categorize the objects they found in the river. Students input data into a pre-designed spreadsheet specifically created for the program as they sort their samples
	7. Data Analysis	Students work on analyzing their data and devising ways to present results. Students are introduced to data analysis through Excel and Tuvalabs software. Students begin to construct their data story.
	8. Create a Data Story	Students create a data story using the graphs they generated. Students incorporate their data collection methods, research questions, and general observations to generate the story. Students then work collaboratively to decide how they want to tell the story.
Conclusion / Discussion	9. Presenting Results	Students compile their work of the past eight weeks to present to the scientist they met in Session 2. Students then work collaboratively with the scientist to generate new potential research questions they would like to explore or like to see explored in the future. Students may also determine if they would like to disseminate their results to a larger audience: their school, community, or local watershed council.

3.7 Conclusions

The eight-week Mar Adentro program guided students through the data process and connected them to the ocean through their local watershed. It was accomplished with the investigation of a pertinent issue: microplastics. There were many program successes and challenges, and the program has subsequently been modified based on feedback from the students as presented in Appendix B.

This prototype program was tested in a small exploratory study with Latina/o high school students to examine the effectiveness of inquiry-based learning for students from a non-dominant minority group. In addition, the program incorporated the framework of creative data literacy. The hope for the program is that students would emerge feeling more empowered in understanding the data process. Several students remarked they felt it was a positive introduction to data and field work, but they still had a lot more to learn. In the middle of the program the student's high school biology teacher commented to me, "I've never seen these kids this animated before in my class. Never. They're usually quiet and reserved."

3.8 Acknowledgements

3.9 References

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Chapter 4

Afterschool Programs as a Space for Solidifying Science Identity Amongst Latina/o Youth

4.1 Introduction

Names have been changed to protect the identity of the students involved.

"So… Data is power?" Gabriela asked after I finish talking about all the different ways data is utilized in our society. I smiled at her, only having just met her and the rest of the students twenty minutes before as I flipped to my next slide.

A picture of our State's Capital building flashed onto the screen, the words "Data is Power" pronounced over blossoming cherry trees. It was almost as if Gabriela had immediately read my train of thought. We began to discuss all of the different ways data shapes our lives. The students asked a few questions as I explained what they could expect in the weeks ahead. These young Latina women would conduct authentic scientific research on microplastics in our watershed, an emergent issue in the modern world.

In the initial design, this research set out to investigate and construct culturally responsive data literacy curriculum. Culturally Responsive Teaching, a framework developed by Dr. Geneva Gay, was developed to effectively support black students in the United States in their educational experiences. Gay's work is an expansion upon Dr. Gloria Ladson-Billing's theory of culturally relevant teaching. Ladson-Billings theorized that in order to foster a culturally relevant classroom, a teacher must require cultural competence from their students, empower their students to be critical of socio-political and economic systems, and demand academic success

(Brown, 2017). Gay asserts culturally responsive teaching is "validating, comprehensive, multidimensional, empowering, transformative, and emancipatory (Brown, 2017, pgs 1146-1147)." To consider a classroom or curriculum culturally responsive, indigenous and multicultural ways of knowing are embraced and validated as equal to western practices. Science education in particular has been scrutinized for alienating students from non-dominant populations (Bevan, Calabrese Barton & Garibay, 2018).

This research is funded through the National Science Foundation (NSF) as part of the creation of a new class of research vessels for coastal Oceanography. These Regional Class Research Vessels (RCRVs) will have the capability to stream data to shore in real time via a data presence system to a data portal. One secondary goal of the data portal is gathering scientific data for use in supporting K-12 and public data literacy education in the United States (US). A target for this secondary goal is that the materials designed around the data are culturally responsive. Promising strategies for developing culturally responsive data literacy education include student driven research projects which investigate social inequalities and the tenets of Creative Data Literacy (D'Ignazio, 2017).

While this research intended to assess if students who participated in the experimental curriculum became more data literate via culturally responsive practices, it elucidated more nuanced and meaningful perspectives on how Latina/o students draw from their cultural capital to build a supportive community around science. This research suggests that strategies utilized for facilitating inquiry-driven, data literacy education are effective in engaging minoritized students. However, their effectiveness for being culturally responsive remains in question when considering the definitions set out by Gay and Ladson-Billings. Education researchers,

overwhelmingly white, should be cautious moving forward when we apply the terms "culturally responsive" and "culturally relevant," as these are pedagogies developed by black women scholars.

Applying culturally responsive or relevant theory to curriculum without fully understanding their implications as multidimensional teaching approaches may white-wash the work of both Ladson-Billings and Gay. Black feminist scholars have critiqued sociologists for applying Kimberlé Crenshaw's Theory of Intersectionality without fully comprehending its implications as a theory developed to center the experiences of black women (Alexander-Floyd, 2012). The theory is now applied universally without strong regards for its origin (Alexander-Floyd, 2012). Education researchers should also be wary of potentially de-centering and universally applying the works of Ladson-Billings and Gay without understanding the connotation of their work.

Culturally relevant teaching was developed to center and validate the culture of black students in the United States within the classroom. Gay expanded upon the theory to assert culture is a multi-dimensional component of a student and how they may learn (Gay, 2018). Both pedagogies are multidimensional approaches typically applied to classroom spaces by teachers (Muñiz, 2019). Informal learning environments may also be culturally responsive or relevant if intentionally designed (Simpkins et al., 2017). STEM curriculum can be created to be culturally responsive if it validates cultural knowledge and practices, but there is no certainty the curriculum will be culturally responsive if used by a teacher who may not apply the pedagogy in their teaching (Brown, 2017).

Rather than validate the cultural responsiveness of the curriculum, the insights gained from this research supports the necessity of long-term STEM community engagement with students from non-dominant groups. The following is a case study examining how adolescent Latinx students draw from cultural capital to support one another's developing science identities, and steps that must be taken for creating and maintaining these informal learning spaces.

4.2 Background

4.2.1 Oregon's Latina/o Community

The Latina/o community in Oregon has been growing at a rate faster than the national average. As of 2016, the Latina/o population represented 12% of Oregon's population and accounted for 72% of population growth since 2000. Sixty-four percent of Oregon's Latina/o population were born in the US. Eighty-five percent of Oregon's Latina.o population originate from Mexico, however approximately 20,000 have roots in Central and South America (Oregon Community Foundation, 2016).

The Latina/o population now accounts for 23% of students enrolled in K-12 schools in the state. Only twelve percent of Oregon's Latina/o population possess a college degree, whereas one third of Oregon's white population completed a postsecondary education (Oregon Community Foundation, 2016). Two percent of degrees awarded from Oregon State University's geoscience program were to US ethnic minorities in 2019. Fifteen degrees were awarded in total to "Hispanic" identifying students within the geoscience program. 598 Hispanic-identifying students graduated from Oregon State University in 2019 (OSU Graduation Summary, 2019).

4.2.1 Cultural Capital

The term *cultural capital* was first introduced by sociologist Pierre Bourdieu in *Cultural Reproduction and Social Reproduction* (Bourdieu & Passeron, 1977). The term refers to non-economic social markers such as education level, speech style, language proficiency, and other socially-perceived cultural advantages that contribute to one's accrual of cultural capital. Bourdieu also identified *economic capital*: one's financial resources and *social capital*: one's institutional and professional networks. The three taken together are the "forms of capital" as they pertain to the standing of individuals in a society (Bourdieu, 1986).

Applying the lens of Critical Race Theory (CRT) as described below, Tara J Yosso criticized the traditional conception of cultural capital. According to Yosso, Bourdieu's definition of cultural capital implies a deficit view of people of color since it rests on the tacit assumption that one principal asset of cultural capital is whiteness. Minoritized students in the US are disenfranchised through the dominant white culture which views them in "deficit," because they may not fit into the white middle-class mold or possess established expectations of white middle class culture. Deficit thinking is especially pronounced in science education where Latinx students may be viewed as "lacking" or "unsupported" in the classroom. (Paik et al., 2020). Deficit thinking has been tied to diminishing Latinx student's self-efficacy and science identity (Hernandez et al., 2017). Rather than analyze minoritized students through their deficits, researchers must examine a student's capital decoupled from biases around race and economic class (Yosso, 2005). Doing so recognizes that students bring their own tools and assets born out of their own authentic experiences. By removing the deficit lens, hierarchical structures of

whiteness are challenged, and we begin to view a minoritized community for their own authentic qualities and not how they are reflected by a dominant cultural mirror. The multi-faceted and authentic cultural capital of minoritized students coalesces into what Yosso describes as *cultural wealth* (Yosso, 2005).

Yosso identifies six types of cultural capital that inform cultural wealth: aspirational, familial, social, linguistic, resistant, and navigational. Aspirational capital is a community's ability to maintain a positive outlook for the future despite real or perceived barriers. These may be the ambitions held by a family for their children or the belief their current status may change. Familial capital is the extended family supporting the student through community history and memory. Social capital is a student's extended network, peers and mentors, who provide support as the student navigates through dominant white society. Linguistic capital is a student's multi-lingual background and the ability to communicate in multiple languages. Resistant capital is the strong history disenfranchised communities have of resisting oppression through challenging the status-quo and maintaining culture despite attempts to erase it. Navigational capital are skills and strategies a student learns for achieving in an institution created to (intentionally or not) suppress the success of communities of color (Yosso, 2005).

4.2.2 Creative Data Literacy and Inquiry-Based, Collaborative Learning

Creative Data Literacy (CLD) was developed by data feminist, Catherine D'Ignazio, as a strategy for teaching data equitably and meaningfully. In her paper on the subject, D'Ignazio outlines five tenets for teaching data creatively: (1) Work with community centered data, (2) contextualize data through biographies or metadata, (3) make data messy, (4) build learner-

centered tools, and (5) value community-driven outputs. Creative Data Literacy illuminates the disparity between experts and non-experts within data science and the necessity of building community data literacy as an emancipatory act in the age of Open Data (D'Ignazio, 2017).

The tenets of CLD were applied to an inquiry-based curriculum which explored a local, actionable environmental issue. The curriculum was designed to facilitate collaboration amongst the students as they moved through a Cycle of Inquiry.

The curriculum centered on microplastics in the local watershed. Microplastics are an emergent issue which now permeate natural environments globally and with potential ill health effects on human beings (Manikkam et al., 2013). The students developed research questions with the help of an eco-toxicologist, built trawls to collect microplastics in their local creek, examined and sorted plastics under a microscope while filling out a data record sheet, and then analyzed and presented their data. Developed around the Cycle of Inquiry, this curriculum allowed students to take control of the scientific process.

The first tenet of CLD was applied by examining microplastics, an issue the students could learn more about and have the agency to take action on. The importance of meta-data was reinforced throughout the program and students filled out their meta-data at the beginning of field work in order to satisfy the second tenet of CLD. The process of student-collected data is inherently messy, so students were able to fully realize the strengths and weaknesses of their data, fulfilling tenet three. Learner-centered tools primarily refers to analysis and visualization tools. For the purposes of this project, a learner-centered tool was not devised. Rather, the online software TuvaLabs was utilized in the data analysis. This software is learner-friendly and does

not require significant domain expertise. It was also made freely available for teachers during the COVID-19 pandemic for a limited time.

At the end of the project students were given multiple options for presenting their data in a framework of "community-centered output." Students were introduced to data sculptures, data art, data music videos, and scientific posters. They worked as a group to determine which output they wanted to collaborate on together.

4.2.4 Science Identity

Science Identity is a student's sense of self-efficacy in science. Previous research points toward a positive science identity as being crucial for predicting the likelihood a student will pursue and succeed in a science, technology, engineering, or math (STEM) career (Carlone & Johnson, 2007). Students with strong science identities view themselves as capable within STEM learning spaces. Many factors contribute to building a student's science identity including support from parents and teachers, performance in the classroom, and a sense of belonging when in science class. Due to the limited participation of students of color in STEM programs at the university level, there is a call for research examining how to support and sustain science identity among underrepresented youth (Bevan, Calabrese & Barton, 2018).

One strategy for building science identity is through designing intentional informal STEM learning spaces for students from non-dominant populations. Intentionally designed informal learning spaces could look include afterschool programs, summer camps, or museum exhibits. Intentionally designed STEM spaces may be constructed to facilitate personal or community transformation, rather than attempt to push students into a career. These spaces must

allow for students to draw from their cultural capital and invite their culture to be a part of the program. Most importantly, they should be continuous and committed to serving the community, rather than a sudden or brief interlude (Bevan, Calabrese & Barton, 2018).

4.2.5 University-Run Engagement Initiatives

Academic institutions commonly operate various outreach and engagement initiatives as a method for informing the public about various research. The emergence of academic science programs participating in outreach and engagement increased with the NSF's required "broader impacts statement", which was implemented in 2000 (McCann, Cramer & Taylor, 2015). Research points to a stark contrast between community outreach and engagement. Outreach is usually classified as a one-way path of information from the institution to the community. This may be through news articles, social media, tabling events, or classroom visits.

Engagement is defined as a university exchanging dialogue with the community and valuing the community's input regarding research, education, or the creation and implementation of new tools. Through engagement, the academic institution steps outside of the ivory tower and engages in dialogue with the community in order to be of service (Boyer, 1996). Ideally, engagement scholarship moves beyond the walls of the institutions and ideas are exchanged with non-academics. Academic institutions committed to engagement scholarship utilize academic work to benefit the communities in which they serve (Boyer, 1996). When defining engagement scholarship, Boyer insisted the K-12 classroom to be the place where engagement scholarship is most pertinent, in order to alleviate the workload of the classroom teacher and ready students for college (1996).

A recent study (Millar et al., 2019) pointed toward long-term engagement as being a far more compelling strategy for boosting student's science identity. An investigation into an astronomy outreach program found their year-long initiative of six star-gazing nights helped boost student's science identity and formed a community of practice around the telescope at the participating schools (Millar et al., 2019).

4.2.6 Research Questions

The inception of this research was to determine promising practices in creating culturally responsive curriculum to support data literacy development for Latina/o students. The paradigm of culturally responsive education is thought to align well with inquiry-driven learning, as students are empowered to make their own decisions throughout the learning process. It is especially salient when paired with knowledge that validates a student's cultural way of knowing through ethnic examples and practices (Brown, 2017).

However, as the research progressed it became quickly apparent that creating a "one size fits all" culturally responsive curriculum is ill-advised, especially when the curriculum comes from outside of the community. While there are curriculum development strategies in STEM which may facilitate a culturally responsive learning experience, the evaluation tools created for this research were ultimately unable to determine if the curriculum itself was "culturally responsive." In addition, maintaining the cultural responsiveness of a program when it transfers from the developer to the classroom becomes dependent on the cultural competency of the teacher.

Culture is not a universal. This process revealed that it is students alongside a supportive teacher rather than specific curriculum that create a culturally inclusive space. The students drew on their own cultural capital to create a collaborative space in which they could explore science. The curriculum served as a vehicle through which they could validate one another's science identities.

While it is vital that science educators highlight the expertise of underrepresented scientists from all different backgrounds and indigenous science, bringing examples into a targeted space without knowledge of the student's background was naïve at best. Cultural examples were not intentionally selected in advance to avoid succumbing to the false assumption that Latina/o identifying people are a homogenous group. After getting to know the students it was learned their backgrounds included Mexico, Chile, and Peru. The theme of sharing language but not culture would be brought up in our final interviews. Due to this factor and the research shifting from culturally responsive education theory to exploring Latina/o student's cultural capital in the context of informal science learning, the research questions transformed into the following:

1. Can the tenets of creative data literacy and inquiry-driven science education work tangentially to support data literacy?

2. In what ways might a Latina/o student draw from their cultural capital in an informal science space?

3. What are the successes, implications, and challenges of the Mar Adentro program?

4.3 Methods

4.3.1 Methodological Approach

An eight-week afterschool program was designed based around the theory of Creative Data Literacy and the Cycle of Inquiry. During the eight weeks students were guided through a full Cycle of Inquiry driven by the data process. The cycle worked tangentially to help students learn about the data process and designing environmental science research. An intrinsic case study approach was utilized in order to investigate promising approaches for engaging Latina/o youth in scientific inquiry and determining whether or not engaging a student fully in the data process helped support their data literacy.

Intrinsic case study was employed as the methodology in this research in order to evaluate the effectiveness of the Mar Adentro Program in its entirety. Case study as a research method focuses on examining a bounded system which is constrained by time and place (Creswell & Poth, 2018). Intrinsic case study focuses on a unique situation and describes the case in detail (Creswell & Poth 2018). The program itself and how the students navigated it was the bounded system. In order to capture a comprehensive picture of the case I analyzed multiple sources of information in order to create a case description and themes (Creswell & Poth, 2018).

Sources of information included reflective notes, student generated materials, and pre and post surveys and interviews. Following each lesson reflective notes were taken on both the successes and challenges students encountered along the way. Because the program took place afterschool, it was independent from the student record, which allowed the collection and analysis of student generated materials.

4.3.3 Study Recruitment and Participants

Students were recruited with the help of the school's Bilingual Education Coordinator. Without the recommendations of the coordinator, it is unlikely these students would have been identified. In addition to these recruitment efforts, AP Spanish classes and general biology classes were visited to inform students about the program. In total approximately 200 students were engaged during these visits. It is unclear if the classroom visits were as productive in recruitment as the involvement of the Bilingual Education Coordinator as all those who participated had spoken with the coordinator beforehand.

Ultimately seven students participated in the afterschool program, all self-identified as either Latina or Latino and English language learners (Table 4.1). The cohort of seven was not cemented until the third class. Part way through the program three of the students had to leave early for sports practice. Six of the seven chose to participate in the online portion of the program which occurred following the Covid-19 related school closure. The research was IRB approved and all students filled out an assent form. Parents and guardians were given opt-out of consent forms in English and Spanish, to be returned to the researcher should the parent or guardian object to their student's participation. No opt-out forms were returned

The seven students were fluent in English but identified Spanish as their first language. Six of the seven students participated in the pre and post survey, and five of the seven students agreed to pre and post interviews (Table 4.1).

Table 4.1: Student Descriptors

Pseudonym	**Cultural Background**	**US Born**	**Scientific Interest**	**Survey Data**	**Interview Data**	**Field Note Data**	**Student Materials**
Gabriela	Peru	No	Aerospace Engineering	X	X	X	X
Nina	Chile	Yes	Veterinary Medicine	X	X	X	X
Julia	Mexico	Yes	Environmental Science	X	X	X	X
*Marina**	Chile	No	Medicine	X	X	X	X
*Sara**	Chile	No	Medicine	X	X	X	X
*Roberto**	Chile	No	Chemistry	X		X	X
Alexa	Unknown	No	Environmental Science			X	

An * indicates
students are related

Two of the students were born in the US and six had recently moved from Latin American countries in the past three years. One of the two students born in the US had moved back to Chile as a child but had recently returned. The group consisted of six girls and one boy. All students were in their sophomore year of high school and approximately fifteen years old.

Three students lived in the same household and were triplet siblings. Four of the seven students, including the triplets, identified their parents as working scientists. One student had a brother who is a working scientist. The student who did not disclose a scientist in the family was born in the US. The pre and post survey results and interviews elucidated that six of the seven students were entering the afterschool program with positive science identities. One student joined the program part way through and did not take surveys or participate in interviews, however expressed interest in environmental science as a career.

4.3.4 Study Site

The study took place at a high school in the Willamette Valley Region in the state of Oregon. The high school is 64% White and 21% Latina/o. Posted around the school are posters advertising support for navigating Deferred Action for Childhood Arrivals (DACA). The school has a Spanish dual immersion certificate program where students can achieve an Oregon Seal of Biliteracy. There are strong science and math offerings at the school and students are required to enroll in three science units during their time in high school. The school is located in a community with close proximity to a large university in the Pacific Northwest.

The program took place in a biology teacher's classroom. Students clustered around one or two round tables at the beginning of the lesson while the researcher explained the goals for the afternoon. Some lessons also took place on campus grounds. The school has a small creek running adjacent which was utilized for data collection as well.

The second half of the program took place online due to the COVID-19 pandemic. It was fortunate that students had examined and organized half of their data at this point so were able to

do analysis online. Six of the seven students chose to participate in the online portion of the program, which met once a week for an hour.

4.3.5 Data Collection

Several instruments were intentionally designed (Creswell & Poth, 2018) in order to elucidate the students overall learning experience in the Mar Adentro Program. Instruments included pre and post surveys, a pre and post interview, and several educational materials including worksheets and data sheets for analyzing student's comprehension. Additionally, the researcher took reflective notes after each session in order to triangulate the data. Reflective notes and program observations were utilized to create a more comprehensive and holistic examination of the student's experience within the program alongside survey and interview data.

Students took a pre and post survey which primarily consisted of open-ended qualitative questions. The pre-survey questions were designed to illicit student interests and learning goals for the program. The open-ended questions in the post survey were examined for evidence that student opinions regarding data and ocean science shifted during the course of the program. The survey also included two graphs and four questions to assess the student's graph-reading proficiency before and after the program.

The survey included a short quantitative section designed to measure student's self-efficacy and science identity. The quantitative portion of the survey consisted of eight questions measured on a scale of 1-7, from strongly disagree to strongly agree. The questions were adapted from a review identifying effective questions for measuring self-efficacy and science identity

conducted by Trujillo and Tanner (2014). Statements rated by students included "When I am in science class, I feel respected," and "I enjoy the labs and activities in my science class."

In addition to the survey, students also participated in two interviews. One occurring at the beginning of program and the other at the conclusion. The first interview was designed to further examine the student's science identities as well as their learning expectations for the program. The final interview questioned students on what they learned from the program and how they believed the program could improve. The pre-interviews were structured and followed the same interview protocol. Post-interviews evolved into semi-structure, allowing the researcher to probe more deeply, to invite further elaboration from students (Packer, 2011).

4.3.6 Positionality

I positioned myself as a participant-observer in the research, seeing myself as both the teacher and researcher within the program (Spradley, 1980). As the program was being tested for the first time, I was also participating in the construction of this new learning experience.

Data analysis occurred through a lens of constructivism, such that the individual cultural and navigational experiences of the students could be taken into account. Constructivism as a research paradigm allows a researcher to "understand and reconstruct the learning constructions (including those of the inquirer) initially held" (Guba & Lincoln, 1994, p 113). Through understanding the constructions of the interviewees and myself, I could create more complex and better-informed interpretations of the data (Guba & Lincoln, 1994).

I personally identify as a cis, middle-class, white woman which grants me certain privileges in the US. I do not share the experience of being bilingual or living outside my own country of origin. I recognize my experience as a middle-class white woman may challenge my

comprehension and interpretation of the student's experiences. I consciously endeavored to remain reflexive during this process to minimize the interference of my own biases with the quality of the data. For example, student-generated data was left out of educational assessment when it was unclear to the researcher if the student did not fully comprehend the material or simply did possess the English vocabulary for describing the material.

4.3.6   Analysis

Data was analyzed holistically to examine the Mar Adentro case in its entirety (Creswell & Poth, 2018). Surveys, interviews, student generated materials, and program observations were utilized to triangulate the data and capture the student's experiences during the afterschool program. Surveys and interviews were originally coded before being examined for deeper themes and patterns (Creswell & Poth, 2018). Student generated materials were utilized to support overall themes found within the survey and interview data.

Organized memos were written throughout analysis as case themes emerged from the data. For example, a diagram of the student's experience was developed and re-designed multiple times throughout analysis (Figure 4.1). Themes and contextual information were inductively transformed into case assertions (Creswell & Poth, 2018). Case assertions were ultimately organized into student experiences and learning outcomes. Yosso's Theory of Cultural Wealth was deductively applied to the student experience case assertions part-way through data analysis. The theory aligned well with the themes and contextual information which emerged from the research (Table 4.2). Student experience is a term which broadly applies to the student's experience within the program and the life experiences they brought into the program. For

example, students developed social capital within the program but brought in linguistic capital (Table 4.2).

Learning outcomes from the program were more broadly interpreted from individual student data to capture the skills and knowledge the students gained from the program. Hypothesis generation, writing definitions of different subject material, reflective worksheets, students speaking to their own perceived learning, and a student-designed scientific poster were all used as a formative assessment of the student's growth in data literacy.

The final case assertions were validated by the students and the school's Bilingual Family Coordinator as the research was finalized. The researcher informed the students and the coordinator about research conclusions. The participants agreed they were appropriate and offered further input. Discussing the results with the Bilingual Education Coordinator and students was the strategy employed for determining the efficacy of the results (Creswell & Poth, 2018). The following results would be negated if not supported in conversation with the students and Bilingual Education Coordinator.

Table 4.2: Student Experience
Code Book

Themes	Case Asserstions	Definitions
Linguistic Capital	Utilizing Both Languages	Student speaks to enjoyment of being able to converse in both their languages with other students.
	Second Language Learning	Student speaks to the challenges, both difficult and enjoyable, of learning in a second language.

Navigational Capital	Community Influence	Student remarks on a community mentor encouraging them to participate in extra STEM learning.
	Scientist Family Member	Student has a family member who works in the sciences.
Aspirational Capital	Positive Science Identity	Student enjoys science, sees science as useful for their future, and/or wants to be a scientist.
	College	Student not only expresses interest in college, but expects they will attend college.
Social Capital	Collaborative Learning	Student enjoys working with peers to learn science.
	Hands-On Learning	Student enjoys feeling like a scientist in the field with other students.

4.4 Results

4.4.1 Cultural Capital and Science Identity.

Yosso's Theory of Community Cultural Wealth was applied to the final case assertions in order to fully frame the student's experience within the Mar Adentro program. The primary cultural capitals students brought into the program were linguistic, aspirational, and navigational. All of the students aspired to enter into a field which requires a strong scientific background and all of them imagined going to college. One student wanted to be an aerospace engineer, two wanted to be doctors, one wanted to be a veterinarian, two wanted to be environmental scientists, and one wanted to be a chemist. The students desire to go to college and pursue STEM degrees indicates aspirational cultural wealth.

Four of the six students possessed significant navigational capital as they came from home environments with a scientist in the family. Three of the four students had a parent pursuing their PhD at the local university and spoke about how their parents supported them with science. Gabriela explained when I asked her about her struggles in science class:

"I had a test yesterday in physics. I understood most of the stuff. Some things like energy and how to use in problems. You have to use geometry and trigonometry. And it's like, sometimes, it's confusing. That's what I'm struggling with. (When I'm struggling I can definitely) ask my teacher, he's always afterschool. And then also my dad."

Having a scientist in the family meant the students were likely supported in their desire to pursue STEM careers. The students felt confident asking for help in their science classes either from teachers or family members, illustrating strong community support. Both the desire to study science and fact that many students had close family mentors reveals these students are supported in developing positive science identities. In addition, those with academic parents or siblings have successful role models for navigating academic spaces. These factors may have inspired them to sign up for the afterschool program in the first place. The students saw an opportunity to learn more about the process of doing science. Once enrolled in the program, the students relied on their linguistic capital to create a space where they could develop social capital.

When I interviewed the students about what they had in common, they all replied some iteration of "Spanish is our first language" or "we like learning". When asked how they were different from one another, many of them were unable to articulate, though a couple mentioned that while they share the same language, they do not share the same culture (Peruvian, Chilean,

Mexican, etc). Julia spoke about how all of their accents were different and how occasionally she could not understand the others. Nina had this to say when asked about how she was similar and different from the other participants:

> "We all want to learn more, (but) each one of us have different personalities. They're different. Like how we think too. Since we are not the same person, we think differently because when we grow up we have other experiences. We don't have the same experience or same culture or same, I don't know, teachers maybe. So we grew up with another way of explaining things or visualizing things, but we still have like the same point sometimes."

In this moment it was almost as if this student explained constructivism without knowing the epistemological approach. While the students collectively share the experience of being linguistic and cultural minorities, they are not all the same person and only the four Chilean students shared culture. When I interviewed students during their lunch period, I observed the four Chilean students sat together in the dining hall, Julia could almost always be found in the Bilingual Education Coordinator's office with other members of the Latino club, and Gabriela ate near the library with a multi-racial group of girls. The students did not spend time together during the school day and it was the collective experience of being students with a shared language and desire to learn which ultimately brought these young people together.

In my interviews with the students, I asked them if sharing a language felt helpful in the experience of the afterschool program. Many of them said it did not matter, because they spoke English during Mar Adentro. Though the student's observations were different from my own, I do not discount them. The observational data from the program records the students spoke

primarily in English with me, but regularly switched to Spanish with one another, especially for social communication. Their responses to my question were shared during the weeks following our mandated switch to online meetings. Their stated ambivalence to using English may have been due to the online learning environment and its impact on the student's ability to socialize with one another.

As the program progressed and the students got to know me, they became more comfortable with speaking Spanish with one another. This was especially true during the days I was minimally involved and the students were conducting research. During our sample collection day, the students primarily spoke in Spanish as they did their field work. On our last day, before we had to move the program online, the students sorted microplastics with microscopes. I observed two of the young women counting their samples in Spanish, I also observed one of the young women translating my instructions to another student. While I am a Spanish language learner, I understood adequately enough to interpret that students were excited about what they were seeing under the microscopes. At one point, I asked the students if they would like to play music and one student put on Mexican folk music. Several of the students sang or hummed along while they sorted their samples. I casually asked Julia if she would have been comfortable choosing this music if white students were in the room. She shook her head, laughed, and said "no." Through bringing in their linguistic capital, alongside their love of science, results in the post survey and interviews point to the students galvanizing one another's science identities (Figure 4.1). In the words of Gabriela: "We all speak Spanish and that's kinda like really cool, because everyone understands everyone, really well, we can talk in Spanish and English. It's fun. It was definitely fun." Julia added:

"All the days, from the days I went, everybody was in a good mood, everybody was friendly. I like to learn more about science and I got to know them (the other students) a little bit more and from when I walked in they were kinda just like strangers, I guess you could say I didn't know them. (Now) I feel like I can have an ongoing conversation without it being so weird, and I feel like I could do that with all of them."

The experience seemed particularly powerful for Julia who does not have a scientist in her family. Her teachers and mentors spoke to me of her developing science identity and their desire to help her succeed. During her post interview she spoke excitedly. Her post survey praised the program. Several times she said to me, "I just really love all of this." I also observed her actively translate English into Spanish for some of the students who needed extra support comprehending some of the science terminology.

In building relationships with other Latina/o students with strong science identities, she may have been supported in science identity. She is also the student who showed the most growth in her understanding of the content and the data process. While she often spoke of how much she enjoyed the collaborative nature of the program, she was not alone in this response. Indeed, it was the collaboration that the students seemed most excited about.

| Latinx Student with a Developing Science Identity (Aspirational + Navigational Capital) | Utilizing Both Languages in an Informal STEM Space (Linguistic Capital) | Collaborative, Student Driven Research (Social Capital) | Affirmed Science Identity |
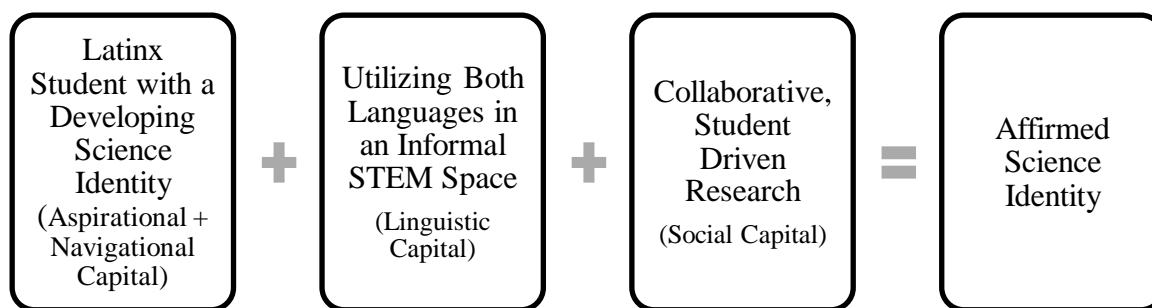
Figure 4.1: Mar Adentro Theoretical Outcome Map

4.4.2 The Power of Inquiry and Collaboration

Overall students fell into one of two groups: students who responded positively to the collaborative nature of the afterschool program, and students who responded to the community research. While groups enjoyed both aspects of the program, half strongly highlighted their enjoyment of working with their peers while the other half highlighted enjoyment of the research. Gabriela emphasized her enjoyment of the collaborative nature of the program in the following exchange: "I definitely like science a lot more. I like the process now. I like going through a process and doing it as a team. I used to think science was more like an individual thing. "

She expressed several times how much she enjoyed participating in science with her friends and was excited to learn that science could be collaborative. This highlights a misconception some students may gain throughout their schooling that science is an action undertaken by an individual. By learning about the collaborative nature of science, Gabriela's developing science identity was enhanced. She was excited science was something she could do

with friends. She commented in the survey with regard to her favorite part of the program in saying, "I liked hanging out with friends while learning."

Nina and Julia also highlighted their enjoyment of working with their friends on a science project and getting to know the other students better. While the triplets all highlighted their enjoyment of the research, they also spoke about how doing research helped them feel like actual scientists. When asked about why she enjoyed the hands-on research aspect of the program, Marina said, "just feel like I really work as a person who dedicates their life for that." Marina had never had the opportunity to do her own research before. She expressed participating in Mar Adentro made her feel like an actual scientist, which was something she enjoyed.

Her brother and sister, Sara and Roberto, expressed similar thoughts in their post-survey. By getting to do hands-on research, they felt like they better understood what it means to be a scientist. The targeted afterschool space allowed the students to work together to explore the data process while drawing from their cultural capital. As one student said in a survey response:

"We are all part of the Latino/Hispanic community, which makes everyone feel very included."

4.5 Learning Outcomes

Mar Adentro was initially designed to test promising practices in data literacy education in order to inform programmatic and curricular development for the outreach and education efforts of the RCRVs. The following is a list of perceived learning outcomes from conversations with the students and lesson observations.

4.5.1 Ocean Science Perceptions

Each student was asked what came to mind when they thought about ocean science. Almost every single student said they thought about fish, with the exception of one who said she was not even aware ocean science existed before the program. This may be indictive of the minimal focus on the ocean in the Next Generation Science Standards. In addition, the students live an hour from the ocean and may have less exposure to ocean experiences or the related science.

4.5.2 Microplastic Awareness

When I originally designed Mar Adentro I viewed microplastics as a vehicle to teach about the data process while providing the students with a topic that could be local and actionable. I was more focused on teaching the students about data and the scientific process than I was on teaching them about microplastics. However, all of the students emerged with a deeper understanding and concern about the impact plastic has on their environment (Table 4.3). In the pre-survey, students were asked what their primary environmental concern was. All of them responded with climate change. The students were asked the same question in the post survey and half changed their answer to plastic in the environment. Roberto, who is an aspiring chemist, said the following at the end of the program about the skills he learned: "I think this would be helpful for my skills in chemistry to research about the bad chemicals that micro-plastics contain that can reach through our bodies."

In his statement, Roberto expressed that he is interested in becoming an eco-toxicologist, grasping that there is still much to learn about the effects microplastics have on the human body.

Table 4.3 Student Thoughts on Plastic

Student	Plastic/Environment Statement
Gabriela	"I didn't know that plastic went into the river... Like from the school into the river... And it's so close... There's trash everywhere and I don't know why!"
Nina	"So example, I bought this recycle (reusable) bags for my vegetables, but I can't make other people buy them or like I'm not making like a huge difference, but I'm making a difference for myself."
Julia	"I still like worry about the ocean and I'm worried about how our future will be with everything going on... And not just like plastic…The global warming things... I feel like there's a lot of things we can't fix quickly, but we could try by reducing some things... And we could get to our goal if we could get to where everybody could participate, then it goes faster."
Marina	"There are a lot more plastic than I thought. I liked learning how to identify them under the microscope."
Sara	"At first I thought plastic was like only in water bottles or containers... I didn't think clothes were made of plastic... Or that it was in the air."
Roberto	"The environmental issues about the pollution to the water concerns me because (there) exists lots of living things around the world living in the water that could die if their habitat is contaminated and because we use a lot of the water as a resource for many things."

4.5.3 Data Literacy

The overall intention of this research project was to determine if inquiry-driven learning utilizing local, actionable data is an effective method for engaging students with the data process. Latina/o students were chosen to participate in the pilot study in order to also explore best practices for university engagement with underrepresented youth. This engagement is especially pertinent for the geosciences, as there are very few Latina/o people represented in the geosciences (Bernard & Cooperdock, 2019). Whether or not local, actionable data helped increase the students understanding of the data process is unclear. Because the students had such positive science identities to begin, I believe they would have been content to explore any data, as some students asked if there could be different content like neuroscience and marine biology in future program iterations.

In the words of Sara when asked if her feelings about data had changed: "I thought it was like a shorter, faster process, but now it's like… you want to do research, it takes years." Her takeaway from the program was that we had just barely begun to explore microplastics in the watershed and that while our data was interesting, it could not tell us very much. She had learned that a good dataset requires large quantities of data over a long period of time before anything useful can be gleaned from it.

In a conversation I had with Nina, we talked about the data visualization programs we used in the online portion. Some of the programs we used were Windy.com and NASA satellite data. We began to discuss the process of making these data tools and she said: "It's like super under-appreciated because people don't think…they do a lot of work for them." She eluded in

going through her own data process an awareness of the human component of data collection.

Data and data visualizations are human created, and she had gained a greater appreciation for the

tools she was using in the program. During our final conversation, Julia exclaimed to me:

> "I used to think of data like it was science and it just had to do with science. But I would
>
> say it has changed because now I see data as anything. Because, I could have sugar right
>
> in front of me and it could be getting people sick. Because sugar gives people diabetes
>
> and stuff. We think of sugar as food or whatever. But knowing it could give people
>
> sickness, I feel like we would collect data from it and stuff like that. So, basically, I feel
>
> now data is everywhere."

Julia ultimately took away the core message of the program: data is information we collect and

analyze to make informed decisions. Through understanding the data process, we can use data to

make change. While the students emerged from the program with a greater appreciation of data,

almost all said they felt like they still had a lot to learn.

The student generated materials further support the student's enhanced data literacy alongside the interview data. Students were able to come up with testable hypotheses prior to data collection based on what they knew about the data collection protocols, plastic use at their school, and the topic of microplastics (Figure 4.2). The students hypothesized they would discover microplastic in the stream and created a null hypothesis that there would be no microplastic. They additionally hypothesized they would primarily find degraded plastic film, due to the prevalence of chip bags around the campus (Figure 4.2).
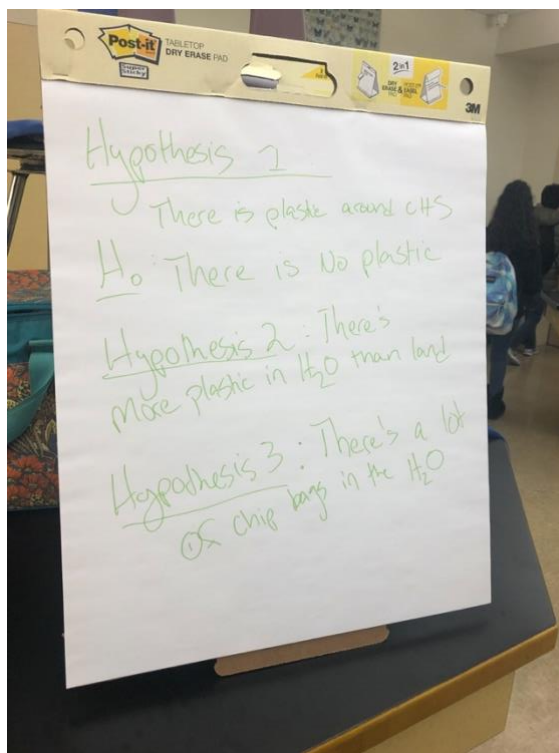
Figure 4.2: Student Generated Hypotheses Prior to Data Collection

The student's high science identities and growth in their understanding of data is also illuminated by the choice they made for their final project. The students were introduced to a number of methods for disseminating data including a conference style scientific poster, data art, science music, or using data to create a campaign to raise awareness. The students ultimately chose to create a scientific poster, because they believed learning how to design posters would be a skill that would help them later in their careers. The poster demonstrates the students understood the limitations of their data because they state their data supports their hypothesis that there would be microplastic in the river. However, they understood while their data does support the hypothesis that they would mostly find degraded plastic film, they also knew they would need more data to actually confirm this hypothesis (Figure 4.3). The students also developed reasonable and interesting follow up questions to their research like "what kind of plastics affect organisms?"
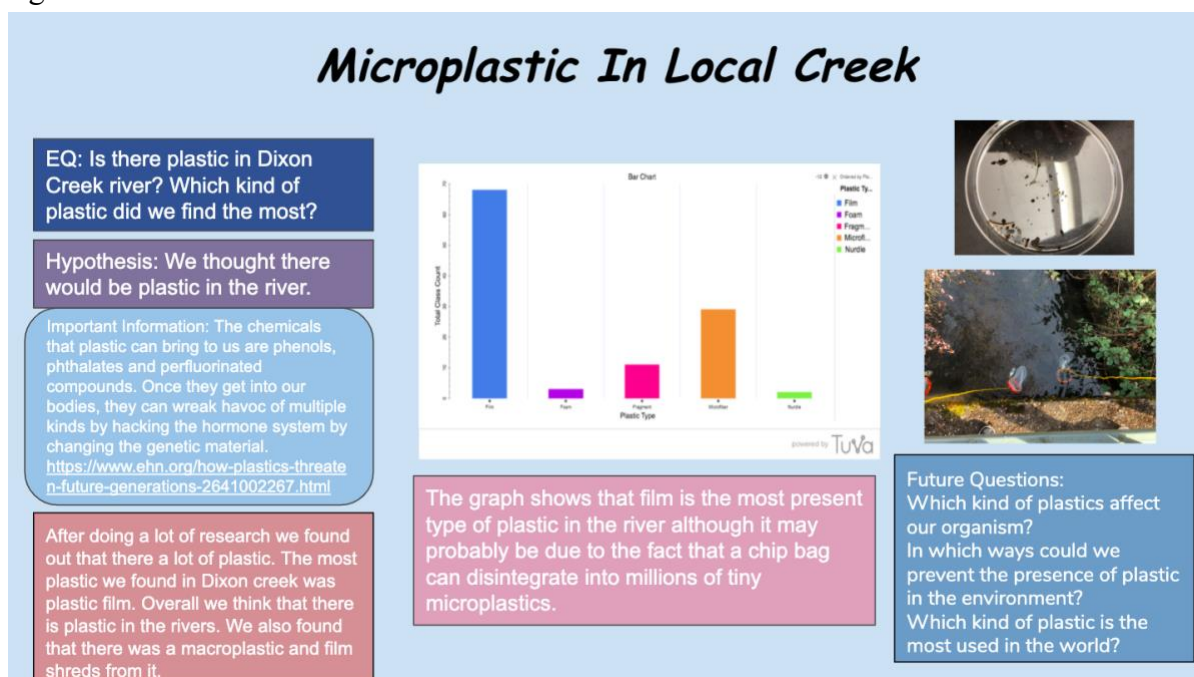
Figure 4.3: Collaboratively Generated Student Research Poster. Students created this in a 45-minute period online during the COVID-19 Pandemic.

4.5 Limitations, Discussion, and Implications

In providing Latina/o students a space where they could explore their developing science identities, students worked together to galvanize one another's enjoyment of science. Through inquiry and collaboration, students felt comfortable bringing in their linguistic capital to conduct scientific research in their native and second languages. The Mar Adentro program points to the power of creating informal learning spaces where English second language learners can explore science together.

Latina/o students are frequently stereotyped as lacking strong engagement with STEM. However, in viewing these students as disinterested, we undermine their success in STEM fields (Hernandez et. al., 2017). This research highlights the pertinence of viewing marginalized students through a lens of cultural capital rather than a deficit lens. I did not anticipate what the student's cultural identity was or if they would or would not have strong science identities. Because I consciously set aside bias and preconceived stereotypes, I was better equipped to construe their true identities as young aspiring scientists with a concern for the environment

There are however limitations to this work. Seven students participated in the program, six of whom participated until the conclusion. The students who participated in the program came into the research with pre-existing, strong science identities, confirming the assumption that students who make time for STEM learning outside of school possess a high degree of interest (Bevan, Calabrese & Barton, 2018). Their attitudes did not shift in post survey (Reference Appendix C) yet many spoke to how the program increased their interest in science, which is a conclusion further supported by their desire to continue the program online during the COVID-19 pandemic. Working to create a program which attracts students with less developed

science identities is encouraged, in order to determine if inquiry-based student research also boosts the science identities of these students.

The program was a pilot and requires re-structuring for growing engagement with the Latina/o community in Oregon. Methods for re-structuring include a longer approach to engaging with students before the beginning of the program, as well as adding more weeks to the program in order to focus more deeply on each step of the data process. Making the program itself bilingual, and bringing in science mentors who identify as Latina/o could also be beneficial to the program's success.

In a final conversation with the Bilingual Family Education Coordinator we discussed while there may have been interest from the Latina/o students across the school, in actuality many did not have the time to commit. Many of the Latina/o students at the high school had afterschool obligations including sports, jobs, homework, and caring for younger siblings. The coordinator recommended a longer and more dedicated approach, increasing effort from the program partners and university in order to build trust with the community. The coordinator also recommended tying the program to the school's curriculum as well as building partnerships with the science teachers. Bilingual materials and support were also recommended, in addition to informing the students that participating in the program would qualify as a senior project, which is a graduation requirement in the state of Oregon. Overall, he believed the program was a good start and was happy the students had a space to explore science in both of their languages.

This research seems to support the value in academic geoscience programs establishing long-term community engagement with minoritized youth for increasing diversity in the field. The geosciences are the one of least diverse scientific disciplines. During 2016 only 6% of PhDs

awarded in the earth, ocean, and atmospheric sciences for permanent US residents were given to people who identify as Black, Hispanic, or Native American. The geosciences are reported to have the lowest proportion of doctoral degrees awarded to minority groups of all academic STEM programs in the United States (Bernard & Cooperdock, 2018). Only 3.8% of tenure or tenure-track faculty in the top 100 geoscience programs in the United States identify as non-white (Dutt, 2020). These statistics highlight that geosciences not only lack diversity, but equity and inclusion. The numbers are not random, they reveal a deeper problem of covertly racist institutional practices inhibiting diversity (Dutt, 2020). One of these practices may be a failure to attract minoritized students before they enter college.

The ultimate conclusion of this research is the necessity of geoscience institutions building relationships with minoritized youth before they enter college. The first step to this process is building strong and trusting relationships with "boundary spanners." A boundary spanner is a person with one foot in the community and the other in the scientific discipline. This program would not have been successful without the help of the school's Bilingual Family Coordinator, who identified and encouraged students to participate in the program. Having a strong relationship with someone who already has the community's trust is vital. My recruitment efforts were minimal in comparison to this community partner whose support was indispensable. Once institutions establish relationships, trust should be maintained through continuous engagement efforts.

If geoscience programs are to address the current lack of diversity within our institutions, we must examine our practices and principles which have created a culture of exclusivity. Long-term community engagement is only one solution for reforming practices. By sparking curiosity

around the geosciences amongst minoritized students, we may begin to encourage their exploration of it as a prospective career path. Through diversifying our academic programs, we will also diversify our ideas, leading to new discovery and a more just exploration of our earth and its processes.

4.6 Opportunities for Future Research

A longitudinal study of the program and its effects on Latina/o student's science identities is highly recommended. This research was a small, exploratory study with a small sample of seven students in the first iteration. Expanding the program to a full school year may yield a clearer view of the effectiveness of collaborative data-focused inquiry for facilitating science identity and data literacy. Likewise, it would be more illuminating to explore the program's effects on students with negative or neutral science identities. This would take more intentional and long-term effort on the part of the research team to build trust with families in the community or adapting the curriculum for testing in high school classrooms. It may also be valuable to have the program finish with time aboard a research vessel. Studying science at sea could provide a powerful experience for students and examining the experience in depth could provide insight into how students respond to immersive learning experiences.

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Chapter 5

Conclusion

5.1 Overview

This research illuminates that while the ocean technoscape and the new Regional Class Research Vessels (RCRVs) are crucial for engaging the public with oceanography, we must be cognizant of how we disseminate our data when we intend to use it for education. Education and outreach materials designed with only an expert lens will be difficult to use in K-12 schools. Instead we must focus on creating outreach and education materials that are genuinely useful for teachers and students. We cannot hope to engage the general public in ocean science if we are not intentional in our design. Scientists desiring to participate in outreach and engagement for K-12 classrooms should challenge their assumptions around the time and effort required for effective outreach. Time and effort are especially pertinent when engaging with non-white, minoritized students.

Designing educational materials for data literacy requires fully understanding the needs of students and teachers. Teachers have minimal time to create lesson plans and learning tools around data and students require a long-term approach in building their data literacy. University-based outreach and engagement teams should work collaboratively with teachers to build and maintain tools and resources for the classroom. The RCRVs outreach and engagement (O&E) efforts must assume that building data literacy in students is a process which will require scaffolded learning throughout a student's education.

This research also determined that alongside the need to be intentional with designing tools for K-12 classrooms, the RCRV O&E teams must also be mindful of their outreach and engagement initiatives in terms of who they serve and why. The geosciences are one of the least diverse of all STEM fields, and while colorblindness may not seem overtly harmful, it significantly undermines the success of people of color (POC) within the geosciences, as we have created institutions that are challenging for POC to succeed and thrive within (Dutt, 2020). This research also illuminates that we must be cognizant when conducting research with people from the Latina/o community. No group of minoritized people is a monolith. The Latina/o population is especially diverse, originating from multiple cultures and countries (Rodríguez, 2013). The students in the Mar Adentro program originated from three different countries and felt their only similarity was language. Viewing Latina/o people as a homogenous group is another example of colorblindness and complicity in white supremacy culture.

While some efforts are being made to recognize our complicity, we must fully commit to re-imagining diverse, equitable, and inclusive geosciences. This research points to the necessity of long-term collaboration with non-white communities when approaching them for outreach and engagement. Community leaders and boundary spanners must be engaged throughout program design and implementation. The Mar Adnetro program would have failed without the help of Juntos and the Bilingual Education Coordinator.

Once these programs are established, they must be maintained in order to retain trust with the community and build interest in the geosciences. While the students who participated in the Mar Adentro program emerged with a deeper appreciation for science, research has demonstrated that short-term outreach with non-white communities can be disruptive and

typically has minimal impact on student's interest in science (Bevan, Calabrese, & Barton, 2018). Several of the participating students in Mar Adentro asked if the program would be returning next year and I was unable to give them a clear answer.

In order to truly commit to building relationships with non-white, especially brown and black communities, the operating institutions for the future RCRVs should strongly consider making changes from within. One of these changes should include seriously considering long-term and dedicated engagement with non-white communities and their boundary spanners. Alongside this, a non-comprehensive list of other strategies may include: uplifting the voices of our non-white colleagues, re-examining our recruitment and retainment processes, and internally examining and educating ourselves about the history of racism in our field and racial justice both individually and within training programs. An external audit of programming from a group of experts in diversity, equity, and inclusion should also be considered for true success.

Data literacy is a powerful tool in speaking truth to power and is a necessary skill for increasingly more careers in the modern workforce. Through creating programming and tools which engage students with the power of data, and creating dedicated programming for minoritized students, the RCRVs will be able to genuinely democratize the data stream.

5.2 Takeaways from Expert Interviews

This research initially investigated best practices for effective and equitable data transfer from researchers to teachers and students through the RCRV data platform. Ultimately, the research determined transferring data effectively requires creating accessible tools built for learners that utilize relevant data while providing context. The research elucidated that data tools

designed for researchers are generally not effective for teaching data skills, because they are designed through an expert lens. Students and teachers require data tools created for the classroom, which actively facilitate development of students' data literacy. Alongside the need for tools is the understanding that building data literacy is a scaffolded process throughout a student's education.

Through developing scaffolded curriculum and building learner-centered tools, oceanographers may balance the power between experts and non-experts, and genuinely invite the public into engaging deeply with ocean science. However, working to create more diversity in geoscience outreach and engagement programs requires more than building curriculum and tools. Collaborative relationships must be established and maintained with boundary spanners and community leaders from non-white communities. These relationships are vital for collaborating on the development of educational programming. To truly commit to diversity, equity, and inclusion means going beyond the outreach and education initiatives and applying them as core values within the institution.

5.3 Takeaways from Mar Adentro

The findings from the Mar Adentro program ultimately demonstrate the power of offering designated STEM spaces to underrepresented learners. The students in the study came together and drew from their cultural wealth, and by doing so cemented one another's science identities. The program also demonstrated the power of collaborative, inquiry-based science lessons where students learn through active research, often incorporating their bilingual strengths. Informal learning spaces are crucial for building data literacy by giving students the

freedom to take control of the data process and explore it in its entirety (Deahl, 2014). The Mar Adentro students ultimately left the program with a deeper appreciation of data and their need to understand it for future careers.

However, the program was a pilot and may not be continued in the future, despite several students asking if the program would be back next year. Experts warn against short-term outreach with minoritized students (Bevan, Calabrese, and Barton, 2018). Building a diverse workforce within the geosciences will require long-term and intentional engagement with students from minoritized communities. Academic institutions should invest in long-term engagement through building relationships and trust with the underrepresented communities and their leaders within their vicinity.

5.4 The Covid-19 Pandemic

The implementation of the Mar Adentro program and associated research was disrupted by the COVID-19 Pandemic. I was unable to finish the program with the students in person. Thankfully we were in a position where the remaining elements of the program could be completed online. Six of the seven students were receptive to analyzing the data we had generated in online sessions. I believe this speaks to the power of student-collected data sets as an effective strategy for engaging students with analysis. It also illuminates their self-efficacy in science.

In our post interviews I asked the students what they thought about the online portion of the program and how they responded to online learning overall. Though none expressed

enjoyment of online learning, comments were made appreciating that Mar Adentro continued online because it provided the opportunity to continue collaboration with their classmates.

5.5 Final Thoughts

I finalized the first draft of this research six days after the murder of George Floyd by a Minneapolis police officer. I am always contending with what it means to be a white person doing social justice research, but especially now, during the Summer of 2020. While I believe there are some strong takeaways from this research, I am also reflecting on what could improve the overall project. Bevan, Calabrese, and Barton warn against short term engagement programs as they are disruptive and do not build trust with non-dominant communities (2018). Developing this program into a genuine partnership between the local school district and Oregon State University might avoid this contention. Another important revision would include actively recruiting Latina/o mentors for the students. Further, I believe this program would be especially powerful if taught bilingually. In addition, given my finding that many of the students were unfamiliar with ocean science, I would add a session for a general introduction to the breadth and depth of ocean research.

Overall, I am amazed and grateful for all the support I received from Latina/o community leaders and my students along the way. I hope this research highlights the need and inspires deeper and more meaningful engagement from the geoscience community.

5.6 Future Research

Future research should examine the development and effectiveness of a research vessel data portal and associated web resources for K-12 students. Research should also examine the

effectiveness of student and teacher at sea experiences for growing science identity and data literacy. A continuation of the Mar Adentro program is advisable and future research could examine the long-term effects of the program. In addition, future research could explore professional development for teachers around data literacy and the data process, and the effectiveness of professional development for increasing teacher comfort around working with oceanographic data.

5.7 References

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Appendix A: Expert Interviews Guides

Research Vessel Outreach and Engagement Professional Interview

(Read introduction). Hello, thanks for taking time to participate in this research. As you know we're doing research on how to make sure the educational resources we're designing for the new fleet of research vessels supports data literacy for K-12 Students and how this might support the greater goal of creating equitable and inclusive outreach programs and curriculum for the new fleet. I'm particularly interested in your experiences working in oceanographic research vessel outreach and education. Everything that you tell me is confidential and I will not attach your name to anything that you say or tell anyone else what you have told me. If I ask you anything that you do not feel comfortable answering please feel free to tell me that you do not want to answer that question. Do you have any questions for me before we begin? Do you consent to participating in this research?

1. Could you give a general description of the work you do?
2. What skills are crucial for effectively doing your job?
3. What do you think is necessary for high quality ship outreach and education?
4. What are some of the challenges of your job?
5. What are your strategies for making research vessels accessible to people historically underrepresented in the sciences?
6. Do you incorporate cruise data into your educational materials?
   a. If yes, what would you say makes for high quality educational data?
7. Do you use real time data in your outreach?
   a. If yes, what types of real time data would you say are good for education and outreach?
8. Do you have any people you recommend I reach out to?

Possible prompts:
- **Tell me more about…**
- **Can you give me an example of…**
- **How did you respond when…**
- **What did you think when…**

Data Literacy Expert Interview

(Read introduction). Hello, thanks for taking time to participate in this research. As you know we're doing research on how to make sure the educational resources we're designing for the new fleet of research vessels supports data literacy for K-12 Students and how this might support the greater goal of creating equitable and inclusive outreach programs and curriculum for the new fleet. I'm particularly interested in your experiences working data literacy. Everything that you tell me is confidential and I will not attach your name to anything that you say or tell anyone else what you have told me. If I ask you anything that you do not feel comfortable answering please feel free to tell me that you do not want to answer that question. Do you have any questions for me before we begin? Do you consent to participating in this research?

1. Could you give a general description of the work you do?
2. What makes for high quality data literacy activities?
3. What makes for high quality data literacy curriculum?
4. What are some challenges in making data accessible for the public?
5. What are some recommendations you have for utilizing opensource research vessel data in K-12 education?
6. What are challenges in utilizing real-time data for K-12 data literacy education?
7. What opportunities do you see in utilizing real-time data for K-12 data literacy education?
8. What are your strategies for making data accessible for populations historically underrepresented in the sciences?
9. What are your strategies for engaging scientists in data literacy for K-12 students?
10. What are your strategies in engaging teachers in facilitating data literacy for K-12 Students?
11. What are the challenges of engaging scientists with K-12 data literacy?
a.   How do you personally overcome those challenges?
12. What are the challenges of engaging k-12 teachers in teaching data literacy?
.   How do you personally overcome those challenges?
13. Do you have any recommendations for people I should reach out to?

Possible prompts:
- **Tell me more about…**
- **Can you give me an example of…**
- **How did you respond when…**
- **What did you think when…**

Blended Diversity, Equity, Inclusion Interview Guide

(Read introduction). Hello, thanks for taking time to participate in this research. As you know we're doing research on how to make sure the educational resources we're designing for the new fleet of research vessels supports data literacy for K-12 Students and how this might support the greater goal of creating equitable and inclusive outreach programs and curriculum for the new fleet. I'm particularly interested in your experiences working to create a DEI culture in the geosciences and supporting equity and inclusion through outreach initiatives. Everything that you tell me is confidential and I will not attach your name to anything that you say or tell anyone else what you have told me. If I ask you anything that you do not feel comfortable answering please feel free to tell me that you do not want to answer that question. Do you have any questions for me before we begin? Do you consent to participating in this research?

1. Can you give me a description of the work you do?
2. Do research vessels play a role in your work?
   a. If so, what do they mean to you?
   b. What do you think research vessels mean to the field of oceanography?
3. What does outreach mean to you?
4. How do you incorporate DEI into your outreach?
5. What do you think are best practices in DEI for geoscience outreach?
6. How can the next fleet of research vessels support DEI in the geosciences?
7. How can outreach for the new fleet of research vessels support DEI in the geosciences?
8. What do you believe might be best practices for research vessel outreach?
9. Do you have any recommendations for people I should reach out to?

Possible prompts:
- **Tell me more about…**
- **Can you give me an example of…**
- **How did you respond when…**
- **What did you think when…**

Appendix B: Mar Adentro Program Curriculum

Mar Adentro
Program Curriculum

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Preface

Mar Adentro is an afterschool program designed to teach high school students advanced data literacy skills through hands-on, collaborative learning. The program is designed with the tenants of Creative Data Literacy. The original pilot of the program worked exclusively with Latinx students in the Willamette Valley. The plan was to consult the students throughout the first program in order to better inform on how to make future ocean science data literacy curriculum more engaging for the growing Latinx population in Oregon.

During the program students work with local researchers to explore the effects of plastics on their local ecosystems and food webs. The entire program was designed as a Cycle of Inquiry. Students who participated in this pilot program were initially guided by a local microplastics researcher to develop research questions during the second week of the program. During the third week of the program students could either conduct a literature review or examine plastic around their school using a study protocol. In the fourth week students designed and built a microplastic trawl. In the fifth week, students then collected water samples in their local watershed with the trawl they designed the previous week. Students sorted plastics under a microscope during the sixth week. Students used relevant software like excel or Tuvalabs or excel to analyze their data. From there, students used their own data to create data presentations. In the end students presented their data to local researchers. If students feel comfortable, they could also collaborate on coming up with solutions to inform their community about plastic in their watershed. The cycle of inquiry concluded with students developing research questions that could potentially be explored further by other Mar Adentro groups.

If possible, as an extension, students could also spend a day at sea aboard a research vessel to collect plastic in the ocean, in order to infer where the plastic in their watersheds ultimately travel. By first introducing students to their local watershed and place-based data, students are then able to connect to the ocean and better understand their connection, despite not living close by.

Mar Adentro was made possible by funding from the National Science Foundation and supports the outreach and education goals of the new UNOLs Regional Class Research Vessels. Mar Adentro utilizes strategies for making data accessible and interesting for students from all backgrounds. By building the data literacy of students through known effective strategies we will ensure they have the skills to work with data in their future careers.

All program materials can be found here.

Why Microplastics

The issue of microplastics was selected as the topic for students to explore because it is data that can be found in the student's local environment and is an emergent and concerning in today's world. Rather than having students explore open resource ocean data, students are engaged in their local environment and are able to be a part of the data collection process. By

having students first explore the data process in a relatable ecosystem there is potential they might be more prepared to conceptualize how their watershed is related to global oceans.

Scientific Background on Microplastics

Microplastics have emerged recently as an environmental and toxicological concern (Rillig et al., 2017; Gasperi et al., 2018; Koelmans et al., 2019). Plastics do not decompose naturally in the environment, but rather break down into smaller and smaller fragments over time. Microplastics are both the broken-down particles of plastic waste and plastic that is industrially produced in microscopic size. A plastic is counted as "micro" if it measures less than five millimeters. The use of plastic has been growing exponentially since the 1940's due to the material's cost-effectiveness, durability, and ease of manipulation. Alongside the growth in plastic manufacturing, is the growth in plastic waste, accounting for over 10% of global human waste. (Cole et al., 2011).

Microplastics initially emerged as an environmental concern in the global ocean. There are spatial areas of the ocean where plastic converges into a visible conglomerate. Ocean gyres are an example. However, evidence points to microplastics being ubiquitous in both the water column and sediments (Cole et al., 2011). Beyond the ocean, microplastics have also been found in air, agricultural soil, and drinking water (Rillig et al., 2017; Gasperi et al.; 2018, Koelmans et al., 2019). There is considerable evidence pointing to marine life consuming microplastics (Wright et al., 2012). Microplastics have potentially detrimental effects on an organism's life after consumption, with variation between species. Detrimental effects include internal abrasions and blockages, as well as observed leaching of polymer-based chemicals into the organism that is likely to cause endocrine disruption and cancer. Microplastics also appear to be bioaccumulating as they move through marine food webs (Wright et al., 2013).

The human health effects of microplastics are relatively unknown at this point in time, despite ample evidence that humans are ingesting plastic. One report claims most people consume the equivalent of a credit card in plastic per week. (Dalberg & World Wildlife Fund, 2019). There is evidence pointing to toxic chemicals binding to microplastics. In addition, until recently, many consumer plastics contained endocrine-disruptors and carcinogens like BPA, DEHP, and DBP (Manikkam et al., 2013).

NGSS Standards

High School- Human Sustainability

Performance Expectation: Evaluate or Refine a technological solution that reduces impacts of human activities on natural systems.

Performance Expectations	Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity
Science and Engineering Practices	- Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-ESS3-6) - Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-ESS3-1) - Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations). (HS-ESS3-2)

Disciplinary Core Ideas	- Resource availability has guided the development of human society. (HS-ESS3-1) - All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS3-2) - Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (HS-ESS3-6) - When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts.*(secondary to HS-ESS3-2)*, *(secondary to HS-ESS3-4)*
Crosscutting Concepts	- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS3-1) - When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs

	analyzed and described using models. (HS-ESS3-6)
	• Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS3-4)
	• Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.(HS-ESS3-3)
	• Modern civilization depends on major technological systems. (HS-ESS3-1), (HS-ESS3-3)
	• Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS3-2)
	• Science is a result of human endeavors, imagination, and creativity. (HS-ESS3-3)
	• Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. (HS-ESS3-2)
	• Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. (HS-ESS3-2)
	• Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues. (HS-ESS3-2)

Mar Adentro Day 1: Program Introduction + Community Building

Overview: The first day of the program is primarily for building relationships between yourselves and the students and to introduce the students to what they will be learning for the next few weeks.

Objectives:

- Students will begin to work on building a supportive community
- Students will understand the goals for the entire program
- Students will learn science is a collaborative process
- Students will (hopefully) begin to see themselves as scientists

Materials:

- Printed surveys
- Pens
- Paper

Preparation:

- Print out necessary materials
- Familiarize yourself with the "Welcome to Mar Adentro" Powerpoint

Activity One, Get to Know You (10-20 minutes):

The goal is of the first activity is to give the students space to introduce themselves to you and each other in detail. Let the students know you will go over the program more in depth at the end of the class, but right now would like to get to know the students. By providing students with the space to give a more in-depth summary of themselves they will hopefully feel more seen in the group. Ask the students the following questions:

- Introduce yourself (name, nicknames, preferred pronouns)
- If you could eat one food for the rest of your life, what would it be?
- What are you passionate about?
- What do you want to be when you grow up?

Give students a moment to reflect on the questions before answering, invite them to write or draw their answers before sharing if they believe it will help them organize their thoughts. This might also be a good time to remind students that while they may know each other from school, there is always opportunity to learn more about friends and classmates.

Once students are done reflecting, invite them to share all their answers to the questions one by one. Give them as much time as they need to answer the questions. If students are reluctant to go first, you as the instructor can share your answers to give them an example.

Activity Two, Community Building:

Data Scavenger Hunt (15-20 Minutes):

Can be Substituted with an Activity of Your Choice.

Prior to handing out the scavenger hunt ask the students the following question:

- What is data?

Have students think-pair-share before popcorning their answers.

Dependent on student answers you can work through forming a definition of data together.

Fun facts about data you might share:

- The dictionary definition of data is "facts or statistics collected together for reference or analysis."
- Datum is an individual unit of measurement, data is the plural of datum
- The origin of the word data is "that which is given"
- Some data scientists argue data should therefore be changed to capta, "that which is taken."
    - This could leave to a conversation about "why do you think that is?"

Hand out the accompanying scavenger hunt and have students work as a group to complete the hand out.

When students are done ask the following questions:

- Did you learn anything surprising?
    - What was it?

Activity Three, Program Overview:

- Show the students the accompanying "Welcome to Mar Adentro" slideshow.
- Conclude the class by thanking them for joining you and letting them know that next week a scientist will be joining the class. Give them some background information on the scientist and the science they do.
- Ask them if they have any questions before letting them go.

Day 2: Meet a Scientist (From Original Program Iteration)

On this day a scientist who works on microplastics is brought into the program to contextualize the issue of microplastics, mentor students at the beginning of the program, and help them develop research questions.

Prior to the Scientist coming in ask them to prepare to speak about the following (you can also send them these prompts:

- Their story, who they are, why the became a scientist, and why the study what they study.
- Why data is important to them, how they collect data, why they have to standardize their data collection protocols. Has this changed over time?
- Tools they use to analyze their data, is there math involved?
- How do they communicate their science when they feel like they have good results?
  After the scientist has presented ask the class to share the Mar Adentro project and what they are planning on doing.

Have the scientist work with them to come up with viable research questions and help them design a workable hypothesis.

Based on the research question the students develop you will then go home and search the literature to come up with some journal articles students can use in their literature review.

Curriculum Outline for Day 3- Terrestrial Survey (An Adapted Version of Susanne Brander's Collecting Terrestrial Plastics Lesson-- Susanne Brander Microplastic Lessons)

Timeframe: Two 1-Hour Periods of One 2-hour period

Target Audience: 9th-12th Grade

Suggested Materials:

- Meter-tape
- Clipboards
- Datasheets
- Scratch paper
- Pens
- Latex gloves
- Trash bags
- Printed Data Sheets

Description:

During this activity students will conduct a terrestrial plastic survey on the grounds of their campus in order to understand the types of plastic waste found around their school.

Objectives:

- Learn how to collect data
- Learn about data collection protocols
- Learn about preliminary research

Preparation:

- Assemble and organize necessary materials
- Read over the original curriculum designed by Susanne Brander.

Warm-Up: Finding Trends (10-15 minutes)

1. Have the students watch the following video: https://youtu.be/C5bkzGa5ha4
2. Ask students the following questions:
   a. Where do you think these plastics come from?
   b. Do you think our school might contribute?
   c. What plastics do you think will be most prevalent around our school?

Activity One: Understanding Protocols

1. Pass out the accompanying datasheet:
2. Give students a few minutes to familiarize themselves with the datasheet.
3. Ask students:
   a. What are some things you notice?
4. Once a student brings up the information at the top, speak to the importance of metadata:

   "Yeah! The stuff at the top like name, date, time, GPS coordinates is metadata. It's actually incredibly important for understanding where the data came from and who collected it, especially during a long-term study. Data can be effectively useless if there's no metadata because it provides context."

5. Have students fill out their metadata
6. Explain the data collection protocol:

   "We're going to go out to a place outside where we think there might be some plastic. First we'll use our meter tape to measure out a plot. Then we'll fill out our metadata. After that we'll walk through the plot, looking for and collecting plastic. Don't forget to mark what plastics you find as you go before putting them in the trash bag!"

7. Check for understanding.

Activity Two: Collect Terrestrial Plastics

1. Ask students to select a location on the campus grounds where they think students might irresponsibly dispose of plastic.
2. Once at the location, hand out plastic bags and latex gloves and partner up the students
3. Have students measure out a 20x20 meter space using meter tapes.
4. Make sure students fill out their datasheet, including start time and GPS coordinates.
5. Provide students time to walk in the plot and pick-up, identify, and mark the plastic they found into the datasheet.
6. If there is time, go set up another plot in a new area.

Activity 3: Share Data

1. Circle up the students
2. Have them compare and share datasheets and compile all of their data together.

Discussion:

Gather the students together at the end of class and ask students the following questions:

- What information did you find particularly interesting?
- Was any information helpful for your research questions you designed with the scientist last week?
- What type of plastic was the most common? Why do you think that is?

After the discussion inform students next week you will be working to build microplastic trawls in order to collect data related to the research question and you will go over your research protocol at the end of the next class. If you are using the 3D printer for the trawl mouth component you can send students home with the opensource link and encourage them to create their own designs with the schematic if they are interested.

<div align="center">

Day 4: Building Microplastic Trawls

</div>

Adapted from: : https://www.instructables.com/id/DIY-Bridge-Trawl/

Timeframe: One 2-hour session
Target Audience: 9th-12th graders

Suggested Materials:

For Making Microplastic Trawl Kits:
    1) Rope
    2) 2 Worm gear clamps
    3) Paint Filters (1 Pack)
    4) 5-liter Paint bucket or 3-D printed component if a 3-D printer is available
    5) A used plastic water bottle with thin neck
    6) Pebbles

Purchase as many supplies as needed to make enough for there to be groups with at most three students in them.

For the warm up activity:
    7) Random materials from around your classroom (cardboard, pipecleaners, markers, paper, etc)

More info can be found here: https://www.instructables.com/id/DIY-Bridge-Trawl/

Description: In this activity students will design and build their own trawl for collecting microplastics in their local watershed. Students will learn about the design process for scientific equipment and build their own product based on guidelines.

Objectives:
- Learn about scientific equipment design and development
- Learn about tools used in environmental monitoring
- Gain skills in cost effective scientific equipment building

Preparation:

Warm-Up Activity

Prior to Class-
- Gather random, disposable materials from your classroom like pipe cleaners and paper cups.
- Print out the attached build prompt worksheet.

Class Day
- Scatter random materials on a table before the students arrive

Main Activity

Prior to Class-
- Purchase all equipment prior to the start of the program.

- If you feel like your students are not able to handle a drill, or there are regulations at your school concerning power tools and students, drill holes in the bucket rim prior to helping students build trawls.
  - You can also purchase an ikea component to avoid disassembling a bucket, or use our template for 3D-printing the component if your school has a 3D printer.
- Assemble kits to make enough trawls for 3-4 students to work together on building a trawl.
- Print out blank design schematics for students to draw out their designs based on provided materials.
- Print instructions for building the trawl.

Background:

Oftentimes scientists need to develop their own tools and equipment for doing research. Scientists also need to be able to adapt quickly in the field if their equipment fails or breaks. A lot of the scientific instruments commonly used today were created by scientists needing to make something to collect their data because the equipment did not exist. An example of this are BINKE Nets and SMURFs designed by Professor Mark Carr who needed a way to capture and collect data on juvenile rockfish. Plankton nets were developed by John Vaughan Thompson on an 1816 voyage because he was curious about the bioluminescent creatures he was seeing in the water one evening. Microplastic trawls are adapted from plankton nets.

There is also a huge need for scientists who are able to design effective research equipment for the aquatic and marine environment. Aquatic instruments often wear out quickly due to corrosion from water, bioaccumulation (animals growing on things), and difficult environmental conditions like waves and heavy stream flow. Designing equipment that can withstand and have a long lifespan in the water is a profitable industry not many people are entering. In this lesson students will learn about how scientists sometimes need to build their own equipment and gain simple building skills.

Activity:

Activity 1: Warm-Up (15 Minutes)

Discussion
- Ask the students the following questions:

  "Where do you think scientists get their scientific instruments from?"

- Invite the students to discuss in small groups. Have students then share their answers with the group.

- Then ask the students:

> "What do you think scientists do if the scientific instrument they need doesn't exist?"

- Have student's popcorn their answers to the question.

Activity 1: Building the Trawls

- Let students know that today you will be building microplastic trawls to collect data from their local watershed with.
- Show students the "Testing Our Waters" website and explain citizen (or street) science to them. http://www.testingourwaters.net/
- Let students know that by the end of class they should have a schematic drawing of their trawl and a working prototype.
- Ask or assign students to groups of 3-4.
- Give each group a schematic design template, a set of instructions, and a trawl kit.
- Inform students they have forty-five minutes to draw and build a microplastic trawl.
- Let students know they can assign roles (designer, builder, team leader) or work collaboratively to complete the build of the microplastic trawl.
  - Also inform students they can work directly off of the directions or be creative with the equipment they have been provided.

Activity 3: Test the Trawls (25 minutes)

- If there is a space at your school available to you for testing the microplastic trawls (ie a local stream or a pool) take students there to make sure the trawls they built work.
  - If there is time and a trawl should be re-built, give students the time to re-evaluate and re-design
  - If there is not time let students know they can work on it at home.
- Circle students up and ask the following concluding question:
  - "What is something you learned about the design process today?"

Day 5: Collecting Data
Timeframe: One 2-hour session, or as many sessions as needed/you have time for
Target Audience: 9th-12th grade

Suggested Materials:

- Microplastic trawls built from the last class
- Student Cellphones
- Clipboards
- Pens
- Data collection sheets
- Measuring tape
- Sifter

- Bucket

Description:

In this lesson students will use the microplastic trawls they built during the previous class to collect data from a local river or stream. Students will use a sampling protocol based on research questions, collect data with their self-designed equipment and available technology, and experience field science in a local setting.

Objectives:

> **Students will**
> - Learn how to design sampling protocols
> - Learn how to collect data
> - Learn how personal technology can be incorporated into environmental monitoring

Preparation:

1. Make sure you know the area you are taking students to prior to traveling there. This might look like testing out a trawl at a bridge or walking along a stream bank to check for potential hazards.
   a. It is also a good idea to examine the conditions of the stream or river you are sampling a day or two before taking students to the sampling area.
2. Make sure you have transportation lined up and permission slips filled out if you are taking students off campus.
3. Gather up all supplies and put them in something easily transportable like a duffle bag or plastic bin.
4. Print out data collection sheets if you are using them.

Background:

Scientists develop protocols before going out into the field. Developing protocols ensure scientists have a standardized data collection strategy which is necessary during data analysis. Recording metadata (location, time, researcher name, etc.) prior to collecting data is necessary for providing context when it is time to analyze. Having standardized collection methods like the amount of time a trawl is held in the water, the distance between each collection spot, and the quantity of samples that need to be collected help scientists create better maps and statistical analysis when the time comes. Deciding how, when, and why data is collected ensures for more high-quality data when it is time to analyze. Random data collection can make data unusable and challenging to interpret. Metadata can also be used to construct a "Data Biography," a data biography is a tool that can help contextualize the data for people not colleting it. In addition to

metadata, a data biography might include information about the scientist, why they chose to collect this data, and potential outliers in the data.

Activity:

Part 1, Observe (15 Minutes)

1. When you arrive at the river or stream with the students set up clear boundaries for a brief exploration.
2. Let students know they have ten minutes to work with the research group they build the trawl with in the previous class to "scout" the river. Tell students to write down what they observe about the river conditions on either a clipboard or in their cell phone.
3. Have students write down their observations in a notebook or on a cellphone

Part 2, Collect (45 minutes)

1. Bring students back from assessing the river and go over the data collection protocol and data sheet with them.
   a. Inform students to space groups apart by twenty meters each.
   b. Before starting the experiment have them observe the conditions right at their exact spot.
   c. Make sure students fill out the metadata on their data collection sheet.
   d. Inform students they will be dropping in the trawls at the exact same time and then holding the trawls in the water for ten minutes before pulling them back up.
2. After the discussion let students know they should have a data collector, a timer, and a data recorder.
   a. If you are using clipboards and sheets, hand these out.
   b. If you are using cellphones for data collection, make sure you have given students access to the data sheet prior to the beginning of class.
3. Assign students to their spots.
4. After 30 minutes of data collection (approximately 3 trawl drops, held for ten minutes) have students come back and circle up.
5. As students are collecting, detach their paint filters when brought up, tie and label, and give students a new paint filter to attach to the trawl. You will hang tied up/labled pain filters somewhere to dry after data collection.
6. Ask and discuss:
   a. What did you notice while you were collecting data?
   b. Could there be anything that might have impacted the data?

Part 3, Wrap-Up (20 Minutes)

1. After data collection have students load up in the vans
   a. Secure the microplastic trawl nets

2. Once you have returned to the school place fine mesh sieves on top of buckets and work with students to spray down the samples.
3. Collect the sieves from students to put in a safe place in to be dried for analyzing next week.
4. Inform students next week they will be sorting and categorizing their samples under a microscope to determine exactly what they found.

Day 6: Processing Data

Timeframe: One 2-Hour Session
Target Audience: 9th-12th Grade
Suggested Materials:

- Microscopes
- Pens and Paper
- Access to the Mar Adentro Data Spreadsheet for each laptop
- Access to the data sorting protocol
- Accompanying IDing Microplastics Powerpoint
- Microscopes
- Microplastic guides
- Forceps
- Petri dishes
- Measuring Grid

Description: In this lesson students will work together to sort and categorize the data they collected during the previous class. Students will use microscopes and research guides to categorize the objects they found in the river. Students will input data into a spreadsheet as they sort it.

Objectives:

Students will-
- Learn how to sort and categorize microplastics
- Learn how to effectively input data into spreadsheets
- Contemplate how to analyze data based on observations

Preparation:

1. Set up microscopes prior to the beginning of class.
2. Set up laptops next to microscopes along with petri dishes and forceps
3. Print out and laminate microplastic ID guides

4. Organize the samples from last week for students to sort based on which group collected it.
5. Download the accompanying powerpoint and set it up to be projected at the beginning of class.

Background:

Before data can be analyzed it has to be organized and processed. All scientists have protocols for how they organize and process their data dependent on the data they are collecting. This usually takes the form of a standardized sheet and standardized methods. Microplastic science is an emergent field and so the methods are constantly being updated.

Activity:

Part 1, Introduction (30 minutes)

1. Inform students that today they will be processing the samples they collected from the week before.
2. Hand out the microplastic ID Guide.
3. Go through the IDing and sorting microplastics powerpoint with students.
   □ Ask students if they have any clarifying questions at the end of the powerpoint.
4. Show students the google spreadsheet where they will be inputting data.
5. Walk students through the spreadsheet and how to fill it out.
   □ Ask them if they have any questions.
6. Show students the microscopes and how to go through sorting samples.

Part 2, Data Sorting (45 minutes)

1. Assign groups to microscopes based on the group they collected samples with the week before.
   a. Inform them they are examining the same sample they collected in the week prior.
   b. Tell them they can have roles like microscope IDer, sample sorter, and data logger and that they will switch roles periodically.
   c. Have them begin to sort samples.
2. Tell them to switch roles between sample sorter, microscope IDer, and Data Logger after about fifteen minutes.
3. You will have to walk around and check on each group periodically and answer their questions.

Part 3, Making Connections (20 minutes)

1. After students have spent thirty to forty-five minutes sorting the samples ask them to pause what they are doing.

2. Ask students to write on a piece of paper which part of the river their sample was collected from (bank, middle, in between center and the bank, etc).
3. Have students go around the room in a "gallery walk" and observe the samples under the microscopes from the other groups.
4. Bring students together and ask them what the observed about the other group's samples.
5. If there is time allow students to continue sorting samples if they need to.
   a. If there is not enough time skip to the wrap-up.

Part 4, Wrap-Up (10 minutes)

1. Circle students up and inform them next week you will all work together to finish processing the samples (if they haven't already) and then begin data analysis.
2. Ask if there are any further questions before letting them go.

Day 7: Analyzing Data

Timeframe: One 2-Hour Session
Target Audience: 9th-12th Grade
Suggested Materials:

- Laptops
- Excel or Google Spreadsheets
- Access to either Tableu Public or TuvaLabs
  - Tableu Public is free software, Tuvalabs is only free for the first five uploaded data sets
- Laminated Tuvalabs "which graph to choose" guide

Description: In this lesson students will use relevant software to analyze the data they sorted and input into excel the week before. Students will determine which graphs make the most sense for visualizing their data and determine if they are able to make statements about microplastics in the river based on their data.

Objectives:
 Students will-
- Learn how to choose graphs to analyze data.
- Learn how to interpret graphs.
- Learn how to make educated statements about the data they collected.

Preparation:

Prior to the day:

- Download, print, and laminate the TuvaLabs "Choosing Graphs" guide
- Download your data analysis software of choice onto laptops prior to the start of the lesson.
- Check over student filled-out data sheets prior to the beginning of class to check for typos/ make sure everything is filled out.
- Compile all of the student data into one large excel spreadsheet if you are not using a collaborative google sheet.
- Make sure laptops are powered up and charged before the lesson begins.
- Look over the accompanying "presenting data" powerpoint prior to class

Day of class:

- Write the student's original research questions on the board.

Background:

Analysis is perhaps one of the more intimidating aspects on the data process. This is where students might encounter "mathphobia," that is the belief that they cannot interpret the data because they are "bad at math." Tools have been developed for helping students feel more confident in understanding graphs. One of these tools is Tuvalabs software, which helps students by creating graphs in real time. Students only have to make conscientious decisions about which variables to use and what sort of graph will best interpret the variables. Tuvalabs has excellent guides for helping students make these decisions. Students can also work with excel or tableau public if they are comfortable with these mediums.

Activity:

Check with students prior to the activity starting to see if anyone needs to finish up sorting through their data sample. Inform students that when other groups begin analysis that they can finish up data sorting. However, if most students need to continue data sorting you should give the class time before turning to analysis.

Activity Part 1: Playing with Graphs (45 minutes)

1. Hand out to student's the TuvaLabs "Choosing Graphs" handout.
2. Invite students to take a couple minutes to look over it.
3. Inform students that today we'll be analyzing their data in an attempt to answer their research question.
4. Ask student's, "based on the visual guide and our research question, which graphs do you think might be most useful for examining our data?"
5. Tell students they can either use excel or TuvaLabs (or both!) for analyzing their data.

6. Give students ample time to play around with both analysis software and assist them as they go.
7. Encourage students to analyze both the large group dataset and their personal data set.
8. When students are done bring them back together as a group.

Activity Part 2: Answering the Questions (20-30 minutes)

1. Once students are circled up ask them to share their observations about the graphs. You can ask them questions like:
   a. What do you notice in the graphs?
   b. Does our data tell us anything about microplastics in the Willamette?
   c. Are we able to answer our research questions using our data? Why or why not?
   d. Do the graphs bring up other questions for you?
2. Once you've worked through these questions with the groups you can start to think about how the students might want to present their data.

Activity Part 3: How to present data?

1. Inform students that the science mentor will be coming by on the last day of class to hear about what the student's learned.
   a. Inform the student's also if they are comfortable and would like to that they can work towards presenting their data in a more public setting like the Hatfield Marine Science Center or to their local watershed council to raise awareness.
2. Show student's the "Alternative Methods for Presenting Data" powerpoint.
3. Faciliatate a round table discussion with the students about how they would like to work on their data presentation next week and how they want to present their data.
4. Inform student's next week they will be building their data presentation.

Day 8: Interpreting Data

Timeframe: One 2-Hour Session
Target Audience: 9th-12th Grade

Note: The final two classes are the most open to student interpretation and will be guided by how the previous six classes go. Preparing for them at the beginning of the program will be considerably more challenging because they are student driven. It might be best to show different types of data presentation throughout each class so students are not thrown when you tell them there are many different ways to present data.

Description: During this lesson students will create a data story using the graphs they generated. Students will incorporate their data collection methods, research questions, and general observations to generate the story. Students will then work collaboratively to decide how they want to tell the story.

Objectives:

- Learn how to present data
- Learn how to create a data story
- Use data to objectively answer research questions

Preparation:

Before class:

- Gather any necessary materials prior to class if students decided during the previous week how they would like to present the data.
- If you were unable to facilitate the conversation on data presentation during the previous week, make sure you feel prepared in leading students through the powerpoint and conversation around data presentation.

Background:

Data has historically been presented through academic or government dissemination. This usually looks like graphs, reports, and presentations. Since the emergence of the open data movement, people have been creating different, more accessible ways to present data to the public. This can look like civic art in the form of sculpture, mural, or performance art. Data visualization and data storytelling have also become popular tools for communicating data. All of the new ways in which non-technical experts present data are designed for helping data feel engaging for non-technical audiences, so that people feel more participatory in the data story. For example, Catherine D'Ignazio led a civic art walk in Boston, MA in which participants wore carved wooden signs with statistics about climate change. They then walked a route of where the new Boston shoreline would be in 2050 based on sea-level rise projections. In this lesson you will show students a myriad of ways they might present data so they are inspired so come up with their own data story.

Activity:

This activity is student driven. At this point student's will have decided how they want to present their data and will be working on their data presentation. Your goal will be to guide and support the students as they work on their data presentation.

If you have time at the end bring the class together and talk to them about strategies for effectively communicating their science. Give them time to practice their data presentation with you. Offer guidance as needed.

Day 9: Disseminating Data and Re-Starting the Cycle
==This lesson will be driven by how the previous lessons go.==

Timeframe: One 2-Hour Session
Target Audience: 9th-12th Grade
Suggested Materials:

Description: In the final lesson students will compile everything they learned in the past eight weeks to present to the scientist they met with at the beginning of the program. Students will then work together and with the scientist to generate new potential research questions they would like to explore or like see be explored in the future. Students may also determine if they would like to disseminate their results to a larger audience like their school, community, or local watershed council.

Objectives:
- Learn how to communicate a data story
- Develop more research questions
- Learn strategies for presenting results to the public

Preparation:

Prior to Class:
- Contact the student's science mentor to come into class on the final day.
- If student's have shown interest in presenting results to other groups like the watershed council or having their data presentation placed in a public space contact the appropriate groups.

Background:

When scientists feel confident about their results of their work, they start the process of "disseminating them." Usually scientists communicate their results to other scientists. This can be in the form of a paper in a journal article. However, before a paper is even published it undergoes review from other scientists and is sent back for edits. Scientists also present their results at conferences in the form of posters and presentations. If a scientist wants to get their information out to the public, they might send out a press release or work with an educational institution to develop curriculum or a museum exhibit. The goal is to let people know about the discovery so they are more informed and involved in the conversation around the discovery. Scientists also usually conclude papers, presentations, and educational materials with recommendations for more work that needs to be done, because the science is continuous. These recommendations may look like new research questions generated by gaps in the research, or other methods that could be used to examine the question, among other things.

Activity:

Part 1, Presenting the Data

Just as the last class, students will be driving how the final class goes. Make sure you are fully supporting and helping them as they give their data presenting to the science mentor. Allow the science mentor time to ask them questions. When they are done presenting circle them up for a final circle.

Part 2, Big Data Discussion

Use the powerpoint on the RV Taani and big data to talk with students about other places they can get data in order to learn more about their ocean and participate in "street science."

Part 3, Ending the Program

During the final circle commend students for all of the hard work they have put into the class. You can wrap up by having a group discussion using the following prompts:

- "What is something you learned during this class that surprised you?"
- "Would you like to speak with other community members about your discoveries? Who will you communicate with? What will you tell them?"
  - This could lead to a discussion of giving their data presentation to a public space (if it's physical) or presenting the information verbally to members of their community.
- "What are some other research questions you can think of that might be interesting for another Mar Adentro class to explore?"

If you have anything else you would like to tell them, this is the time. In addition, if you are taking them on a research vessel, you should talk to them about the details.

Congrats, you made it through.

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Appendix C: Student Surveys & Interview Guides

<u>Survey</u>
<u>Please give your thoughts to the following questions:</u>

1. **What do you think about when you hear the word "data?" Why?**

2. **What environmental issues concern you?**

    Why?

3. **Imagine a scientist. Could you please describe what the scientist looks like? (This question is removed in post-survey)**

4. **Is understanding scientific concepts something you believe will be helpful for you in your future career?**
    Yes or No: _____

    Please explain your answer to Number 4:

5. **How do you feel when you are in a science class? Why?**

6. **Do you like to visit the ocean? Yes or No:___ (This question is removed and asks the students what they liked about the program and what could be improved about the program in the post-survey)**

If yes, please explain what you like to do when you visit the ocean:

f no, can you please explain why:

STATEMENT	STRONGLY DISAGREE	MODERATELY DISAGREE	SLIGHTLY DISAGREE	NEITHER	SLIGHTLY AGREE	MODERATELY AGREE	STRONGLY AGREE	I DON'T KNOW (Check box for this answer)
When I am in a science class, I feel respected.	1	2	3	4	5	6	7	
I see myself as a "science person."	1	2	3	4	5	6	7	
I am a scientist.	1	2	3	4	5	6	7	
I feel like I belong in my science class	1	2	3	4	5	6	7	

I enjoy the labs and activities in my science class.	1	2	3	4	5	6	7	
When I am in a science setting, I try to say as little as possible. .	1	2	3	4	5	6	7	
I feel comfortable at School.	1	2	3	4	5	6	7	
People at School accept me.	1	2	3	4	5	6	7	

## Your opinions about science and school

1. **Please circle a number that corresponds with your feelings about each statement.**

5. On Page 6, Figure 1 shows an example of what a typical CTD graph looks like. A CTD is a scientific instrument that analyzes the salinity and temperature of the ocean.

What is the trend in the temperature graph?

What is the trend in the salinity graph?

*Figure 1: Example Conductivity, Temperature, Depth (CTD) Graph*
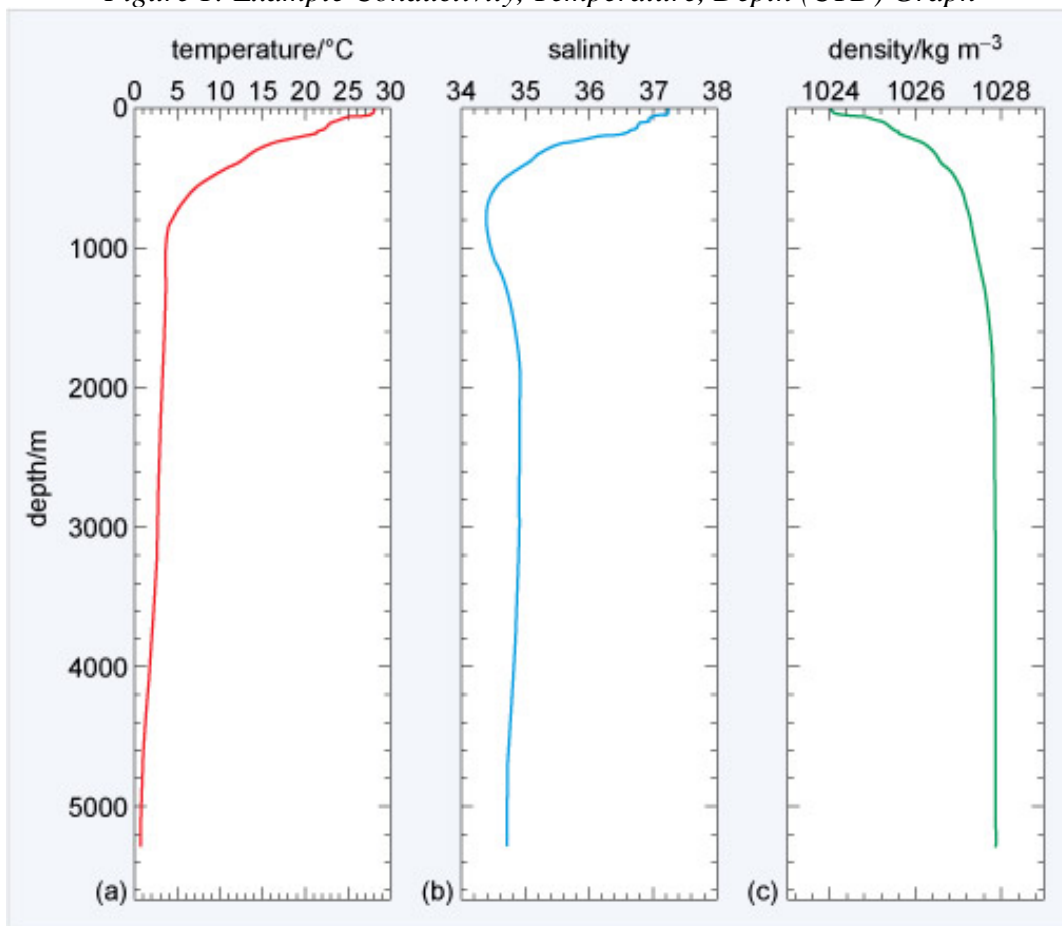
(Credit: The Open University)

6. On Page 8, Figure 2 shows types of plastic waste generated over the course of 75 years. Please answer the following questions regarding Figure 2 to the best of your ability.

What does this graph tell us about plastic use over time?

What type of plastic waste is generated the most?

Figure 2: Global primary plastic waste generation (in million metric tons) according to industrial use sector from 1950 to 2015.
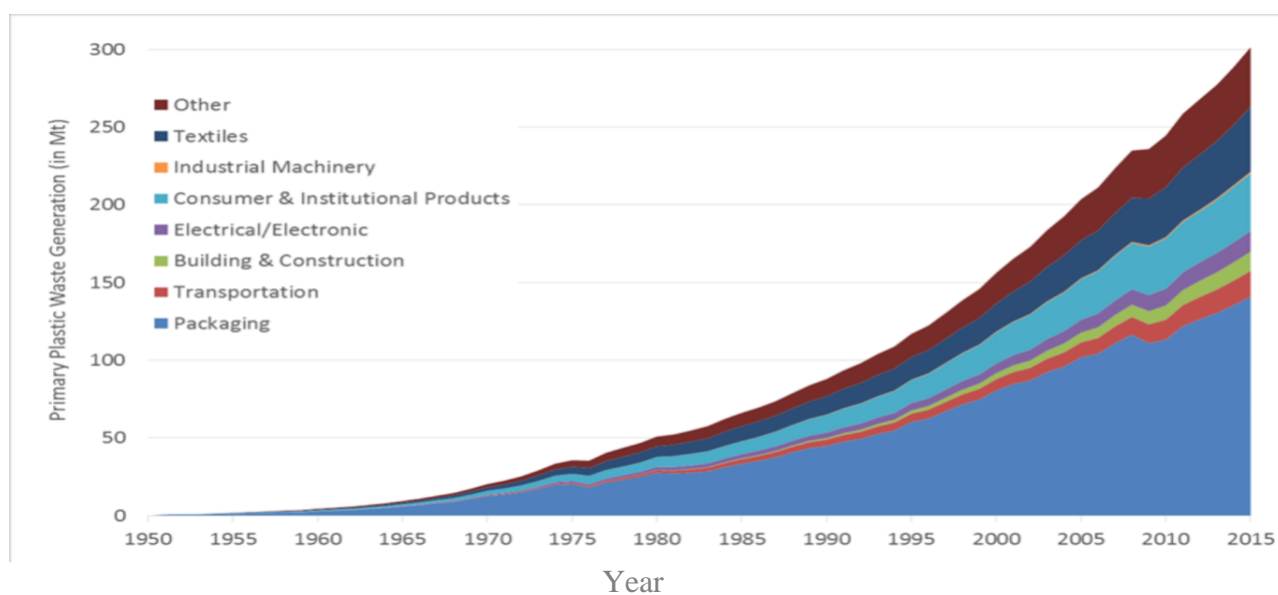
(Credit: Geyer, Jambeck, Law, 'Science Advances' July 2017)

6. Please answer the following questions:

How would you describe yourself? (For example: Male, Female, Transgender):

_____

What grade are you in? (Check one) 9TH_____ 10TH _____ 11TH_____
    12TH_____ OTHER _____

What is the science class you are currently enrolled in?

_____

Check all of the following activities you participate in or have participated in:

AP Statistics: ___	AP Computer Science	Robotics Club: ___
AP Biology: ___	Principals: ___	Club Latino: ___
AP Chemistry: ___	AP Computer Science: ___	Green Club: ___
AP Physics: ___	AP Spanish: ___	Band: ___
	AVID: ___	

Juntos: ___
Equity Club: ___
National Honor Society:

___
Science Club: ___
Chess Club: ___
Orchestra: _

Interview Guide
Students

Program Beginning Interview

(Read introduction). Hello, thanks for stepping away from the activity to have this discussion with us. As you know we're doing research on making sure the curriculum we've developed is something that is interesting and fun for you. I'm particularly interested in your experiences in science class and what about science you like and don't like. Everything that you tell me is confidential and I will not attach your name to anything that you say or tell anyone else what you have told me. If I ask you anything that you do not feel comfortable answering please feel free to tell me that you do not want to answer that question. Do you have any questions for me before we begin?

1. What do you think of when you think about ocean science?
2. What is something about the ocean that you'd like to learn more about?
3. Why did you sign up for the afterschool program?
4. Are you taking a science class currently?
   a. If yes, which subject?
   b. What about your science class do you enjoy? Why?
   c. What is something in your science class that you are struggling with? What about it is difficult?

(Read Wrap Up) Thanks for answering my questions, I enjoyed hearing about your experiences. Do you have any questions for me before we wrap up?

Possible prompts:
- **Tell me more about…**
- **Can you give me an example of…**
- **How did you respond when…**
- **What did you think when…**

Program End Interview

(Read introduction). Hello, thanks for stepping away from the activity to have this discussion with us. As you know we're doing research on making sure the curriculum we've developed is something that is interesting and fun for you. I'm particularly interested in your experience with the afterschool program. Everything that you tell me is confidential and I will not attach your name to anything that you say or tell anyone else at what you have told me. If I ask you anything that you do not feel comfortable answering please feel free to tell me that you do not want to answer that question. Do you have any questions for me before we begin?

1. Did you have a favorite part of the afterschool program?
    a. What was it?
    b. Why?
2. Was there anything you did not enjoy in regards to the afterschool program?
    a. What was it?
    b. Why?
3. Of all of the things we've learned about, is there a subject you would like to explore further?
    a. Which one?
    b. Why?
4. Have your feelings about science changed since participating in this program?
    a. How have your feelings about science changed since participating in this program?

(Read Wrap Up) Thanks for answering my questions, I enjoyed hearing about your experiences. Do you have any questions for me before we wrap up?

Possible prompts:
- **Tell me more about…**
- **Can you give me an example of…**
- **How did you respond when…**
- **What did you think when…**