Spring 2021

# Call To Climate Action: Leveraging Living Collections To Inspire Pro-environmental Behavior In Virtual Informal Science Education Programs

Meghan Carter

# **Call to Climate Action: Leveraging Living Collections to Inspire Pro-Environmental Behavior in Virtual Informal Science Education Programs**

by

Meghan Carter

A capstone submitted in partial fulfillment of the requirements for the degree of

Master of Arts in Education: Natural Science and Environmental Education.

Hamline University, St. Paul, Minnesota

May 2021

Capstone Project Facilitator: Dr. Jana Lo Bello Miller

Content Expert: Christina Moscat

**ACKNOWLEDGEMENTS**

Thank you to my family for embracing my unusual interests and encouraging me to use my compassion and ferocity to make a real difference.

And to my fiance, Clark. I could not, and would not, have done any of this without you. Thank you for the unconditional support, all the desk-side dinner deliveries, and for entertaining my late night talks about what the world needs and what we want to do about it.

## TABLE OF CONTENTS

# CHAPTER ONE

# INTRODUCTION

## Introduction

As the climate crisis has shifted from a future to present-day environmental issue, it is essential that formal and informal educators have the tools they need to effectively engage people in climate change conversations and climate action. This is especially true for educators preparing to teach the current generation of middle and high school students whose livelihood and future will undoubtedly be altered by the impacts of climate change. So, what role can informal science learning centers, like museums, zoos, and aquariums, play in this critical conversation? While leveraging living collections, like animals and plants, in education programs and exhibits has been strongly linked to generating empathy for nature, what does it take to motivate adolescents to change their day-to-day behaviors and take personal and collective action on the climate crisis? For the project, I have investigated the question, *Does using living collections in informal science education programming influence a high school student's likelihood to demonstrate pro-environmental behavior related to the climate crisis?*

This first chapter will offer insight into my personal experiences in nature and my path to pursuing environmental education as a career. It also explains the urgency of the climate crisis and how it relates to my interest in effective climate change communication strategies. This chapter closes with the Museum of Science's history of offering climate change and high school programs and how we can answer questions we have about climate change programs and exhibits by offering and evaluating a virtual Climate High School Science Series this Spring 2021.

**Personal Background**

Like many other environmental education professionals, I had a connection with nature and animals from a very early age. Growing up in a suburban town in Rhode Island, my family members were not outdoor enthusiasts to any degree. We did not regularly camp in state forests or hike local trails, but we did spend a significant amount of time at the beach each summer. Some of my earliest memories in the outdoors include me wading in tide pools for hours collecting periwinkles to keep in a bucket for the week at our rental house in southern Rhode Island. I spent hours observing the aquatic snails, comparing their behaviors, and aptly claiming I could tell the difference between each one. I'd also spend a weekend each summer at my family's camp in central Maine, where I'd bring a friend to kayak the lake and spend full days in the depths of their woodlot building a fort out of fallen trees. Through many Maine winters, that fort still stands 15 years later.

Entering into my undergraduate at Unity College in Unity, Maine, I chose to pursue a Bachelor of Science in Captive Wildlife Care and Education as I was set on being a Zookeeper. It was one of the few jobs I was aware of that would let me work with animals and advocate for environmental conservation. I enjoyed all my first year courses and the summer after my freshman year I landed a Zoo-wide Internship at Roger Williams Park Zoo in Providence, Rhode Island. On the job, I found myself mostly relishing in the few and far between moments where I could directly communicate with the public. I also witnessed on many occasions zoo visitors incorrectly identifying the animal on exhibit, or sharing inaccurate information with a child, and the visitors quickly move on to the next exhibit before taking the time to learn more. It had me asking myself: *What is the rationale for having these animals in captivity for education if people aren't set up for success to learn from them?* From this moment, I became deeply interested in how people learn in informal education settings, how to effectively connect people to the natural world, and communicate conservation issues.

The following summer, I was hired as a Conservation Intern at The Wilds in Cumberland, Ohio where I supported their residential camp program, Wildecamp. That summer was a turning point for me. While the days were long and a good night's sleep was rare, I was energized by the work and the campers I was serving. I was also newly interested in the wildlife management strategies The Wilds could uniquely use as North America's largest conservation facility. I was torn between two very different fields: Environmental Education and Wildlife Management. After discussing these pathways with faculty advisors, I decided to continue as a double major in Captive Wildlife Care and Education and Wildlife and Fisheries Management. Thatsummer, I returned to Roger Williams Park Zoo as a Zoo-Camp Counselor and received more formal training on social-emotional learning and the importance of play. I grew to not only care about the curriculum and delivery but about individual children with unique needs. Returning for my final year of undergraduate, I excelled in wildlife management courses yet I continued to find myself drawn to education. I established the Education Team for our Undergraduate Waldo County Black Bear Study and led a group of 25 students in developing research-informed, standards-driven black bear educational programming for the local school district. In class, I remember having a particularly interesting Wildlife Capstone class as we discussed the history of climate change awareness and how the simple choice of words in early climate change campaigns and ads have influenced decades of inaction and distrust in the science. It was then that I realized there was a certain finesse to environmental education that I did not know existed before, and I wanted to master it.

In 2015, I completed my undergraduate degrees and I primarily looked for jobs in the environmental education field. I took a temporary position as an Environmental Educator at Fortson 4-H Center in Hampton, Georgia. This job pushed me to an edge of environmental education I hadn't yet experienced, like facilitating high ropes courses and balancing science instruction with strong religious beliefs of teachers and students. After this, I pursued a STEM Coordinator AmeriCorps position through Maine Campus Compact in Lewiston, Maine where I helped publish and disseminate a state-wide Landscape Analysis of STEM Education and fostered university and community partnerships to bring STEM education and resources to underserved K-12 schools throughout Maine. This position was unfortunately not a good fit for me as I quickly realized that I preferred to be on the frontlines of education rather than behind the scenes researching the field and building capacity. Leaning back into my background in informal science education, in 2016, I was offered a job at the Museum of Science in Boston, Massachusetts as a School Visits and Youth Programs Education Associate. In this role, I worked primarily with high school students as they fostered their relationship with science through field trips, community service, and employment. I also learned to develop and deliver live science presentations using live animals, liquid nitrogen, and the world's largest Van de Graaff generator for large school and public audiences. This position was the perfect opportunity to get back to what I loved doing: memorable, exciting, science education.

Almost five years later, that is where I still am. I am a Lead Educator in Education Programs at the Museum of Science working with school and general audiences to build their lifelong love for science. And yet, I still wonder: *How do we know we're achieving our education goals? How do we know these programs are making the difference we claim?* Now, as I continue to work with high school audiences, I have grown increasingly excited about developing a program to engage high school students in meaningful, relevant science, like climate change, and offer them the opportunity to learn more, share their opinions, ease anxieties, and be a part of the solution to one of the world's biggest challenges.

**Project Rationale and Context**

Global climate change is posing an enormous risk to human civilization and the health of our planet. Even so, it has still not received the attention and urgency it deserves from policymakers and the general public. Although there have been decades of campaigns and initiatives around climate change education and action, it continues to remain a low priority for many Americans (Swim, et al., 2017). Many Americans consider climate change to be a non-urgent issue compared to the economy, terrorism, and health care (van der Linden, Maibach & Leiserowitz, 2015). This lack of concern and public engagement will delay the political and personal action needed to mitigate these challenges and adapt to our new future. To meet this community need, some Informal Science Learning Centers (ISLCs) and nature centers have experimented with education programs and exhibits to engage the public, raise concern, and encourage action around the climate crisis (Geiger, et al., 2017).

Historically, the Museum of Science has developed a handful of climate change programs for school and general public audiences. These have included high school events, adult programs, community forums, and public current science and technology live presentations. With the Museum of Science starting to draft and develop two new temporary and permanent exhibits related to the climate crisis, there are many questions being asked internally about what and how schools, students and teachers want to learn about this often complex yet important topic. There is also a growing interest in utilizing our living collections, like live animals and plants, to localize the climate crisis story and foster visitor empathy for the natural world. And finally, there was the biggest question: *What does it take to motivate a visitor to take personal or collective action to help solve the climate crisis after they experience the exhibits?* To begin answering these questions, the education team was asked to develop school and public programs that could provide this valuable insight.

Having organized our yearly High School Science Series (HSSS) program for the last few years, I was asked to lead the development of three virtual high school events in Spring 2021 that each took a different lens on the climate crisis. I decided to work living collections into one of the events to see if it generated a stronger likelihood to act on the climate crisis compared to more human-focused stories like climate justice or endangered heritage sites. The High School Science Series program has typically funded ~300 Massachusetts high school students and their teachers to visit the Museum each month to learn about a science, technology, engineering, or math (STEM) topic through interactive exhibits, hands-on activities, and local expert speakers or panels. The challenge is that, with the COVID-19 pandemic, there are no in-person school field trips to the Museum of Science until at least September 2021, if not longer. Because of this uncertainty, we needed to pivot to a fully virtual Climate High School Science Series. Luckily, through other school and general public education initiatives, we have established the technological infrastructure to curate and offer both asynchronous and synchronous learning experiences for the virtual climate series. This includes developing high production quality short science videos, hosting interactive live panels over Zoom Webinar for up to 1,000 participants, and offering pre- and post- panel teacher and student resources. By hosting these virtual events, we will be able to collect participant feedback, questions, and concerns that will be invaluable to my institution's climate change exhibit and program development process.

**Summary**

This introductory chapter focused on my personal experiences with nature, my individual journey through the environmental education field, and how I became interested in the finesse and effectiveness of climate change communication. It also discussed the urgency of the climate crisis and how there is a growing interest in high school and public climate change programming. These points of expertise, interest, and demand eventually led to the development of my project, the virtual Climate High School Science Series, and asking my research question: *Does using living collections in informal science education programming influence a high school student's likelihood to demonstrate pro-environmental behavior related to the climate crisis?*

The next chapter offers a review of the role Informal Science Learning Centers can play in engaging the public in climate change conversations and the rationale for high school climate change programming. It also covers a review of literature that shares effective strategies for communicating climate change, identifying what leads to behavioral change, and how living collections have been connected to fostering empathy and encouraging pro-environmental behavior. Chapter Three offers further insight into the capstone project, including the Climate High School Science Series Framework, setting and audience, Next Generation Science Standards connections, and the proposed assessment that could be used to determine if there was a significant change in the likelihood of students taking pro-environmental action before and after each virtual climate event. Finally, Chapter Four will reflect on the virtual High School Science Series by recapping the major learnings, revisiting the literature review, sharing implications and limitations, suggesting possible avenues for future research, and explaining how the results of this research will be shared to contribute to the overall field of informal science education and climate change communication.

# CHAPTER TWO

# LITERATURE REVIEW

## Introduction

Informal Science Learning Centers (ISLCs), like museums, aquariums, and zoos, often care for and use living animal collections as ambassadors to engage and educate their visitors on local and global environmental topics, like habitat conservation, deforestation, and the climate crisis. ISLCs frequently claim that one of their primary goals is to inspire the public to take action to protect the health and future of the planet. In this capstone project and paper, I will be asking: *Does using living collections in informal science education programming influence a high school student's likelihood to demonstrate pro-environmental behavior related to the climate crisis?* To answer this question, I will be developing and hosting a virtual Climate High School Science Series at the Museum of Science that incorporates both animal and human climate stories to encourage pro-environmental behavior in high school students. This literature review will share the role that ISLCs play in their community and why many ISLCs historically haven't fully participated in climate change education initiatives. We will also explore why high school students are a key audience to engage in climate change educational programs and best practices for communicating climate change to the general public. Finally, we'll look into the most recent research of what leads to behavioral change, what is pro-environmental behavior, and how ISLCs could leverage living collections, like animals and plants, to foster empathy and inspire pro-environmental behavior.

**The Role of ISLCs in Climate Change Education**

My capstone will be utilized within the context of an Informal Science Learning Center (ISLC). With this, we'll start with what ISLCs are, their relationship with their community, and their history of communicating complex scientific topics, like climate change.

Approximately 850 million people visit ISLCs across the United States every year (Katz-Kimchi & Atkinson, 2014). The Museum of Science itself sees more than 1.5 million visitors a year, making it the second most attended cultural institution in New England (Museum of Science, n.d.). These learning centers are considered hot spots for organizing knowledge for the sake of the general public (Katz-Kimchi & Atkinson, 2014). ISLCs have been found to offer a trusted, non-political space for children and adults to explore unbiased scientific information (Falk, et. al, 2007). ISLCs also supplement formal science learning and have the ability to reach a broad and diverse audience (Geiger, et al., 2017). For example, the Museum of Science has its own *Engineering is Elementary*™ STEM Curricula that supports formal Pre K- 8 teachers in building their computer science and engineering curriculum (Museum of Science, n.d.). ISLCs are typically highly interactive and connect learning to kinetic and visceral experiences (Clayton, et al. 2014). With such high visitation rates, they play an important role within their communities and can shape collective values and public understanding in pivotal ways (Luke, 2002). With media, like news and journalism, seemingly limited in their ability to engage the public in major attitudinal and behavioral change (Katz-Kimchi, 2014), there is an opportunity for ISLCs to use their broad reach and trusted relationship with schools and communities to initiate critical conversations around time-sensitive global challenges, like climate change.

According to the Intergovernmental Panel on Climate Change (IPCC), climate change "refers to a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer" (2018). While some changes in climate can be attributed to natural factors, like volcanic eruptions and solar irradiance, there is no doubt that the change we are seeing today is being driven by anthropogenic, or human, behavior and the burning of fossil fuels (IPCC, 2018). This change in our climate is already showing to be detrimental to both human and ecological health (IPCC, 2018) and there is an immediate need to respond to this global crisis in a substantial, communal way. To tackle this lack of urgency, researchers have suggested that climate scientists should cultivate and spread education and awareness through public forums with a large platform and reach, like ISLCs (Stevenson, et al., 2014).

Although the need for action on the climate crisis is clear, many ISLCs have hesitated to present and host climate change education programs for a number of reasons. First, due to the complex nature of climate science and mechanics, it is not easy for visitors to visualize or internalize the problem compared to other environmental concerns, like endangered species and pollution (Swim, et al., 2017). This comes along with the challenge of concisely and accurating explaining the causes of climate change to an audience who may have limited science literacy and may feel defensive about having a potentially politicized conversation (Geiger, et al., 2017). To address the deficit of climate change programming, in 2013, the Association for Zoos and Aquariums (AZA) adopted a commitment to climate change education to encourage their institutions to engage the public in this critical conversation (Swim, et al., 2017).

Further, there is a widening gap between scientists and the general public that can act as a barrier to science communication. Only recently have universities and science museums started collaborating to build replicable models for on-site science communication at ISLCs. An example of this type of collaboration is Living Laboratory. Living Laboratory is an on-site research program at the Museum of Science that connects researchers, informal educators, and Museum visitors. As visitors get to learn more about science and have fun through engaging activities, the university researchers collect data through observation during or surveys after the experience to advance science research (Museum of Science, n.d.). These types of partnerships offer effective communication training for scientists provided by museums and bring more recent scientific research, like climate research, into ISLCs (Parker, Cockerham, & Foss, 2017).

It is clear that ISLCs play an incredibly important educational role within their communities. Thus, it is imperative that ISLCs expand that relationship by inviting their visitors to participate in programming around global challenges like climate change. Although climate change is a complex problem that can be challenging to communicate, ISLC visitors tend to be more receptive to climate change communication than the general public and very few deny climate change's existence (Geiger, et al., 2017). By committing to hosting these timely conversations, ISLCs can become more relevant and influential than ever in today's most pressing science concerns, especially for young people who feel the burden of these challenges but may not feel equipped to process the problem and engage in possible solutions.

**Why Engage High School Students in Climate Change Education?**

With nearly a quarter of the United States population being under 18 years old (Flora et. al, 2014), engaging young people in the climate crisis and climate action is essential. Childhood sociology researchers have encouraged society to view school-aged children not as growing humans, but as complete humans themselves (Byrne, et al., 2014). In this, they should be empowered as citizens of the community to engage in societal issues like climate change. However, it is reported that some schools fail to bring young students into these conversations because of their controversial nature or because teachers do not feel prepared to answer the questions that may arise from the debate (Sadler, 2009). Researchers have also found that by bringing students into conversations that have real-life applications, like climate change, children are better able to make meaning of their learning beyond the classroom (Byrne, et al. 2014).

While education is not the silver bullet solution to cracking the climate crisis, climate literacy has been linked to a young person's willingness to accept climate change as a perceived risk (Stevenson, et al. 2014). It's also been found that high school students in particular are less knowledgeable about climate change than adults. On a test conducted to measure climate science knowledge, more than half of high school aged students failed, compared to one third of adults (Flora et al. 2014). Since climate literacy is connected to climate action, it is also no surprise that national surveys have also found that high school students have less or weaker intention of engaging in pro-environmental actions when compared to their parents (Mead, et al. 2012).

There is also the growing issue of climate change becoming highly politicized and the spread of misinformation from political parties to undermine society's ability to agree on solutions and take action. For adults, worldviews and political affiliation have a larger influence over a person's perceptions of climate change when compared to climate change education (Stevenson, et al. 2014) and political ideology is one of the biggest predictors of someone's climate acceptance or denial in the United States (Clayton, et al., 2014). However, ISLCs have the ability to share information about environmental issues without being viewed as affiliated with a certain political party (Clayton, et al., 2014). Further, worldviews and political affiliations are largely just starting to be formed in adolescents. Because of this, addressing and correcting climate change misconceptions through education is more easily done with adolescents when compared to adults (Stevenson, et al., 2014).

Although adults are seemingly more knowledgeable about climate science than adolescents, it has been found that children can have a direct effect on their parents' concerns about climate change. A study conducted in 2019 worked to indirectly create climate concern in adults by teaching their adolescent children about climate science and global climate change. They found that parents of children that learned about climate change in class reported higher levels of concern about climate change. This was especially true among male parents and parents who consider themselves conservative and initially had reported low concern prior to the study. Interestingly, daughters seemed to be more effective at influencing their parents' climate perceptions than sons (Lawson et al., 2019). These findings suggest that multi-generational audiences can be reached through adolescent climate science education programming as the students bring their new knowledge and potential concerns home to share, discuss, and process with their family members.

Children are also acutely aware of the threat climate change poses for future generations. Young people are more susceptible to it's lifelong impacts on their physical and mental health than adults (Sanson, Van Hoorn, & Burke, 2019). While climate change education programs have started to be more regularly developed at ISLCs and other education centers, they are mostly geared toward elementary school students and program availability decreases as a student gets older (Park & Kim, 2020). By engaging young people, especially high school students, we can address concerns they may have for their generation's future while also building feelings of resiliency and hope.

People of all ages could benefit from climate change communication and educational opportunities. While global and national policies have encouraged schools to teach environmental literacy in middle and high school and many state standards require climate change to be in the curriculum, not all schools and teachers are required to teach this topic (Johnson, 2019). By offering high school students and their teachers informal science education experiences that focus on climate change, like the virtual Climate High School Science Series, we could increase climate literacy, alleviate feelings of anxiety, and engage students in real-world climate solutions.

**Effective Climate Change Communication Strategies**

One glaring challenge to communicating climate change is making the problem seem urgent and personal. Much of the climate change messages that come from scientists, media, and the government share future consequences of climate change over very long timeframes. Because of this, most people have reported perceiving the threats of climate change as distant and in the future. This is a flawed approach because people generally are less concerned about planning for the future when compared to addressing day-to-day problems. This is compounded by the optimism bias that states that people tend to believe that others are more likely to be affected by the same risk. As a result, people also tend to perceive climate change impacts as something that affects other people and locations but not themselves (van der Linden, Maibach & Leiserowitz, 2015).

Another persistent challenge to communicating climate change is that it is difficult to keep the message positive and it can be tempting to rely on generating fear to get the point across. ISLC educators have reported struggling with the social challenges that come with discussing a topic, like climate change, that can be inherently depressing or negative (Fraser, et. al, 2013). ISLC educators have also reported being concerned about their ability to explain the complexities and threats of climate change while keeping visitors engaged and interested in the topic throughout a presentation (Swim & Fraser, 2013).

Similar to generating fear, some climate change communicators and organizations have turned to using guilt to encourage people to take climate action. However, it has been found that people tend to avoid behaviors that result in negative emotions, like guilt and sadness, when compared to taking action that result in positive emotions, like pride. This is referred to as "anticipated emotions". It is thought that anticipated emotions and pro-environmental behavior can be linked to one another, particularly around pride and guilt which are frequently evoked by climate change campaigns and communicators (Schneider et al., 2017). For example, Schneider et al. (2017) investigated this by asking over 1,000 study participants to reflect on their future pride or guilt they may feel as a result of either taking or not taking a particular pro-environmental action. After the reflection, they were asked to make five environmental decisions. The results suggested that those who were asked to reflect on future pride had a higher likelihood of pro-environmental behaviors than those that reflected on future guilt (Schneider, et al., 2017).

Even with all of these challenges, there have been many successful approaches to climate change communication. For one, psychologists identify hope as a key component to effective climate change conversations and encouraging people to engage in environmental problems. Most researchers agree that individuals who have hope are more likely to achieve their goal. Hope can also alleviate sources of anxiety and helplessness that climate conversations can often produce. The reasonable person model (RPM) is a framework that has been used to cultivate these feelings of hope and encourage positive environmental behavior. The framework includes three domains: Model Building (someone's understanding and building their content confidence), Being Effective (build capacity to avoid frustration and fatigue), and Meaningful Action (believe in and know how to make a difference). Researchers who have used this framework in climate change education programs have claimed that these three domains directly correlate with generating feelings of hope in high school students (Jie Li & Monroe, 2019).

Other effective climate change communication techniques that draw from psychological science have established five best practices for improving public engagement in climate change. These five best practices include: emphasize the problem as local and personal, facilitate more affective engagement, understand and use social group norms, frame solutions in immediate action, and appeal to long-term environmental goals. This approach has been particularly useful in encouraging policymakers to move away from the statistics and instead highlighting personal experiences, more locally relevant stories, and solutions that pose more of an opportunity for a gain rather than a loss (Linden, Maibach, & Leiserowitz, 2015).

One of the most widely known and tested climate change communication approaches is run by the National Network for Ocean and Climate Change Interpretation (NNOCCI). NNOCCI encourages Strategic Framing as an approach to effective climate change communication. Strategic Framing is designed to engage the audience in a more informed civic discussion and can influence a person's understanding, interpretation, and willingness to act. It encourages the use of a neutral and reasonable tone when presenting climate facts and facilitating conversations. Strategic Framing uses the following questions: "*Why does this matter to society? How does it work? How do we improve the situation?*". Through this framework, it shows that problems have solutions and encourages the public to get involved in collective, public action rather than just individual, private action (FrameWorks Institute, 2017). Research has shown that institutions that have sought out NNOCCI's climate change communication training on how to use Strategic Framing are more comfortable with providing climate change education programming than those that have not (Swim, et al., 2017).

And finally, some climate change communication experts believe that there are three cornerstones to effective climate change engagement: cognitive engagement, affective engagement, and behavioral engagement. These three dimensions are also referred to as the Head, Heart, Hands Model for Transformative Learning. Cognitive engagement (Head) involves growing a better understanding of the topic. Affective engagement (Heart) is based on feelings and emotions that are triggered by the topic. Similar to RPM, it is also related to the feeling of hope as a person grapples with the uncertainty of an outcome. Behavioral engagement (Hands) is defined by someone's willingness to participate in an action that relates to the topic. This can include both individual or collective action. It has been found that when informal science educators have been trained on this model to communicate climate change, visitors report having a better understanding of climate change, feel a sense of hope, and an increased likelihood to engage in community action (Geiger, et. al, 2017).

While all of these approaches will be used to inspire the Climate High School Science Series Framework, the Head, Heart, Hands model for Transformative Learning will be primarily used to build this capstone project. This model is best suited for answering the research question as animal and human stories can be shared in the "heart" section and pro-environmental behavior can be encouraged through the "hands" section.

**What Leads to Behavioral Change?**

It is not enough for people to simply know the science behind climate change (Heald, 2017). They must also be empowered and able to take personal or political action against the crisis. In order to foster behavioral change, one must first foster self-efficacy. Renowned psychologist Albert Bandura coined the theory of self-efficacy, stating that people are not likely to attempt to solve a problem if they don't first believe that their actions, individual or collective, can make a difference (Heald, 2017). People will also look at the overall value of the public good, the likelihood their actions will make a difference, and compare the benefits and costs of participating to decide whether they will act (Lubell, Zahran, & Vedlitz, 2007).

Even so, knowledge is often seen as the necessary piece to influence and predict a person's behavior. However, it is widely recognized that system knowledge, or the understanding of how variables relate and interact in a system, plays the smallest role in influencing behavioral change (Bofferding & Kloser, 2016). Action knowledge, meaning a person's understanding of the actions they can take, and effectiveness knowledge, which is a person's understanding of the positive and negative results from their behaviors, can have a larger influence on a person's likelihood to take pro-environmental action that has the most impact (Frick, Kaiser, & Wilson, 2004).

One aspect of encouraging behavioral change that is often neglected in climate change education is the social cognitive theory. Social cognitive theory explains that people learn appropriate social norms or behaviors through first-hand interaction or through large mediated messages (Katz-Kimchi & Atkinson, 2014). With humans being highly social, group norms and a sense of belonging have an important role in decision making (van der Linden, Maibach, & Leiserowitz, 2015). People tend to observe the behavior, assess the pros and cons of the behavior, and see if the individual is rewarded or punished for that behavior (Katz-Kimchi & Atkinson, 2014). The behavior and attitudes of family members, peers, colleagues, and community members can have a major impact on an individual's likelihood to display pro-environmental behavior (Clayton, et al., 2014). Because of these social tendencies, some researchers recommend appealing to collective efficacy, or the belief that a group can make a difference, rather than personal efficacy (van der Linden, Maibach, & Leiserowitz, 2015).

Psychologists also widely agree that there are two main drivers of motivation: intrinsic and extrinsic sources. Extrinsic sources rely on external pressures or initiatives to motivate behavioral change. Examples of this could include monetary incentives. Intrinsic sources rely on personal internal values. These values typically make a person feel happy or fulfilled (van der Linden, Maibach & Leiserowitz, 2015). Initially most researchers believed that people are primarily motivated by extrinsic sources, like money, to perform certain behaviors (Miller, 1999). However, recent studies have shown that people generally intrinsically care about the environment and health of others (Stern et al., 1999). Additionally, some studies suggest that intrinsic sources are more effective at producing long lasting behavioral change when compared to extrinsic sources (van der Linden, Maibach & Leiserowitz, 2015).

Caplow (2019) suggests that institutions using living collections to encourage behavioral action should use the value-belief-norm (VBN) theory. This theory relies on established environmental values to move toward explaining consequences, acknowledging responsibility, and changing their behavior. Caplow encourages the use of this theory with live animals by delivering a compelling narrative that establishes the animal's value, identifies the threat, and offers responsive actions to address the threat. While she recognizes that this model is not complex enough to reach all the factors that are involved in enacting behavioral change, it provides a strong structure to help visitors understand conservation messages (Caplow, 2019).

Taking all of these factors into account, it is evident that teaching the science behind climate change is not enough to motivate personal behavioral change. One must also consider the perceived social norms, appeal to collective efficacy when possible, incorporate a cost-benefit analysis of decisions, and make a strong case that specific actions can be taken to make a measurable difference.

## Leveraging Living Collections to Foster Empathy

Live animals and plants have long been incorporated into educational programming at nature centers, zoos, aquariums, museums, and environmental learning centers. There is a good reason for it. Live animals can improve learning, generate feelings of empathy, and build personal responsibility skills (Fuhrman & Rubenstein, 2017). For this paper, we will define empathy as “an emotional response congruent with perceived welfare of another”. It has long been thought that fostering empathy for nature is a viable strategy for encouraging more positive environmental attitudes (Berenguer, 2007). We will examine how empathy can be fostered by live animal experiences and how empathy can be connected to positive attitudes and behaviors toward the environment.

Daly & Suggs (2010) looked at how and why animals, like class pets, are used in formal classrooms. After conducting a teacher survey, they found that class pets are a useful teaching tool for supporting social-emotional development and fostering empathy in their students (Daly & Suggs, 2010). Similarly, Povy & Rios (2002) conducted an investigation at Point Defiance Zoo and Aquarium in Tacoma, Washington. In this study, they looked at how visitors responded to a standard clouded leopard exhibit versus visiting a clouded leopard interpretative program that involved an animal keeper and a live leopard. When comparing the data, the researchers found that the live interpretative leopard program increased visitor interest and more effectively delivered scientific and emotional messaging (Povey & Rios, 2002).

Drissner, et al. (2013) also looked at how visiting small animals, like invertebrates, can alter a young student’s attitude and emotion toward nature. For their study, they surveyed 89 sixth grade students on their attitudes toward different invertebrates like beetles, spiders and centipedes. Afterwards, they went on a half-day visit to see some of these small animals in a

"Green Classroom" at a Botanical Garden. Using a follow-up survey, they found that most students had more positive attitudes and emotions about the small animals after their visit to the Green Classroom (Drissner, et al., 2013). This study pairs well with earlier research from Lindenmann-Matthies (2002), which supported the claim that you can only care about or miss a species if you have some kind of attachment to or relationship with it.

Other researchers have looked into whether some living organisms generate empathy in humans more than others. In a study that surveyed 3,500 participants, individuals answered questions about their empathetic and compassionate reactions to photographs of different living organisms. Through the survey, they found that people reported higher empathy and compassion ratings for primates and other mammals when compared to coral, plants, or mushrooms. These results suggest that a person's empathy and compassion for a living thing decreases as the organism is more evolutionarily divergent from humans (Miralles, Raymond, & Lecointre, 2019). This research should be taken into account when selecting live animal or plant species to highlight during informal science education programming, such as the virtual Climate High School Science Series, as selecting species that are evolutionarily similar to humans may be an advantage for fostering empathy in participants.

While most of the research regarding the connection between living collections and empathy involve animals, plants can also be an important component of an ISLC's living collection and could be considered as a part of this project and investigation. According to Pollan (2015), plants make up 99% of Earth's biomass. Even so, plants have been largely unseen and underappreciated, resulting in what experts call "plant blindness" (Guanio-Uluru, 2020). There is a surprising lack of research regarding the relationship between live plants and fostering empathy during informal learning experiences. However, in a study that investigated the impact of plants in university classrooms, they found that there was a statistical difference in students' perceptions of a learning experience if plants were present in the classroom. In this case, students reported higher levels of enthusiasm and perceived organization of the instructor (Doxey, Waliczek, Zajicek, 2009). Another study looked at the presence of green walls in elementary school classrooms. They found that students in classrooms with a green wall scored better on selective attention tests and positively influenced classroom evaluations and reported well-being (van den Berg, 2016). Finally, there was a 2017 study that looked at the impact of an after school hydroponics program on elementary aged children (Patchen, Zhang, & Barnett). The researchers specifically looked at whether the program fostered positive attitudes toward science by conducting a pre and post survey of participants. They found that participating students, both female and male, reported a decrease in anxiety and increased desire toward science (Patchen, Zhang, & Barnett, 2017). While these studies did not use plants to teach the content in a class or course, the studies do suggest that the presence of plants during an educational program or courses can help a child or young adult have a more positive learning experience overall.

It is clear that researchers have been able to draw a connection between living collections and empathy. However, can this connection still be made through a virtual or digital experience? One of the earliest digital connections made between empathy and pro-environmental behavior was done by Shelton and Rogers in 1981. For their study, participants watched videos of industrial whaling and attempts from environmental groups to save the whales. The participants were then asked to rate their attitudes toward saving the whales. Through this assessment, they found an uptick in positive attitudes toward saving the whales (Shelton & Rogers, 1981). While this is not a recent study, it does provide valuable insight into the effectiveness of using digital assets, like videos, and the power they can still have in generating pro-environmental attitudes.

Schonfelder and Bogner (2017) also tested the power of using digital tools to teach about living animals. These researchers compared and evaluated the effectiveness of two secondary school education programs: (1) A live honeybee encounter at a beehive and (2) an eLearning tool connected to a remote beehive. They found that both approaches lead to a growth in conservation knowledge and that the digital learning experience allowed for some individuals who otherwise would have been fearful of the in-person animal experience to enjoy and learn from the program (Schonfelder and Bogner, 2017).

Live collections, whether in-person or digital, are an excellent tool for informal science educators and institutions to foster empathy and positive environmental attitudes in their visitors. However, additional steps need to be taken for people to move from simply caring about animals and nature to taking action to participate in conservation efforts.

**Leveraging Living Collections to Encourage Pro-Environmental Behavior**

ISLCs are deeply rooted in their ability to motivate behavioral change and often claim that one of their key goals is to encourage pro-environmental behavior. For the sake of this paper, pro-environmental behavior is defined as “behavior that positively impacts the environment”. Pro-environmental behavior is influenced by both external factors, like federal regulations, and internal factors, like personal health. Further, some people choose pro-environmental behaviors for reasons outside of protecting the environment, like saving money (Krajhanzl, 2010). By understanding these influencing factors, ISLCs can more effectively map the factors needed to bring people to a particular pro-environmental behavior.

ISLCs have been able to support their claim to fostering pro-environmental behavior with research that shows a visitor’s experience with captive animal collections influences their empathetic concern for nature (Young, Khalil, & Wharton, 2018). It has been found that zoo visitors generally attempt to establish a connection with animals through eye contact, imitation, and perspective taking (Clayton, Fraser, Saunders, 2009). This connection to animals has been shown to increase and foster an individual's environmental identity, or a person's ability to see themselves in the interconnectedness of nature. This perceived connectedness to nature has been related to a person's attitudinal response to climate change and can lead people to demonstrating more pro-environmental behaviors (Clayton, et al., 2014).

While the previous section supported a strong relationship between live animal experiences and empathy, there must also be a connection between empathy and positive environmental behavior. Batson's Model of Altruism has shown that empathy can improve behaviors and attitudes toward subjects and objects (Batson, 1991). Berenguer (2007) decided to take this claim a step further by testing the connection between empathy and environmental attitudes. For their study, they had 60 university students randomly assigned to four experimental conditions: low empathy, high empathy, bird, and tree. Each participant was scheduled for an individual session where they were asked to read an introduction and learn about the community outreach funds at their university. The participants then received a sheet with written instructions and a picture of a bird or tree to view. Those that were in the high empathy group were asked to imagine how the bird or tree in the picture felt about something negative that happened to it. Those in the low empathy group were asked to take an objective perspective while viewing the photo of the bird or tree. Participants then answered an Interview Response Questionnaire to report their empathetic feelings for the bird or tree. They were also asked whether they'd like some of the university's community outreach funds to be allocated to the Association of Environmental Protection. The results suggested that those who were asked to take the perspective of the bird or tree reported higher feelings of empathy and stronger environmental attitudes by opting to take action and allocate community outreach funds to environmental protection (Berenguer, 2007).

Similarly, researchers conducted a nation-wide study to examine the relationship between zoo and aquarium visitors' sense of connection to animals and their self-reported engagement in pro-environmental behaviors, especially those related to the climate crisis. With over 3,500 survey participants, they found a significant relationship between a sense of connection to animals and self-reported pro-environmental behaviors. Interestingly, they found that political affiliation did not appear to affect that relationship, suggesting that a connection with animals can provide a baseline for engagement and communication strategies to involve all people in pro-environmental behaviors (Grajal, et al., 2017).

Some ISLCs have also helped visitors understand and relate to ongoing environmental concerns. Zoo studies have found that when a visitor has a higher understanding of a species and the conservation challenges they're facing, they have a higher intention for future conservation actions (Pearson, Dorrian, & Litchfield, 2013). They have also shown to increase a visitor's sense of seeing themselves in the solutions to environmental problems (Luebke, et al., 2012). Schwartz (2013) suggests that using animals in educational programming can increase positive perceptions of nature and promote pro-environmental behavior.

Swanagan's study at Zoo Atlanta is a strong example of zoo visitors being inspired to take pro-environmental action after viewing an interpretive animal program (2002). Through conducting exit interviews, offering petition signing, and providing solicitation cards, researchers found that visitors who participated in the interactive elephant interpretation were more likely to actively support elephant conservation than those that simply visited the traditional elephant exhibit and read the associated signage (Swanagan, 2000).

## Summary

While there have been many assessments of climate change education initiatives and the effect of living collections on a person's likelihood to take pro-environmental action, there has been little research examining the relationship between leveraging living collections and inspiring pro-environmental behavior in high school students participating in a virtual informal education program at an ISLC. The aim of this investigation is to assess whether using living collections in virtual climate change education programming increases the likelihood of pro-environmental behavior in high school students. To accomplish this, I created a 3-part virtual Climate High School Science Series event at the Museum of Science, Boston. Each event has a different climate theme: (1) Wildlife, (2) Endangered History, and (3) Climate Justice. Using the Head, Heart, Hands Model for Transformative Learning, all three events offer an opportunity to learn the science of climate change, learn about the populations it is impacting, and to answer a "Call for Climate Action". By conducting a pre- and post- self-guided close-ended questionnaire, I will assess whether using living collections in informal climate science education programming is effective at increasing the likelihood of a high school student to support and demonstrate pro-environmental behaviors.

Chapter Two described the role Informal Science Learning Centers (ISLCs) could play in increasing public engagement and understanding of the climate crisis and the value of including high school audiences in these offerings. It also reviewed a number of reasons why an institution may hesitate to teach climate change content and offered effective climate change communication strategies, including the Head, Heart, Hands Model for Transformative Learning.

Finally, Chapter Two shared research findings around leveraging living collections to foster empathy and increase the likelihood of pro-environmental behavior.

Chapter Three will discuss my capstone project, the 3-part virtual Climate high School Science Series at the Museum of Science, Boston. It will describe the three events and detail the Climate High School Science Series Framework, Next Generation Science Standards (NGSS) Connections, and the Pro-Environmental Behavior Scale. Finally, Chapter Three will offer insight into the setting and participants as well as the recommended assessment to determine whether using living collections in virtual climate change programming increases the likelihood of pro-environmental behavior in high school students.

# CHAPTER THREE

# METHODS

## Introduction

The previous chapter's literature review established a background of climate change education in Informal Science Learning Centers (ISLCs) and how using living collections in informal climate change education programs has the potential to increase the likelihood of pro-environmental behavior in high school students. Chapter Three will start with an overview of the associated capstone project, a 3-part virtual Climate High School Science Series. It will then move into the framework that was used to develop and deliver the Climate High School Science Series and the Next Generation Science Standards (NGSS) connections that were used to inspire the context of some of the learning materials. I will then share the setting and participants for this climate series. Finally, I will detail how participant data will be collected and assessed to answer the research question, *Does using living collections in informal science education programming influence a high school student's likelihood to demonstrate pro-environmental behavior related to the climate crisis?*

## Project Description

For my project, I created a 3-part Climate High School Science Series that was facilitated for high school students and their teachers virtually through the Museum of Science in Boston, Massachusetts by Informal Science Educators and external guest experts. The Climate High School Science Series included three events that each took a different lens on the climate crisis: Wildlife, Endangered History, and Climate Justice. The themes for these events were selected based on the Museum's unique ability to tell the story and insights needed for upcoming climate change-related temporary and permanent exhibitions. The Wildlife event utilized the Museum of

Science's living collections, including live animals and plants, while the Endangered History and Climate Justice events leveraged community relationships to tell human-focused stories. Each event included a personalized Educator Guide, an Introductory Climate Science Video, a 30-minute synchronous Live Expert Panel on Zoom, and a follow-up *Call to Climate Action* Resource List. Teachers were welcome, but not required, to sign up for all 3 events. Because of this, the events were not linked and each event did not rely on the building of information and experiences from the previous event(s).

**Climate High School Science Series Framework**

*Head, Heart, Hands Model for Transformative Learning*

To maintain consistency across programs, each event followed the same framework. While I shared many frameworks that have been shown to support climate change education programs in informal and formal science learning environments, this series primarily utilized the Head, Heart, Hands Model for Transformative Learning as outlined in the literature review. This model is widely accepted in the environmental education field as a method for teaching content and encouraging pro-environmental behavior (Gieger, et al. 2017). It was also chosen because it fits into the Museum of Science's existing framework for high school events and it easily supports both asynchronous and synchronous virtual programming. Using this model, each event included the following assets:

A. *Educator Guide:* A 3-4 page educator guide was developed for each event to support the lead teacher and set program expectations. This guide provides a description of the event, defines relevant vocabulary, states the Next Generation Science Standards (NGSS) connection(s), details the introductory video and provides pre- and post-video student questions, describes the backgrounds of the live panel experts, provides the necessary log-in information for the webinar, mentions the follow-up Call to Climate Action, and offers additional resources.

B. *Introductory Video*: An asynchronous introductory video has been written, filmed, edited, and shared for each event to support cognitive engagement (“Head”). Each video is 5-10 minutes long and delivers relevant climate science information based on the event’s theme. This video is meant to be watched prior to the program and will prepare students for the live expert panel.

C. *Synchronous Live Expert Panel:* A synchronous live expert panel was offered for each event to support affective engagement (“Heart”). The live expert panels were facilitated live on Zoom at a designated date and time. The recordings were made available to participating schools after each event and will be archived on the Museum of Science’s YouTube Page. Each live expert panel was 30-minutes long and included time for polling and interactive Q&A. The Wildlife event had animals as the guest experts (Axolotl, Eastern Screech Owl, and Central American Boa Constrictor) and was led by Museum of Science Educators and Live Animal Care Center Staff. The Endangered History and Climate Justice events included community partners as guest experts and was moderated by a Museum of Science Educator.

D. *A Call to Climate Action:* Each synchronous live expert panel was closed with a “Call to Climate Action” that offered next steps to support initiatives that work to monitor and/or solve the climate crisis to support behavioral engagement (“Hands”). This included citizen science projects, local policy advocacy, and individual behavioral changes. This Call to Climate Action was also distributed in a follow-up email to the lead teacher with more information and links to share with students.

*Next Generation Science Standards (NGSS) Connections*

Each event was aligned with Next Generation Science Standards (NGSS) to connect with classroom learning, generate school administration buy-in, and assist in the recruitment of teacher participants. These standards were primarily used to inform the direction of the introductory video content (NGSS Lead States, 2013)

A. Wildlife Event- "Wildlife and the Warming Climate"
    a. *HS-LS2-6.* Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
B. Endangered History Event- "Endangered History: Climate and Culture"
    a. *HS-ESS2-5.* Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.
C. Climate Justice Event- "Climate Justice"
    a. *HS-ESS3-1.* Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

*Pro-Environmental Behavior Scale (PEBS)*

According to Markle (2013), many studies have attempted to use questionnaires to measure the performance of pro-environmental behavior. However, most lack the consistency needed to relate the different findings and too frequently focus on behaviors that don't have a significant impact on the environment. To improve pro-environmental behavior assessment, Markle created the Pro-environmental Behavior Scale (PEBS). This questionnaire offers 42 questions that ask about a person's behavior choices, consumer choices, and personal demographics. The questionnaire also included questions that touch on different types of activities, like consumerism and environmental citizenship behaviors. Markle (2013) found that this approach helped capture the many ways a person may engage in pro-environmental behavior and prioritized the behaviors that have the most impact on the biggest environmental concerns. It also offered a standardized way for researchers to assess a change in pro-environmental behavior (Markle, 2013).

Unfortunately, due to the complex nature of collecting data from minors at a one-time virtual event, student data was not able to be collected during this program. However, I am proposing a methodology for using PEBS to develop a pre- and post-event student questionnaire to be potentially used in the future. To gather data on whether using living collections during virtual informal science education programs increases the likelihood of pro-environmental behavior in high school students, I would conduct a self-guided close-ended student questionnaire. Students would complete this questionnaire before and after each event. Once all the events have passed and the data is collected, I would compare the pre- and post- student questionnaires and assess whether there was a significant change in the responses before and after each event. I would then be able to compare those changes to see if the Wildlife Event featuring living collections resulted in a greater change in likelihood to practice pro-environmental behavior when compared to the Endangered History and Climate Justice Events.

**Setting and Participants**

The Climate High School Science Series was hosted by the Museum of Science, Boston. The Museum of Science is one of the world's largest science centers and one of New England's most highly attended cultural institutions. Each year the Museum welcomes up to 1.5 million visitors into its exhibit halls and has served over 14,000 students through its award-winning engineering curriculum (Museum of Science). The Museum of Science is also an Association of Zoos and Aquarium (AZA) accredited institution. This designation means that they meet the highest standards for animal care and management. More than 120 individual animals, representing over 50 species, are currently under the care of the Museum of Science. These live animals can be found on exhibit throughout the exhibit halls and in the Live Animal Care Center (LACC). Many of these animals act as animal ambassadors and assist in teaching life sciences and conservation through live presentations and traveling community programs (LACC, Museum of Science).

Staying true to its mission “to inspire a lifelong love of science in everyone”, the Museum of Science pivoted to virtual education offerings during nation-wide shutdown due to the COVID-19 pandemic. Through this transition, a new virtual school initiative, “MOS at School”, emerged. MOS at School supports virtual live interactions and asynchronous experiences for schools across the United States. The live interactions can include both earth and space science and life sciences topics. All programs are currently free of charge for schools and educators through Zoom and advanced reservations are required (Museum of Science, 2020).

The Climate High School Science Series was developed as a part of the new Spring 2020 MOS at School offerings. My audience for this Climate High School Science Series was high school students and their teachers in the United States. MOS at School had not reached high school audiences yet, in part because it is not our biggest audience during more normal times. However, this audience has been of major interest to potential donors to support staff time and student access. We also have a strong history and foundation of hosting in-person high school events over the last 20 years. New England schools were particularly recruited to participate through targeted outreach to ensure the climate stories we share are relevant to our viewers and the climate challenges their communities are facing. Participating schools were recruited through marketing efforts, like educator mailing lists, and through our existing partnerships with traditionally underserved and economically disadvantaged schools. With keeping the programs free of charge, we aim to have diverse participants that perhaps have not been able to visit the Museum of Science in-person previously. Teachers register their classrooms for this program in advance. Students are not able to register as individuals. Participation was entirely virtual due to the COVID-19 pandemic. The capacity for each event was 900 students and teachers, making the total series capacity 2,700 students and teachers. Asynchronous assets were shared with the lead teachers via email up to 2 weeks before the program while synchronous assets were streamed on Zoom using Open Broadcaster Software (OBS) at a designated date and time.

**Assessment**

Assessment is vital to this virtual Climate High School Science Series as it will determine whether using living collections during informal science education programs increases the likelihood of high school students demonstrating pro-environmental behaviors. As mentioned previously, this program was not able to be assessed this year due to the challenges of collecting survey responses from minors for virtual events. However, I am proposing a methodology for collecting the data to answer the research question. This methodology includes a self-guided close-ended questionnaire to assess a high school student's likelihood to engage in pro-environmental behaviors before and after each event.

Using the 42 questions from PEBS as a guide, I selected eight questions to include in my pre- and post-event questionnaire for high school participants. The pre-event questionnaire would be sent 2 weeks prior to each event and responses could be accepted up until the morning of each event. The post-event questionnaire has the same eight questions and would be sent 2 weeks after each event and responses could be accepted up to 1 month after each event.

It was essential that the questions I chose were choices that high school students made for themselves rather than an adult making for them. For example, high school students often have choice over the length of their shower, their mode of transportation, and engagement in environmental-focused extracurricular activities. However, high school students often do not have choice over the groceries that are purchased, the energy efficiency of their home appliances, or the amount of their household income that is donated to environmental advocacy groups. Finally, the questionnaire was intentionally kept short and close-ended to increase the chance of student participants finishing the questionnaire and submitting their thoughts both before and after the event. The questions and close-ended response options in the questionnaire can be found in Table 1 (below).

*Table 1*: Pre- and post-event self-guided questionnaire and close-ended response options

| **Questions** | **Response Options** |
|---|---|
| Over the next 30 days, how often will you choose public transportation, walking, or cycling, as your method of travel? | a. Every time<br>b. Most of the time<br>c. Half of the time<br>d. A few times<br>e. Never |
| Over the next 30 days, how many times will you have a meat-free meal? | a. Everyday<br>b. Four to six times a week<br>c. Two to three times a week<br>d. A few times a month<br>e. Once a month<br>f. Never |

| | |
|---|---|
| Over the next 30 days, how often will you turn off the light switch when leaving the room? | a. Every time<br>b. Most of the time<br>c. Half of the time<br>d. A few times<br>e. Never |
| Over the next 30 days, how often will you turn off the TV when leaving the room? | a. Every time<br>b. Most of the time<br>c. Half of the time<br>d. A few times<br>e. Never |
| Over the next 30 days, how often will you decrease the amount of time in the shower to conserve water? | a. Every time<br>b. Most of the time<br>c. Half of the time<br>d. A few times<br>e. Never |
| Over the next 30 days, how often will you talk with family members or friends about climate change or the environment? | a. Everyday<br>b. Four to six times a week<br>c. Two to three times a week<br>d. A few times a month<br>e. Once a month<br>f. Never |
| Over the next 30 days, how often will you wait to have a full load of laundry or a full dishwasher? | a. Every time<br>b. Most of the time<br>c. Half of the time<br>d. A few times<br>e. Never |
| Over the next 30 days, will you participate in any Citizen Science projects? Some examples include: Wicked Hot Boston, FireFly Project, Project Penguin, etc. | a. Yes<br>i. If so, which one(s):<br>b. No |

After all of the events have occurred and the pre- and post- questionnaires have been gathered, the data could be assessed to determine if there was a significant change in the likelihood to demonstrate pro-environmental behavior from before and after each event. Since the Wildlife event is the only event in the series leveraging living collections, I would be able to compare if using living collections in virtual informal climate science education programs is more or less effective at increasing the likelihood of pro-environmental behavior in high school students when compared to using human-stories for the Endangered History and Climate Justice event.

**Conclusion**

Chapter 4 offers a cumulative summary and reflection on what I've learned through developing this project. It will also provide insight into how this project could be further developed to continue to investigate the influence of living collections in climate change communication and increasing the likelihood of the public engaging in pro-environmental behavior.

# CHAPTER FOUR

# REFLECTION AND CONCLUSION

## Context

The purpose of this virtual Climate High School Science Series was to answer the research question, *Does using living collections in informal science education programming influence a high school student's likelihood to demonstrate pro-environmental behavior related to the climate crisis?* The virtual Climate High School Science Series aimed to answer this question by incorporating living collections, like animals and plants, into some of the informal science programming to determine if it increased the likelihood of pro-environmental behavior in high school students. This chapter will examine the learning process of developing and hosting the 3-part virtual Climate High School Science Series. It will also reflect on the Literature Review and determine which sources were most relevant or important. This chapter will review the implications and limitations of the project and suggest future research. Finally, it will discuss how I plan to share the results of the project and how they may benefit the field of informal science education and climate change communication.

## Major Learnings

One major takeaway from this project is the growing market for high school programs that create context for classroom learning and connect students to resources outside of their classroom. These resources could include living collections, like animals and plants, or access to diverse community field experts. When reviewing teacher feedback, teachers shared that they registered their students for this program for a few main reasons. For one, teachers felt that their students would benefit from seeing a different side of learning that showed real world connections and applications of their classroom curriculum. Secondly, teachers shared the value of students being able to learn directly from experts in the field and ask them questions about content and their career pathway. I was expecting to see comments about how they wished we incorporated more human stories into the *Wildlife and the Warming Climate* event since teachers have grown to expect a STEM career-focused offering from us. However, I was surprised to see that many teachers found the animals to increase their students' interest in the event and were grateful for the novel connections we were able to make to their classroom learning with our animal ambassadors.

Another learning outcome from this project was the desire for teachers to have their students attend multiple events around the same topic. Historically, the High School Science Series Program would feature different STEM topics each month, like computer science, human health, and ecology. This virtual Climate High School Science Series was the first time we offered three events that each took a different lens on the same topic. While teachers were welcome to sign up for just 1 event, many took this as an opportunity for students to gradually grow their knowledge of the topic. Forty-two percent of our participating schools registered for at least 2 of the 3 events. This was an added bonus for us as we could plan ahead and intentionally build upon the previous month's conversation.

Another interesting takeaway from this project was the increased accessibility of the program for both local and national audiences. Ninety-six percent of our registered schools were from Massachusetts, but we did have a few outliers. For example, we had a small Inuit community join us from Alaska for our *Endangered Heritage: Climate and Culture* and *Climate Justice* events. This demographic would have never been able to attend these events in person, but by offering it virtually, they are able to connect with our educators and resources and share their lived experiences with our Live Experts. In addition, we saw many local schools sign up a small group of students (less than 7 students and 1 teacher). This was not possible for in-person programs in the past as the Museum of Science has a minimum for students and teachers per field trip. Additionally, teachers couldn't justify paying for transportation to the Museum for such a small group of students. However, by offering this program virtually, teachers could register students that expressed interest in attending and didn't need to worry about transportation arrangements or getting approval from other teachers to release those students for a field trip.

**Literature Review**

A key aspect of my initial literature review investigated effective climate change communication strategies and possible models for the virtual learning experience. It was clear that hope was a key aspect to effective climate change communication. Jie Ling and Monroe (2019) introduced this with their reasonable person model that connected feelings of hope to pro-environmental behavior. The reasonable person model was very similar to the Head, Heart Hands Model for Transformative Learning in that it called for 3 main components: Cognitive Engagement or Model Building, Affective Engagement or Being Effective, and Behavioral Engagement or Meaningful Action (Jie Lin & Monroe, 2019, Geiger, et. al 2017). These 3 components greatly informed the format and tone of the asynchronous and synchronous aspects of the virtual Climate High School Science Series. Overall, I would say that the Head, Heart, Hands Model for Transformative Learning was an effective model for this virtual informal science education program. For example, by creating an introductory climate video for cognitive engagement, the students seemed better prepared for affective engagement with the Live Expert Panel by asking deeper, more relevant questions.

Another essential piece of my literature review was the Pro-Environmental Behavior Scale (PEBS). The Pro-Environmental Behavior Scale offered a well-tested list of 42 questions that assessed a person's behavior choices, consumer choices, and personal demographics. It also included questions that touched on different types of behaviors, like consumerism and environmental citizenship, and prioritized behaviors that made the biggest environmental impact (Markle, 2013). This list of questions was an invaluable resource when developing the pre- and post-event self-guided questionnaire for students. I was able to review the questions and select those that were most relevant to the high school audience and the decisions they can typically make or influence within their personal and family circles. While I wasn't able to facilitate the questionnaire this season, it has a chance of being used when evaluating future climate-themed high school programming.

**Implications**

While I wasn't able to answer my research question with collected data, there are tentative conclusions that could be drawn from teacher feedback and student engagement during the Live Expert Panels. For one, teachers reported excitement and interest from their students during the Live Expert Panel that featured animals from the Museum's Live Animal Care Center. They felt the animals were a diverse representation of taxa and that they were a learning resource their classroom or school would not be able to provide independently of this program. Teachers also shared that the animals helped students make a more personal connection between the animals they care about and the overall challenge and urgency of climate change, which again, is difficult to do in the traditional classroom.

However, in terms of student engagement, more questions were asked during the human-focused High School Science Series events. Based on my informal review of the Q&A

boxes, students seemed to ask more questions during the human-focused events because they could ask questions directly to specific panelists. They could also ask them questions about their personal career pathways. These types of questions are not an option for students when the panel features just animals. This suggests that there could be a better mix of both animal and human guests during a climate education program that could provide an opportunity for students to connect with wildlife while also hearing from a community expert whom they could ask questions directly to.

**Limitations**

One major limitation was the inability to collect direct feedback from participating high school students at this time. As discussed earlier, I was not able to carry out my pre- and post-event self-guided questionnaire because students under the age of 18 would need to submit a parent or guardian permission form for us to collect and use the data. Because of this, I am unable to make a data-driven conclusion on whether using living collections in informal science education programming increased the likelihood of pro-environmental behavior in high school students. There is a possibility of collecting these forms in the future with a small subset of participants, i.e. partner schools or only attendees 18 and older, but it was not an option for this virtual Climate High School Science Series.

Another limitation was the rapid development timeline. While we weren't able to gather feedback from students, we were able to gather feedback from participating teachers after each Live Expert Panel. The post-event teacher survey was designed to assess the quality and value of the event resources (i.e. Educator Guide, Introductory Video, Call to Climate Action, etc.) and the live Zoom webinar experience. The feedback the teachers offered has been incredibly valuable, however, our rapid development timeline of this series did not allow space or time for us to incorporate their suggestions into the next event's resources. For example, we found it takes about 6 weeks to research, storyboard, write, film, and edit each Introductory Climate Science video. As we gathered post-event teacher feedback in late February for the *Wildlife and the Warming Climate* event, we could not apply that feedback to the March *Endangered History: Climate and Culture* event because the resources were already well on their way to being finalized. We do hope to incorporate their feedback into next year's in-person and virtual high school programming.

A final limitation was our audience reach. While we managed to engage a few groups outside of Massachusetts, the large majority of our attendees were from Massachusetts or the New England area. We were excited to offer this virtual program for all U.S. High Schools and recruited our Live Expert Panelists strategically to represent practicing scientists from across the country. Even so, we quickly realized that our mailing lists and educator relationships are still very local because the majority of our offerings were in-person before COVID-19. We certainly enjoy having our local audience join us, but it could have been an interesting opportunity to bring youth from across the nation together to discuss this urgent global issue.

**Future Research and Projects**

Of course, the first step I'd like to take is to conduct the suggested pre- and post-event self-guided student questionnaires to fully answer whether using living collections in virtual informal science education programs increases the likelihood of high school students demonstrating pro-environmental behavior. It could also be interesting to apply this same research question to in-person informal science high school programming once it is safe to do so. However, another avenue I'd really like to explore is whether some animals are more effective at engaging students or adults in climate change and pro-environmental behavior than others. With previous research showing that humans feel more empathetic to taxa that are more evolutionarily related to them (Miralles, Raymond, & Lecointre, 2019), it could be interesting to offer events with similar learning experiences but intentionally showcase living animals that are highly related, moderately related, or distantly related to humans to see how it may affect their likelihood to engage in pro-environmental behavior.

**Communicating Results**

There are a number of ways the results of this project could be communicated. For one, the Museum of Science is expanding their new *MOS at School* initiative and will undoubtedly use the teacher feedback from this project to identify opportunities to build synchronous and asynchronous virtual high school offerings for the upcoming school year. This feedback may also be used by the Museum's Education and Advancement Leadership teams to apply for external funding to support the development of these programs.

Further, there are two climate change-focused exhibits being developed at the Museum. Both exhibit development teams plan to leverage the virtual High School Science Series' asynchronous resources and teacher feedback to support content and programming decisions. For example, an exhibit that is being developed will feature different World Heritage Sites that are vulnerable to climate change. That exhibit team may use portions of the *Places in Peril: Cities Facing the Climate Crisis* Introductory Video within the exhibit or as a part of their virtual offerings connected to the in-person exhibit. They may also use the Call to Climate Action Resource List to inspire general visitors to get involved after attending the in-person exhibit.

**Benefit to the Profession**

As stated in the literature review, climate change is a complex challenge that is difficult to communicate in an effective and engaging way. It can leave students and ISLC visitors feeling hopeless, overwhelmed, and unsure of how to get involved in solutions. This project has offered another model for ISLCs to consider when developing climate-focused school programs that include content delivery, affective engagement, and age-appropriate action items. The teacher feedback and student questions will be catalogued and shared internally within the Museum of Science to inform future climate exhibits and educational programming so we can continue to fulfill our mission and serve our community's current needs and concerns.

**Conclusion**

This paper and project aimed to answer the research question, *Does using living collections in informal science education programming influence a high school student's likelihood to demonstrate pro-environmental behavior related to the climate crisis?* This question acted as a guiding compass throughout the literature review and the development of the virtual Climate High School Science Series program. Through this investigation, I've learned that effective climate change communication incorporates feelings of urgency, relevance, and hope. I've met many diverse and impressive community experts that serve as excellent role models for young people as they consider careers that may help solve one of the world's biggest challenges. I've grown to understand, appreciate and leverage different modes of engagement, and realized that climate change education is more than content delivery and knowledge, but personal connections, emotion, and motivation to act. It is my hope that this virtual Climate High School Science Series will serve as a foundation for future exhibits and programming that will engage students and general visitors in individual and collective climate action.

## BIBLIOGRAPHY


Batson, C. (1991). The altruism question: Toward a social-psychological answer. Lawrence Erlbaum.

Berenguer, J. (2007). The Effect of Empathy in Proenvironmental Attitudes and Behaviors. *Environment and Behavior,* 39(2): 269-283. DOI: 10.1177/0013916506292937.

Bofferding, L., Kloser, M. (2007). Middle and high school students' conceptions of climate change mitigation and adaptation strategies. *Environmental Education Research,* 21(2): 275-294. DOI: 10.1080/13504622.2014.888401.

Byrne, J., Ideland, M., Malmberg, C., Grace, M. (2014). Climate Change and Everyday Life: Repertoires children use to negotiate a socio-scientific issue. *International Journal of Science Education*, 36(9): 1491- 1509. DOI: 10.1080/10900693.2014.891159.

Caplow, S. (2019). The presentation of environmental values, beliefs, and norms in live animal interpretative experiences. *Environmental Education Research,* 25(8): 1158-1173. DOI: 10.1080/13504622.2018.1479837.

Clayton, S., Fraser, J., Saunders, C. (2009). Zoo experiences: Conversations, Connections, and Concern for Animals. *Zoo Biology,* 28(5): 377-397.

Clayton, S., Luebke, J., Saunders, C., Matiasek, J., Grajal, A. (2014). Connecting to nature at the zoo: implications for responding to climate change. *Environmental Education Research,* 20(4): 460-475. DOI: 10.1080/13504622.2013.816267

Daly, B., & Suggs, S. (2010). Teachers' experiences with humane education and animals in the elementary classroom: implications for empathy development. *Journal of Moral Education*, 39(1): 101-112.

Doxey, J., Waliczek, T., & Zajicek. (2009). The Impact of Interior Plants in University Classrooms on Student Course Performance and on Student Perceptions of the Course and Instructor. *HortScience,* 44(2): 384- 391. DOI: 10.21273/HORTSCI.44.2.384.

Drissner, J., Haase, H., Rinderknecht, A., & Hille, K. (2013). Effective environmental education through half-day teaching programmes outside school. *ISRN Education*, 2013, 1-6. DOI: 10.1155/2013/503214

Falk, J. H., Reinhard, E. M., Vernon, C., Bronnenkant, K., Heimlich, J. E., Deans, N. L. (2007). Why zoos & aquariums matter: Assessing the impact of a visit to a zoo or aquarium. Silver Spring, MD: Association of Zoos & Aquariums.

Flora, J., Saphir, M., Lappe, M., Roser-Renouf, C., Maibach, E., Leiserowitz, A. (2014). Evaluation of national high school education program: The Alliance for Climate Education. *Climate Change,* 127: 419- 434. DOI: 10.1007/s10584-014-1274-1.

FrameWorks Institute. (2017). Expanding Our Repertoire: Why and How to Get Collective Climate Solutions in the Frame. Retrieved from: https://climateinterpreter.org/sites/default/files/resources/collective_solutions_expanding_our_repertoire.pdf

Fraser, J., Pantesco, V., Plemons, K., Gupta, R., Rank, S. (2013). Sustaining the Conservationist. *Ecopsychology*, 5(2): 70-79. Retrieved from: DOI:10.1089/eco.2012.0076

Frick, J., Kaiser, F., Wilson, M. (2004). Environmental knowledge and conservation behavior: exploring prevalence and structure in a representative sample. *Personality and Individual Differences,* 37(8): 1597- 1613.

Fuhrman, N. & Rubenstein, E. (2017). Teaching with animals: The role of animal ambassadors in improving presenter communication skills. *Journal of Agricultural Education,* 58(1), 223-235.

Geiger, N., Swim, J., Fraser, J., Flinner, K. (2017). Catalyzing Public Engagement With Climate Change Through Informal Science Learning Centers. *Science Communication*, 39(2):221- 249. Retrieved from: https://journals-sagepub-com.ezproxy.hamline.edu/doi/full/10.1177/1075547017697980

Grajal, A., Luebke, J., DeGregoria Kelly, L., Matiasek, J., Clayton, S., Karazsia, B., Saunders, C., Goldman, S., Mann, M., Stanoss, R. (2017). The complex relationship between personal sense of connection to animals and self-reported proenvironmental behaviors by zoo visitors. *Conservation Biology,* 31(2): 322-330. DOI: 10.1111/cobi.12780.

Guanio-Uluru, L. (2020) Imagining Climate Change: The Representation of Plants in Three Nordic Climate Fictions for Young Adults. *Child Lit Educ* 51, 411–429. https://doi-org.ezproxy.hamline.edu/10.1007/s10583-019-09387-4

Heald, Seth. (2017). Climate silence, Moral Disengagement, and Self-Efficacy: How Albert Bandura's Theories Inform our Climate Change Predicament. *Environment Magazine*, 59(6): 4-15.

IPCC, 2018: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.

Home: Museum of Science, Boston. (n.d.). Retrieved February 08, 2021, from https://www.mos.org/

Jie Li, C. and Monroe, M. (2019). Exploring the essential psychological factors in fostering hope concerning climate change. *Environmental Education Research,* 25(6): 936- 954. DOI:

10.1080/13504622.2017.1367916.

Johnson, S. (2019). Teachers and students push for climate change education in California. *EdSource*. Retrieved from: https://edsource.org/2019/teachers-and-students-push-for-climate-change-education-in-california/618239

Kahan, D., Peters, E., Wittlin, P., Slovic, L., Ouellette, L., Braman, D., Mandel, G. (2012). The Polarizing Impact of Science Literacy and Numeracy on Perceived Climate Change Risks." *Nature Climate Change,* 2(10): 732-735. DOI: 10.1038/nclimate1547.

Katz-Kimchi, M. and Atkinson, L. (2014). Popular Climate Science and Painless Consumer Choices: Communicating Climate Change in Hot Pink Flamingos Exhibit, Monterey Bay Aquarium, California. *Science Communication*, 36(6): 754-777. DOI: 10.1177/10755470.

Krajhanzl, J. (2010). Environmental and Pro-environmental Behavior. *Health Education: International Experiences,* 21: 251- 274.

Lawson, D., Stevenson, K. Peterson, M., Carrier, S., Strnad, R., Seekamp, E. (2019). Children can foster climate change concern among their parents. *Nature Climate Change,* 9, 458-462. DOI: 10.1038/s41558-019-0463-3

Linden, S., Maibach, E., and Leiserowitz, A. 2015. Improving Public Engagement with Climate Change: Five "Best Practice" Insights From Psychological Science. *Perspectives on Psychological Science*, 10(6): 758-763. DOI: 10.1177/1745691615598516

Lindenmann-Matthies, P. (2002). The Influence of an Educational Program on Children's Perception of Biodiversity. *The Journal of Environmental Education,* 33(2): 22-31. DOI: 10.1080/00958960209600805

Live Animal Care Center: Museum of Science, Boston. (n.d.). Retrieved November 16, 2020, from https://www.mos.org/exhibits/live-animal

Lubell, M., Zahran, S., and Vedlitz, A. 2007. Collective Action and Citizen Responses to Global Warming. *Political Behavior*, 29(3): 391-413.

Luebke, J. F., Clayton, S., Saunders, C. D., Matiasek, J., Kelly, L.-A. D., Grajal, A. (2012). *Global climate change as seen by zoo and aquarium visitors*. Brookfield, IL: Chicago Zoological Society. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.460.1111&rep=rep1&type=pdf

Markle, G. (2013). Pro-Environmental Behavior: Does it matter how it's measured? Development and Validation of the Pro-Environmental Behavior Scale (PEBS). *Human Ecology,* 41(6): 905-914. DOI: 10.1007/s10745-013-9614-8.

Mead, E., Roser-Renouf, C., Rimal, r., Flora, J., Maibach, E., Leiserowitz, A. (2012). Information seeking about global climate change among parents and their adolescents: the role of risk perceptions and efficacy beliefs. *Atl J Commun.* 20(1): 31-52. DOI: 10.1080/15456870.2012.637027.

Miller, D. (1999). The norm of self-interest. *American Psychologist,* 54, 1053-1060.

Miralles, A., Raymond, M., Lecointre,G. (2019). Empathy and compassion toward other species decrease with evolutionary divergence time. *Scientific Reports,* 9(1): 19555. DOI: 10.1038/s41598-019-560069.

MOS at School: Museum of Science, Boston. (2020). Retrieved November 16, 2020, from https://www.mos.org/mos-at-school

NGSS Lead States. 2013. *Next Generation Science Standards: For States, By State*s. Washington, DC: The National Academies Press.

Park, W. and Kim, C. (2020). The Impact of Project Activities on the Cultivation of Ecological Citizenship in High School Climate Change Club. *Asia-Pacific Science Education*, 6: 41-69. DOI: 10.1163/23641177-BJA00005.

Parker, C., Cockerham, D., and Foss, A. (2017). Communicating Climate Change: Lessons Learned from a Researcher-Museum Collaboration. *Journal of Microbiology & Biology Education*, 19(1): 1-5.

Patchen, A., Zhang, L., & Barnett, M. (2017). Growing Plants and Scientists: Fostering Positive Attitudes towards Science among All Participants in an Afterschool Hydroponics Program. *J Sci Edu Technol,* 26: 279-294. DOI: 10.1007/s10956-016-9678-5.

Pearson, E., Dorrian, J., and Litchfield, C. (2013). Measuring zoo visitor learning and understanding about orangutans: evaluation to enhance learning outcomes and foster conservation action. *Environmental Education Research,* 19(6): 823-843. DOI: 10.1080/13504622

Pollan, Michael. (2015). Foreword. In Stefano Mancuso and Alessandra Viola (Eds.), *Brilliant Green: The Surprising History and Science of Plant Intelligence* (pp. xi–xiii). London: Island Press.

Povey, K., & Rios, J. (2002). Using interpretive animals to deliver affective messages in zoos. *Journal of Interpretation Research*, 7(2): 19-28.

Sadler, T. D. (2009). Situated learning in science education: Socio-scientific issues as contexts for practice. *Studies in Science Education*, 45(1), 1 –42.

Sanson, A., Van Hoorn, J., and Burker, S. E. L. (2019). Responding to the Impacts of the Climate Crisis on Children and Youth. *Child Development Perspectives*, 13(4): 201- 207. DOI: 10.1111/cdep.12342.

Schneider, C., Zaval, L., Weber, E., Markowitz, E. (2017). The influence of anticipated pride and guilt on pro-environmental decision making. *PloS ONE,* 12(11): 1-14. DOI: 10.1371/journal.pone.0188781.

Schonfelder, M. and Bogner, F. (2017). Two ways of acquiring environmental knowledge: by encountering living animals at a beehive and by observing bees via digital tools. *International Journal of Science Education,* 39(6): 723- 741. DOI:10.1080/09500693.2017.1304670

Schwartz, Jessamy. (2013). Raptors in education: How educators use live raptors for environmental education (Doctoral dissertation). Retrieved from the University of Minnesota Digital Conservancy, http://hdl.handle.net/11299/187548. Sturgis, S. (2018) Educational policy. Lanesboro: MN. Eagle Bluff Environmental Learning Center.

Shelton, M., & Rogers, R. (1981). Fear-arousing and empathy-arousing appeals to help: The pathos of persuasion. *Journal of Applied Social Psychology*, 11, 366-378.

Stern, P., Dietz, T., Abel, T., Guagnano, G., Kalof, L. (1999). A value-belief-norm theory of support for social movements: The case for environmentalism. *Human Ecology Review,* 6, 81-98.

Stevenson, K., Peterson, M., Bondell,D., Moore, S., Carrier, S. (2014). Overcoming Skepticism with Education: Interacting Influences of Worldview and Climate Change Knowledge on Perceived Climate Change Risk among Adolescents. *Climatic Change,* 126(3-4): 293-304. DOI: 10.1007/s10584-014-1228-7.

Swanagan, J. (2000). Factors influencing zoo visitors' conservation attitudes and behavior. *Journal of Environmental Education,* 31(4): 26-31. DOI: 10.1080/00958960009598648.

Swim, J. and Fraser, J. (2013). Fostering Hope in Climate Change Educators, *Journal of Museum Education*, 38(3): 286-297, DOI: 10.1080/10598650.2013.11510781

Swim, J., Geiger, N., Fraser, J., Pletcher, N. (2017). Climate Change Education at Nature-Based Museums. *The Museum Journal*, 60(1): 101-119.

van den Berg, A., Wesselius, J, Maas, J., Tanja-Dijkstra, K. (2016). Green Walls for Restorative Classroom Environment: A Controlled Evaluation Study. *Environment and Behavior,* 49(7): 791-813. DOI: 10.1177/0013916516667976.

van der Linden, Maibach, E., and Leiserowitz, A. (2015). Improving Public Engagement With Climate Change: Five "Best Practice" Insights From Psychological Science. *Perspectives on Psychological Science*, 10(6): 758-763. DOI: 10.1177/1745691615598516

Welcome to living laboratory! (n.d.). Retrieved February 08, 2021, from https://www.mos.org/living-laboratory

Young, A., Khalil, K., and Wharton, J. (2018). Empathy for Animals: A Review of the Existing Literature. *The Museum Journal,* 61(2): 327- 343.