FOSTERING ENVIRONMENTAL IDENTITY WITH HIGH SCHOOL STUDENTS

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By

Cam-Tu Trinh

Dissertation Committee:

Tara O'Neill, Chairperson
Lori Fulton
Linda Furuto
Jon Yoshioka
Joseph Jarret

Abstract

SBiC is a sustainability focused biodiversity curriculum developed for high school chemistry students. The curriculum was designed based on students learning chemistry concepts in class along with lessons and activities to gear them toward a sustainable attitude with the local environment. From that, students designed and carried out scientific investigations using real data they collected around their school. This qualitative case study explored the impacts of students with SBiC, as well as their interactions with the environment. Data were collected through various surveys, participant reflections, observations, focus group interviews and student artifacts including the physical garden they built from empty milk cartons and a final video to summarize the process of how to build the garden. To track the environmental identity development of 30 students as a whole case and three students as an embedded case study, a hierarchical scale was developed and utilized. The scale included three vertical stages and eight sub stages that ran horizontally. The scale was built on the analysis of students' expressions and thoughts. Three stages were documented and arranged from the common themes listed from their expressions. Starting from the first stage, which contained ideas most students commonly mentioned, more complex thoughts and ideas were introduced as students moved up the scale. Findings indicated that after exposure to the SBiC curriculum, 21 students had ascended across the sub-stages of the first stage, eight students had completed the curriculum ending at the start of the second stage, and only one student had reached the third stage at the end of the study.

Keywords: environmental identity development, sustainability

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Introduction

Statement of the Problem

After twenty years of teaching, I found that the beliefs I grew up with as a child played an important part in my journey as a teacher. I recall growing up in Vietnam in the 1980s and early 1990s, living with constant lack of food and necessities, absence of clean water, and deficiency of electric power. These memories are so vivid to me today. Reflecting upon these experiences, I have come to recognize that sustainability has always been an important part of my life. On an even larger scale, sustainability is vitally important for the survival of humanity. Currently, humanity is facing a series of challenges, including climate change, biodiversity loss, and decreasing availability of cheap fossil fuel energy, which when taken together, constitute a sustainability crisis.

According to Eisner (2004), "Students will be living in a world different from the one they now occupy, and schools should enable them to deal with that world" (p. 6). As a science teacher, I believe it is crucial to ensure that my students are aware of the connection between their actions and the environment. Developing students' environmental knowledge and skills will help them to see the beauty of the world, and to better understand themselves in the process (Davis & Elliott, 2003). Engaging students with learning opportunities that expose them to the broader community will keep students actively involved as they enjoy the natural world. The challenge is to find the measure of the impact on students who participate in a chemistry class that intentionally includes hands-on environmental education projects. Therefore, it is my belief

that including environmental education in the chemistry curriculum will positively influence students' attitudes and behaviors toward the natural world.

Rationale for the Study

The impetus for this study is based on two goals:

1. Design a sustainability focused biodiversity curriculum (SBiC) to be used in a chemistry course;
2. Explore the impact of students' environmental identity at the beginning, middle, and the end of participation in SBiC.

To study environmental identity in a school context, this research tracked students' behavior toward and attitudes about the environment. This information will identify the impacts of participation in SBiC on high school students' environmental identity and suggest ways to improve their behavior. Providing students with opportunities to strengthen their connection with the natural world will support their environmental identity development and foster environmentally positive behaviors (Green et al., 2015).

Sustainability Focused Biodiversity Curriculum (SBiC) and Environmental Supports

In just a few years, the youth of today will fall heir to the environmental, social, and economic challenges intensified by the generations that came before them. In order to prepare these young people to disentangle these complicated issues and propose viable solutions, they need to learn the skills and knowledge to protect our Mother Earth. Researchers have found that the most effective way to foster good attitudes, motivation, and commitments is to encourage responsible action and behavior in the support of the environment (Kollmuss & Agyeman, 2002). Many are still struggling to solve the dilemma that Zavestoski (2003) captured in his question: "How is it that so many people claim to be concerned about the environment while at the same

time making life-style choices that lead to environmental destruction?" (p. 297). By exploring answers to this question, science educators can develop a curriculum aimed at preparing students to make decisions that support the environment and act in sustainable ways, thereby achieving one of the major goals of both science and environmental education (Duschl et al., 2007).

In July 2011, the National Research Council (NRC) released A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas, which identifies key scientific ideas and practices all students should learn by the end of high school. One goal of the NGSS is to help all learners in our nation develop an understanding of science and engineering that will help to sustain the planet for future generations (Krajcik, 2013).

To promote the development of students' sustainability skills and knowledge, I integrated a sustainability focused unit (SBiC) into the Chemistry curriculum that provided students with opportunities to practice personal environmental behaviors with the Earth. I selected three life science topics from the Next Generation Science Standards (NGSS) for High School Life Science such as the dynamics of ecosystems, functioning and resilience, and natural selection and evolution. These three major topics include subtopics including factors affecting biodiversity, interactions in ecosystems, and impacts of human activity on the environment. However, in order to stay true to the Chemistry curriculum and to maintain consistency in content with other class periods, I selected two major topics from the NGSS for High School Physical Science, 1) factors affecting energy flow in chemical reactions in ecosystems, and 2) behavior of atoms/molecules in bonding interactions and phase changes.

Current events related to the environment were also introduced in order to promote students' understanding of the complexity of our worlds' issues and to propose some ways to solve those issues. As we worked through the chemistry class syllabus, I intentionally designed

field trips and outdoor experiences that incorporated chemistry labs to link what students were learning in class with what they were observing and discussing about their local environment. Most importantly, these experiences provided the opportunity for students to discuss what actions are needed to build a more sustainable future. This curriculum was implemented in my Honors Chemistry class from January to May 2018. Figure 1 presents the summary of SBiC with four major components through the lens of sustainability.

Figure 1

The Scope and Sequence of Sustainability Focused Biodiversity Curriculum (SBiC)

The first component, “Valuing Biodiversity” focuses on the unique biodiversity of the school garden. Students discovered the relationships and interconnections among species and the

importance of biodiversity to the long-term sustainability of humankind and other living species on Earth. Since students were currently in Chemistry class, they had learned how to apply their knowledge about chemical ions in order to identify the ions (such as iron, calcium, etc.) in soil. Application of acids and bases as well as gas laws came to be useful when the class began evaluating the quality of water and air, respectively. This component was different from typical Biology and Environmental Science classes, because students were introduced to the concepts through chemistry lessons, and received a more in-depth description regarding the abiotic factors of the area before evaluating the biotic factors in the school garden.

Next, in “Building Biodiversity”, students planned, designed and created spaces in the schoolyard to increase native biodiversity. Students also decided how they would alter the abiotic and the biotic factors to increase the biodiversity on the school ground. This was yet another way that makes SBiC stand out from Biology and Environmental Science, because students were aware of the quality of abiotic factors of the location they wanted to build their biodiversity, so they could improve the quality of individual abiotic factors. For example, they would add more nutrients to poor soil, or select higher quality water in order to nourish their garden.

Thirdly, in the “What’s in its future?” phase, students constructed a garden that fits the needs of their plan. Lastly, in “Taking Actions", students measured the biodiversity on the school campus before, and after the implementation of their plan by collecting data to demonstrate their understanding of how biotic, abiotic and human factors can affect biodiversity.

Purpose of the Study

Many studies regarding environmental identity have focused on adults and higher education (Clayton et al., 2011; Evans et al., 2012; Hinds & Sparks, 2009; Kempton & Holland, 2003). Relatively little is known about high school students’ environmental identity. Therefore,

understanding students' environmental identity may be an important first step to determine how to influence their attitudes and behaviors toward the natural world. The purpose of this study is to seek an understanding about how students express their environmental identity after participating in SBiC. Specifically, this study utilizes qualitative methodology to identify the environmental identities of participants and to analyze how SBiC influenced these identities. To that end, this study employs a case study approach to explore specific characteristics of environmental identity development of participants, including, *environmental awareness, environmental action,* and *taking initiative*. Findings of this research provide contributions to broaden our understanding of environmental identity in youth and how their potential impacts influence care for the environment.

Research Questions

Studying environmental identity enables educators and environmentalists to gain a better understanding of why individuals act in particular ways toward the environment and how to increase pro-environmental behaviors. Little work exists about the relationship between environmental identity and environmental decision-making. This study will inform environmental education by answering the following questions:

1. What instructional tools when added to the chemistry class will help students to focus on the idea of sustainability?
2. How does a high school student's participation in a teacher-designed sustainability curriculum impact the expression of their environmental identity?

Significance of the Study

Research indicates that there are many problems associated with the lack of initiative on sustainable practices and the lack of knowledge about sustainability. Wiek et al. (2011) found

that sea level rise, desertification, poverty, lack of education, and other environmental complexities result from dynamic cause and effect chains from local to global inadequacies in sustainability practices. Researchers have become increasingly aware of humanity's inability to "fix" the problems (Wiek et al., 2011). In addition, even larger problems arise when the "fix" tends to be linked to the outcomes of the problems, and not the root cause of the problem, highlighting the need for educational programs focusing heavily on sustainability.

In addition, Haugh and Talwar (2010) found a specific need for education to expand on the basic principles of sustainability, and recommended that practitioners incorporate sustainability into teaching and learning activities with the purpose of increasing awareness and knowledge of environmentalism. By including a sustainability component into the science curriculum, students may learn to take responsibility for their actions and create a more sustainable planet in the future Including a sustainability component in curriculum at the high school level may help students realize that their daily choices affect the environment and that they can make environmentally responsible choices to lessen the detrimental impact on the earth and promote sustainable living practices.

Finally, learning more about the way that students view the environment in relation to their sense of self may inform the impact of environmental learning programs. According to Kempton and Holland (2003), learning more about participants' identities and how their experiences in environmental learning programs influence their identities, will help us to better understand the true effect that environmental learning programs have on participants. Knowing more about how environmental identities are formed, changed, and modified can help practitioners adopt best practices in environmental learning programs (Payne, 2000).

Limitations of the Study

There are at least three limitations to the scope of this research. First, the study only focuses on environmental identity development for high school students enrolled in one Honors Chemistry class in a public high school; therefore, results from this study only reflect on the experiences and perceptions of adolescents in the course studied. Second, the time constraints inherent in the researcher's dissertation program required the researcher to narrow the potential range of student participants. Third, the researcher's involvement and familiarity with the student participants may have influenced the participants' responses as well as her interpretation of their responses.

Definition of Terms

While the terms used in this study may be familiar to readers, terms often have multiple definitions or interpretation of definitions. Therefore, below I provide specific definitions of terms critical to understanding this study. For the purpose of this study, the following alphabetical list of key terms are defined within the context of their use and are included to provide clarity to the study.

Biodiversity refers to the diversity among and within all living species and their habitats. The negative human impact on biodiversity is represented by habitat loss, invasive species, pollution, overpopulation, and overharvesting (Wilson, 2007).

Environmental education encompasses the broad range of approaches relating to education about and for the environment.

Environmental Identity defines how an individual views herself in relation to the natural world. Environmental identity is part of the way in which an individual forms herself and develops a sense of connection to some part of the non-human natural environment, based on

personal history, emotional attachment, and/or similarity. This connection in turn affects the ways in which an individual perceives and acts toward the world. It reflects the belief that the environment is important to a person and is an important part of who that person is (Clayton, & Opotow, 2003).

Environmental Identity Development. There are three stages of environmental identity development proposed by Kempton and Holland (2003). The first stage is the *salience*, or awareness of environmental problems. The second stage is *empowerment*, or identification as an actor in the environmental context and gaining agency in solving problems. For example, an individual can act effectively either alone or as a member of a group to make a positive change for the environment. The final stage is *activism*, or becoming more knowledgeable about how to engage in environmental action, mentorship and educating less experienced members (Kempton & Holland, 2003).

Pro-environmental behaviors or Sustainability responsible behaviors. A person's behaviors that are consciously chosen to minimize the negative impact of one's actions on the natural and built world (e.g. minimize resource and energy consumption, increase use of non-toxic substances, and reduce waste production) (Kollmuss & Agyeman, 2002).

Sustainability is the conservation, protection, and regeneration of resources over an indefinite period of time. Central to the concept of sustainability is the idea that today's decisions affect the future of human health and well-being, the environment, and the economy (Manitoba, 2002).

Sustainability Focused Biodiversity Curriculum (SBiC). This curriculum, developed by the dissertation author, promotes biodiversity, a required science concept for high school students. The SBiC includes outdoor activities, an introduction to the skills needed to understand

the complexity of the world's current environmental issues, and encourages students to build a deeper connection to their community, while meeting the requirements of a high school science course. For the full version of SBiC, see Appendix A.

Overview of Chapters

This study focused on the process of designing a sustainability focused biodiversity curriculum (SBiC) and the implementation of the curriculum in order to understand how high school students express their environmental identity. Chapter 1 introduces the background of the study by providing the importance of the topic: exploring environmental identity in high school students. Chapter 1 also provides the problem statement, purpose of the study, research questions, significance of the study, and key terms. Chapter 2 presents a review of the literature that pertains to place-based education, sustainable education, and environmental education. Also the three stages of environmental identity are explored through integrating the relevant literature and through the lens of social practice theory. Chapter 3 describes the methodological approach used to collect and analyze data and the characteristics of the participant sample. The data analysis process is further elaborated on with examples of how the data was organized and coded in order to generate the overarching themes to answer each research question. Toward the end of Chapter 3, the validity, reliability and ethical considerations of the study are addressed. Chapter 4 presents three findings from the data analysis, the design of SBiC, the development of The Scale of Environmental Identity used to track the changes seen in participants over time and the moderate impacts of the implementation of SBiC on participants. Chapter 5 concludes this dissertation with a discussion of the implications of this work for designing learning environments and use of a tool to track environmental identity. There is a summary of findings,

answers to the research questions and suggestions for how future researchers can build upon this study.

Chapter 2

Review of Literature

In order to present the previous work pertinent to the research questions of this study, Chapter 2 is divided into three sections. The first section describes the sustainability challenges in high school curriculum that this study is designed to address. Applying the concept of sustainability to chemistry curriculum has identified three bodies of literature that represents for teaching and learning sustainable development: place-based learning, sustainable education, and environmental education. The second section reviews research findings about environmental identity and social practice theory. The final section explores how environmental identity is currently being interpreted and applied in the field of educational research.

Teaching and Learning Sustainable Development

According to Kellert and Wilson (1993), life has existed, evolved, and survived extinction for 3.8 billion years. Surviving species of mass extinctions have often evolved to occupy newly vacated niches. The five previous mass extinctions have been attributed to geologic catastrophes. However, the current or sixth extinction is attributed to anthropogenic climate changes as well as habitat loss, overexploitation, and invasive species. Humans have contributed greatly to the sixth extinction. Gullone (2000) agrees that from prehistory to the present, 10 to 20% of the earth's species have gone extinct due to the actions of humans. Baskin (1997) states that less than 5% of the global land surface is set aside for parks and protected areas and more than 95% of the planet's land area is already under direct human influence. As a result of exponential population growth, humanity currently faces a wide range of issues such as biodiversity loss, climate change, poor air and water quality. Although humanity has made some progress in addressing these areas, the public lacks the understanding that the environment is not

well equipped to successfully tackle these challenges (Benavot, 2017; Crompton & Kasser, 2009; Kollmuss & Agyeman, 2002; Wiek et al., 2011). An overarching question of how to achieve appropriate sustainable development has emerged as one of the most critical questions that humanity needs to answer. Because the topic of sustainability is so broad and complex, identifying and recognizing the scope for integrating the concepts, issues and values of sustainable development in the curriculum is challenging for teachers (Rao, 2014).

Science educational initiatives have been designed and implemented to support the development of environmental sensitivity in the youth, as well as their awareness of the environmental issues, and environmental actions. Studies of sustainable development at the elementary level demonstrate that both classroom learning and direct experiences with nature increase students' connections to nature, and strengthen their science content knowledge and skills (Brock, 2010; Klemmer et al., 2005; Wilson, 2007). At the high school level, results of research on sustainable development are similar. Researchers have seen students gain insights and beliefs to promote their personal actions to protect and restore the Earth's ecosystem (Blatt, 2003, 2004, 2005; Dubel & Sobel, 2008; Stapleton, 2015). In my review of literature around sustainability, I did not find any studies that have directly explored sustainable development education in high school chemistry classrooms. Thus, this study builds upon previous literature by exploring how specifically, high school chemistry students adapt to a sustainability implemented curriculum that serves a purpose to impact students' environmental identity. I chose three approaches to make sense of teaching and learning sustainable development: (a) place-based education to connect students with real world learning, (b) sustainability education to help students understand their role to survive and adapt to changing environmental conditions over an indefinite period, and (c) environmental education to entails practice in decision-making about

issues concerning environmental quality. In the next section, I describe why I selected each approach for teaching and learning sustainable development.

Place-Based Education

The first approach for teaching and learning sustainable development is place-based education (PBE), which involves the principle of "authentic environmental commitment emerges out of firsthand experiences with real places on a small manageable scale" (Sobel, 1996, p.34). According to Sobel (1996), PBE begins with creating a caring attitude towards the familiar (local) area, moves outward to explore the surrounding area, and leads to social action and re-inhabitation. Re-inhabitation refers to identifying, conserving, and creating knowledge that nurtures and protects people and ecosystems (Gruenewald, 2003). My study focuses on the re-inhabitation of the natural environment adjacent to an urban high school. PBE recognizes that ecosystems and communities vary around schools, therefore schools need to design their own programs to take into account the natural ecosystems and sociocultural systems specific to their location, resources, and needs (Lieberman & Hoody, 1998). Based on the demographics of the Title I high school in my study, SBiC is designed to engage students who may see themselves as outsiders to the field of science (Brickhouse, 1994), and are not comfortable with real-world science activities that provide opportunities to develop questions and design investigations of local ecosystems.

Building on the earlier work of Sobel (1996), Knapp (2008) defines PBE as "the process of using the local community and environment as a starting point to teach concepts…across the curriculum [that] emphasizes hands-on, real-world learning experiences" (Knapp, 2008, p.7). I recognize that this definition highlights that PBE focuses in on locally-relevant projects, and addressing the needs of the whole community. In order to apply that statement into this study,

students collected air samples around school as a tool to assist them in making real world connections with the concepts they learned in class, and assimilate their knowledge into global issues. Reporting on another feature of PBE, Colvin (2013) emphasizes context, personal relevance and uses local place or community as the integrative site to connect learning (Colvin, 2013). Colvin believes that if students continue to explore and act within their local place with experience, confidence, and a sense of efficacy, students can transform from a local to a global perspective. He argues that PBE makes a strong case for influencing a student's sense of place and the development of an identity that includes the environment in the definition of self (Colvin 2013; Thomashow, 1995). Whether it is the immediate schoolyard, local watershed, or community garden, the site is examined intensively from multiple perspectives, often to solve community problems. This continued exploration and action within their local environment provide youth with experience, confidence, and a sense of efficacy that can activate multiple dimensions of student environmental identity development. The results of Colvin's research suggests that an Honors Chemistry class with a PBE designed curriculum such as SBiC, can engage students out into a local place with a purpose, one that can create local awareness, personal meaning, and encourage initiative.

In addition, urban students often face a disconnect between school science and their everyday experiences, often causing them not to see the importance of science in their lives. This disconnection contributes to students not being engaged or interested in science (Basu & Calabrese Barton, 2007). One way to address students' indifference is to provide environmental education programs that engage students in real-world science experiences in the places that are familiar to them (Boullion & Gomez, 2001; Calabrese Barton & Berchini, 2013; Lim & Calabrese Barton, 2006). Traditionally, environmental education programs have not focused on

connecting urban students to their local environments; instead, the environmental education program content examines global-scale environmental topics, such as climate change, rainforest destruction, and air pollution. This approach does not recognize that it is important for students to connect with and appreciate their local environment before they are asked to think about and offer solutions for global environmental issues (Sobel, 1996). As an alternative to traditional science and environmental programs, environmental educators have proposed that a better approach to teaching and learning uses the local environment as a framework in which students can construct their own learning, guided by teachers (Brock, 2010; Klemmer et al., 2005; Wals, 2012; Wilson, 2007).

Using students' relationships with a place may locally differentiate the curriculum and provides more authentic learning experiences for students. Incorporating place into the science curriculum can allow students to bring their own ontologies into school science experiences where students can confirm their existing identities and bring their local ecological knowledge to science learning experiences (Adams et al., 2016). Since places are multidimensional entities whose meaning is formed as people interact with them, individuals will experience places differently and science educators can bring these multiple perspectives into the classroom to better understand a given place. Science teachers need to reflect on their notions of place and how their identities affect their understanding, or sense of a place.

Sustainability Education

Understanding how environmental identities can be fostered in high school students represents an important area to explore within the discussions of a sustainable future. Therefore, I selected the second approach for teaching and learning sustainable development is sustainability education. Before exploring this approach, I want to address why sustainability is

important to contribute through the curriculum I designed. Even though the United States developed policies and initiatives to support environmental issues, the nation is still heavily relying on coal, natural gas, and petroleum as an energy source (EIA, 2021), making these initiatives and policies not enough for moving forward to sustainable approaches. In fact, the United States' dependency on the natural resources makes the country one of the highest contributors of carbon dioxide (CO_2) in the world. Thus, this behavior makes it challenging for United States to move toward sustainability (McKeown, 2002, p.12). Despite all this, the United States government can play a critical role on moving toward a sustainable future not only for its benefit, but also for the benefit of all nations (Deep Decarbonization Pathways Project, 2015). In short, the second approach of sustainability education focuses on environmental awareness and helps students understand why they should engage in activities that promote sustainability (Kimaryo, 2001; Najam et al., 2007).

Furthermore, Roberts (2007) emphasized the importance of increasing awareness by incorporating both science subject matter and its role in life situations. To reflect on his suggestions, I developed the curriculum which I incorporate chemistry lab activities to emphasize on local environmental issues. UNESCO (2005) also suggested that students learn the requisite scientific knowledge about the environment, and sustainability education should help them gain insights and beliefs to promote their personal actions. This model suggested by UNESCO has been utilized by many countries. For example, China has implemented sustainability education projects to enhance the curriculum to help changing students' attitudes towards sustainability issues. The curriculum includes "Four Respects": respect for nature, science, cultural diversity, and for all (Zhang, 2010; Qiaoling, 2011). In another instance, Zimbabwe has aimed to address many obstacles in relation to environmental sustainability issues

from vulnerability to climate change, degradation of natural resources, poverty and widespread diseases which make implementation of sustainability education challenging. Mesa University in Zimbabwe integrates its university training program to provide leadership and curriculum materials, through a specifically designated program directed for sustainability education (Wals & Kieft, 2010). There are many examples of science curriculum across Europe following the UNESCO recommendations, such as, Germany emphasizes student apprenticeships in collaborations between school and environmental organizations (Hierche, 2012), Turkey moving from smaller sustainability education in units of biology to incorporating knowledge and sustainability issues in the elementary grades as well (Tenriverdi, 2009). In the United States, teaching sustainability is also acknowledged within *A framework for K-12 Science Education: practices, cross cutting concepts and core ideas)* (National Research Council, 2012). This framework suggests teaching students to make connections with components of a system because sustainability issues are linked and part of a "whole". To connect students between nature and an urban environment, Caniglia et al. (2016) employed mental mapping as students conducted walks outside to help students understand the important and complicated environmental issues. Steiner and Posch (2006) discussed real world case studies to generate "a demand for learning" in searching for the meaning of sustainability.

The literature on sustainable education in China, Germany, and Zimbabwe, had helped me design SBiC for this study. Starting with the UNESCO framework, which is being used by the United States and other countries, I went through my sustainability education through making sense of the chemistry ideas being taught in my class so student could apply practical skills with environmental issues. As for the "Four Respects' curriculum in China, I had reminded the students about the importance of respecting nature and caring for our Earth throughout the

course. In order to encourage the apprenticeships which have been successful in Germany, I had invited guest speakers from Wastewater Treatments and Facilities from Kapolei (O'ahu) to talk to the students about the irrigation projects being done, to inspire and give students perspective of the concepts they are learning. Finally, with similar intentions of sustainability education in Zimbabwe, SBiC was a curriculum designated specifically for sustainability education in my chemistry classroom.

Environmental Education

The final approach I drew from for teaching and learning sustainable development is environmental education. I selected environmental education because while it happens in both formal and non-formal education, there is a large body of literature that discusses learning environmental education taking place in the non-formal learning setting. I selected to draw from the non-formal environmental education literature in order to build a more flexible learning environment while implementing the SBiC unit in my high school chemistry classroom. That way, students can both gain knowledge from my class, and recognize the concepts that have been taught to them in their daily lives, leading to critical thinking in circumstances such as a park or beach cleanup. According to Marsick and Watkins (2001), learning in non-formal environmental education settings is not highly structured but it is intentional. Livingstone (2001) defines it as when "teachers take responsibility for instructing others without sustained reference to an intentionally-organized body of knowledge in more incidental and spontaneous learning situations" (p.2). Schugurensky (2000) defines non-formal education as "all organized education programs that take place outside the formal school system" (p.2). He then continues by giving several examples, such as after school programs, or Saturday school. He believes that non-formal

programs can even give students the first-hand experiences that may be difficult to do in formal schooling and therefore effectively compliment classroom learning.

For the purpose of this study, non-formal education utilizes the broad range of approaches relating to education about and for the environment. For example, in the sustainability focused biodiversity curriculum (SBiC), field trip experiences, coupled with classroom preparation, analysis, and reflection, provide learning experiences about the environment. Rone (2008) offers a working definition that fits nicely with SBiC: "A field trip is a group trip that affords lived social experiences in a social context for the purpose of firsthand observation and learning" (p.238). For this study, the focus of field trips includes learning about the biodiversity aspects of the local environment (around the school) as well as human interaction with and impact on the environment. In addition, environmental learning programs raise participants who not only hold a knowledge base about environmental problems and issues, but also help them gain an awareness of how they can help to solve the world's environmental problems if they are willing to take action (Stapp, 1970).

The Needs for Sustainability Curriculum in Science Classroom

The needs for SBiC are greater today than ever before. The Intergovernmental Panel on Climate Change (IPCC) reports that the global climate system is warming, contributing to increasing global average air and ocean temperature, an increase in melting snow and ice, and rising sea level average (IPCC, 2018). Climate change is dramatically affecting both abiotic and biotic factors in the ecosystem and human communities around the world are facing challenges never before seen. Though inherently complex, these challenges can be better understood through scientific analysis and mitigated by those with a strong grasp of the subject.

Additionally, the recent climate changes are having significant impacts on ecosystems around the world. Research by the National Academies found that 40% of wild plant and animal species have shifted their range to stay within their required- climate range. Other species have nowhere to go as their ranges disappear and their ability to adapt is limited (Board, 2019). One such example is the American Pika, an alpine mammalian species in the Logomorpha family whose low elevation range boundary has risen 145 meters since 1999 while the upper elevation range boundary has remained largely unchanged (Beever et al., 2011). Research has also shown a shift in phenology: certain biological events, such as the arrival and departure date of migrating birds and the flowering date of plants, are occurring up to 15-20 days earlier than a few decades ago (Board, 2019). This would not be problematic if species lived independently from one another because a change in one event would only affect a single species; but because inter-species interactions are essential for the survival of many, if not all species, such changes are having dramatic effects on ecosystems around the world. Although many of these environmental problems were worsened by the actions of previous generations, the current and future generations will be responsible for finding solutions. Science offers an important lens through which to view environmental problems and create solutions. This is why I embedded SBiC into my Chemistry curriculum.

Educating the youth who will inherit these challenges with knowledge and skills to confront these issues is essential for the successful adaptation of individual species, human and other biological communities, and the entire ecosystem. Rather than focus on the preservation of communities as they are now, rising generations will need to set realistic goals and create strategic plans to conserve Earth's biodiversity. Strong scientific literacy, analytical skills and an understanding of ecological principles are necessary for the success of any forthcoming plan.

SBiC in Chemistry curriculum

Environmental science appears to have reached a point of stagnation at a critical time. Many high schools offer a separate, stand-alone environmental science course as an option; almost as an elective or remedial course for students who need to make up science credits. This is understandable upon inspection of the former Hawaii Content and Performance Standard (HCPS III) which consisted of lists upon lists of conceptual knowledge students had to "know". This functional model of "knowing" created quite a challenge to science teachers across grade levels because of a lack of objective measures in assessing this requisite knowledge. Further, the staggering amount of conceptual science knowledge required to be taught per grade level left little to no room to incorporate environmental education.

The Next Generation Science Standards (NGSS), currently phasing in across the nation, offers an opportunity to integrate environmental science topics through the careful incorporation of disciplinary core ideas (DCI), crosscutting concepts (CCC), and science and engineering concepts (SEC). Instead of teaching science in the traditional format of separate disciplines such as biology, chemistry, and physics, the objectives of NGSS are to integrate related concepts throughout a curriculum and instruct students to engage in critical thinking and problem-solving at multiple levels of instruction.

Environmental Identity

Although studying environmental identity is not a new idea, its application to educational research is relatively recent. Erikson (1968) proposed a process of identity development that is progressive and sequential. According to Erikson, identity development is marked by stages, and an individual compares him-or herself to those around him/her. He also noted that identity

development is a lifelong process to resolve physical, emotional, and psychic conflicts that lead to experiencing the world in a more adjusted and fulfilling way.

According to Stevenson et al. (2013), environmental identity is one aspect of environmental education that transcends the boundaries of what we know about human-environment relationships. He identifies three aspects of identity in the context of environmental education (a) how individuals see themselves in relation to the environment, (b) how the meanings attached to the self in this relationship might guide environmental teaching and learning, and (c) how this learning might motivate participation in solving multi-faceted environmental problems (Stevenson et al., 2013).

The study of environmental identity emerged in the literature during the last fifteen years. Its roots began in the fields of environmental philosophy, such as Deep Ecology, and psychology, including developmental, environmental, and psychoanalytic branches (Thomashow, 1996; Clayton & Opotow, 2003, Holmes, 2003). Currently, the concept of environmental identity is examined across disciplines but with little consensus on an exact definition (Clayton & Opotow, 2003). Several general aspects unite various perspectives. First, Clayton and Opotow (2003) note that some authors prefer the term "ecological identity" because "it better describes a sense of the self-concerning nature or as part of an 'ecosystem' versus the 'environment' which could be confounded with the built or social environment (p.12). However, Clayton and Opotow (2003) prefer the term "environmental identity scale" (EID). They modified a number of the scales and constructs that have been used to study collective identification with people in order to understand the self in terms of feedback a person believes they receive from their experiences with nature (Thomashow, 1996: Clayton & Opotow, 2003). This viewpoint encompasses how one feels and thinks about the natural world. Also, this connection has a

positive connotation, meaning that people perceive their relationship with the natural world with positive, rather than negative feelings (Clayton & Opotow, 2003). This does not mean that people necessarily feel positive about environmentalism or environmental activism. For example, ranchers may see themselves as land stewards' co-existing with the natural world, but they may not feel positive about the environment or consider themselves environmentalists (Opotow & Brook, 2003).

Next, environmental identity is thought to provide one way to understand people's actions and behaviors toward the environment, such that someone who has a stronger environmental identity is more likely to act favorably toward the environment (Clayton & Opotow, 2003; Stets & Biga, 2003).

Social Practice Theory

In 1998, anthropologists Holland and colleagues introduced a social practice theory of identity in their book entitled *Identity and Agency in Cultural Worlds.* The theory is based on the work of Mead, Vygotsky, Bakhtin, and Bourdieu and has greatly influenced identity research in numerous disciplines. Recently, their theory has been applied to the study of environmental education (Blatt, 2013, 2014; Stapleton 2015; Williams & Chawla, 2016). In their book, Holland et al. (1998) acknowledge the situated learning that comes from participating in communities of practice (Lave & Wenger, 1991). Social practice theory takes on the assumption that identities are formed through discourse and action over time, emerging from the social interactions and experiences that occur within cultural and historical influences (Holland et al., 1998). "Personal identities develop when one interprets oneself and/or is treated as a character in such a world" (Holland, 2003, p.32). One "figures" who they are through the relationships and experiences they have with others living in these worlds, acknowledging that identity can be heavily influenced by

social structure. Holland named that as the “figure worlds”. Social practice theory recognizes that through individual agency, identities have the potential to transform social structures, altering the figured worlds we live in (Holland et al, 1998). Holland-extended this social practice theory of identity to the figured world of environmentalists, studying multiple identities in practice and their integration into other figured worlds.

Environmental Identity Development

Applying social practice theory, Kempton and Holland (2003) examined the relationship between identities and the process of committing to environmental actions. Through surveys and in-depth “identity interviews” with members of environmental groups, they articulated three dimensions of environmental identity formation related to action. They used a qualitative approach, which was quite different from the Environmental Identity Development scale developed by psychologists to quantitatively measure one’s connectedness to nature (Clayton, 2003). While Kempton and Holland’s (2003) research was conducted with adult environmentalists, it provides an established starting point for this study. Three dimensions they described are salience or awareness, identification as an actor, and increasing practical knowledge and resources for action.

Increased salience or awareness

Kempton and Holland (2003) found that environmental action must first be recognized before one can become an actor in that world. Their study showed that an increased salience or awareness for an environmentalist typically comes from an environmental threat that affects their way of life. Other environmentalists recalled positive experiences in nature as instrumental in their transition to acting, by allowing them to look at nature with a different perspective.

In this stage, an individual becomes more aware of his/her relationship with the natural environment, environmental issues, and how others are involved with environmental actions (Stapleton, 2015). Also, the individual in this stage may view himself/herself as harmful to the environment, yet still connected to the environment in some way (Blatt, 2013). In Kempton and Holland's study, interviewees often describe this stage of increased salience by using the word "aware" or "waking up". This was the result of direct experience with local environmental destruction or a connection with a larger environmental issue.

Identification as an actor

Using the lens of social practice theory, Kempton and Holland (2003) suggest that a person must experience the world of environmental action in order to identify with it. This initially requires taking some responsibility for an environmental threat, recognizing that the situation will not resolve itself. This leads to a consideration of the role of environmental actors. They suggest a subsequent step may be required to take on the role of actor, referring to it as "reformulations" (p. 333). The reformulation occurs when an individual gains a sense of empowerment, during which an individual believes that he/she can act effectively either alone or as a member of a group. Kempton and Holland also noted that action could precede identity when individuals take on an enabling role in a figured world, one that identifies them as an environmental actor and subsequently leads them to take on that role. As a result, for a person to identify with the role of environmental actor requires that they care about the consequences of their actions, as it relates to how others in that figured world perceive them (Kempton & Holland, 2003; Stapleton, 2015).

Increasing practical knowledge and other resources for action

Kempton and Holland (2003) found that as the figured world of environmental action becomes more salient through practice, and individuals identify themselves more in relation to environmental action, they become more knowledgeable about how to engage in environmental practice. The knowledge attained through environmental action makes the individual an "expert" in doing their part to help combat environmental issues. As an "expert", individuals in the activism stage take on mentorship roles. Kempton & Holland developed this final stage after analyzing the identities of individuals already participating in activist behaviors.

Roles and Benefits of Environmental Identity

In searching to address the gap between environmental awareness and pro-environmental behavior (Kollmuss & Agyeman, 2002), environmental psychologists have recently turned to a consideration of the role of identity in shaping and influencing a person's thinking and behavior related to the environment (Clayton & Opotow, 2003). While social identity (Hogg & Abrams, 1988) generally has been directed toward discovering how a person organizes information about oneself, environmental identity investigations focus more specifically on how a person connects to the nonhuman natural environment (Clayton, 2003). By considering environmental identity, environmental psychologists are working to establish the relationship between a person's connection to the natural world and his/her pro-environmental behavior and attitudes.

The roots of this notion of a person's relationship with the natural world are found in the work of Aldo Leopold (1949). Leopold found that how human beings see themselves as part of the natural world is of central importance in determining how they will feel and act toward the environment. Leopold (1949) believed that as long as we see land strictly as a commodity rather than viewing ourselves as interconnected to the land, we will continue to abuse it. In his view,

coming to understand the environment as a community of which we are members, establishes a relationship to the environment and fosters behaviors that demonstrate love, respect, and care of the Earth. Environmental psychologists generally refer to this trait as a person's *connectedness to nature* (Mayer & Frantz, 2004). According to Mayer & Frank (2004), connectedness to nature is thought to be an operationalization of a person's environmental identity; thus, a quantitative measure of connectedness to nature is considered an indicator of a person's environmental identity. In his study, Tam (2013) utilized a variety of validated instruments to understand how people identify themselves with the natural environment and the relationships they form with nature. Two of the instruments used were the Connectedness to Nature Scale (CNS) and the Self in Nature Scale (SNS). Recently, these instruments have been modified for use with both children and adults, and allow for comparative studies of environmental identity based on individual age. These modified versions are known as the Connectedness to Nature Scale, Revised (CNS-R) (Frantz & Mayer, 2014) and the Inclusion of Nature Self Scale (INS) (Liefländer et al., 2012).

From the standpoint of an educational psychologist, environmental identity influences the decisions individuals make (Crompton & Kasser, 2009). Identity, or whom they think of themselves as being, may be very important in understanding people's relationships with the environment. For the sustainability focused biodiversity curriculum (SBiC) activities were developed to determine how students view their own and society's relationship with the environment. For example, do students see themselves as part of a group that participates in environmental preservation; do they feel the environment is important to their well-being; and/or do they see value in protecting the environment? If the environment is a strong component in

how a person defines themselves, they will be more invested in caring for the environment (Clayton & Myers, 2009).

Environmental Identity through the Lens of Social Practice Theory

In a series of three papers, Blatt (2013, 2014, 2015) describes different aspects of a qualitative case study that deeply explores student environmental identity development and maintenance in an integrative environmental science course for senior students. Her research across all three papers is clearly guided by social practice theory (Holland et al., 1998; Kempton & Holland, 2003). Specifically, Blatt applies Kempton and Holland's (2003) three dimensions of environmental identity development to the classroom context, which emphasizes (human) group membership as a mediating factor of identity development and behavior. However, Blatt (2013, 2014, 2015) states that her interpretation of environmental identity aligns with Thomashow's (1995) definition of ecological identity, which emphasizes a deep emotional connection with nature. The two theoretical foundations appear to conflict. Furthermore, the classroom-based environmental science course described in her study does not appear to support an emphasis on physical context. Blatt (2013, 2014, 2015) also referenced numerous other theoretical influences in her research. Her first paper focused on behavior change, exploring how sociocultural factors such as student background, social interactions, and classroom structures impact environmental identity and behavior (Blatt, 2013). She then used theories of symbolic interactionism to emphasize the interaction between identity, emotion, and behavior, and the identity theory of emotion to interpret students' reactions to classroom experiences (Stryker, 1980, 2004). In doing so she presented a valuable framework for the complex process of environmental identity development in student learning about environmental issues in a classroom context (Blatt, 2013, p.483). In all of her papers, she discusses the emotional aspect observed in her research. Blatt

(2013) found that a student's emotional response to issues-based activities, identity conflicts, and the willingness to critically reflect on new information can all impact the development of environmental identities and their associated behaviors. However, it was noted that these are socially derived emotional responses, arising from human social context. This varies considerably from emotional responses arising from physical context, such as the emotional connections to nature described within her introductions and the definition the interpretation is grounded in her papers (Blatt 2013, 2015). While this is not meant to discredit the valuable research that Blatt (2013, 2014, 2015) has contributed, it is mentioned to highlight the need for clarity when integrating social and physical interpretations of environmental identity. In fact, Blatt (2013, 2014, 2015) should be commended on her comprehensive and long-term study exploring environmental identity and the role of emotions in student learning within the classroom context.

On the other hand, Williams and Chawla (2016) exhibited the most successful integrations of physical and social contexts of environmental identity. They applied significant life experience methodologies, specifically reflective narratives, to qualitatively explore how informal nature programs influence identity development in youth. This is a common approach for significant life experience research, which has produced much research emphasizing the importance of extended and meaningful childhood exploration in nature for environmentalists and environmental professionals (Chawla, 1998; Tanner, 1980). This however, represents a unique significant life experience study because it was paired with the theoretical lens of social practice theory (Holland et al., 1998). While Williams and Chawla (2016) acknowledged the importance of developing a deep connection with nature, referencing Thomashow (1995) and Clayton (2003), they clearly stated their intentions to reserve the term ecological identity to

represent their connection with the environment. They clearly distinguished from what they termed a social environmental identity that referred to the human social context. Williams and Chawla (2016) creatively integrated both ecological identity and environmental identity into a framework, recognizing that both have an important place in non-formal environmental learning programs. Their research has also shown that, through careful research design, theoretical influences emphasizing both physical and social context can be integrated.

Summary

After reviewing literature regarding the sustainable biodiversity curriculum and its relation to the biodiversity crisis, three key elements were identified. Sustainable education, environmental education, and place-based learning are the elements governing the design of activities for high school students to explore the development of their environmental identity. The review of the environmental identity literature revealed that multiple interpretations of environmental identity exist, and vary significantly in relation to the social context in how environmental identity develops. This research, therefore, focuses primarily on the work of Kempton and Holland (2003) and their social practice theory, which explores the effectiveness of applying social practice theory to environmental identity and environmental action. Clayton and Myers (2009) note that, “Identities develop through experiences, which are interpreted in part through social understanding. Giving people the opportunity to be involved together in conservation activities allows them to label themselves as conservationists,” (p.72).

Chapter 3

Methods

The following passages present the methods used to collect and analyze data on the student environmental identity development. This chapter includes the following areas: (a) description and rationale of methodology, (b) methods of data collection, (c) overview of the SBiC, (d) triangulation, (e) data analysis procedures, (f) and the study's limitations.

The purpose of this study was to investigate how the Sustainability focused Biodiversity Curriculum (SBiC) implemented in an honors chemistry class, impacted high school student environmental identity development. To achieve this goal, the design of this study used teacher research with embedded case study.

Rationale for Teacher Research Methodology

In doing social science research, it is important to locate oneself socially. My research is conducted from my social location as an immigrant woman, with a strong background in science and love for the environment. My social location as an immigrant with a love of nature is important to indicate as part of the lens through which I analyze the data (Weiner, 2004)

In this study, I have the privilege of the position as an "insider" from the aspect that I am the participants' teacher. Cochran-Smith and Lytle (1993) write about the significance of insider positioning:

> Many teachers have sophisticated and sensitive observation skills grounded in the context of actual classrooms and schools. In analyzing the patterns and discrepancies that occur, teachers use the interpretive frameworks of practitioners to provide a truly emic view that is different from that of an outsider observer, even if that observer assumes an ethnographic stance and spends considerable time in the classroom. (p.18)

Moreover, Cochran-Smith and Lytle (1993) argue that:

> Teachers are uniquely situated to conduct such inquiries: they have opportunities to observe learners over long periods of time and in a variety of academic and social situations, they often bring many years of knowledge about the culture of the community, school, and classroom; and they experience the ongoing events of classroom life in relation to their particular roles and responsibilities. This set of lenses sets the perspectives of teachers apart from those of others who look into the classroom. (p.15)

In addition, Cochran-Smith and Lytle (1993) write that interpretive researchers' understanding of one classroom experience can help to deepen our understanding of all classrooms. They consider this an aspect of generalizability:

> …we can see that teacher research, like all forms of research (educational or otherwise), is a fundamentally social and constructive activity. Not only can each separate piece of teacher research inform subsequent activities in the individual teacher's classroom, but also each piece potentially informs and is informed by all teacher research past and present. Although teacher research is not always motivated by a need to generalize beyond the immediate case, it may in fact be relevant for a wide variety of contexts. (Cochran-Smith & Lytle 1993, p. 24)

As Cochran-Smith and Lytle (1993) suggest, teacher research could be considered to be "relevant for a wide variety of contexts". Teacher research is generally considered as a process consisting of teachers determining research "problems" in the context of their schools and classrooms, arising from discrepancies between teachers' personally-held professional theories and the results of their practice. Teachers may want to use investigative methods appropriate to the problems, systematically observe the results, analyze those results in light of their

professional knowledge and then share the results with others while at the same time enacting change in their classrooms (Cochran-Smith & Lytle, 1990, 1993, 1999). In this type of research, the students act as the informants (Hubbard & Power, 1993), helping the researcher understand the world from the students' perspective. In the current study, the problem situation, as considered by the researcher, focused on high school students' awareness of environmental issues and how to change their behavior and action toward the environment. Central to all definitions of teacher research are (1) the teacher's unique dual role of being an active participant and researcher (Baumann & Duffy-Hester, 2000; Hubbard & Power, 1999), (2) the teacher's responsibility of reflecting on practice and then taking action to improve one's own practice, or "a mixture of reflection and practice, or praxis, in which a teacher-researcher's personal theory and theory within a field converge and affect one another" (Baumann & Duffy-Hester, 2000, p.78), and (3) the teacher's use of a systematic plan and methodology for gathering and analyzing data (Baumann & Duffy-Hester, 2000; Henson 1996).

Reflecting on the first definition of teacher research, in my own research of implementing the sustainability focused biodiversity curriculum (SBiC) to my Honors Chemistry classroom, I had a dual role. My first role as a teacher and active participant allowed me to teach and learn simultaneously with the students in the SBiC curriculum, who were sophomores in the Chemistry class. In my second role as a researcher, I collected and analyzed the data, as well as interpreted the findings.

The second definition of teacher research related to my goal and purpose was to gain understanding of my participants' perspectives toward the environment. It is necessary to understand my actions as a teacher and to reflect on how I am tracking students' environmental development process. As I gained understanding of the research question by tracking their

environmental identity before, during, and after participation in SBiC, I purposely selected specific environmental issues and current events to discuss with students. I selected the activities or projects which I had believed to benefit the purpose of my research, and throughout the SBiC curriculum I was able to recognize which teaching techniques worked and did not work. After reflecting on every lesson, I was able to actively improve and change my teaching approach, in order to cater to the students' learning styles and to create a good environment for them to learn in.

Thirdly, the last central idea of my research was the systematic approach in which I had gathered and analyzed data. As a teacher researcher, my goal was to determine students' development of an environmental identity when they participated in a curriculum which included a sustainable behavior component. This study focused on a new way to teach the SBiC in a high school chemistry classroom. In my approach to teacher research, the first step was to create and administer a pre-survey at the start of the class in order to identify students' awareness of environmental issues in their community. The data results then informed additions to the curriculum aimed at improving students' sustainability knowledge and behaviors.

Rationale for Cases Study Methodology

Case Study Design

The data are presented in both a case study and an embedded case study. The chemistry class serves as the larger case study while three selected students serve as the embedded case. Merriam (1998) describes the purpose of a case study in qualitative research in this way:

> A case study design is employed to gain an in-depth understanding of the situation and meaning for those involved. The interest is in process rather than outcomes, in context

> rather than a specific variable, in discovery rather than confirmation. Insights gleaned from case studies can directly influence policy, practice, and future research (p.19)

The current study reflects Merriam's description of a case study. My goal is to gain an in-depth understanding of students' development of their environmental identities related to the implementation of the SBiC. To capture that understanding, I explored three characteristics of environmental identity namely, environmental awareness, environmental actions and taking initiatives.

Merriam (2009) asserts that a case study reveals a rich, descriptive picture of the problem in question. My case study aims to gain a rich description of the interaction between content learned by students in the classroom and the expression of their environmental identities in the community as measured by their actions.

A case study provides "interpretation in context" by concentrating on a single entity, the case (Merriam, 1998, p. 27). In order to gain a rich description of the study's participants in context demands an understanding of the multi-layer situation involving the sociocultural elements that are affecting the students during their life experiences both inside and outside of the classroom. Description of the case as an entity (the chemistry classroom and embedded case study participants) can show the interaction of significant factors characteristic of the participants' environmental identity and pro-environmental behavior. Yin (cited in Merriam, 1998) explains case study as a design suited to situations where it is impossible to separate the phenomenon's variable (environmental identity) from its context (science classroom) as it is described and unfolds over a period of time through raw data such as surveys, observations, videotaping and interviews.

Merriam (1998) describes qualitative case studies as being comprised of three special features: particularistic, descriptive, and heuristic (Merriam, 1998, p. 29). The three elements will be applied to this study in the following ways:

Case study research is particularistic. *Particularistic* means that case studies can focus on particular situations, events, programs, or phenomenon. The specificity of focus on a particular phenomenon allows for more holistic views of a situation to evolve. In focusing on implementing SBiC in one classroom as a "case" and six select participants as "embedded cases", the characteristics of environmental identity are observed.

Case study research is descriptive. *Descriptive* means that the end product of a case study is a rich, "thick" description of the phenomenon under study. Merriam (1998) adds that a thick description is a term from anthropology that means "the complete, literal description of the incident or entity being investigated" (p. 23). Descriptive case studies are also labelled as holistic, lifelike, grounded and exploratory. Thus, the knowledge from the descriptive case study is different from other research knowledge because it is more contextually accessible to convey the researcher's understanding of the case. In my study, details were carefully recorded to ensure that all variables were considered in representing the characteristics of environmental identity expressed by the participants. Vivid descriptions included experiences, feelings, quotations, activities and challenges.

Case study research is heuristic. *Heuristic* means that the case study can help the readers' understanding of the phenomenon by bringing about the discovery of new meaning, extending the reader's experience, or confirming what the reader knows. This study can expand the reader's comprehension of the development of the participants' environmental identity related to the implementation of the SBiC unit. Merriam (2009) described a case study as both a

research process and an end result. Once the system is defined and the case is limited to one unit of analysis, the case study then has the ability to provide a "holistic description and explanation" to help "uncover the interaction of significant factors characteristic of the phenomenon" (p.43). Findings from this study are summarized and conclusions generated through comparison and discussion of current theories reported in studies found in the Literature Review section. The nature of *heuristic* case study can bring about the discovery of *meaning* and *context*, which allows for the exploration of how students are making meaning of their experiences in the context of the chemistry classroom.

The specific context of my study was a chemistry course that met every other day from Monday to Friday from 1:45-3:00 PM from August 7, 2017 to May 25, 2018. Data for the proposed study were collected from January 8, 2018 – March 30, 2018. This course is listed as Chemistry Honors and Chemistry is required credit for all high school students. The course catalog description states that Honors Chemistry is an introduction to the fundamental concepts of atomic and molecular structure, chemical reactions, and conservation of matter and stoichiometry. Even though Honors Chemistry curriculum is identical to General Chemistry, the main objective of Honors Chemistry is to prepare students for entering into a first-year college chemistry course at any major university. Many students who take the Honors Chemistry are admitted to four-year state universities, ivy-league colleges, and ivy-league universities.

Embedded Case Study Design

Three students from the last section of Honors Chemistry were chosen to highlight different aspects of the whole case. Olivia, Damien, and Edward were chosen because they were actively involved during SBiC implementation, and each of them displayed different levels of engagement with the environment before SBiC. For example, Edward did not show awareness

about the environment at first, whereas Olivia, on the other hand, demonstrated a great concern about the environment and she was actively involved in many community clean-ups around Oahu. Damien was chosen because he had difficulty perceiving environmental action even though he was aware of environmental issues. As shown in Chapter 2, the characters demonstrated by the three students are the important behaviors to track on the development of environmental identity. Yin (2009) highlights that one of the unique strengths of a case study approach is the ability to utilize a diverse array of evidence. In fact, Creswell (2013) implies that using multiple sources of information are almost expected in case studies. The embedded case study design allowed multiple sources of data to be collected. Two forms of data collections listed below were specifically designed to encourage reflective and emotional thought about experiences and feelings related to SBiC. Data collected included three focus group interviews that occurred before, during, and after the SBiC, and an individual SBiC journal for reflection.

Description of the Case

Description of the High School

The setting of this qualitative case study was an urban Title I public high school in the United States during the 2017-2018 school year. The school is a four-year comprehensive high school with enrollment of approximately 1,594 students in grades 9 through 12 (see Table 1). The school year is divided into two 18-week semesters and the school days consist of seven 75-minute class periods.

Table 1

Data Collection Timeline for Spring 2018

Time	Course Content	Field trip	Survey	Field notes	Student reflection	Videotaping	Focus Groups Interview
1/08/18-1/19/18	Project 1: Valuing biodiversity	In-class	Pre	Daily			
1/22/18-1/31/18		School garden		Daily	Reflection # 1	Field trip	Meet 1
2/05/18-2/16/18	Project 2: Building biodiversity	School campus		Daily			
2/20/18-3/2/18	Project 3: What's in its future	School campus		Daily	Reflection # 2	Activity, class discussion	Meet 2
3/05/18-3/16/18	Project 4: Taking Action	In-class	Post	Daily		Activity	
3/16/18-3/30/18			Post		Reflection # 3		Meet 3

The student population of this school is extremely diverse. In the 2017-2018, School Status and Improvement Report (SSIR) the student population consisted of 22% Filipino, 20.3% Chinese, 11.3% Micronesian, 9.6% Japanese, 9.1% Native Hawaiian, 8% Indo-Chinese, and smaller populations of Black, Hispanic, Korean, Portuguese, Native American, Tongan, White, and others (SSIR, 2017). Approximately 57% of the students qualified for free or reduced lunch during this school year, establishing the school as a Title 1 institution. An estimated 11% of students spoke English as a second language (ESL), and 10% received Special Education Services. At the start of the 2015-2016 school year, the school began implementing three career

houses for tenth through twelfth grades: Business, Arts and Communication (BAC), Health, Human and Public Services (HHPS), and Industrial, Engineering and Technology (IET). Teachers of each House had a collaboration period during the school day to discuss curriculum, teaching strategies, and to plan various activities. The students involved in this study were in Health, Human and Public Services (HHPS).

Description of Participants

Participants of this study were thirty-three students who were registered in the last period Honors Chemistry class, during the 2017-2018 school year. They were 13-15 years old, grades 10 and 11, and were randomly assigned to the class by the school registrar. Based on information provided from longitudinal data services (LDS) and the Hawai‘i State Assessment (HSA) results, the participants' mathematical and science abilities ranged from basic to high and reading levels ranged from first grade to post-high school.

All study participants were exposed to the standard block schedule: 75 minutes every other day for the entire academic year (August 1, 2017 through May 26, 2018). The Honors Chemistry course was identified as a college-preparatory class. Based on feedback from past students, the primary motivation for taking the course was to strengthen their high school transcripts to aid in admission to college and university. Study participants had maintained a GPA of 3.0 or higher and they wished to pursue careers in Math or Science. Many of the students participated in after school activities such as school clubs (e.g., math club, computer club, and the go green project, etc…) and/or school sports teams (e.g., varsity soccer, volleyball and tennis).

Sampling Criteria

For this research, purposeful sampling was used to select three participants for the embedded case study. Purposeful sampling is widely used in qualitative research for the identification and selection of information-rich cases for in-depth study (Patton, 2002). This approach involves identifying and selecting individuals who are especially knowledgeable about or experienced with a phenomenon of interest (Creswell & Clark, 2011). In addition to the knowledge and experience, Bernard (2002) discusses the importance of a participant's availability and willingness to participate and their ability to communicate experiences. Patton (2002) argues that the "logic and power of purposeful sampling is in selecting information-rich cases for study in depth…studying information-rich cases yields insight and in-depth understanding rather than empirical generalization" (p.230). An information-rich case is important because the researcher can learn a great deal about a particular issue, central to the purpose of the inquiry (Suri, 2011). While all Honors Chemistry students participated in the SBiC, three participants were purposefully selected for the focus group interviews. Purposeful selection involves selecting students who represent the diverse demographics of the class, have completed all portions of the SBiC experience and, based on review of completed student work, can provide information that assists in addressing the research question (Teddlie & Tashakkori, 2009). Because people tend to talk more openly when they are in groups of people with similar backgrounds or experiences, it was important to ensure that participants in my focus groups, had something in common with each other beyond the Chemistry class and SBiC. For this reason, I selected two male and one female student participants who were high school sophomores, and who in addition to meeting the selection criteria, had attended the same middle school within the state of Hawaii.

Measures for Ethical Protection of the Participants

The first step in protecting the participants was securing the University of Hawaii's IRB approval (IRB 2016-31038) which was received on October 28, 2017. There were no known risks associated with this current study. Next, I explained to the participants the goal of the research and asked participants to complete a consent form. I stated clearly to all students that participation was voluntary and if they chose to not participate in the study, they would still fully participate in the Chemistry class lessons and activities. For students who agreed to participate, a parent consent form was sent home because participants were minors. The names of the participants were recorded on a master list which I alone retained and updated to keep track of the progress of the research. If individual statements were cited, they were attributed to a participant by pseudonym name. In addition, all interviews or discussions were held in my classroom in order to guarantee a comfortable level of privacy. All participants were informed that they could withdraw from the study at any time if they became uncomfortable with any aspect. Students who chose not to participate in the study were required to participate in regular course activities but data, for purposes of this study, were not collected.

Sources of Data

The research questions, "What instructional tools when added to the chemistry class will help students to focus on the idea of sustainability?" and "How does a high school student's participation in a teacher designed sustainability curriculum impact the expression of their environmental identity?" were explored via the collection of the following qualitative data sources: pre-post survey, participant observation, videotaping classroom based student activities, and three focus group interviews. The first layer of data collection was primarily addressed

through pre-post surveys, participant observations, and videotaping classroom activities. Embedded case study data were collected through focus group interviews.

Data was collected throughout the Spring 2018. Table1 shows a basic timeline for data collection as well as content taught during these months.

Survey

Campbell and Stanley (1963) outlined successful survey assessment design and threats to validity. The main threats to internal validity include small sample size relative to questions posed, short duration time between administration of pre-and post-survey, and low geographic diversity (Campbell & Stanley, 1963). Since the research conducted rested solidly on qualitative methodology, the survey was issued in order to gain a greater understanding of the participants' environmental attitudes and behaviors before and after the SBiC program.

The survey inquired about demographics, and knowledge related to attitudes about and practices of pro-environmental behaviors (i.e. knowledge of environmental issues, action strategies, action skills, attitude toward the environment, and attitude toward sustainable behavior). Twenty multiple-choice questions with a five-point Likert scale with answers ranging from "1- Strongly disagree", "2-Disagree,", "3-Neutral/Not Sure," "4-Agree," and "5-Strongly agree" were used. The results of the multiple- choice questions were score pro- environmental sentiment. The higher the number, the greater pro- environmental sentiment was demonstrated and vice versa. Responses to the survey were tabulated to determine the overall scores of each participant in order to gain multiple perspectives on their behaviors toward the environment. Therefore, no quantitative statistics were run on data obtained from the survey.

Pre-Survey. An environmental survey was given to students at the beginning of the second semester of school year 2017-2018 in order to identify the knowledge and perception of

students' environmental attitudes and behaviors (Opotow & Brook, 2003). In the pre-survey, participants were asked to complete the three short answer questions to determine their attitude, and actions toward the environment (see Appendix D for the contents of the survey). The Pre-Survey was given to 30 participants in the Chemistry Honors class at an urban high school. Student participants took the survey during their class time and it took approximately 15-30 minutes to complete the form.

Questions that were posed to participants at the start of the program as well as the end of the program included, 1) "Do you think it is important to learn about living things around you* (school, home)? Yes or no, then explain", 2) "What is your motivation to continue environmental behaviors?", and 3) List up to three things you can do to take care of the environment in school/home?

Post Survey. On the last day of the scheduled class of the SBiC program, all students who completed the pre-survey were asked to complete the post-survey. Knowledge and attitudes were again assessed using an identical version of the pre-survey. In addition, two new open-ended questions were added to the post-survey in order to fully understand the participants' perceptions of anthropogenic environmental impacts, and their sustainable lifestyles after they completed the SBiC program.

The survey consisted of 23 questions, 20 multiple-choice and 3 open ended (see Appendix B for the contents of the survey). The first 20 multiple-choice questions measure both environmental attitudes and behavior, with each domain containing 10 representative survey questions. All questions use a five-point Likert scale with the options of "Strongly disagree", "Disagree,", "Neutral/Not Sure," "Agree," and "Strongly agree". The three short answer questions were, (1) "Do you think it is important to learn about living things around you*

(school, home)? Yes or no, then explain", (2) "List up to three things you can do to take care of the environment in (school/home)", (3) "What is your motivation to continue environmental behaviors?"

Participant Observation

During participant observations, the researcher encountered events as they unfolded in naturally occurring situations, and attempted to "experience events and meanings in ways that approximate members' experiences" (Emerson et al., 1995, p.2). In the context of this study, I recorded observations of each student for the total duration of time I implemented the SBiC with my Honors Chemistry class throughout the second semester. These observations came from joining students in classroom activities, or facilitating students doing group work. I spent time with students outside the classroom, sometimes I acted as a chaperone on field trips, or seeing students maintaining their garden after school or on the weekend.

Field notes were kept daily in a field journal, including both reflexive and reflective sections. Using the framework provided by Gee's (2003) discourse analysis (as discussed in the next chapter) and the unit of analysis of activity (as discussed below in this chapter), observations focused on relationships and interactions among participants as they participated in classroom activities. Throughout the research period, it is critical to observe and record data regarding peer-peer interactions, as well as interactions between the students and the teacher (Gee, 2003).

Overall, participant observation also allows the researcher to observe the enacted curriculum by being present during classroom activities, allowing a record of daily activities to be kept as well. In my observations, I focused on how students' understanding of their relationship with the environment impacted the expression of their environmental identity. Of

specific interest, were the factors influencing students' environmental identity and behavior. As such, I focused my recorded observations on noticeable expressions of emotion, moments of self-reflection and questioning by students, as well as patterns indicating more passive or active roles in the classroom providing information about the role of social norms. Field notes recorded during participant observations were helpful in identifying contradictions within the classroom structure that emerged during the semester in addition to acting as a formal check to ensure accuracy of the other forms of data.

Videotaping

In addition to the usual techniques of writing a diary and daily field notes of student class assignments, and observations, my data collection was enhanced by the use of videotaping. Videotaping provides an expanded opportunity to observe interaction and communication in natural settings (Knoblauch et al., 2015). Using video as a tool to collect data makes visible valuable images and the sequences of body movement in knowledge generation. I videotaped the class several days during the semester during interactive activities when I ~~a~~nticipated discussion with students or group work would occur. The video camera was placed in a stationary position during the activities, so as to not be distracting, although it was moved occasionally to focus on specific students or groups. Video was not taken when students were reading or writing individually, or completing worksheets or tests.

Focus group interview

Four class projects were assigned to students during the SBiC implementation (see Appendix C). After completion of each project, a sub-group of students who had submitted consent forms participated in a discussion-type focus group interview. The purpose of focus group interviews was to obtain student perceptions about their environmental identity.

Focus group interviews were used specifically to develop a deeper understanding about students' backgrounds with biodiversity topics, and what participants' felt were the strongest influences upon them (both inside and outside the classroom) regarding their environmental identity and environmental behaviors. Focus groups allowed participants to use memories and experiences of the group, and to use the group dynamic to enhance thinking (Bogdan & Biklen, 1998). Krueger and Casey (2000) explained that the focus group presents a natural environment because "participants are influenced and influenced by others-just as they are in life" (p.11), and they work well to determine the perceptions and thinking of people about issues, service or opportunities.

In addition, Morgan (1997) stated that "focus groups are basically group interviews" (p.2). The focus group relies on group interaction around topics that are introduced by the researcher who serves as the group's moderator (Morgan, 1997). Focus group interviews were used as one of the instruments of this study because, as Morgan (1997) pointed out, using a focus group is an effective tool to produce data and insights on the research problem that would not have been possible without the group interaction. In addition, Morgan mentioned the "ripple effect" only occurs in the focus group interview. For example, one participant's response may bring out memories and experiences from the other participants who may have been in similar situations to protect the environment.

Another benefit of the focus group is the collection of rich data through participants' feeling of comradeship. Dwyer & Buckle (2009) state, "participants might be more willing to share their experiences because there is an assumption of understanding and an assumption for shared distinctiveness; it is as if they feel, you are one of us" (p. 58).

Furthermore, during focus groups interviews, data is socially constructed from different viewpoints through group interaction of individuals who have knowledge on the topic (Patton, 2002). Participants make responses based upon hearing other participants' comments, each having the ability to share their knowledge of a specific topic (Kruger & Casey, 2000; Merton, Fiske & Kendall, 1956). Expanding upon the views of others tends to produce high quality descriptive data. Topics that participants would talk about in everyday life often provide the best focus group interactions (Macnaghten & Meyers, 2004). The synergy and dynamism generated in focus groups produce powerful interpretive insights (Kamberelis & Dimitriadis, 2005). For this reason, discussions in focus group interviews will revolve around how participants see themselves in relation to the environment.

Procedures for Analyzing Data

My ultimate goal is to accurately present my findings in a narrative format to clearly describe the events that took place in my classroom, while at the same time, making efforts to eliminate my personal biases. I chose to follow Clark and Creswell's (2011) process of qualitative data analysis model (Figure 2) to code and analyze my data. To understand the impact of environmental identity for individual students in period 7 Honors Chemistry class during the third and fourth quarter of SY 2017-2018. I began with open coding from daily field notes. I transcribed and reviewed the field notes as quickly as possible to allow important and interesting ideas to emerge early in the research process. Topics of interest discovered from field notes as well as ongoing video analysis were utilized to choose topics for discussion during focus group interviews. Therefore, the different forms of data collection informed each other at all stages of the research.

Clarification and validation of data accomplished by triangulation, is a method using multiple sources of data to confirm the emerging findings (Gay & Airasian, 2000). The triangulation was performed by the analysis of multiple data sources including pre- and post-survey, daily field notes, students' reflections and focus group interviews. Data analysis occurred from the beginning of the study when SBiC was introduced and continued months after the last meeting of the focus group. As suggested by Meriam (1998), case study analysis begins with the first document read. Emerging insights, feelings, and tentative hypotheses direct the next phase of data collection, which in turn leads to refinement or reformulation of questions. Qualitative research is not static; rather it is active, changing to produce dependable and reliable information. Initially, I began the data analysis process by reviewing field notes and watching the videotapes recorded during class time. While analyzing the data, I generated common terms and insights. From this analysis, common themes begin to emerge.

Figure 2

Process of qualitative data analysis model

Measure # 1
- Pre-Survey
- Reflection # 1
- Focus group interivew #1

Measure # 2
- Reflection # 2
- Focus group interivew #2
- Project: Milk2Carton

Measure # 3
- Post-Survey
- Reflection # 3
- Focus group interivew #3
- Video

Rationale for Using a Qualitative Thematic Analysis

Thematic analysis was used to categorize, summarize, and analyze the data points. This type of analysis is "a form of pattern recognition within the data, where emerging themes became

categories for analysis" (Fereday & Muir-Cochrane, 2006). Atride-Stirling (2001) has suggested that thematic material can be organized into three types of themes: basic themes, organizing themes, and global themes. *Basic themes* are the lowest-order assertions in the text and can be organized into patterns that will lead to the identification of larger *organizing themes*. Further analysis can then be used to detect comprehensive *global themes* which are used to "encapsulate the principal metaphors in the text as a whole" (p. 388). Once these relationships have been organized into patterns, it then becomes possible to create thematic networks that can be used to describe, explore, summarize, and interpret textual data. This interpretation is then compared to the literature review and used to re-examine the original research question. The end analysis involves using thematic networks to find a "cohesive story and create meaningful relationships amongst the various data sources" (p.402).

This study contains information regarding how the data was collected, reviewed, and analyzed to determine the frequency of the occurrence of contexts associated with three stages of environmental identity: (a) environmental awareness, (b) environmental action, and (c) taking initiative. The research completed in this study used a qualitative analysis and a grounded theory approach.

Glaser and Straus established Grounded Theory (GT) in the 1960's (Creswell, 2007). Researchers utilize GT to determine a general description of a development or procedure when there are no theories that explain or clarify the research problem. GT may be utilized to explain unique situations, validate a new potential method, or may be used to describe intricacies discovered during a research study (Creswell, 2007). This approach matches the steps followed in this study where the research studied the environmental identity development of high school participants.

Merriam (2009) suggests that a Grounded Theory (GT) approach focuses on the discovery of a new theory. The end results of GT study is the construction of a new concept that is substantiated by the data collected throughout. Further, the use of GT is most appropriate when using a qualitative method to explore human interactions or social processes (Merriam & Simpson, 2000). This information validates the use of GT for this study as the data collected was based on human interactions that took place during participants involved in class activities, group projects, or focus group interviews.

Charmaz (1990) established the importance of GT in explaining the theories behind observed procedures. The most common procedures alluded to include those from the fields of sociology, nursing, education, psychology, and other social sciences (Creswell, 2007). Further, Glaser & Strauss (1967) suggests that theories used in the social sciences to create predictions for behaviors, can provide a practical application to an approach, provide a perspective on the observed actions, and can give guidance to research on a particular behavior.

Additionally, Glaser (1999) continued that GT is a valid qualitative method as it utilizes the knowledge and expertise of the practitioners. When reviewing the data of a GT study, the researcher uses their expertise to create categories for the data, offer ideas and explanations for the themes that emerge from the data, and suggest theories that develop due to their vast knowledge of the topic. Therefore, this approach is "grounded" in the data collected by the researcher regarding both the impact of the SBiC and also the movement of the participants on the scale of the environmental identity which was invented by the researcher.

Data for most GT studies comes from observations and interviews of the participants (Glaser, 1999). After data is collected, data is coded and analyzed to determine if more data is needed and where to find it. The researcher uses their knowledge and insights to organize data

into comparative groups to determine the differences and similarities that arise to form theoretical categories. This is often referred to as “emergent coding”. First, the researcher often attempts to convert the qualitative data to quantitative form by looking for themes within the data followed by tallying the number of times those themes appear. Therefore, the analyst frequently begins by coding all of the data first and then assembles, assesses, and analyzes this data into a theoretical frame called themes (Glaser, 1965).

Another option is for the researcher to not be confined by coding first. In this style, called *a priori* coding, the researcher approaches the data with themes already in place in effort to look for predetermined theoretical ideas. Here the analyst typically explores the data looking for information that validates the pre-constructed theory (Glaser, 1965). Creswell (2007) states that the use of *a priori* codes can be used to explain a theoretical model and has added validity when combined with emergent coding.

Glaser (1965) suggests another method that combines the coding procedures of the first approach with the theory development of the second approach in a constant comparison. In this approach, the researcher can accomplish both, somewhat at the same time. As the researcher analyzes the data and assigns codes to it they are constantly looking at this information and forming a theory that is constantly changing and evolving as suggested by the data. Glaser (1965) titled this “The Constant Comparative Method of Qualitative Analysis” and suggested that the resulting theory is more likely to be consistent with the data, more plausible, and more accurate. It is also suggested that this method is still dependent on the researchers’ skills and knowledge of the material to make these decisions.

During this study, the researcher served as the “instrument” making judgments regarding the intent of the participant’s answers (Charmaz, 1990). By using this approach, the grounded

theorist determines the feelings of the participants as they express their opinions of the phenomenon or process at hand (Creswell, 2009). The GT model places considerable onus on the researcher to be as subjective as possible as they describe the ideas behind the research, ask the questions carefully, and infer the responses of the participants. Using this approach, this study analyzed the behaviors, actions of the participants toward the environment.

The selection of GT combined with both emergent and *a priori* coding was appropriate for this study for three reasons. First, no existing theories could be found that suggest implementing an unit of biodiversity sustainability that could impact high school students. Second, the topic of the study was theoretical and projecting. Participants gave their opinions or feelings about the environment and applied their knowledge to build a community garden. Third, for the focus group interviews, three participants with heterogeneous experiences and backgrounds were purposely selected. It was a necessity that the researcher be able to ensure that all questions were asked and perceived properly in order to achieve results that truly represented the participants' responses.

Methods of Data Analysis

In this phase of the study, I described the credibility and rigor of the findings and conclusions that I drew. Under the canopy of credibility, the findings of this study were limited to thirty participants who registered in the last section of Honors Chemistry from a public high school. However, rich, thick descriptions of the data are provided "so that readers will be able to determine how closely their situations match the research situation, and hence, whether findings can be transferred" (Merriam, 1998, p. 211). From this perspective, other concerns of credibility are discussed below.

Credibility

Merriam (1998) discussed ethics during analysis of the data. This is a reminder that I was the filter of the data, and I had to be aware of my own biases while reading the stories of my participants. Merriam has written "Deciding what is important--what should or should not be attended to when collecting and analyzing data--- is almost always up to the investigator" (p.216). Biases cannot be "swept under the carpet" and forgotten. Once all participants' responses were in front of me, I read them again for repeating words, phrases, or ideas that seemed to emerge from the voices of participants. Next, I sorted participants' responses into categories by constantly comparing them to each other. This constant comparison helped me in devising rules that described the category properties and allowed me to step back and gain objectivity to the data. Writing notes and memos during transcription also helped me to make sense of the data as well as to capture the "Aha" moment until a common theme emerged.

Patton (2002) listed several different types of triangulation; two mentioned were relevant to this study. The first was "checking the consistency of what people say about the same thing over time" (p.559). In this study, I could compare data from participants' pre- and post-survey with the same types of questions and short answers. During the time of implementation of the curriculum, I could compare data from students' first, second and third round reflections to see if there were changes in their attitudes, behavior and actions toward the environment. In addition, focus group interviews were conducted with three students every two weeks, which provided me with "rich and thick" data.

A second type of triangulation is "…comparing perspectives of people from different points of view, for example, in an evaluation, triangulating staff views, client views, funder views, and views expressed by people outside the program" (Patton, 2002, p.559). In this study,

using triangulation, I could verify emerging patterns because the themes were present in at least three sources: surveys, reflections, projects, and focus group interviews.

A third type of triangulation was member checking. During weeks of transcriptions of the focus group interviews, three embedded case participants all agreed that I could contacted them by phone or email if any questions arose during transcribing the video. When the transcription was completed, each participant viewed the verbatim transcription to check their part. Also, I have been fortunate to work closely with my advisor, Dr. O'Neill who checked my claims to avoid bias. I constantly received feedback from her via weekly meetings and phone discussions whenever I needed. This feedback was useful because it gave me the opportunity to see another researcher's perspectives on the same contexts, or quotations that I interpreted from students' voices. It allowed me to deepen my thinking and strengthen the clarity of my data.

Chapter 4

Findings

Introduction

This chapter contains the analysis of the data collected from January to May 2018 as a teacher-researcher in a high school chemistry classroom. The data presented addresses two specific research questions, which guide and define the research context:

1. What instructional tools when added to the chemistry class will help students to focus the idea of sustainability?
2. How does high school student participation in sustainability-focused biodiversity curriculum (SBiC) impact the development of their environmental identity?

Three findings presented from the data analysis are:

(1) Inquiry-based class lessons that are integrated with outdoor activities to create an environmental sustainability focused chemistry class

(2) the need to create a Scale of Environmental Identity Development (SEID) to indicate three aspects of environmental identity, which are constructed in a hierarchical way corresponding to the development of environmental identity, and

(3) participants demonstrated moderate growth in relation to their environmental identity following the SBiC.

Finding 1: Inquiry-based class lessons that are integrated with outdoor activities to create an environmental sustainability focused chemistry class

Lesson plans were structured to convey information to students in a way that incorporated current issues, lab experiments that were designed for students to test the samples that they collected around the school campus, and additional outdoor activities all designed to answer the

question that students often ask, “Where would we ever use this in our lives?” The SBiC consisted of lesson plans that reflected on three essential components:

(1) Open daily lessons with current issues for students to wonder about,

(2) Modification of three essential labs from traditional chem labs, and

(3) Creating opportunities for outdoor and community based activities. Each of these three components is discussed in more detail below.

Daily Lesson Opening with Current Issue to Wonder

At the time the data was collected, my teaching responsibilities involved three courses: one section of Advanced Placement of Chemistry, two sections of Honors Chemistry, and two sections of General Chemistry. While the scope of work in the two Honors Chemistry sections was identical and are fully described in Appendix A, the section in the last period of the day included the SBiC. At the beginning of a typical Honors Chemistry section, I started with a Warm-up (See Appendix A) to prepare students for the class and to review material covered in the previous class, then, I began the new lesson. At the end of the class, students filled out an Exit pass (See Appendix A) before they left for the day.

In contrast, for the Honors Chem section with SBiC implementation, I started with a discussion of an article that I had assigned them to read at home, then we did class discussion and students wrote the reflections before they left. Sometimes I introduced the new lesson with an educational video about a current issue in the world.

To align with the material I needed to cover for Honors Chemistry curriculum in the second semester, such as stoichiometry, gas laws, acid-base, I selected three major topics for students who participated in SBiC to explore: soil, air, and water quality. With the connection

between that lesson and the data collected for this research, I will provide details about each of the major topics that I implemented into SBiC.

When students participating in SBiC studied the quality of soil, they read an article called, “Soil Chemistry-Sifting Through the Past " in Chem Matter 2001 (see Appendix B). To illustrate the differences between the design of my chemistry classes, I compare the two excerpts below, both taken from video footage, in Table 2 below. The first excerpt came from my period 3 Honors class and the second is from the last period of the school day, in which I implemented SBiC.

Table 2

Class opening from Regular Honors and Honors with SBiC in relation to Soil Analysis

Opening lesson from Period 3 (Honors Chem)	Opening lesson from Period 7 (Honors Chem with SBiC implementation)
Cam-Tu: All right, today, um… we’re going to take a look at this reaction (*shows the equation on the SmartBoard*) between zinc and sulfur. It’s used a lot in model rockets. And today we are going to go a little differently than, um . . . the lectures that you‘re used to. Um, instead of me just doing the demo for you and figuring out the amounts ahead of time, I want you guys to try to figure this out.	Cam-Tu: Today we’re going to talk about the article I assigned you to read last class. Here’s my question to you and this is what I want you to think about for one minute. Ok, actually take more time to think about it. Write it down in your journal... and...don’t say anything out loud. “Explain the meaning of “the record is written in the chemistry of soil”.... Ok...Put down your thoughts…..

Table 2 (continued)

Class opening from Regular Honors and Honors with SBiC in relation to Soil Analysis

Opening lesson from Period 3 (Honors Chem)	Opening lesson from Period 7 (Honors Chem with SBiC implementation)
Okay, our problem today is, if I start out with 13 grams of Zinc, how much sulfur do I use so that I could get zinc sulfide? You have to think hard today: How do we get to the mass of sulfur? What chemical reaction do I need to look at? Um, this is the reaction we're going to be looking at (*reveal equation on the Smart Board)*. It's a reaction that is used in rocket fuel model (*read out loud):* Zinc plus sulfur goes to zinc sulfide...	(*after 5-10 minutes*) Now put your pen or pencil down…I am going to put you into a group of 3, in 3 minutes, your group must come up with 3 ideas that you want to present to the whole class.

In Period 3- Honors Chemistry without SBiC implementation as shown in the first excerpt, I started the new lesson with a general problem that required calculations. Previously, students had practiced and gotten used to a specific type of calculations, balancing chemical equations, finding moles of a substance from given masses, and using mole-ratio to determine the products of the reaction.

The main difference of Honors Chemistry with SBiC implementation is the application of the chemistry concepts in real world situations. In the second excerpt, I gave students time to put down their thoughts about the article they had read in the last class, and engaged them in a group discussion to voice their thoughts. The article that I assigned to the class, discussed how chemists analyzed soil by looking at the pattern of element distributions such as, phosphorus, sodium,

calcium, or even lead. This article was read after students had already analyzed data from a Chroma- soil test they performed the day before. The article provided another perspective on soil analysis. Previously, students identified what ions were present in the soil sample they collected around the school campus. For example, when the chromatography test paper showed a red color, students realized that iron was presented. If the grey was color shown, no ions detected and the soil was not healthy. In the article they read, James Myers, the archaeologist, explained how he analyzed the soil using argon-based inductively coupled plasma (ICP). Students found it very interesting to read because they learned that soil tests are used extensively in real life. By answering the question, "Explain the meaning of: The record is written in the chemistry of soil" in his journal, one student wrote:

> It was an eye opener when I knew that the soil contains a lot of records. By looking at the distribution of elements in the soil samples, scientists can reconstruct many activities. For example, soil with high phosphorus was from farms with animals. When a soil sample contains sulfur, or metal ions like cadmium or lead, it was from the demolished or burned building, etc...What I liked when reading the article was how the chemists traced plant products in the soil and tried to determine the types of plants they could grow. This was great information as I could use it in choosing the right seeds for my garden.

Another essential lesson that I added to the sequences of environmental sustainability focused class was "Air Quality". Both air quality and air pollution are important concepts the participants need to understand in order to see how the choices they make directly impact the air they breathe. In the two excerpts below, both taken from video footage, the first came from my

period 3 Honors class and the second came from my last period class in which I implemented SBiC.

Table 3

Class opening from Regular Honors and Honors with SBiC in relation to Air Quality

Opening lesson from Period 3 (Honors Chem)	Opening lesson from Period 7 (Honors Chem with SBiC implementation)
Cam-Tu: Today, we're doing gas laws. Do you know that each of you inhales approximately 8,500 L of air each day….Ok, write it down on your paper, convert 8,500 L to lbs…. I want to see how you set up the dimensional analysis on your paper….. Very good….The correct answer is 25 lbs of air because 8,500 L is an inexact number so you have to count the significant figures. How many significant figures in 8,500L?...Right….it's two sig. figs because trailing zeros with no decimal points are not significant…	Cam-Tu: Students, we just finished gas laws and we've learned about the relationships among four variables: pressure, volume temperature, and number of moles. Today, I am going to talk about air quality. As I assigned you to read the article, "Clean the Air" from last class, I want you to answer 4 questions in your journal. … (*shows 3 questions on SmartBoard)* *What is ozone?* *How does it get in the air?* *Why is there a problem?* *Why can't we stay out in the sun for too long?* Ok, I will give you 10 minutes to jot down your thoughts. (*After 9 minutes*) Students, you have 1 minute left, let's wrap it up (*after 1 minute*) Now put your pen or pencil down...I am going

	to put you into a group of 2. Next class, your group will present those 4 questions using PowerPoint or google slides.

Table 3 (continued)

Class opening from Regular Honors and Honors with SBiC in relation to Air Quality

Opening lesson from Period 3 (Honors Chem)	Opening lesson from Period 7 (Honors Chem with SBiC implementation)
	Then, in your journal, write about 150 words about what you learn after researching the topic of Ozone. Are there any questions for me to answer? Female # 1: How long do we have to present? Cam-Tu: Oh, I forgot to mention that you only have 1 minute and 30 seconds for your presentation and the same amount of time for your group to answer questions from the audience...Any more question… Male # 1: How many slides do I need to create? Cam-Tu: Alright, no more than 3 slides, and the fourth slide is for references. Don't forget to copy down where you find the sources, ok...and speaking of that, other than ChemMatter magazine, you must find another trusted source such as Scientific Journal, Science News, Times, etc.

Table 3 contains two excerpts. In the first excerpt, I opened up a new lesson with an interesting fact about the average amount of air people inhale daily. I reviewed the concepts that the students learned in the previous units, such as significant figures and dimensional analysis. This style of teaching is what I've been doing for more than twenty years. I would always start by providing the students with some interesting facts about the new lesson they were going to

learn, and then continue on with my lecture notes that corresponded to the assigned students' textbook reading completed before coming to class. To correct their work, students had the freedom to ask questions, or search for the answers in the back of the textbook. As a result, students mostly learned from the textbook and there was no relation with their lifestyles or issues related to the environment.

In contrast, the Honors class with SBiC implementation, I was curious about how the students thought about the lecture I conducted, and how I could address the current issues about the Earth that tie with the chemical concepts that I just lectured about. In the second excerpt, students read the article, "Clean the Air" as the evening reading assignment for the next day discussion. To assess how well students understood the reading assignment, I posed four questions about the ozone layer, and they had about 10 minutes to write down their thoughts. The next day, students presented what they previously wrote down with their partner. Most students found this topic interesting to research because they found that there was a lot of new information they did not previously know, such as how great the human impact is on the depletion of the ozone layer. See Appendix C for viewing Students' Presentation about the ozone. After students studied the ozone topic, they were asked to write about what they had learned. I received many reflections from students who raised their concerns about the bad ozone layer and how humans would need to help to mend the hole.

One student wrote:

> Humans have damaged a gigantic portion of nature and depletion of the ozone layer is one of them. The title of the article includes the words "Clearing the air" alarmed us the development of the ozone hole. Well, it's not really a true hole, but instead an area of depleted ozone that forms over Antarctica in Spring and in the Southern Hemisphere in

Fall. How would humans help to repair the ozone hole? Well, The United Nations (UN) adopted the Montreal protocol which limits or bans the emissions of gases that deplete the ozone layer.

Acid rain was another important topic that I perfectly aligned with the Acid and Bases unit. Students in both Honors sections learned about the basic concepts of acid and base, how to read the pH scales and calculate the concentration of hydrogen ions. See Appendix A for Daily Schedule-Honors Chem SY 17-18. For the Honors section with SBiC, I introduced the problem to the class by asking students to read an article from ChemMatters titled “The Fox River Fish Kill " and then having them brainstorming the potential causes of the fish kill and what they would test the water for. While the causes of the kill were reported in the article, students came up with their own solutions about how to test the water for various ions. On the next class day, I provided students with data to analyze. They came to the conclusion about what killed the fish based on the data. After students determined that the cause of the fish kill was due to higher concentration of hydronium ions [H+] in the water, they read about acid rain in their textbook and investigated what causes acid rain through a mini lab.

In the next section, I will elaborate on the three labs that are related to the three topics that I selected in designing the SBiC.

Three Essential Chemistry Labs vs. Traditional Chemistry Labs

In traditional chemistry class, students perform teacher-structured experiments (Kelly & Finlayson, 2007). Researchers named these structured experiments as “cookbook labs” or “lab manuals”. According to Clough (2002), “In typical cookbook laboratory experiences, most all these decisions are made for students. Not only does this represent the nature of scientific inquiry, but because most of the thinking is done for students. They have little reason to engage

in the cognitive activities known to be essential for robust learning" (p. 87). In addition, Monteyne and Cracolice (2004) argue that "cookbook labs" encourage students to follow a recipe, however they do not encourage creativity, conceptual understanding, and thinking skills.

My intention was to design and implement a sustainability focused biodiversity curriculum (SBiC) that connected what students were learning and doing in class with the skills they would apply to solve issues for the local environment. I took into consideration different lab experiments for students to critically think on the science practices for the current topics being taught in other chemistry sections. Furthermore, the selected labs should enforce "creativity" and strengthen "conceptual understanding" in the students. Each lab was designed to align with the three topics I chose to teach when implementing the SBiC: air, water, and soil. Table 4 provides the curriculum of both Honors class with new design lab activities for implementing SBiC. Table 5 demonstrates an outline of the descriptions and objectives of each lab conducted in both Honors sections.

Table 4

Daily Lesson Plan of both Honors Sections from January 2018-May 2018

Date	**Reg. Honors**	**Honors with SBiC**
1/08/2018 - 1/19/2018	**Stoichiometry (8 days)** Mass-mass problems · % yield calculations · Energy calculations · Mass-volume problems · Volume-volume problems · Limiting reagent problems · LAB: Determine Ca^{2+} from TUMS	Stoichiometry (8 days) Mass-mass problems · % yield calculations · Energy calculations · Mass-volume problems · Volume-volume problems · Limiting reagent problems · **LAB: Determine Minerals in Soil**
1/22/2018 -- 3/02/2018	**Gas Laws (9 days)** · Kinetic theory · Boyles, Charles, Gay-Lusscac's Laws · Dalton, Graham, Ideal Gas Law · Gas density and molecular mass	Gas Laws (9 days) · Kinetic theory · Boyles, Charles, Gay-Lusscac's Laws · Dalton, Graham, Ideal Gas Law · Gas density and molecular mass

	· LAB: Molar Volume of a Gas	· **LAB: Ozone**
3/05/2018 - 3/16/2018	**Solutions (9 days)** · Dissolving process · Molar concentration · Colligative properties · LAB: Ice cream	Solutions (9 days) · Dissolving process · Molar concentration · Colligative properties · LAB: Ice cream
Date	**Reg. Honors**	**Honors with SBiC**
3/19/2018 - 3/30/2018	**Reaction Rates (7 days)** · Factors affecting rates · Determine rate laws from data · Graphing zero, 1st, and 2nd order · Reaction pathways · LAB: Rate Law for Crystal violet reaction	Reaction Rates (7 days) · Factors affecting rates · Determine rate laws from data · Graphing zero, 1st, and 2nd order · Reaction pathways · LAB: Rate Law for Crystal violet reaction
4/02/2018 - 4/09/2018	**General Equilibrium (7 days)** · Equilibrium concept · LeChatliter's principle · Equilibrium calculations (R.I.C.E) · LAB: Equilibrium Constant K_c	General Equilibrium (7 days) · Equilibrium concept · LeChatliter's principle · Equilibrium calculations (R.I.C.E) · LAB: Equilibrium Constant K_c
4/10/2018 - 4/20/2018	**Acids and Bases (8 days)** · Review of acid and base concepts · pH scales and calculations · Titration and calculations · Hydrolysis · Common ion effect · LAB: Acid/Base Titration	Acids and Bases (8 days) · Review of acid and base concepts · pH scales and calculations · Titration and calculations · Hydrolysis · Common ion effect · **LAB: Ocean Acidification**
4/23/2018 - 4/30/2018	**Electrochemistry (9 days)** · Oxidation numbers · Balancing redox reactions · Voltaic cells · EMF calculations · Electrolytic cells · LAB: How do batteries work?	Electrochemistry (9 days) · Oxidation numbers · Balancing redox reactions · Voltaic cells · EMF calculations · Electrolytic cells · LAB: How do batteries work?
5/02/2018 - 5/11/2018	**Thermodynamics (7 days)** · Enthalpy · Entropy · Gibbs Free Energy · LAB: Heat of Combustion	Thermodynamics (7 days) · Enthalpy · Entropy · Gibbs Free Energy · LAB: Heat of Combustion

Table 5

List of Chemistry Labs Objectives for Regular Honors and Honors with SBiC

	Regular Honors Chemistry	Honors with SBiC
Lab # 1	Determine % Ca^{2+} in TUMS: In this lab, students used the reaction of TUMS with water to inflate a balloon. They then used the ideal gas law to determine the number of moles of gas produced by chemical reaction	Determine Minerals in Soil: Students evaluated the quality of soil, bio-fertilizers, and the health of plants using chromatography. Students selected soil samples from around the Science building and they analyzed their sample using the soil chromatography method.
Lab # 2	Molar Volume of a Gas: Students investigated the chemical reaction between citric acid and baking soda used in the self-inflating balloon. They applied their knowledge of gas laws and stoichiometry in order to determine the quantities of reactants used to produce carbon dioxide to inflate the balloon.	Ozone: Students prepared the ozone monitoring test strips, they then placed the test strips on classroom windows, above and underneath plants and bushes. Next, they used the Relative Humidity Schoenbein Number Chart to calculate the concentration of ground level ozone.
Lab # 3	Acid Base Titration: Students determined the concentration of hydrochloric acid with known concentration of NaOH. Students constructed the titration curve using Excel and determined the equivalent point of the curve. They calculated the percent of error of their calculated lab value with acceptance value of hydrochloric acid.	Acid rain titration: Students determined the concentration of hydrochloric acid (the rain water) via titration. Students titrated a sample of rain water containing unknown concentration of HCl with known concentration of NaOH. Then they used their data to calculate the molarity of hydronium ion [H^+]. Finally, they calculated the percent of error of their calculated lab value with the acceptance value of HCl.

As shown in Table 5, three labs were conducted in Honors Chemistry implementing SBiC included: determination of minerals in soil, ozone lab, and acid rain titration.

Lab # 1: Determine Minerals in Soil. Students were asked to select soil samples around the school campus that they would analyze using the soil chromatography method. Prior to Lab #1, I had covered the basics of soil chromatography (Pleiffer Chroma-Test) and how to get data from the chromatogram (Chroma-Test paper). After collecting the chromatogram from their testing sites, students were instructed to form groups based on their testing site and compare their chromatogram among each other. Students identified the quality of the soil samples they collected based on the color on the chromatogram. If the chromatogram showed reddish brown, orange, or yellow color, it indicated the healthy soil. Poor soil was represented by grey/black colors. Students were able to connect soil chromatography with the quality of soil and the health of plants.

One student mentioned that she felt the soil activities provided a better understanding of chemistry and its applications, “This lab gave me a better understanding of chemistry and how you apply it so hopefully I think that will help me in my future science classes.”

In conversations with another student from this class, he felt that the soil lab improved his ability to plan for the next experiment. He expressed that the soil lab gave him an opportunity to plan and determine what variables to investigate and how he interpreted his own data collection:

> Well, I never had the experience for experiments before with biology labs. This lab was a lot more in-depth and it helped me to be able to find all the different variables and account for them before I actually did the experiment. So if you get some results that are not similar to other groups, you would definitely have to re-collect the sample and redo the lab again.

The excerpt above shows that the student knows how to conduct the experiment properly and he knows all the steps that are required for conducting the lab experiment.

Even though I believe that the soil lab was another essential activity to add to my SBiC, many participants did not connect it to the real world applications. One reason I believe was that I did not have guiding questions or extended questions to steer students' thinking toward real life experience. However, when constructing the planter for the project, "Carton2Garden", students indicated that analyzing the soil sample could guide them on how to make ideal conditions for the growth of their plants. One student expressed that thought in his reflections:

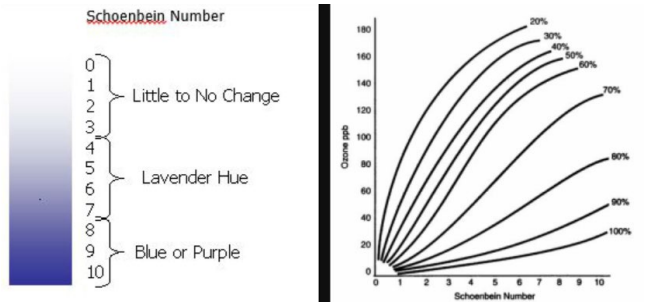
> The soil samples that we collected and tested, and the data that was gathered from it [the soil] would affect our garden specifically and our school in general. By understanding what type of soil we have, it gives us a better understanding of the methods we need to go about when building our garden. For example, knowing the composition of soil, it could let us know how often we need to water our plants, where we need to plant them, what kinds of plants are suitable for our soil, and many other crucial things that could improve or adjust to improve on the health of our plants.

Lab # 2: Ozone Lab. Or "Determining the molar volume of carbon dioxide gas" from citric acid and baking soda was the lab activity on the Chemistry curriculum, and students needed to find the volume of carbon dioxide from given quantities of baking soda and citric acid. My aim was to have an activity that connected students to the local environment and other than a lecture, thus, I substituted the "Molar Volume of CO_2 Lab" with the "Ozone Lab". I adopted this lab activity from ChemMatters, September 2002 (See Appendix C). Students were required to explore the air quality around our school campus. This lab's purpose was to show students that the ozone produced during the day in the troposphere could be observed within eight (8) hours. In the morning, students picked up the ozone monitoring test strips, then I assigned four different locations spread out around school to each group of students to expose their test strips, either

indoors or outdoors. For example, some groups had placed 3-5 test strips on the wall inside the classroom, whereas others placed inside the locker, some placed above and underneath plants/bushes, or on the staircase, etc. I also reminded students not to place the ozone test strips in direct sunlight.

Figure 3

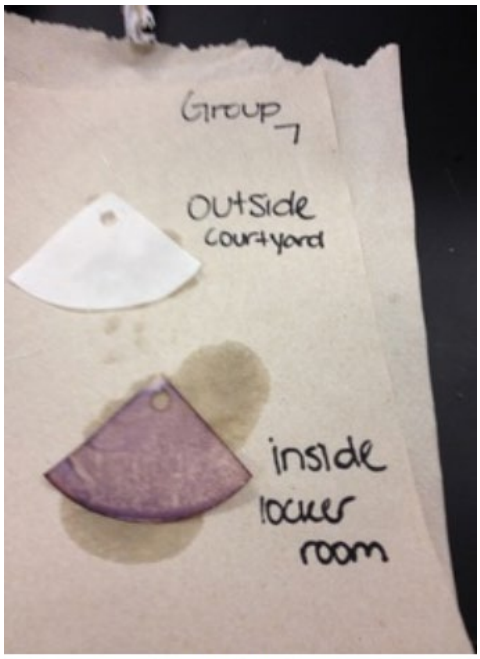
Schönbein number scale and relationship between Schönbein number and relative humidity



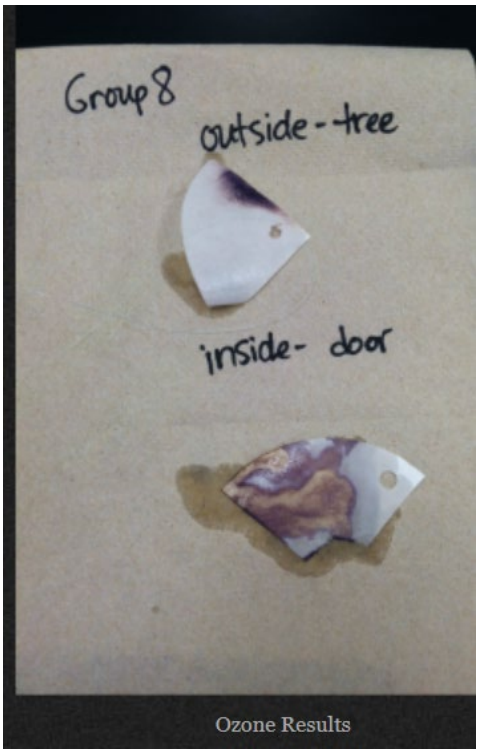
After the test strip was exposed for eight (8) hours, students observed the color on the test strips and assigned the Schönbein number based on the Schönbein color scale. Figure 3 indicates the scale of Schönbein number and relationship between Schönbein number and relative humidity. When the ozone is present, the test strips would change color. For example, little to no color change, would display an ozone level between the values 0-3, a lavender hue indicates levels from 4-6, and blue/or purple shows the level of ozone between 7-10. At the end of the day, students collected their test strips, labeled them, and sprayed them with enough water to get them moist and placed their test strips on the board to compare. Figure 4 shows the results of ozone test strips from groups 7 and 8.

Figure 4

Sample of Students' Ozone Lab Test Results



Results



Ozone Results

Next, students used the Relative Humidity Schönbein Number Chart (see Figure 3) to calculate the concentration of ground level ozone. After analyzing data and finding out which locations contain the highest concentrations of ozone or in contrast, one question I asked the students in their reflection, "What information have you added to your knowledge about the world after conducting this lab?" One student stated that:

> This lab involves real world experience because people measure ozone all the time to make sure it is safe for our community to be outside. It provides safety for our communities and ozone has a great effect on our world. I learned a lot from this experiment. I learned that there is ozone in our school. I enjoyed doing this lab because of the real world connection!

This expression communicates that the student enjoyed doing this lab and realized the "ozone lab" connected to real world experience because measuring the ozone concentration may bring safety to the community.

Another student wrote, "This lab fits into the bigger picture because it can affect many people. By being able to test the ozone levels in the atmosphere, it can help people with lung problems and asthma know when it is safe to go outside." This expression also shows that after doing the lab, the student realized that air quality does affect everyone and including community members with possible health problems.

In the next expression, one student demonstrated his great concerns about the rating from the American Lung Association and the high number of people with health issues:

> This lab connects to the real world as air quality affects the health of humans. According to the American Lung Association (ALA), urban Honolulu has an "A" for both tropospheric ozone levels and particulate matter. With a population over 950,000 people, 173,000 people in Honolulu County have asthma, COPD, or other cardiovascular diseases. I wonder why these people in Honolulu have a harder time breathing even though we have a good air quality standard. With this lab such as this [ozone lab] and research by institutes similar to the ALA, we can determine acceptable and unsafe conditions for emissions from cars and other sources so that less people get sick.

In summary, this lab allowed students to measure the air quality around school. Instead of only reading the textbook and duplicating the lab experiment published inside, students could determine the ozone content in their local environment. By analyzing the results they obtained from the lab, they gained knowledge and applied it directly to their everyday lives. The concept

of gases and air is very complex, but through students' reflections, Lab #2 was able to help students better understand ground level ozone and its effect on the community.

Lab # 3: Acid Rain Titration. Acid rain titration was replaced with the Acid/Base titration that I used for regular Honors Chemistry. This lab was designed to determine the concentration of acid rain via titration. Students tested a hydrochloric acid (HCl) sample, which was designated for acid rain, by performing a titration with a known concentration of sodium hydroxide, NaOH. Next, students compared the results to see if a sample would pass inspection by finding the percent error of their calculated lab value with the acceptance value of hydrochloric acid. Students in both Honors Chemistry classes performed acid base titration. However, I renamed the unknown hydrochloric acid as "rain water". Besides answering questions about how to find the concentration of HCl, and the equivalence point of the titration, students in SBiC had extended the questions to the topic of acid rain. For example, acid rain contains some strong acids such as nitric acid and sulfuric acid. Why doesn't acid rain burn you, or which region of the United States has the most acid rain and why would this region have the most acid rain? Some students remembered that I had told them that acid rain is too diluted to harm humans, many students still claimed that acid rain does not contain strong acids, even though the question states that it does. These students were confusing diluted solutions with weak solutions. This misconception was addressed and clarified when the lab was discussed in class the next day.

Outdoor vs. Indoor Activities

The third instructional tool that I included in the existing chemistry curriculum to enhance the idea of sustainability focused was outdoor activities. Since this was the last class of the day, I could arrange field trips or allow students to collect test samples around the school

campus. I also wanted to be the first science teacher in my school to build the school garden by virtue of being a statement about our environmental advocacy, and I wanted students to feel interconnected with the environment.

Moreover, adding activities and tasks related to the school garden could help the students to connect what they learned in class and apply it to the real world. For example, understanding the level of mineral ions in soil could improve soil fertility, and using probes to measure the pH of the soil can help us monitor the health of the soil. Finally, determining other external factors such as air and water quality can contribute to the plant growth, etc. The final project is called“Carton2Garden”. Students collected 100 milk cartons and they designed a garden to grow plants. Figure 5 demonstrates a student build a garden from 100 milk cartons that she collected from the cafeteria.

Figure 5

Student Assembled 100 Milk Cartons to Build a Garden

Figure 6 demonstrates different designs of “Milk2Carton” Project.

Figure 6

Gardens Designed by Students of SBiC after Six Weeks

This project turned out to be more successful than I thought. This project not only brought the curiosity in students but many students "were hooked" to their garden. One student wrote in her reflection:

> Participating in the Carton2Garden project influenced me to perform environmentally sustainable behaviors. These behaviors include conserving resources such as water and energy, and avoiding wasting energy and resources. Our Carton2Garden project was

> targeted to conserve water, and it made me more aware of the small things that we can do. I was inspired to be creative, and it gave me motivation. Along the process of the project, I enjoyed maintaining the garden, such as watering and planting the species, and as plants successfully grew, it gave me hope and motivation. My eyes opened up to the beautiful nature we take for granted, and our small actions can help preserve the environment. Our group hopes to influence the whole community with our garden to help the environment.

The reflection demonstrated of her participation in doing the project had opened her eyes for doing the right thing for the environment. She was motivated and wanted to influence the community to help the environment.

The involvement in the Carton2Garden has brought students to realize the complexity of gardening skills and how to take care of the garden. One student wrote:

> Growing a garden was no easy task, especially, when you never had the experience of growing a garden in your entire life. However, even though we know how to test soil, water, and the quality of air, we were faced with many obstacles. We learned a lot of gardening and soft skills such as the importance of responsibility that we would not have been able to learn without this project.

At the beginning of her essay, one student opened her thoughts about how important the role of each member in the group contributed to the success of the garden:

> Through the process of taking care of our garden, we learned that our actions played a big role in the success and development of our garden. As we watered the plants and provided them with sunlight, we found that we were able to positively impact their growth. Also,

> when we forgot to water on some days, there would be severe outcomes. We made sure to take care of our bug problem by finding the bugs and squishing them. With the other students and their garden, the school garden generated a unique group of species that you can't find anywhere else.

In the conclusion, she indicated in doing the milk carton project, she realized the meaningful act of recycle and how that would help Mother Earth or environment:

> Participating in Carton2Garden influenced us as students because we realized that we could make a difference in the environment one milk carton at a time. We learned how to find innovative ways to turn waste into something useful which would ultimately benefit our environment.

Most students in Period 7 echoed the change in their behaviors after building the school garden. Some students showed appreciation for connecting them to the environment which they have forgotten about and they wanted to continue on doing the right thing for the environment:

> Participating in Carton2Garden has influenced me to think about planting outside of the school project and start my own garden. From this project, I learned that plants really need the attention and care to grow in a healthy manner. The different types of seeds grow in different rates, and the amount of water as well as when and how often the plants should be watered are all important. The soil composition is important as well, making sure there are nutrients in the soil for plants to grow. The reason for this influence is because I want to contribute to my environment and grow long-term crops such as vegetables and fruits to provide free food from the crops I planted. Other than planting my own garden, Carton2Garden has also influenced me to find sustainable ways for other things such as recycling plastic and paper, solutions to pollution and cleaner atmosphere,

and reducing the burning of fossil fuels. It's influenced me because I want to contribute to the environment and improve it by reducing the human health risks and the save Earth's resources.

Finding 2: Constructing the Scale of Environmental Identity Development (SEID)

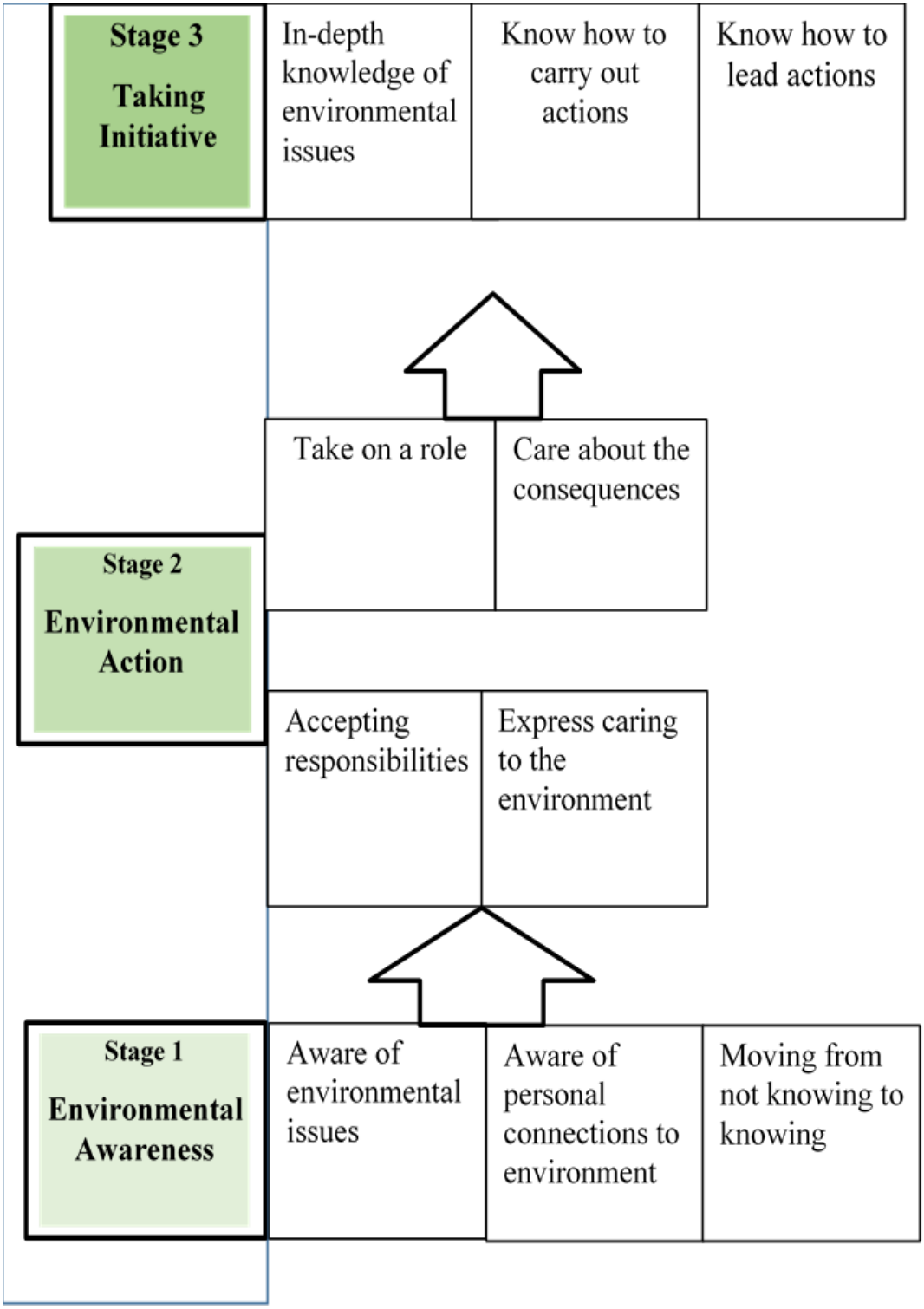
Observing participants' growth in environmental identity is the central focus of this study. During the data analysis, I realized along the way that there needed to be a dependable scale to keep track of the development of participants' environmental identity throughout the course of the study. Kempton and Holland (2003) examined the relationship between identities and the process of committing to environmental actions. Through surveys and in-depth interviews with 159 members from environmental groups, Kempton and Holland articulated three dimensions of environmental identity formation related to action. These three dimensions include *salience, identification as an actor,* and *increasing practical knowledge and resources for action ('knowledge from doing')*. Kempton and Holland's research was conducted with adult environmentalists, thus making their model a good reference as I conducted my study with high school students. Their model was borrowed to examine the impact of the SBiC on the growth of students' environmental identity. The Scale of Environmental Identity Development (SEID) was constructed using a hierarchical categorization of environmental identity based on three stages: environmental awareness, environmental action, and taking initiative.

Even after referencing a model used in previous studies, there was still no way of comparing the growth of participants' environmental identity. There was a need for a tool to track the participants' movement of their own identity. Their environmental identity development is based on how often they spoke about the related topics and the emotions they revealed while discussing the topics. Most participants started at the first stage, a few were at the second, and

none were placed in the third and final stage. SEID was formulated to capture the common patterns observed across all participants. The name of three central stages from SEID were the emerging themes that I discovered related to my research questions: (1) Environmental Awareness, (2) Environmental actions, and (3) Taking Initiative. In addition, sub-stages within the three existing SEID stage were added to complete the tracking of participants within each stage (See Figure 7). Throughout the course of the study, it was noticed that some students did not move vertically from one stage to another. Thus, sub stages were added with SEID to observe the true growth of every participant in-depth or further. A chart was created after all five data points (pre-post surveys, students' reflections, focus group interviews, artifacts, and researcher's field notes and observations) were compiled to help visualize which stage participants were on before, during, and after the SBiC.

Figure 7

The Hierarchical Scale of Environmental Identity Development



Organization of the SEID

Overview. The scale is constructed to operate vertically and horizontally. The vertical arrangement runs from bottom to top in a hierarchical fashion with the most common codes placed at the bottom, and the lesser common codes placed at the top of the scale. The horizontal arrangement runs from left to right in a hierarchical fashion with the sub-categories within the vertical alignment, and the sub-categories at the left containing the most quotes and the sub-categories to the right are the least frequent students achieve. I used thematic analysis to identify common themes and sub-themes to answer the research question. I chose the model suggested from Kempton and Holland to discover the themes. I initially coded for as many potential themes as possible and paid attention to accounts or expressions in the data that departed from the dominant story emerging from the analysis.

The three aspects of environmental identity identified by Kempton and Holland (2003) were used as themes to focus on the analysis. These three themes (environmental awareness, environmental action, and taking initiative) provided the initial categories for analysis. I found 579 unique responses that indicate the environmental identity development from 60 surveys, 90 student reflections, and 3 focus group interviews. In the category of "Environmental Awareness", 345 responses corresponded to this theme. Also using Kempton and Holland's (2003) model as a reference, 226 responses reflected "Environmental Action", and 8 reflected "Taking Initiative". Table 6 represents the count of responses and percentages shown for each stage across the entire study.

Table 6

Participants' Responses of Surveys, Reflections, Interviews and Artifacts

Emergent codes	**Definition of Themes**	**Examples**	**# responses**	**Percentage**
Stage 1: Environmental Awareness	• Becoming attentive and knowledgeable about the environmental problems • Becoming conscious about environmental threats	- Knowledgeable about the natural issues, disasters. - Draw conclusions about ecosystem functions. - Know the relationship between human and nature	345	59.6%
Stage 2: Environmental Action	• Acquiring a sense of agency • Taking responsibility for actions • Caring about actions consequences • Skills needed to protect and improve environment		226	39.0%
Stage 3: Taking Initiative	• Learning practical activities associated with action. • Awareness of network of other actors		8	1.4%
TOTAL			579	100%

Below is a detailed explanation of the SEID arrangement in both vertical and horizontal fashion. In Figure 7, the three stages of SEID were organized vertically based on the number of times students reflected them through the data points, surveys, observations, field notes, reflections and interviews. I grouped the list of themes under three categories: Environmental Awareness, Environmental Action and Taking Initiative. For example, *Environmental Awareness* is marked as Stage 1. Stage 2, *Environmental Action* was aligned with "identification as an actor", and Stage 3, *Taking Initiative* is known as "knowledge from doing" in this study. In my

study, the ranking of each stage depends on how often participants expressed their ideas and actions throughout the implementation of SBiC (See Table 1). Codes found most commonly amongst their answers would rank as Stage 1, the starting point in the process of tracking their environmental identity. If a participant displayed knowledge about environmental issues and concerns in a response of theirs, their quote was classified as a Stage 1indicator. Table 7 below shows a sample of student responses and their SEID stage.

Table 7

Data Analysis and Sample Student Response for Each Stage

Stage/Theme	Student Response	Interpretation
Stage 1: Environmental Awareness	Just by looking around your surroundings, there's rubbish out on the streets and in nature. There's also not a lot of greenery around as much as a long time ago. (Interview # 1)	Pollution Waste generated
	Humans can help. We're part of the reason that everything's so messed up so I think it's right to right the wrongs that we've done (Post-survey)	Human could undo the wrong doing by helping the environment.
	Human have damaged a gigantic portion of nature through processes such as deforestation and urbanization (Pre-survey)	Deforestation Urbanization
	Today, I feel like our environment is getting worse day by day. People are not aware about the environmental issues we have today, or even of they are aware, they don’t do anything to support and improve our surroundings. Some people also do not believe in environmental issues, such as global warming. I feel like our community do not have enough awareness about what is going on, especially in Hawaii because we don't really feel the impact of environmental issues. (Interview # 2)	Lack of environmental responsibility

Stage/Theme	Student Response	Interpretation
Stage 2: Environmental Action	It inspired me to continue to help reduce waste for the better of everything on this planet.(Reflection # 3)	Continue with good habit Waste reduction
	This project made me feel I had a purpose because I was not only doing it to benefit myself, I was doing it to benefit the school, the community, and the environment.	Become aware of purposeful doing
	I think our garden had a positive impact to the students in our Science Department because I've seen people taking videos of our garden and posting it in their social media saying that they are impressed on how we used milk carton to make our garden. (Interview # 3)	Positive influence to science department, school. Idea of building garden could be disseminated
Stage 3: Taking Initiative	As a president of the Leo Club, I sign up my club for volunteering pick up trash every month through the program, where we call it "Monthly Beach Clean-ups". Students and administration have passed by our gardens and asked what we were doing. From those opportunities, we shared our experience growing and constructing our gardens, and were able to share our message of sustainability and environmental friendliness. (Reflection # 3) We talked to others about our garden, and they want to try out this project too, and they asked us how to do it. We were so excited to share with them everything we really want them to do it so that would have a good feeling like us too!!! (Interview # 3)	Take a lead in good action to help the environment Proud of doing something good. Disseminate idea of sustainable action Doing something good, educate others to do good deed for the environment

Placing in Stage 1 of SEID, *Environmental Awareness*, participants indicates that they are aware of environmental problems and human impacts such as pollution, deforestation, and urbanization, and how these issues are not being resolved due to lack of environmental responsibility.

As for Stage 2 of SEID, *Environmental Actions*, participants placed here have shown some kind of responsibility for their actions which help and/ or protect the environment. For instance, codes displayed for Stage 2 contain more cohesive understanding of environmental actions, and show that the participants are aware of the environmental issues at hand, displaying actions and behaviors towards living more sustainably. Table 7 demonstrated a participant wishes to continue to reduce waste by purchasing just enough food for his family. This is what placed him in Stage 2.

Stage 3 was developed because there appeared to be only one participant who became aware of how to carry on and lead the environmental activities. Such activities include conducting beach clean-ups and volunteering to clean up after school assemblies or sporting events. Stage 3, *Taking Initiative*, is a more exclusive stage, as no students are placed in at the start. Only one participant reached Stage 3 after the SBiC. Table 7 demonstrates the participant at Stage 3 when she expressed her pride of initially taking action through her leadership role to help the environment.

To evaluate participants' shift on the SEID vertically, I observed students' reflections on their knowledge toward the environment through surveys, lab reports, reflections, projects, and focus group interviews. Additionally, I utilized observations and field notes to confirm what stage each participant belongs to, looking for the areas of overlap through more than one data point.

Stage 1: Environmental Awareness

Environmental awareness is an initial stage in developing environmental identity. In this study, environmental awareness is defined as an understanding of environmental issues and showing acknowledgment of human's positive and negative impact on the ecosystem.

Environmental awareness was captured on the surveys with three statements, such as, “I care about the environment, I am aware of environmental issues, My feelings about nature affect how I live my life.” Likert scale options ranged from “Strongly Agree” to “Strong Disagree”. When participants selected “Agree” or “Strongly Agree” to two out of three survey questions above, they earn a “checkmark” for their answer. No checkmark is given if they agree with one statement. Choices of “Neutral,” “Disagree,” or “Strongly Disagree” do not earn any “checkmark” (✓).

On top of the survey, two open-ended questions, “What comes to mind when you think about the environment?” and “What environmental issues are you aware of?” were added to grasp participants’ general knowledge about global and local environmental issues. Most participants were aware of commonly known environmental problems such as global warming, climate change, pollution, threats to biodiversity, deforestation, littering, and energy conservation, just to name a few. Most respondents listed two or three issues important to them. One participant asserted that all environmental issues were important; “I believe all environmental issues are important. All these issues affect human life and humans need to take care of the environment and need to be aware of these issues and their importance because once the Earth is gone, it is gone, it can never come back.”

Another participant noted environmental issues were connected, saying “all of these issues link off one another, they are not just one example of negative environmental behavior, and they all linked together in some way. For example, a flood is linked to global warming, climate change, and deforestation.” A “checkmark” (✓) was given if participants could identify any of the issues listed above.

Kempton and Holland (2003) found that increased salience in environmentalists typically comes from an environmental threat that influenced the individual. One's experiences would help her recognize the importance of environmentalism. Such experiences include observing the destruction of neighborhoods for industrialization purposes. This observation led a few participants to become more aware of environmental destruction in other areas. Another experience of local pollution led to a recognition of pollution as a systemic issue (Kempton and Holland, 2003). To be in line with Kempton and Holland's study, one question, "What experiences, role models, or events have influenced your feelings toward the environment? In what ways have these experiences, role models, or events influenced your feelings?" had students reflect on personal experience during the first group interview. One subject recalled that when living with a host family in Japan, the experience made him aware of the way he could live his life to helping the environment. Another person explained a fond memory from living in Hong Kong, when her parents always remind her of living sustainably to protect the environment. Only being high school students, their experiences do not reflect those of the environmentalists in Kempton and Holland (2003). However, students provided examples of role models such as host families or parents that exhibit living sustainably. Their responses on role models in the first focus group interview helped to characterize their lived experiences and provided more details regarding their tracking on the environmental identity.

Participants place in Stage 1 if they have earned at least two checkmarks (✓) either from any of two of the data points (surveys, reflections, interviews, observations). Having only one checkmark does not place them in Stage 1 of EIDS.

Although three distinctive stages were established and organized vertically using Kempton and Holland's model, I could not examine the participants' ideas, practices and actions

in detail. Twenty-one (21) participants remained on Stage 1 from the beginning to the end of the study, seeming as if they had exhibited no change. Thus, sub-stages were added to the three vertical stages. Adding sub-stages to each existing stage helped me keep track of participants who were at the same stage from the beginning to the end, and with that I was able to determine whether or not they constituted their environmental traits from one sub-stage to another. In other words, with the sub-stages added on, I could recognize in more detail if the participants did not shift vertically, they could shift horizontally, or both ways.

Sub-stage 1-1: Aware of environmental issues. Thirty participants in this study were able to name more than five environmental issues ranging from local to global. "Global warming" and "climate change" were the two themes that they listed. Table 8 below lists of the environmental issues that students mostly mentioned.

Table 8

List of environmental issues

• Acid rain • Air pollution • Biodiversity loss	• Climate change • Deforestation • Global warming • Overpopulation	• Ozone layer depletion • Resource depletion • Waste generated • Water pollution

Sub-stage 1-2: Aware of personal connections to environment. The second way participants show awareness of personal connection to the environment is when they view themselves as part of the natural world, or when they feel like the natural world is a valued component of their living. For example, Sharmaine expressed her concerns about environmental issues in a different manner: "The Earth hurts us (climate change, natural disasters) because we hurt it. I don't want our planet to become a dessert. I want my children and grand-children to see the natural beauty of our flora and fauna."

Damien started and ended with concerns about whether humans must have good environmental behaviors to protect the environment: “Knowing that if you don’t have good environmental behaviors, Earth may be a place that can’t have human life. A lot of continents and countries are affected by global warming and that is because of humans.”

Sub-stage 1.3: Moving from not knowing to knowing. In their study, Kempton and Holland pointed out that when participants were exposed to an emotional event, or were influenced by people who have shown characteristics of environmental commitment, such events appear to leave an impact on the participants’ thoughts or feelings about the natural environment. Knowing this, I added activities that increase the knowledge to consider that the participants moved from not knowing to knowing, and they moved along in the way of environmental identity trajectory.

Table 9 demonstrates the summary of how three sub-stages were added to Stage 1 to track participants who did not show the growth vertically, but they showed the movement horizontally.

Table 9

Data Analysis Codes and Student Quotes of Sub-Stages in First Stage of Environmental Awareness

Theme		Sample student quotes
Environmental Awareness	Aware of environmental issues	Just by looking around your surroundings, there's rubbish out on the streets and in nature. There's also not a lot of greenery around as much as a long time ago. (Interview # 1)
	Aware of personal	Humans can help. We're part of the reason that everything's so messed up so I think it's right to right the wrongs that we've done (Post-survey)

	connections to environment	Human have damaged a gigantic portion of nature through processes such as deforestation and urbanization (Pre-survey)
	Moving from not knowing to knowing	Today, I feel like our environment is getting worse day by day. People are not aware about the environmental issues we have today, or even if they are aware, they don't do anything to support and improve our surroundings. Some people also do not believe in environmental issues, such as global warming. I feel like our community do not have enough awareness about what is going on, especially in Hawaii because we don't really feel the impact of environmental issues. (Interview # 2)

Stage 2: Environmental Action

In Stage 2, I looked into understanding how my participants went from being aware of the environmental issues or concerns to developing committed active engagement in the community. Examples of such engagement may be living sustainably, participating in an environmental event, or volunteering to clean up local beaches, etc. Environmental action is defined as a specific pro-environmental behavior that has been performed by the participant. In this study, environmental action was captured on the pre- and post-survey with three unique questions asking of the frequency of several pro-environmental behaviors. They are, "It is my responsibility to take care of the environment, I always think about how my actions affect the environment, Many of my everyday decisions are affected by my thoughts on energy use." Likert scale options ranged from "Strongly Agree" to "Strong Disagree". When participants selected "Agree" or "Strongly Agree" to two out of three survey questions above, they would earn a "checkmark" for their answer. "No checkmark" if they agreed with one statement only. Choices of "Neutral," "Disagree," or "Strongly Disagree" would not earn any "checkmark" (✓).

Similarly to Stage 1, two open-ended questions, "What is your motivation to continue environmental behaviors?" and "List up to three things you can do to take care of the

environment in school/home?" were added to the survey to grasp the participants' general knowledge about their pro-environmental behaviors and to confirm if they possess some pro-environmental behaviors. Most participants were aware that current state of direct impacts their future. This idea is echoed in the following quotes, "My motivation is from my drive to want to be alive in the future, I also love nature and feel that since nature does so much for us, the least we could do is take care of the environment like it does to us, my motivation is that, if we continue to care for our environment then my children and their children will live good lives, I want to live in a clean world in the future, I want the world to still be livable when I'm older, or I don't want our planet to become a dessert, I want my children and grandchildren to be able to see and enjoy the natural beauty of flora and fauna, not to see a wasteland."

Three commonly mentioned actions in participants' surveys were conserving electricity and water, recycling, walking to school rather than by car. Their answers are written in either past or present tense, to indicate that these are actions the participants already partake in, not actions they hope to do or know about. Table 10 lists all the actions of thirty participants.

Table 10

List of Environmental Actions

Environmental actions	
• Pick up trash • Recycle plastics, paper, and cans • Throw and pick up trash • Ride the bus/bike • Mind usage of water • Conserve electricity • Don't liter • Take shorter showers to conserve water • Unplug things that aren't in use. • Find alternative ways of transportation (walking, cycling)	• Tighten faucets so no water wastage • Turn off lights when not in use. • I reduced consumption • I conserve water • By having schools put up recycling bins, we can reduce litter/pollution to the environment • At home, energy use can be minimized by turning off unnecessary power sources • Eating all of our food reduces food waste. • Reuse plastic bags

• Go for renewable energy sources (solar panels, hydro powered machines) • Only take as much of a natural resource as you need (fish, plants)	• Join programs that go out and clean our environment.

While the students were aware of environmental issues, they also expressed a lot more care about environmental issues and increasing environmental actions in their daily lives. One student commented:

> I learned that the environment is really important. Also, that what I do affects my environment because according to what I did, my plants benefited or did not from the garden. For example, I forgot to water plants for a few days, they would not grow properly. Therefore, taking care of the environment should be one of the most important priorities.

In another student's assertion, he said:

> Through working on this project, I have gained the knowledge and realization that taking care of the environment is very important. I display this now by regularly checking up on and watering my garden. In the future, I will display the same concern and care for other practices that benefit the environment, such as waste management and recycling, as I have had experience with my actions this past school year.

During SBiC, I frequently heard from the participants about their behaviors and their newly demonstrated attentiveness and earnestness for the Earth. In terms of enacting behaviors, they made comments such as, "I get so serious now," "I'm crazy about not wasting electricity," "I get so mad at them, and "I'm like, No, you have to recycle!"

Although I may not be able to collect observation data on whether all thirty participants actually performed their claimed actions, I could get a sense of what environmental actions

meant to the embedded participants. To get this information, during the first focus group interview, I asked all participants to answer: “What actions do you take for the environment?” All participant responses indicated that they generally had an awareness of environmental issues and they were inspired to act on those issues. In the last focus group interview, I asked my participants, “What five environmentally sustainable behaviors or lifestyles do you live? And why?” Table 11 recorded their actions throughout the SBiC.

Table 11

Environmental Actions of Three Embedded Case throughout SBiC

Participant	Surveys	Focus group interview #1	Focus Group interview # 3
Olivia	•Recycle; •Tighten faucets so no water wastage; •Turn off lights when not in use.	Being the president of the Leo Club and Go-Green Club has helped me because now I am more aware of how much the environment and all organisms that live within are affected by our careless actions, and that my small steps to help do amount of something.	First, I voluntarily pick up trash every month through my school’s LEO club program, where we call it “Monthly Beach Clean-ups”. Second, my family also switched to using LED lights, which helps save energy usage. Third, I often take quick showers, and try to save water by not taking long hot baths. My fourth lifestyle is that I collect cardboard boxes, Styrofoam, and other materials that would come with items I purchase, and use those materials for later projects. And lastly, I recycle my plastic bottles, cans and used papers, where I collect to a certain amount and recycle everything when it is full.
Damien	•Conserve electricity; •Don't liter; •Pick up trash and throw it away.	Knowing that if you don’t have good environmental behaviors, Earth may be a place that can’t have human life. A lot of continents and countries are affected by	I try to incorporate environmentally sustainable behaviors or lifestyle. The 5 things I do is: being aware of the amount of water I am using, never wasting food, donating my clothes to other

		global warming and that is because of humans.	people if I no longer fit or wear them(and in good condition), growing my own vegetables, and picking up trash on when I am outside. I do these things to help and preserve the environment. I feel better knowing that I am doing less harm as I can to the environment.

Table 11 (continued)

Environmental Actions of Three Embedded Case throughout SBiC

Participant	Surveys	Focus group interview #1	Focus Group interview # 3
Edward	•Pick up trash •Recycle; •Ride the bus/bike		First, I use public transportation to go school, or even if I am going out because it can reduce annual carbon monoxide emissions. Second, I use recycled bags instead of plastic bags whenever I am buying from the stores, because it reduces the chance of plastic pollution. Third, I carry a water bottle instead of using water cups every time I drink to reduce the amount of water cups being thrown per year. Fourth, I reuse things for my projects that is found at home, like boxes and ribbons from my present to not only recycle but to reduce my spending. Lastly, I volunteer for events, such as beach clean-up and picking trash to clean our environment for our own safety.

As shown in Table 11, all three participants in my embedded case study increased environmental action in their home lives, with the majority of their behaviors related directly to

their projects. At the beginning of the study, when asked to list their actions that show their care for the environment, their responses were similar to all of others who were involved in this study. There was a great jump of their actions from the interview # 1 to interview # 3. For example, two out of three stated that they paid more attention to the amount of time they showered. Olivia reported changing the light bulbs in her house, and being conscientious not only to turn off the light at home, but also at her friend's house when she visited. All three reported expressly that they "put into practice" all the behavior changes that they hoped to teach others after the completion of SBiC. Edward reported that he recycled more and frequently. He even reminded his friends and family to pick up their litter and recycled plastics, cans, and paper. Like Edward, the majority of the students reported more consciousness and action regarding trash and recycling.

Sub-stages of Stage 2:Environmental Action. There are four sub-stages: accepting responsibilities, expressing care for the environmental, taking on a role and thinking as environmentalist. Although they were not able to be observed in this study, the sub-stages listed below indicate the behaviors of environmental identity before reaching Stage 3. Since not all of the participants demonstrated these behaviors, one student from the embedded case study surpassed the Stage 2, and ended in Stage 3.

Sub-stage 2.1: Accepting Responsibilities

Sub-stage 2.2: Care about consequences

Sub-stage 2.3: Taking on a role

Sub-stage 2.4: Thinking as environmentalist

Stage 3: Taking Initiative

This final stage consists of taking initiative through environmental action. This means that participants see action as an outcome of increased salience and empowerment (Kempton & Holland, 2003). In this study, when participants understand who and what is involved in environmental work, know what needs to be carried out, and become mentors for others, they are placed on Stage 3 of SEID. In addition, participants reach Stage 3 when they have played a key role in their community, such as leading a Go-Green or Environmental Club, teaching a class about environmental concerns, or meeting with school administration to discuss saving electricity school wide, and so much more. Throughout my study, only one participant who was placed in the last stage due to her actions and the environmental knowledge.

Table 12 shows the emergent themes that I utilize as a guideline for placing students on the SEID.

Table 12

Emergent Themes of Three Stages Indicators

Stage 1:Environmental Awareness	• Global warming • Climate change • Acid rain • Air pollution • Water pollution • Biodiversity loss	• Ozone layer depletion • Waste generated • Resource depletion • Overpopulation • Food production • Deforestation
Stage 2: Environmental Action	• Reduction water consumption • Decreasing energy usage • Green purchasing • Public transportation • Walk to school	• Saving nature resources • Recycle • Buy local products • Plant trees Reducing Food Waste
Stage 3:Taking Initiative	• Expert in helping combat environmental issues • Key role in the community	

Through learning and doing *Carton2Garden Project*, the participants expanded their awareness of the issues and their view of how they could impact the environment. Many stated that learning by doing increased their awareness of what the issues were, made them more conscious of their behaviors and the impacts of those behaviors, and expanded their view of the reach of environmental issues.

Below is the reflection of one participant after completing the SBiC:

> In my opinion, several environmental skills are essential to have. One such skill may be awareness. Having basic common sense of what you are doing and how it may affect the environment around you is important in knowing what you should and should not do, and also encourages you to think of better ways you can do something without hurting the environment. Another skill may be the knowledge of how to tend to or grow plants. Everyone in life has to learn how to take care of each other, because we all care for others. If we can care for others, then we certainly should show that we can take care of the Earth; and a small plant even more so. By being able to properly germinate, plant, and take care of a plant, we gain valuable skills such as attentiveness, patience, and responsibility." (Female15, Reflection#3)

Finding 3: The impact of SBiC on participants' environmental identity based on the Scale of Environmental Identity Development (SEID)

The Scale of Environmental Identity Development (SEID) is a tool to capture the growth of the thirty students as a whole, and three embedded cases. Below I explain how the whole case

(i.e., the class) generally move along the SEID and then describe more specific movement of students via three embedded case study students.

Whole Case Study Findings

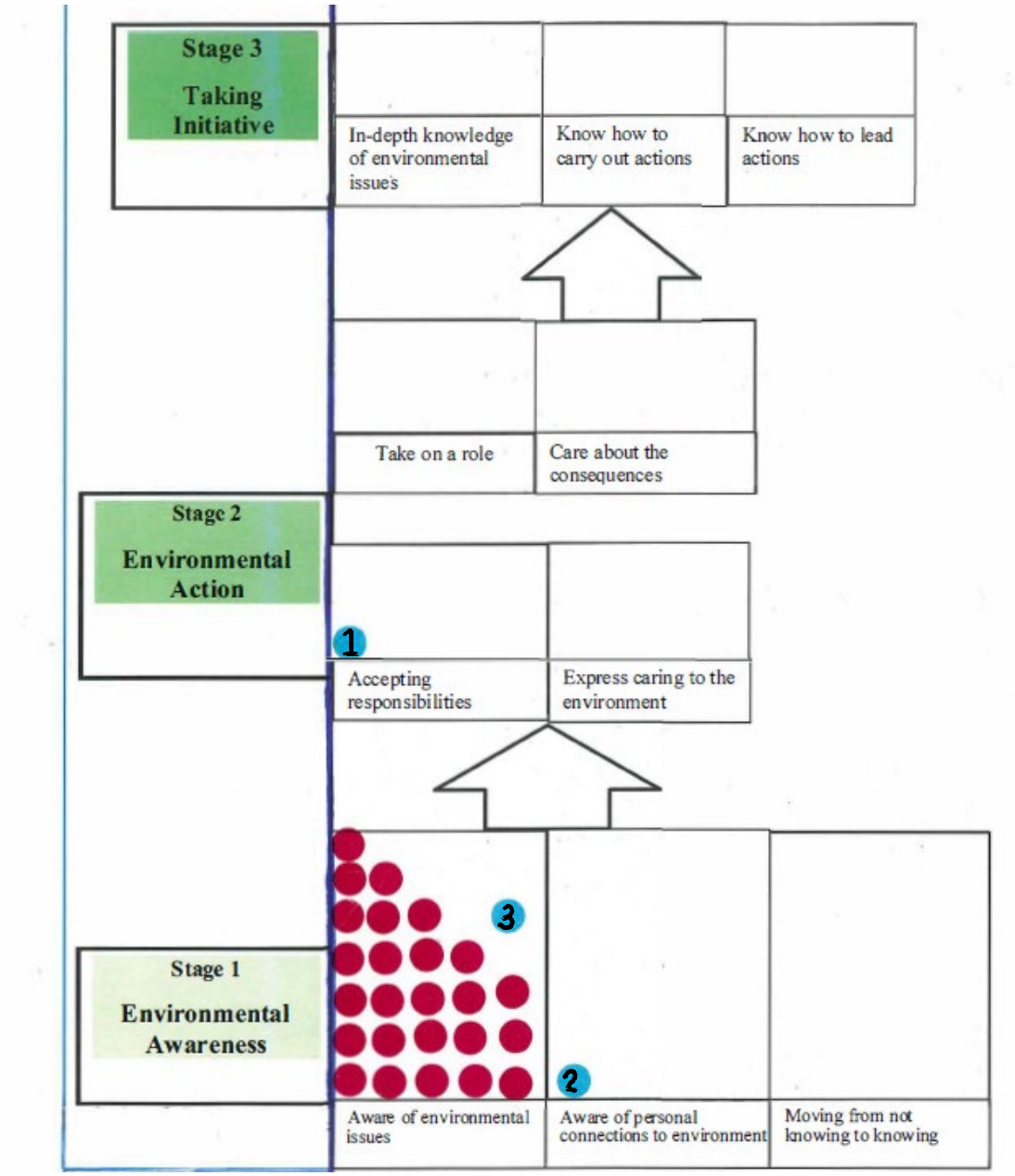
Analyzing using SEID revealed small or marginal shits in participants' environmental identities from the first stage of the unit to the end of the unit. Out of thirty participants, 29% shifted from Stage 1a to Stage 1b, 39% shifted from Stage 1b to Stage 1c, and 18% shifted from Stage 1c to Stage 2. Only one of the embedded case study students, demonstrated a shift from Stage 2 to Stage 3. (See Figure 8 and 9)

Figure 8 demonstrates the placing of students on the scale of SEID before The implementation of SBiC. Twenty-eight students were placed on Stage 1 and Sub Stage-1A after taking the pre-survey because they provided accurate descriptions of environmental issues based on their initial survey answers. Every participant was asked in the pre-survey to list at least 5 environmental issues they know of, and had successfully done so, demonstrating their environmental understanding of current issues. Participants had specifically mentioned environmental issues such as global warming, climate change, deforestation, over populations just to name a few. One student on Stage 1, Sub-Stage 1B because he was aware of personal connections to nature, "I share the same habitat/environment with the living things. I hold power to greatly impact the lives of other living things, for better & worse". There was one student who began on Stage 2, one stage completely above other participants This student mentions "I don't want the Earth to suffer in return having humans and living things suffer as well. My motive is to prevent further pollution in our environment so I volunteered to beach cleanup every month with Leo Club". She described in her pre-survey about her environmental activities, even though the

question had not explicitly asked for such. She accepts her responsibility to take care of the Earth by going out and already doing activities such as beach cleanups, placing her in Stage 2.

Figure 8

Tracking of Students' Environmental Identity before SBiC Implementation



Note. Each red dot represents a participant from the whole case, and each blue dot represents a participant of the embedded case, according to their case number.

Figure 9 demonstrates the tracking of students on the scale at the end of the implementation. Looking at Sub-Stage 1A, two students did not move at all, because their responses had stayed similar throughout. For example, in the pre and post survey, there is one open-ended question asked, “Are you aware of environmental issues? Yes or No, list 5 environmental issues that you know”. One of two students left that question blank both before and after the SBiC. The other student had answered with a “yes”, but did not further elaborate or list examples for both surveys. Also, these two students did not mention any attitudes or behaviors as well as their actions toward the environment. As a result, they remained on Stage 1, Sub Stage 1A. Eight students in Stage 1 Sub-stage1B had moved from the previous Sub-stage 1A. To evaluate these students, another open ended question asked “Do you think it's important to care about the living things around you? Yes or no, explain.” These eight students had seen that human activities and other organisms in the environment are all interconnected. Quotes such as, “Yes, I do believe that it is important because it’s on us for our future. Method of activity and living that is cyclical rather than linear in the hope of drawing less on the environment. Our well-being and the well-being of other living things are interrelated. We must learn about the organisms around us in order for all of us to coexist in harmony”, or “Yes, because you need to be mindful of your actions, and how they can impact the living things around you, good or bad”.

The next cluster of eleven students moved horizontally from Sub-stage 1A to Sub-stage 1C because they had shown a lot of knowledge in their post-survey, about environmental issues, and human impact. They were specifically aware of the actions that needed to be done in order to make a difference regarding the environmental issues they listed. The reason these students were not in Stage 2, because they had not mentioned specifically in their three reflections, or lab reports that they had taken such actions themselves. In short, this group of students in Sub-stage

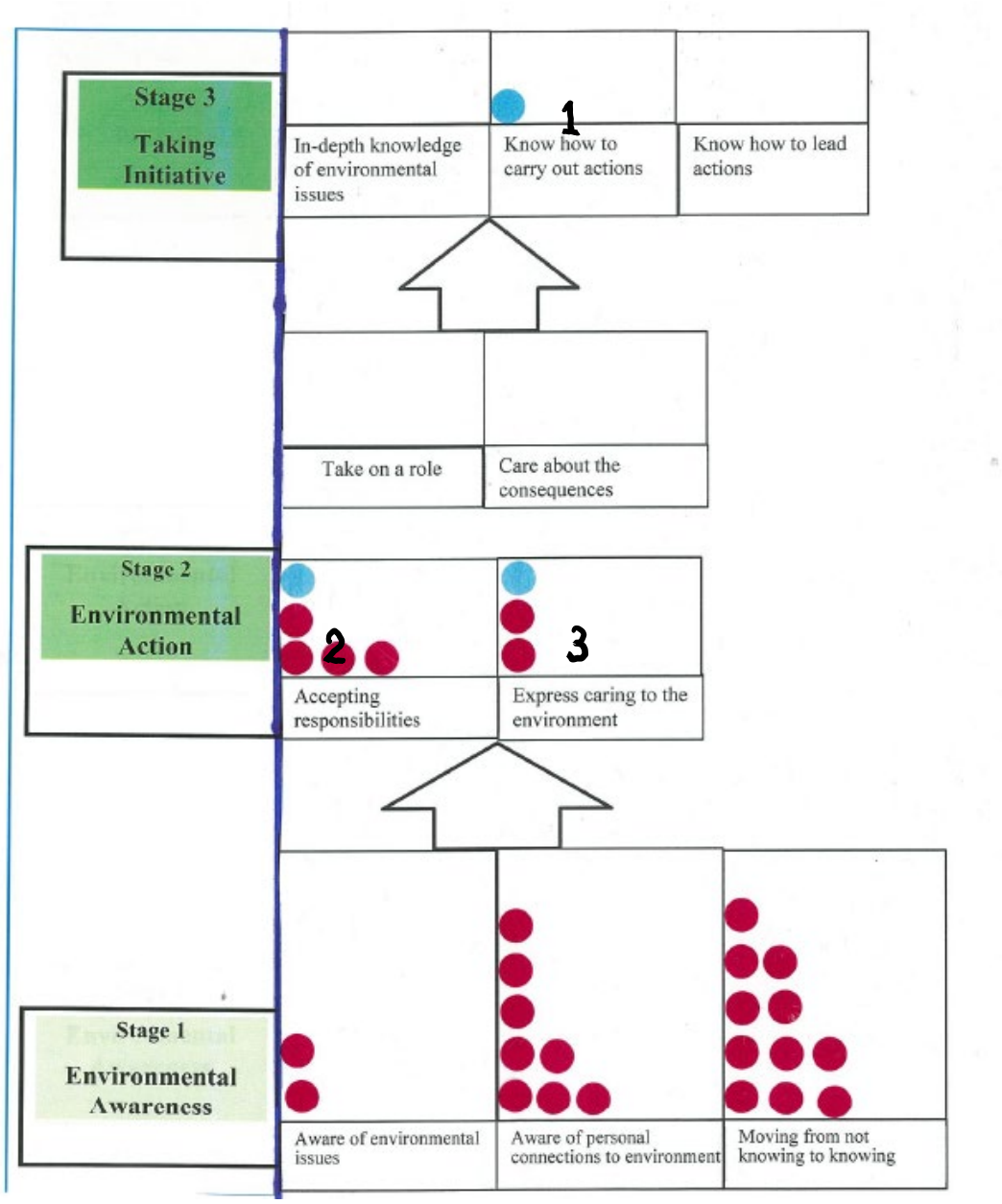
1C were aware of the need to take action on environmental issues, but did not portray these actions themselves. Some responses from this group to demonstrate that they understand the environmental issues such as, “After doing lab activities and projects on how everything contributes to a clean environment, I think humans have to do their parts too”. This student did not elaborate on what tasks or actions that humans need to do to contribute to a clean environment, and because of that, this student was placed on the last sub-stage of Stage 1.

As for Stage 2, “Environmental Actions”, I had observed these eight students moved up from Stage 1 during the building of their milk carton gardens. They had shown their care for their garden or school, and I had noticed that they were also doing things such as recycling on campus, and throwing away any litter they see. They had also put in their reflection, “Throughout the entire journey of this project [Milk Carton], we involved many students from our school. Asking around for milk cartons, not only that but also asking to borrow tools. From the project we got many students collaborate together to help everyone achieve the goals of one hundred milk cartons per group, which in fact did build some teamwork. The project had sort of got our entire school involved in a sense which really is something, even assemblies don’t get as many people involved as this.” Clearly, this student demonstrated he cared for the environment by involving many people in helping him complete his project. Another quote such as, “recycling has been the easiest sustainability action to maintain because I have the recycling bin at home, it makes more convenient for me”. This student stated on action that she practiced regularly and because of that, she moved from Stage 1 to the beginning of Stage 2, “Accepting Responsibilities”. Finally, one student was placed in Stage 3 at the end of the curriculum. This is the same student who had started off in Stage 2, at the start of the study (see Figure 8). This

student was observed more closely in the embedded case study, so more details about her development of environmental identity will be told in more detail there.

Figure 9

Tracking of Students' Environmental Identity after SBiC Implementation



Note. Each red dot represents a participant from the whole case, and each blue dot represents a participant of the embedded case, according to their case number.

Explanations of How Students Move Stages

At the beginning of implementing SBiC, pre-survey questions served as the starting point to assess students' knowledge about environmental sustainability (See Appendix A for full description of Pre-post survey). Survey questions were grouped into different stages of the SEID. For example, questions were identified with *Environmental Awareness*, including "I am aware of environmental issues, my feelings about nature affects how I live my life, my relationship to nature is important part of who I am." When participants selected *Agree* and *Strongly Agree* to the survey questions, I placed them on Stage 1: Environmental Awareness. Twenty-seven out of thirty students or 90% were on Stage 1 of SEID. None of the students from the whole case presented the connections with human and nature, except one student from the embedded case.

Throughout the SBiC implementation, I brought up the connections of environmental systems and sustainability. For example, I showed students photographs of my grandmother's hometown, how water was being treated for bathing and drinking. I used those pictures as an interest hook for the day and I brought up an issue to consider, such as what if Hawaii, in specific, or the whole wide world did not have clean water to utilize, what would they do? During class instruction at all times, I encouraged a lot of back and forth dialogue with the students to informally assess their thoughts or understanding about the environmental system. I also discussed the kinds of environmental issues that are impacted by human activities, and reinforced these ideas regularly. In summary, I provided many examples of environmental issues and helped students visualize how they interconnected.

Post-Intervention

I assessed students' initial and final expressions through pre- and post-survey, three reflections, three lab reports and final project. To determine students' growth, I looked for

changes in language or definition which include an understanding of how students demonstrated about environmental issues, and environmental actions.

The quotes listed in Table 13 highlight how the participants grew in their interpretation of their relationship with the environment, through their own beliefs and experiences. For example, Female15 at the beginning of the SBiC, she was on Stage 1, Sub-Stage 1A. On the third reflection, she demonstrates the impact of her conceptions of the human-environment relationship based on her experience with taking care of her garden over time. At the end of the curriculum, she was still on Stage 1, Sub-Stage 1C because she explained the interconnection between human and environment, and she did not list any actions to take care of the Earth. Male3 exhibits his belief that humans must make decisions to care about the Earth instead of destroying it. He ended up on Stage 1, Sub-Stage 1C as same as Female15. On the other hand, Female10 shows the growth of motivation to do the right thing to help the Earth, she moved up to Stage 2 at the end because she listed some actions that could help the Earth. A majority of the participants felt that humans and the environment are interconnected, and they understood that personal actions contribute to the changing state of the Earth.

At the end of SBiC implementation, students collected 100 empty milk cartons from school cafeteria and they designed to build a garden from those. At first, students did not appear to make strong connections to the environment. After collecting and analyzing data from soil, ozone and acid rain, students seemed to have a better understanding of environmental issues or human actions. One student wrote: “On this planet, we have soil, oxygen and water, which are essential to human live as well as other organisms. If we are destroying it, we are not only killing animals, plants, etc., but we are killing ourselves. I’ve learned that if we start to do any simple activities, like recycle, we can actually help our Earth”

Table 13

Students' Expression Regarding Relationship between Human and Environment

Participant	Reflection # 1	Reflection # 3	Interpretation
Female15	Environment is all the living things around you because there can be other humans +animals they deserve as much as you to.	I learned that the environment is really important. Also, that what I do can affect my environment because according to what I did, my plants benefited or did not from the garden. For example, I forgot to water plants for a few days, they would not grow properly. Therefore, taking care of the environment should be one of our most important priorities.	Expand knowledge on how important the environment is. There should no lacking of take care of it even for a short time.
Male3	Environment gives us knowledge about where we live and how to take care of it. We need the living things alive, so let's make sure we know what we are doing with it.	We have powers of manipulation over our physical universe which make our choices crucial to other forms of life on the planet. We are caretakers or destroyers, and because we also have the gift of self-consciousness we must collectively make certain decisions about how we live.	Human should take care of the Earth instead of destroy it
Female10	Environment are all the livings that are a part of our world and we should be aware of our surrounding as well.	On this planet, soil, water and air are essential to human live as well as other organisms. By destroying it, we are not only killing animals, plants, etc., but also ourselves. This motivates me to do simple activities (such as recycle, turn off lights when not in use) which I can help our Earth.	Show the growth of motivation to do the right thing to help the Earth

Table 14 indicates the growth of students in the whole case and the embedded case. Each checkmark "✓" is earned when a student's context matches with the corresponding description

on the SEID more than three times. If students demonstrate their expressions less than three times, they will not earn a checkmark.

Table 14

Summary of the Growth of All Participants

Participant #	Stage 1		Stage 2		Stage 3	
	Before	After	Before	After	Before	After
1	✓			✓		
2	✓			✓		
EMBED # 1			✓			✓
4	✓	✓				
5	✓	✓				
EMBED # 2	✓			✓		
7	✓	✓				
8	✓	✓				
9	✓	✓				
10	✓	✓				
11	✓			✓		
12	✓			✓		
13	✓	✓				
14	✓	✓				
15	✓	✓				
EMBED # 3	✓			✓		
17	✓	✓				
18	✓	✓				
19	✓	✓				
20	✓	✓				
21	✓	✓				
22	✓			✓		
	Before	After	Before	After	Before	After
23	✓	✓				
24	✓	✓				
25	✓	✓				
26	✓	✓				
27	✓	✓				
28	✓	✓				
29	✓	✓				
30	✓			✓		

Next, each check mark "✓" from Table 14 was counted and numbered into Table 15 as shown below.

Table 15

Tracking of 30 Participants' Environmental Identity before and after SBiC implementation

			Before	After
STAGE 1	Aware of environmental issues	Whole case	27	
		Embedded case	1	3
	Aware of personal connections to environment	Whole case	0	15
		Embedded case	1	3
	Moving from not knowing to knowing	Whole case	0	0
		Embedded case	0	3
STAGE 2	Accepting responsibilities	Whole case	0	15
		Embedded case	1	3
	Express caring to the environment	Whole case	0	8
		Embedded case	0	3
	Care about the consequences	Whole case	0	8
		Embedded case	0	1

Embedded Case Study Findings. The following findings focus on the experiences of three students (Olivia, Damien and Edward) in my embedded case study. The results for each student were divided into sections corresponding to each stage of the SEID presented in Figure 8 (pg. 102). Section 1 of three focuses on the environmental identity of each student before the intervention. Section 2 corresponds to the student's environmental identity during the course

content and interacting with other elements of the class culture. Finally, in Section 3, the effect of the course content is analyzed and compared amongst other cases.

Embedded Case Study Student 1. Olivia was a sophomore student in a public high school. Her parents live in Hong Kong and she moved to Hawaii a few years ago. Since she does not live with her parents, she has taken on many of the tasks that adults often perform in a household, such as buying food and supplies for her living. She lives with her older sister who is a student of the University of Hawaii. She does not participate in any team sports at school, but she likes to participate in many clubs that involve volunteering such as Key Club, Leo Club. Olivia is the president of the school's LEO Club.

Pre-Intervention Enviornmental Identity. Olivia came into the class with a strong environmental background. She spent time volunteering outdoors. Every month she leads her Leo Club to do beach cleanup across Oahu. Every three months, along with other Leo Clubs from other public and private schools on East Honolulu, she participates in pick up trash along the roadsides, or Ala Wai or Makiki Stream. On her free time, she reads news about the environment. At the beginning of the unit, Olivia showed some signs of being in stage 1, *environmental awareness*, and stage 2, *environmental action*.

Every time Olivia comes to class, she always spends a few minutes of her time to update me about what she did over the weekend, whether she recently read an interesting article, or if she harvested new vegetables from her yard. During the first focus group interview, Olivia stated, "My sister is not part of any organization that is environmentally active, but we try to- we recycle a lot, we use organic cleaners, cleaning products, and she would scold me if I bring home a plastic water bottle." (Focus group interview #1, 1/22/2018).

Olivia's statement indicates that her sister shows sustainable behavior, and it is evident that Olivia learned from her sister when initiating these environmental actions. Olivia always carries her hydro flask around at school, and she packs her lunch box with reusable utensils. Due to Olivia's pro-environmental behavior, she has already accepted her responsibility in the environment, and not just her, but her family also cares about the consequences that the future holds if environmental action is not taken. She has already placed herself into Stage 2 of the SEID, where personal action is undertaken. In discussing the major environmental influences on her, Olivia mentions that she has developed that lifestyle growing up, since she has lived in Hong Kong for several years. She recalls when that her parents had to purchase water from some neighbors due to the old system of water pumps. She lived on a high rise in Hong Kong. Her family can only use two buckets of water for cooking and personal hygiene.

In her pre-survey, when asked about her concerns about the environment, she answers, "My concern is of global warming increasing as the years go by, and the lives of aquatic animals, as there are many news stories about how fish and turtles eat anything they see, including plastics."

Environmental Identity Expression During Intervention. Olivia actively engaged with the course content and maintains high grades in the SBiC unit. She often reflects strongly with the issues discussed in class, and tries to figure out how they fit in and relate with her prior knowledge about the topic.

Olivia was much more outspoken during the focus group interviews than the other two participants. Olivia repeatedly spoke of showing her peers the effects of their actions. She did not appear to critically reflect on her potential role in the problem during the interview, and she seemed to perceive a means for future action.

Her Stage 2 of environmental identity "Accepting responsibilities to the environment" echoes when describing the environment, "One earth is all we have. Once it's done, it's over." Yet, she is quick to assert that, "In our current community, everything is dependent on technology; however, these technologies make use of resources that came from our environment. If the environment is not maintained well, the resources being used would constantly be decreasing more and more, and soon we will have a limited amount left. So, it's important for our community to know what we are dealing with in order to maintain the amount of products being produced through resources that come from our environment." (Reflection #1, 1/18/2018).

The quote above is an example of how Olivia shows her understanding of the relationship between human actions and the environment. She notes that if humans utilize all of the resources from earth, eventually there would be not enough for the future generations.

Olivia entered the class thinking that she herself is an environmentally responsible person, until she took the ecological footprint calculator as part of an in-class assignment, which makes her realize she has a ways to go. As she says: "When we took the ecological footprint quiz, I got something like 'If everyone on Earth lived like you, we would need 6.5 Earths', and I was a little surprised, and I wasn't sure like what I could do to change that beyond- like I mean there's only so much that I can do, you know."

Olivia expresses a small frustration here, and this is a common response to environmental identity disconfirmation, where the individual blames others or external aspects of their situation for the discrepancy. However, rather than letting these results discourage her, Olivia finds a sense of empowerment and ultimately ends up changing a significant behavior of hers, which was giving up eating meat during all her lunches. In Olivia's reflection, she attributes this decision to activities in class: "I still eat meat, but I try to eat less. Instead of bringing a roast beef sandwich

to school, I have peanut .butter and jelly." She admits after completing of the "Carbon Footprint" activity, that she was back to her old habit by consuming meat during dinner on the weekends. Thus, it seems as if there is a limit to the change that Olivia is able to make in response to reduce her carbon footprint.

Another sign of Olivia's empowerment is when she builds a milk carton garden as a part of an in-class project. This project was a team project. Students chose their own team members and together they have to build a garden with recycled cartons. Olivia's group decided to build the garden based on the milk cartons they collected from school. She then realizes that she has to do something for the school. When she sees students throw the aluminum cans in the trash bin, or when they leave their lunch trays on the ground, she says, "I was so mad when I saw someone just walk away without throwing away their trash even though the trash can is only a few steps away." Olivia displayed emotion here as she noticed the act that could harm the environment.

Olivia showed empathy, a typical response from other participants in the class, and, unlike most of her peers, she was unafraid to take a critical stance on society's inaction. On the Mole Day celebration, Olivia suggested that each student must bring in a plate, utensils instead of I provided to the students as I always do for the last 20 years. She then added while I made an announcement, "If you bring in disposable utensils, you will not be able to taste food from other groups." Even I consider myself an environmentalist, I did not see the big picture of being environmentalist. I hope she would continue this habit think of the environment on every step or action you do.

On the last activity of the SBiC, participants were required to maintain the garden they build for one month in order to get a maximum points. In order to maintain the garden well, participants must water regularly, add fertilizer one a week, monitor the garden from other

species around. There was time when Hawaii was raining for five days straight, most of the plants were ruined because there was no drainage of their cartons, or lack of caring. Olivia's planters on the other hand, was still standing. When I asked her during the focus group interview, this was her sharing:

"David (Olivia's partner) and I took the bus to come to school to move the planter out of the rain, and to the hallway. Yah, I am glad that we designed the movable planter, so it was easy to carry. We had to catch a bus by ourselves, and we were so cold and wet! But afterward, seeing our plants were still alive after rain because we had rescued them, we were so happy!"

Olivia again indicated her strong connectedness with the environment. She expressed her environmental identity as "taking a role" and "care about the consequences". Kempton and Holland (2003) noted that action can precede identity when individuals take on an enabling role in a figured world; they identify them as an environmental actor to others in the community. This causes them to see themselves as an "environmental actor" and subsequently leads them take on that role. As a result, person that identify with the role of "environmental actor" requires that they care about the consequences of their actions, as it relates to how others in that figured world perceive them. Olivia knew all along that if she did not move her plants out of rain, her plants would be ruined afterward. Also, she did not act by herself, instead, she called on her team members for help. Her act confirmed that she was on the last sub-stage of Stage 2, and ready to move on to Stage 3 (see Figure 1, pg. 76).

She later goes to talk to the principal and asks for his permission to put ten recycle bins around school. Still yet, the blue recycle bins are still located under each building and as I pass by a recycle bin on campus, I am reminded of Olivia's desire to make the community more sustainable. This act has confirmed that Olivia knows exactly what needs to be done and she

carries on her act to help the environment. And because of that, she is ready to move to Stage 3, gaining knowledge through environmental action.

Post-Intervention Environmental Identity. During the last focus group interview, Olivia reported monitoring her boyfriend by telling him what to do, such as to put his trash in the garbage and recycle his plastic bottles, and by teaching him what she was learning in the SBiC. She seemed to feel pride in being able to "educate" her boyfriend. She was excited to share her experiences of what she was learning to her boyfriend, and other close friends. Her enthusiasm increased when she realized that she was the environmental expert in relation to her friends.

Olivia was the only student who has reached Stage 3 of the SEID. In the third stage of environmental identity, a person knows how to carry on actions or lead action. Olivia carries on her strong environmental identity, as she wants to have a club that aims to educate high school students about environmental issues and how to live sustainably. Not surprisingly, she grows to become the president of the Go-Green Club.

Overall, Olivia came to class with a strong environmental identity resulting from her lifestyle at home, reading, and volunteering. The SBiC serves to strengthen her environmental values, while disconfirming aspects of her consumer-materialist identity. Her decision of knowing how to carry on an environmental behavior is a significant step for her in furthering her environmental identity development. When developing the SEID, I created a hierarchical scale with Stage 3 because of Olivia. She has surpassed all of the participants and she was the only one to reach Stage 3, ranking the highest on the SEID. I see Olivia as a budding environmentalist, indicating that she will take her environmentalism to new levels in the future.

Embedded Case Study Student 2. Damien is also a high school sophomore, and is in the same class as Olivia. Damien is a small, quiet student who is very cooperative. Damien gets

along well with his peers and tries hard to do well. His parents are very involved with him and want him to do his best. They have always made appointments during every parent conference. Unlike Olivia, Damien has a very full plate and involves himself in many clubs and volunteering opportunities. He is a valuable member of the school's National Honor Society, Math Team, Science Olympiad, and Science Bowl Team. He is also the first Vice President of the school executive student body government. He hardly has any free time for himself, and is always busy. Damien's household consists of three people, his father and his mother.

Pre-Intervention Environmental Identity. Unlike Olivia, Damien's family of three was very big on their consumptive behavior, owning two refrigerators, five computers, three televisions, gaming consoles such as an Xbox, and a PlayStation 2, in addition to buying excessive amounts of food that often "go bad". In the first focus group interview, Damien says that his household only consists of three people, and they use 10 dishes for dinner. He says that because there are so many dishes used during the preparing and eating of the meals, it always takes his mom roughly two hours to finish cleaning dishes well.

Damien has developed a sense of environmental awareness because of a trip he made to Japan, where he stayed there for a month as an exchange student. Damien stayed with a Japanese host family who lived sustainably. At first, Damien had a hard time cutting down his shower time shorter, and he was surprised when he found out that dinner was served on only one dish, and that they didn't need to use up as much time and water to wash dishes. Damien has also developed good habits such as turning off all lights and electronics at 9PM, to prevent using up too much energy and electricity. When he comes back home, the good environmental behaviors that he learned from his time in Japan go down the drain as it was only a temporary behavior of

his. In his survey however, he shows an in-depth understanding of environmental issues of how the actions of humans affect the environment.

Environmental Identity Expression During Intervention. During the second focus group interview, Damien expresses how he feels limited as to what he could change in his living style. Here he is blaming his living situation (external circumstances) for the negativity he is feeling. He seems to be moving up on the SEID. However, rather than changing a more culturally-embedded behavior like Olivia, which was meat-eating, he decides to change many smaller behaviors to reduce his carbon footprint. The following vignette is the excerpt of the second focus group interview between Damien and I, after the class completed a carbon footprint activity.

ME: Hi Damien, is there anything that you changed right after the carbon footprint activity?

D: Um, I use less water in brushing my teeth. Before, I loved hearing the sound of running water when I was brushing my teeth, so I just let the water run the whole time while I brush my teeth. I also take shorter showers now.

ME: How much shorter?

D: *smiles* Around 3-5 minutes.

ME: Nice, nice. So, is that a change, or you already did that?

D: It's a change. I used to take 30-45 minutes shower, and I used to take two showers a day.

ME: Huh!?

D: Yes, during the summer time, I might take more.

ME: Wow, okay, and now you only take one shower a day and 5 minutes shorter than usual.

D: Pretty much!

ME: Oh, okay. Anything else that you've noticed?

D: Um,…my dad likes to turn on the lights even though no one is in the room and he always leaves the TV on, even though he is not watching.

ME: Okay

D: I now go into the room and turn off the lights, and if he does not watch TV, I turn it off.

ME: How often do you do that?

D: Very often now.

ME: What did your dad do?

D: He did not say anything, so I think he is okay.

ME: Why does it matter to you now?

D: I think I did not realize that until now. Or maybe my parents never complain about the electricity bills...I don't know.

ME: How about your mom? Does your mom spend two hours watching dishes? Did you try to do anything to help her?

D: Yes, and I don't know how to tell her.

The above vignette shows Damien has changed his behaviors by conserving water. In addition, the behaviors are mostly Damien can make on his own and they do not require the support of others. This is an important example of the types of changes that are feasible for

individuals to make on their own. One great extent is that he is able to change his dad's energy consumptive.

Post-Intervention Environmental Identity. After seeing what Olivia did for the school by putting around the recycle bins, Damien noticed and writes in his reflection "By having schools put up recycling bins, we can reduce litter/pollution to the environment. At home, energy use can be minimized by turning off unnecessary power sources, eating all of our food reduces food waste."

Damien also notes in his final reflection that "Through working on this project[Carton2Garden], I have gained the knowledge and realization that taking care of the environment is very important. I display this now by regularly checking upon and watering my garden. In the future, I will display the same concern and care for other practices that may benefit the environment, such as waste management and recycling."

At the beginning, Damien and his family had something known as a "consumer-materialist" identity, where they bought a lot of food and they used a lot of energy and water. The selection indicates that now, he pays more attention to preserving and recycling. The effect of the SBiC seemed to be shifting Damien from Stage 1 to the beginning of Stage 2, "Expressing caring to the environment".

Overall, Damien is a great example of a student who is willing to critically reflect upon and consider changing some aspects of his lifestyle after he realizes his consumer identity is disconfirmed. One of the major differences between Damien and Olivia would have to be parental influences. Damien gradually alters the consumptive values of his family, such as energy conservation. Interestingly enough, Damien is also able to find ways to adjust his actions once he realizes that there are a number of ways to do so, and he learns that many of it is in his control.

At the end of the intervention, he is placed in Stage 2 of SEID, where he knows that there are actions that can be enacted even within his limited circumstances as a teenager living at home, signifying a substantial change in his environmental identity development.

Embedded Case Study Student 3. Edward, just like his two previous classmates, is also a sophomore. He is quiet and never misbehaves, despite always preferring to sit in the back of the classroom. Oftentimes Edward radiates an airy and aloof vibe to him, and he does not show any interest in science, often doing things only when he feels like it. He frequently fails to turn in work on time and does not participate in class often. He is a very capable student and could be earning good grades, but he does not put forth his best effort. I got to learn about Edward more through the focus group interview.

Pre-Intervention Environmental Identity. Edward grew up spending lots of time outdoors participating in athletic recreational activities such as running, playing basketball, biking, and even fishing with his dad. Edward's environmental identity coming into class is mostly based on these outdoors recreational experiences, which he realizes are not eco-friendly. Edward comes to class with limited environmental knowledge on the issues discussed in class and he describes, "the Earth is kind of going down," and he is quite open to learning new information about the issues, where he suggests, "If am more informed about it, I might change my lifestyle (realistically) to help conserve or contribute my efforts to help the world". Due to his lack of environmental knowledge and participation in environmental behaviors, Edward is at the low end of Stage 1 of SEID.

Environmental Identity Expression During Intervention. For the first focus group interview, Edward was quiet most of the time, and he only spoke when I called on him. However, during the second focus group interview, Edward talked more voluntarily. The following vignette

shows how Edward's environmental identity increases as he gains an awareness of issues he knew little about prior to SBiC.

> E: Say if I didn't work with my partner and build the Carton2Garden, I wouldn't have known that I could make a great impact on the environment.
>
> ME: What impact did you learn from building the garden?
>
> E: Well, first collect 300-500 milk cartons for my group to build the garden….and we have like, 10 groups, so our class collects the total of 5,000 milk cartons….and our school has about 2000 students….so about 2,000 milk cartons are in the trash…..daily….If we can build something useful from the milk cartons so we will have less trash in school.
>
> This statement shows that Edward is aware of the issues at hand, littering and recycling. Edward is now more attentive of issues regarding littering throughout the school campus and he is willing to do something about it. Starting out as a free floating, lazier student, Edward now has developed a drive and a sense of urgency when it comes to caring about the environment.

Post Intervention Environmental Identity. During the third focus group interview, Edward has become aware more of environmental issues, he realizes the environmental reasons for several of his pro-environmental actions. Edward states, "Yeah, I always turn off the lights and stuff. I mean, I've always done that before, but you know, now thinking about that, you know, it's actually using the energy, doing it cause of the energy reasons, not just to help my parents out" Edward also becomes more committed to his environmental actions that are affirmed by the class, including not littering. Here, Edward is describing how he has changed his behavior after the SBiC is done.

E: I would say, you know, recycling and stuff, I definitely throw my can in the recycle bin, or I would always just go to the garbage or something. Now I make the extra walk to the recycle bin downstairs, even if the garbage is literally three feet from my hand.

ME: Excellent!

E: Yeah, I do, I really do, you know, one time, I walked with my friend, and he threw his food wrap on the ground since there is no trash can nearby so I'm like… 'Hey bro…pick it up…' and my friend was laughing… so I knew that he wouldn't pick it up…so I picked up his trash and put the trash in my pocket…ME: Wow, that's fantastic!

E: Yeah, I was really mad at my friend...for littering. Cause in the beginning of class, I was like, "Oh yeah, recycling [with a negative, sarcastic tone]', but it really makes a big difference, you know, after I saw how 300 milk cartons could turn into a garden, you know, it's just a little change, but at least I'm going for it.

Overall, Edward represents a student that begins the class with limited knowledge of environmental issues, and through positive experiences and an open mind, his environmental identity is substantially impacted by participation in SBiC. Rather than making drastic changes in his behavior, Edward becomes more committed to activities such as recycling and not littering, which he considers feasible and worth the extra effort. Through his open commitment to the actions stated above, Edward ultimately serves as a role model for his friends. It is also important to note that Edward entered the higher rank in Stage 2 of SEID, which is "Take on a role" and "Care about the consequences". One major difference between Damien and Edward is their willingness to make changes. Interestingly, Edward comes to class with limited environmental knowledge on the issues and concerns compared to Damien, and since he is very open and is

willing to change his behaviors, Edward demonstrates a big movement on the path to develop his environmental identity.

Chapter 5

Discussion and Implications

Overview

This research study, *Fostering Environmental Identity with High School Students* presents valuable data and interpretations for teachers and researchers on the topics of promoting pro-environmental behavior, or living sustainably with high school students. This chapter begins with a brief summary of the overall study to reintroduce the importance of this topic, the purpose, and the objectives as framed by the research question. After is a summary of the results in the context of the research question and the scale created to evaluate the growth of participants' environmental identity. Finally, I will provide suggestions for future researchers to build upon this study.

Summary of the Study

I initially embarked on this study because I felt that environmental awareness was an important topic. In their longitudinal study of environmental knowledge with high school students, Gambro and Switzky (1999) state that "a majority of individuals possess a low level of environmental knowledge, and they cannot apply the knowledge that they learn to confront environmental issues and make decisions concerning future environmental hazards." Clearly, the future of Mother Earth is dependent upon educators raising the level of environmental knowledge in students. This statement is my primary exigence for this study, encouraging me to start a strong push in environmental education at the high school level.

The purpose of this study was to develop and improve curriculum and instruction, namely a sustainability focused biodiversity curriculum (SBiC), and evaluating the developed curriculum's influence on students' environmental identity.

For theoretical underpinning, the Conceptual Framework for environmental identity development that was constructed by Kempton and Holland (2003) was referenced. Kempton and Holland's model included three aspects of constructs that showed the growth of environmental identity: *salience, empowerment, and activism*. In this study, three stages of environmental identity were built upon the three common themes while analyzing data collected from students via reflections, interviews, and personal statements.

The study was bound by the number of participants (30) as a whole case and three (3) embedded case studies. I used several approaches in order to gain insight into the perspectives of participants regarding their environmental development (1) pre-post surveys, (2) participants' reflections, (3) pre- and post-tests, (4) focus groups interviews, (5) artifacts, (6) observations, and (7) field notes. I utilized a *maximum variation* purposeful sampling strategy, in which considerable effort was made to select participants that represented the diversity of the participants in factors such as gender, ethnicity, academic standing, and family socioeconomics.

Summary of Results

Two research questions of this study asked, "What instructional tools when added to the chemistry class will help to focus on the idea of sustainability?" and "How does a high school students' participation in a teacher-designed sustainability curriculum impact the expression of their environmental identity?" The answer to the first research question is embedded in the finding one presented in Chapter 4. The answer to the second research question is framed by findings two and three. A detailed explanation of this researcher's answer to each of these questions is provided below.

Design SBiC

By implementation of the sustainability focused biodiversity curriculum, I found that I can make a difference in students' environmental identity. It shows that if we design a curriculum that focuses on environmental identity, even the shift is relatively small which raises implications such as if we should implement the designed curriculum more often, or extend the curriculum to be more than 6 weeks, or applied the curriculum over years, etc. If these steps are taken, perhaps it could help to make a greater impact on students.

Based on what was learned in this study, seeing teaching SBiC just for three months had a marginal impact, there are multiple areas of support educators can offer to students, and thus we need to create a system on teaching and learning about environmental identity in students. This can be achievable in advocating for environmental identity in social media, advertisements, and more, to spread of environmental curriculum within chemistry context on a longer term.

Impact of the SBiC

To address the second research question, "How does a high school student's participation in a teacher-designed SBiC impact the expression of their environmental identity?" I utilized a hierarchical scale (see Figure 7) categorized by environmental identity based on three main aspects: *environmental awareness, environmental action, and taking initiative.* To keep track of the students' present behavior of environmental identity, I also created a flow chart for each participant. When all sub-stages of Stage 1 are established, then Stage 2 would be observed next. In this study, one participant reached Stage 3 because she was influenced by her family members and she was very active in community service. As the SBiC curriculum was introduced, participants began to think more about environmental issues. They then learned more and had success experiences that reinforced their learning about environmental issues as they collected

the empty milk cartons and turned them into a garden. I felt the need to design a SEID scale because of the students I worked with, who made it a place-based scale. However, others could take this SEID scale as a starting point and adapt it to their own workplace. For example, elementary teachers can use SEID, and instead of building up on three vertical stages, they can focus on Stage 1 and 2, and alter it with more sub-stages for Stage 1, or reduce 1 or 2 sub-stages for Stage 2. For higher educators, this scale could be utilized as the starting point and from there, they could add more stages vertically instead of expanding it horizontally. Overall, the SEID can be flexible to use as a starting point and depending on the participants' expression, the scale could expand in both directions, horizontally and vertically

Implications of Findings

The findings from this research confirmed that environmental identity development is possible to foster within the classroom context through designed curriculum. However, the movement is marginal. In order to make this curriculum to be impactful, more teaching tools or resources are needed over longer of time. I provide some suggestions in the future research section below.

The findings highlight that providing students with the opportunity to be aware of the local environmental issues, providing students with the opportunity to be an environmental actor, providing them the time and space to investigate such issues, giving them an opportunity to reflect on their actions, and allowing time to discuss ideas with their peers, were the key elements to fostering student environmental identity development within a classroom context.

The current study builds upon Kempton and Holland's (2003) research on adult environmental activists to accommodate high school students learning about sustainability issues within the education system. Kempton and Holland applied three stages of identifying

environmental identity to learning environments with a comprehensive and immersive focus on environmental issues. To widen the spectrum of observing environmental identity in people, this study extends it to the high school classroom context. This an important addition to the literature, as the classroom context represents a group with varying degrees of interest and commitment to the environment. The current study added more stages in tracking people's environmental identity which in turn may track down more people into a group with similar behaviors, or actions.

Blatt (2010) also studied environmental identity in students who enrolled in an environmental science program in a high school setting. She explored one class of environmental science over the course of a year, she explored the process of change in students' environmental identity and pro-environmental behaviors. She found that students who had an environmental background, were open to new environmental information, thought critically about environmental issues, displayed environmental behavior before coming to class, would change their environmental behaviors, and learned new ideas about environmentalism. She also found that these students who had a positive attitude towards school, and had a good relationship with the teacher and with their peers, were more likely to develop environmental behavior during her study. The current study found similar results in that the participants who had an environmental background before participating in SBiC, were interested in learning and exploring more about the environment. The dissimilarities of this study with Blatt's study was that she did not track or observe the impact of students throughout the year course. What I have been able to contribute to the field, was a hierarchical scale that I constructed, allowing me to observe the movement of students' environmental identity sequentially. The scale that I could track students runs vertically and horizontally.

The utilization of the SEID scale and its sub-stages are a valuable tool that can be used for other educators as well. I had initially created the stages and sub-stages based off of the first student reflections, and by recognizing the needs of the students. Thus, other instructors in other situations can use this SEID scale as a starting point and tailor it according to their teaching environment. For example, university educators can expand on their scale vertically, adding in more stages as more intricate concepts are introduced at the post-high school level. Elementary school educators, on the other hand, can focus on one stage, movement between the sub-stages alone, to simplify the curriculum for their students.

Recommendations for Future Research

This study focused on tracking the development of environmental identity of high school students by using SBiC. The scale of the growth of environmental identity was constructed to examine the growth of students over five months. There have not been any studies conducted where the students are tracked over a number of years to document how their environmental identity develops with age. This study could be expanded in two years as the participants are senior of their high school, and in four years as they are in the second year of their young adulthood. Next, the results in two, and four years would be compared with this current study. In addition, if participants continue to learn more environmental education in their years, their environmental identity could be tracked as a result of a longitudinal study.

In addition, this current study has described areas where further research is needed to both confirm and expand upon its results. We must continue to work as a researching community to help inform educators and students about the best practices to augment the environmental learning of our students. This study marks another step along the path to accomplishing this

worthy mission. After all, the youth are our future, and we must pioneer their education for them to be able to take action towards protecting this world.

Regarding the SBiC scale I created, I was not able to use it in its entirety in this study, specifically Stage 2 was not able to be observed in much detail. Implementing this curriculum to a time frame of an entire school year rather than three months may allow for a more in depth research, and for more time to observe the students' growth.

I had initially expected students to progress through the SBiC scale in a faster pace. However, it came down to students such as those in my embedded case study, who had first came to class with prior knowledge regarding the environment. Creating an initial survey to get a better grasp about their prior knowledge and experiences with environmental awareness would give me a much better perspective and expectation for their growth.

For me as a science teacher, without facts and concrete evidence, it is difficult to bring to students' attention about the current issues of the environment. From these observations and the words of the thirty participants, I realized that making a difference toward global environmental issues is a very large task to tackle, coming from a high school students' perspective. Thus, as Sobel (1996) proposed PBE , starting on a smaller scale and community, such as a school garden or local beach clean-up, can encourage students to later on take more ambitious ventures in sustainability. For example, when students had gone to the beach clean-up, they were astonished and proud of what they had achieved, looking at all trash and plastic they had picked up. Seeing their work in a small community make a big difference. This motivated students to go on and learn about larger scale.

Limitations of the Study

This qualitative study is subject to the following limitations:

1) Qualitative research is subjective because researchers must rely on subjective judgments of participants to interpret the phenomenon under investigation (Merriam, 2009). Three participants in the embedded case study were asked to share their perspectives and experiences with the sustainability focused biodiversity curriculum (SBiC). The researcher served as the instrument of data collection and analysis, which, by human nature, has the potential for bias in the interpretation of the results.
2) As a part of qualitative inquiry, the process of data analysis involves finding out what another person is thinking (Creswell, 2013). Knowing the inner workings of another's consciousness involves asking a series of thoughtful and response provoking questions. Some questions pertinent to this study might have been overlooked by the researcher and resulted in not covering the entire range of participants' experiences.
3) Because of the researcher's position as their instructor, some participants might have been reluctant to openly share their feelings and experiences toward the environment due to grades being accountable.
4) The study is limited to a bounded system of one research site; one science classroom in a public high school over a period of 5 months. The findings relied on a small sample of 30 students served as a whole case and 3 students as an embedded case.

The period of the study might have limited the outcomes of the results. However, the findings in this current study might be transferable to similar settings and contexts, such as other science classes, biology, or environmental science at the same high school or other school within the state of Hawai'i and nationwide (Merriam, 2009).

Overall, I seek to qualitatively describe and interpret the interactions and discourse of a specific group of students (Honors chemistry class, SY: 2017-2018) during a particular time (January –May 2018) and this environmentally immersive learning environment. Therefore, replication of the full experience and finings is impossible; rather, depth in understanding of the experience and represented identities and contributions to the development of an adolescent with the environment is the ultimate goal.

Appendix A

Honors Chemistry Daily Schedule - Semester 2

Week 1

	Honors Chemistry 2016-2017	Honors Chemistry 2017-2018		
Date	**Daily Assignments (previous year)**	**Daily assignments Period 3**	**Daily assignments Period 7**	**Homework and Announcements**
Monday **1/6**	-Goal setting and semester reflection -Notes: Bohr, Lewis Structures, Valence electrons -Introduce Periodic trends project	-Catch up on break -New Seats -Goal setting and semester reflection and binder clean out -Notes: Bohr, Lewis Structures, Valence electrons	-Catch up on break -New Seats -Goal setting and semester reflection and binder clean out -Notes: Bohr, Lewis Structures, Valence electrons -Introduce Periodic trends project	-Bohr, Lewis Structures, Valence electrons
Tuesday **1/7**	-Periodic trends project -SIRs Symposium in Commons: Learn about Science Investigation Research opportunities!	-Notes: Bohr, Lewis Structures, Valence electrons -Periodic trends project	-Notes: Bohr, Lewis Structures, Valence electrons -Periodic trends project	-Bohr, Lewis Structures, Valence electrons -Periodic Trends Project
Wednesday **1/8**	-Warm up (Review Bohr, Lewis Structures, Valence electrons) -Periodic trends project	-Warm up (Review Bohr, Lewis Structures, Valence electrons) -Periodic trends project	-Warm up (Review Bohr, Lewis Structures, Valence electrons) -Periodic trends project	-Periodic trends project
Thursday **1/9**	-Periodic trends project completion -Trends review -Trends practice	-Trends review -Trends practice -Periodic trends project completion	-Trends review -Trends practice -Periodic trends project completion	-Periodic trends project
Friday **1/10**	-Warm up (Trends review) -Periodic trends notes, review, and practice -Open work time	-Warm up (Trends review) -Periodic trends notes, review, and practice -Open work time	-Warm up (Trends review) -Periodic trends notes, review, and practice -Open work time	-Periodic trends project

Week 2

	Honors Chemistry 2016-2017	Honors Chemistry 2017-2018		
Date	**Daily Assignments (previous year)**	**Daily assignments Period 3**	**Daily assignments Period 7**	**Homework and Announcements**
Monday **1/13**	-Warm up (Periodic trends) -Periodic Trends half sheet review -Notes and practice - ions and ionic compounds	-Warm up (Periodic trends) -Periodic Trends review and explain -Notes and practice - ions and ionic compounds	-Warm up (Periodic trends) -Periodic Trends review and explain -Quiz Periodic Trends -Notes and practice - ions and ionic compounds	-Ionic compound practice
Tuesday **1/14**	**Double Period** -Warm up (periodic trends and ionic compounds) -Notes - Covalent molecules -Quiz Periodic Trends -Covalent practice open work	-Warm up (periodic trends and ionic compounds) -Quiz Periodic Trends -Review and practice Ionic compounds -Notes and practice - Covalent molecules	-Warm up (Ionic compounds) -Review and practice Ionic compounds Notes and practice - Covalent molecules	-Notes - Covalent molecules -Lewis Dot Structure Practice
Wednesday **1/15**	-Warm up (review covalent) -Covalent resonance and exceptions to octet rule	-Warm up (review covalent) -Covalent resonance and exceptions to the octet rule -VSEPR Modeling Simulation -VSEPR Practice	-Warm up (review covalent) -Covalent resonance and exceptions to the octet rule -VSEPR Modeling Simulation -VSEPR Practice	-Lewis Dot Structure Practice
Thursday **1/16**	**Double Period** -Warm up (review covalent) -Review HW examples -Covalent notes summary and formal charge -Formal charge practice	-Warm up (review VSEPR) -VSEPR Summary, notes, practice	-Warm up (review VSEPR) -VSEPR Summary, notes, practice	-Lewis Dot Structure Practice

	-VSEPR Modeling Simulation			
Friday **1/17**	-Warm up (Formal Charge) -VSEPR Notes and examples -VSEPR Modeling Simulation	-Warm up (VSEPR drawing and class challenge) -Open work complete LDS VSEPR practice problems	-Warm up (VSEPR drawing and class challenge) -Open work complete LDS VSEPR practice problems	-Lewis Dot Structure Practice -VSEPR

Week 3

	Honors Chemistry 2016-2017	**Honors Chemistry 2017-2018**		
Date	**Daily Assignments (previous year)**	**Daily assignments Period 3**	**Daily assignments Period 7**	**Homework and Announcements**
Monday **1/20**	MLK DAY! No School			VSEPR Practice
Tuesday **1/21**	-Warm up (VSEPR) -Team Review (LDS, VSEPR, Formal Charge) -Practice VSEPR handout -Polar Notes and Practice	-Warm up (Formal Charge) -Notes Formal Charge and practice with packet	-Warm up (Formal Charge) -Notes Formal Charge and practice with packet	-Polarity Practice -LDS Packet
Wednesday **1/22**	-Warm up (review VSEPR) -HW Questions -Quiz LDS VSEPR FC -Polarity guided notes and practice	-Warm up (LDS, Formal Charge) -Polarity guided notes and practice -Lab - Polarity investigation -Practice bond and molecular polarity	-Warm up (LDS, Formal Charge) -Polarity guided notes and practice -Lab - Polarity investigation -Practice bond and molecular polarity	-Polarity Practice
Thursday **1/23**	**Double Period** -Warm up (review bond polarity notes and practice problems -Notes - bond and molecular polarity -Lab - Polarity investigation	-Warm up (review bond polarity notes and practice problems) -Lab:Polarity Investigation Part 2 -Notes - Bond and molecular polarity -Practice bond and molecular polarity	-Warm up (review bond polarity notes and practice problems -Notes - bond and molecular polarity -Practice bond and molecular polarity -Complete lab questions	-Polarity Practice

	-Practice bond and molecular polarity	-Complete lab questions		
Friday **1/24**	-Warm up (bond and molecular polarity review) -Open work	-Warm up (bond and molecular polarity review) -Quiz LDS VSEPR FC -Open work finish Polarity -Open work finish Polarity Lab questions and practice	-Warm up (bond and molecular polarity review) -Quiz LDS VSEPR FC -Open work finish Polarity Lab questions and practice	-Polarity Practice

Week 4

	Honors Chemistry 2016-2017	Honors Chemistry 2017-2018		
Date	**Daily Assignments (previous year)**	**Daily assignments Period 3**	**Daily assignments Period 7**	**Homework and Announcements**
Monday **1/27**	-Warm up (notes metallic bonds) -Notes summary Enthalpy and metallic bonds -Lab Olympic Pennies	-Warm up (review polarity and polarity lab investigation) -Lab Olympic Pennies -Notes summary Enthalpy and metallic bonds	-Warm up (review polarity and polarity lab investigation) -Lab Olympic Pennies -Notes summary Enthalpy and metallic bonds	-Olympic Pennies and metallic bonding lab handout
Tuesday **1/28**	-Notes: Metallic and Types of Bonds Properties -Types of Bond and Properties Lab Part 1	-Notes summary Enthalpy and metallic bonds -Polarity Practice and types of bonds notes -Lab Prep	-Notes summary Enthalpy and metallic bonds -Polarity Practice and types of bonds notes -Lab Prep	-Chemical Bonding Review and Lab questions -Test Monday
Wednesday **1/29**		-Notes: Metallic and Types of Bonds Properties -Types of Bond and Properties Lab Part 1	-Notes: Metallic and Types of Bonds Properties -Types of Bond and Properties Lab Part 1	-Chemical Bonding Review and Lab questions -Test Monday

Thursday **1/30**		-Types of Bond and Properties Lab Part 2	-Types of Bond and Properties Lab Part 2	-Chemical Bonding Review and Lab questions -Test Monday
Friday **1/31**	-Types of Bond and Properties Lab Part 2	-Warm up (Chapter Review class challenge) -Chapter 7 Chemical Bonding Review day -Open work and Lab completion	-Warm up (Chapter Review class challenge) -Chapter 7 Chemical Bonding Review day -Open work and Lab completion	-Chemical Bonding Review and Lab questions -Test Monday

Week 5

	Honors Chemistry 2016-2017	**Honors Chemistry 2017-2018**		
Date	**Daily Assignments (previous year)**	**Daily assignments Period 3**	**Daily assignments Period 7**	**Homework and Announcements**
Monday **2/3**	-Notes Intermolecular forces -Practice Intermolecular Forces	-Chapter 7 Test -Notes Intermolecular forces -Practice Intermolecular Forces	-Chapter 7 Test -Notes Intermolecular forces -Practice Intermolecular Forces	-Practice Intermolecular Forces
Tuesday **2/4**	LATE START -Chapter 7 Test	LATE START -Warm up (IMF review) -Notes IMFs and Physical properties -In class practice IMFs	LATE START -Warm up (IMF review) -Notes IMFs and Physical properties -In class practice IMFs	-Practice Intermolecular Forces
Wednesday **2/5**	-Warm up (IMF review) -In class practice IMFs -Notes IMFs and Physical properties -IMF Lab prep	-Warm up (IMF review) -IMF Unknown Lab -IMF practice due tomorrow	-Warm up (IMF review) -IMF Unknown Lab -IMF practice due tomorrow	-IMF Unknown Lab -IMF Practice packet
Thursday	**Double Period**	-Warm up (HW Q&A)	-Warm up (HW Q&A)	-IMF Unknown Lab

2/6	-Warm up (IMF review) -IMF Unknown Lab -IMF practice due tomorrow	-IMF Lab completion -Lab w typed data tables due Monday	-IMF Lab completion -Lab w typed data tables due Monday	-IMF Practice packet
Friday **2/7**	-Warm up (HW Q&A) -IMF Lab completion -Lab w typed data tables due Monday	-Warm up (Friday Challenge) -IMF Open work: Review, practice, lab completion -Heating Curve Intro packet and Lab Prep -Self Character Eval	-Warm up (IMF Properties Review) -IMF Open work: Review, practice, lab completion -Heating Curve Intro packet and Lab Prep -Character Eval	-IMF Unknown Lab -IMF Practice packet -Heating curve prelab

Week 6

	Honors Chemistry 2016-2017	**Honors Chemistry 2017-2018**		
Date	**Daily Assignments (previous year)**	**Daily assignments Period 3**	**Daily assignments Period 7**	**Homework and Announcements**
Monday **2/10**	-Heating and Cooling Curves notes and practice -Heating and Cooling curve water lab pre lab and prep	-Warm up (Heating curve prediction) -Heating Curve of Water Lab, notes, practice	-Warm up (Heating curve prediction) -Heating Curve of Water Lab, notes, practice	-Heating curve lab due Thursday
Tuesday **2/11**	-Warm up (heating cooling curve calculations) -Heating and Cooling Curves notes and practice	-Warm up (heating cooling curve lab data review) -Heating and Cooling Curves notes and practice	-Warm up (heating cooling curve lab data review) -Heating and Cooling Curves notes and practice	-Heating curve lab due Thursday -Heating Curve practice due Friday
Wednesday **2/12**	-Warm up (Heating calc) -Heating curve calc group practice -Heating Curve openwork: Lab or HW	-Warm up (Heating of fusion intro) -Notes and Practice: Heating Curve calculations -Heating curve calc group practice	-Warm up (Heating of fusion intro) -Notes and Practice: Heating Curve calculations -Heating curve calc group practice	-Heating curve lab due Thursday -Heating Curve practice due Friday

Thursday **2/13**	**Double Period** -Phase changes diagram intro chemquest: -Review Phase Diagram and practice	-Warm up (Heating calc) -Heating curve calc group practice -Heating Curve openwork: Lab or HW	-Warm up (Heating calc) -Heating curve calc group practice -Heating Curve openwork: Lab or HW	-Heating curve lab due Thursday -Heating Curve practice due Friday
Friday **2/14**	-Phase Change open work	-Phase changes diagram intro chemquest: -Review Phase Diagram and practice	-Phase changes diagram intro chemquest: -Review Phase Diagram and practice	-Quiz next week

Week 7

	Honors Chemistry 2016-2017	**Honors Chemistry 2017-2018**		
Date	**Daily Assignments (previous year)**	**Daily assignments Period 3**	**Daily assignments Period 7**	**Homework and Announcements**
Monday **2/17**	Presidents Day	**No School - Presidents Day**	**No School - Presidents Day**	
Tuesday **2/18**	-Warm up (Phase Diagram) -Triple Point Dry Ice -Phase Diagram open work	-Review Phase Diagram and practice reading diagrams -Notes and Practice with phase diagrams	-Review Phase Diagram and practice reading diagrams -Notes and Practice with phase diagrams	Practice Phase Diagrams
Wednesday **2/19**	-IMF and Phase Changes Review Day	-IMF and Phase Changes Review Day -Phase Diagram open work -Triple Point Dry Ice	-IMF and Phase Changes Review Day -Phase Diagram open work -Triple Point Dry Ice	Practice Phase Diagrams
Thursday **2/20**	-Review Question	-IMF and Phase Changes Review Day	-IMF and Phase Changes Review Day	Review for Quizzam on Phase Changes

	-Quizam: IMFs and Phase Changes		-IMF and Phase Changes Review Day	
Friday **2/21**	Once Strange Rock	-Quizzam on Phase Changes -Introduce KMT with straw activity	-Quizzam on Phase Changes -Introduce KMT with straw activity	How does a straw work?

Week 8

	Honors Chemistry 2016-2017	Honors Chemistry 2017-2018		
Date	**Daily Assignments (previous year)**	**Daily assignments Period 3**	**Daily assignments Period 7**	**Homework and Announcements**
Monday **2/24**	-Warm up (One Strange Rock Review) -Introduce KMT, Diffusion, and Gas Pressure conversions -Gas Pressure Demos with Bell Jar, index card and cup, vacuum seal	-Warm up (Gas Pressure intro) -Introduce KMT, Diffusion, and Gas Pressure conversions -Gas Pressure Demos with Bell Jar, index card and cup, vacuum seal -Dalton's Law -Sulfur hexafluoride video(s)	-Warm up (Gas Pressure intro: How does straw work, crumbled paper vs flat paper) -Introduce KMT, Diffusion, and Gas Pressure conversions -Gas Pressure Demos with Bell Jar, index card and cup, vacuum seal	-Gas Law Pressure Conversions
Tuesday **2/25**	-Warm up (Pressure conversions and pressure review) -Finish gas pressure demos, vacuum seal -Dalton's Law -Sulfur hexafluoride video(s)	-Warm up (Pressure conversions and pressure review) -Finish gas pressure demos -Dalton's Law -Sulfur hexafluoride video(s)	-Warm up (Pressure conversions and pressure review) -Finish gas pressure demos -Dalton's Law -Sulfur hexafluoride video(s)	-Gas Law Pressure Conversions

		-Begin Gas Law Packet	-Begin Gas Law Packet	
Wednesday **2/26**	-Warm up (Dalton's Law diffusion, pressure conversions review) -Gas Law Packet open work	-Warm up (Gas Laws) -Gas Law Packet open work	-Warm up (Gas Laws) -Gas Law Packet open work	-Gas Law Packet
Thursday **2/27**	-Gas Law Packet open work	-Review lab observations -Gas Law Notes Boyles and Charles Law and practice -Gas Law Packet open work	-Review lab observations -Gas Law Notes Charles Law and practice -Gas Law Packet open work	-Gas Law Packet
Friday **2/28**	-Gas Law Packet open work -Combined Gas Law	**Institute Day**	**Institute Day**	

Week 9

	Honors Chemistry 2016-2017	**Honors Chemistry 2017-2018**		
Date	Daily Assignments (previous year)	**Daily assignments Period 3**	**Daily assignments Period 7**	**Homework and Announcements**
Monday **3/2**	-Warm up (review Gas Laws) -Character Checklist -Gas Law Packet completion -Introduction Ideal Gas law	-Warm up (Gas Laws) -Lussac's Law -Gas Law Packet open work -Return Quizzam	-Warm up (Gas Laws) -Lussac's Law -Gas Law Packet open work -Combined Gas Law	-Gas Law Packet

Tuesday **3/3**	-Quiz Gas Laws -Ideal Gas law -Mass of Air in the room prep -Ask an Expert Day	-Warm up (Review Lussac's Law/Gas Laws) -Combined Gas Law -Introduction Ideal Gas law	-Warm up (Review Lussac's Law/Gas Laws) -Combined Gas Law -Gas Law Open work -Introduction Ideal Gas law	-Gas Law Packet
Wednesday **3/4**	Observation with Dianna -Mass of Air in the room Challenge	-Quiz Gas Laws -Ideal Gas law -Mass of Air in the room prep	-Quiz Gas Laws -Ideal Gas law -Mass of Air in the room challenge	-Ideal Gas law -Mass of Air in the room challenge
Thursday **3/5**	-Breakout Box Review!! -Review Ideal gas Law -Mass of Air in the room Challenge (completion)	-Review Ideal gas Law -Mass of Air in the room Challenge (completion)	-Review Ideal gas Law -Mass of Air in the room Challenge (completion)	
Friday **3/6**	-Warm up (ideal gas law) -Review Ideal gas Law -Introduce Gas Stoich -Gas Stoich practice	-Breakout Box Review!	-Breakout Box Review!	

Week 10

	Honors Chemistry 2016-2017	Honors Chemistry 2017-2018		
Date	Daily Assignments (previous year)	**Daily assignments Period 3**	**Daily assignments Period 7**	**Homework and Announcements**

Monday **3/9**	-Warm up (Gas Stoich) -Gas Stoich Team Practice	-Warm up (Gas Stoich) -Gas Stoich Class Practice	-Warm up (Gas Stoich) -Gas Stoich Notes and Practice -Molar volume and stoich	-Gas Stoich Practice due Thursday
Tuesday **3/10**	Warm up (Gas Stoich) -Gas Stoich Team Practice -Hot Air Balloon Prep	-Warm up (Gas Stoich) -Molar Volume -Gas Stoich Team Practice -Hot Air Balloon Prep	-Warm up (Gas Stoich) -Gas Stoich Team Practice -Hot Air Balloon Prep	-Gas Stoich Practice due Thursday
Wednesday **3/11**	-Warm up (Gas Stoich review) -HW Questions and practice -Hot Air Balloon Lab	-Warm up (Gas Stoich review) -HW Questions and practice -Hot Air Balloon Lab	-Warm up (Gas Stoich review) -HW Questions and practice -Hot Air Balloon Lab	-Gas Stoich Practice due Thursday
Thursday **3/12**	-Hot Air Balloon Lab	-Hot Air Balloon Lab -Review guide work	-Hot Air Balloon Lab -Review guide work	-Review guide work -Test Tuesday
Friday **3/13**	-Hot Air Balloon Lab Completion -Review guide work	-Hot Air Balloon Lab Completion -Review guide work	-Hot Air Balloon Lab Completion -Review guide work	-Review guide work -Test Tuesday

Appendix B
Current Issues to Wonder

Article Reading # 1: Soil Chemistry—Sifting Through the Past

Mystery Matters

Soil Chemistry—Sifting Through the Past

By Lois Fruen

Reprinted by Permission of Chem13 News: *February 2000 issue pages 1 and 4.*

Visit one of James Myster's dig sites, and you'll notice a few remains of chimneys and root cellars—little else. But walk around the late 18th century site with Myster, and he points to the places where people lived and penned their animals. He can tell where the occupants grew their gardens, butchered their animals, and cooked their food. He'll even tell you where their privies stood. Myster does all of this sleuthing without digging trenches or excavating artifacts. For Myster, a chemist as well as an archaeologist, the record is written in the chemistry of the soil.

The people who once occupied the site not only constructed buildings, they carried out all kinds of activities that affected the chemistry of the underlying soil. By looking at the distribution of elements in the soil samples, Myster can reconstruct many of those activities. For example, farm animals add phosphorous-rich manure to the soil. By looking at patterns of phosphorous distribution, Myster locates areas where animals were penned. He knows that animal flesh and fats also contain high concentrations of phosphorus in the forms of phospholipids; and bones, teeth, and antlers—generally discarded during butchering—contain calcium ions and phosphorus in apatite. When calcium and phosphorous are abundant in the soil sample, he suspects that meat was processed in the area.

Myster also conjectures where gardens once grew. Prolonged gardening depletes most elements from the soil, especially calcium, magnesium, nitrogen, phosphorous, and sulfur. Where he finds traces of plant products in the soil, he tries to determine the types of plants the inhabitants grew. Wheat, corn, nuts, and potatoes are rich in magnesium, manganese, and strontium ions; dark green plants contain iron and magnesium ions. In fact, the Mg^{2+} ion is at the center of every chlorophyll complex in all green tissues of plants.

What is most interesting is the way Myster can map where buildings once stood even though no visible evidence of the structures exists today. Soil from areas where buildings once stood contains accumulations of materials specific to the activities performed in the buildings. For example, soil under smokehouses contains high sodium ion concentrations, because freshly salted meat, hung from the rafters, dripped briny greases onto the dirt floors. Soil under privies has very high concentrations of phosphates. Soil around buildings where the people once lived might have traces of calcium ions from plaster and lead ions from paints.

Myster can even predict the location of buildings by thinking about the prevailing wind patterns. He expects the concentration of sulfur and certain metal ions like cadmium, chromium, lead, and nickel deposited by the wind during the early industrial age, to be less evenly distributed where the buildings once stood. Acting as soil covers, the floors in buildings tend to shield the soil underneath from these wind-borne accumulations.

Where buildings were demolished or burned, the soil contains the records. Wood is high in potassium and contains

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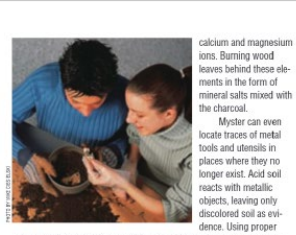

calcium and magnesium ions. Burning wood leaves behind these elements in the form of mineral salts mixed with the charcoal.

Myster can even locate traces of metal tools and utensils in places where they no longer exist. Acid soil reacts with metallic objects, leaving only discolored soil as evidence. Using proper safety and disposal techniques, Myster and his assistants spray potassium thiocyanate to outline the decomposed remains of iron implements. The trace remains of other metals help to determine the makeup of the implements that people once used.

To analyze soil samples from archaeological sites, Myster uses an argon-based inductively coupled plasma (ICP) emission spectrometer to analyze for certain elements. ICP measures both the distinctive wavelengths of different elements and the intensity of the energy given off when valence electrons in the elements are excited. ICP can identify the following elements: Al, As, B, Be, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, P, Pb, S, Sr, Ti, and Zn. In ICP, elements are extracted from a 3-gram sample of soil with 0.76 M HCl/HNO_3 solution. A precipitate forms, and the mixture is centrifuged. The supernatant is injected into the ICP spectrometer for analysis (see Figure 1). The distinctive wavelengths of light emitted identify the elements, and the intensity of the light gives the concentration of the elements in the soil sample. (see Figure 2).

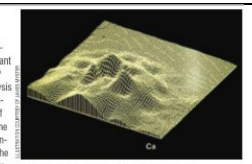

Figure 2. This ICP spectrum identifies a strong presence of calcium in a soil sample from a protohistoric archaeological site in Tennessee.

To determine the amount of organic material in the soil, Myster measures total carbon (TC) using an automated carbon analyzer. After calibrating the TC analyzer with calcium carbonate, he places a 2-gram sample of dried soil in a small ceramic crucible for burning in the controlled environment of the analyzer. He compares the postburn to the preburn mass to calculate the percent carbon.

Since organic compounds are derived from biological sources, he gathers soil samples from an area he knows has not been heavily influenced by human use. He analyzes these samples and compares the data to those gathered from the site. Myster uses the off-site data as a baseline to approximate the duration and intensity of human use at the site under study.

Although he has not made extensive use of other tools and methods of analytical chemistry to analyze organic remains, Myster is excited about the potential of using spectroscopy and DNA testing. Using these tools to analyze samples from around privies might yield information about diet and health of the inhabitants.

Myster points out that soil represents a complicated whirlpool of activity. There are so many variables. As a result, separating naturally occurring chemical characteristics of soils from those that result from human activity can be difficult. But when coupled with traditional archaeology, soil analysis is a very valuable tool.

Excavating a site is a drastic and destructive process. Once dug, a site is forever altered, meaning that no researchers can ever repeat the work. Chemical analysis can help scientists to get it right the first time. Pre-dig laboratory work helps to locate promising areas, differentiate features, and even suggest how deep to dig. With this information available, only areas established by settlement patterns are disturbed. Soil chemists are playing an increasingly vital role in archaeology.

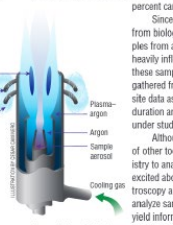

Figure 1. In an ICP, the vaporized sample is directed to an argon gas source that excites the valence electrons of elements in the sample.

James Myster

James Myster's interest in archaeology dates to his school years. He describes it this way:

I was raised in southern Minnesota and became interested in history when I noticed all the old abandoned houses, farms, barns, and mills around our town. I wondered about the people who once lived there. I thought about all of their stories! At the same time, I developed a passion for forensic detective work and even considered preparing for the FBI academy. When I went to college, I found a way to combine these two great interests into one study—archaeology! Archaeology illuminates the past through the careful scientific study of the things people leave behind.

James Myster explains soil-testing procedures to a Hamline University student on a historic farmstead site in Minnesota.

Lois Fruen is a chemistry teacher at the Breck School in Minneapolis, MN. This article is part of her series "Chemistry of Archaeology" published by *CHEM13 NEWS*.

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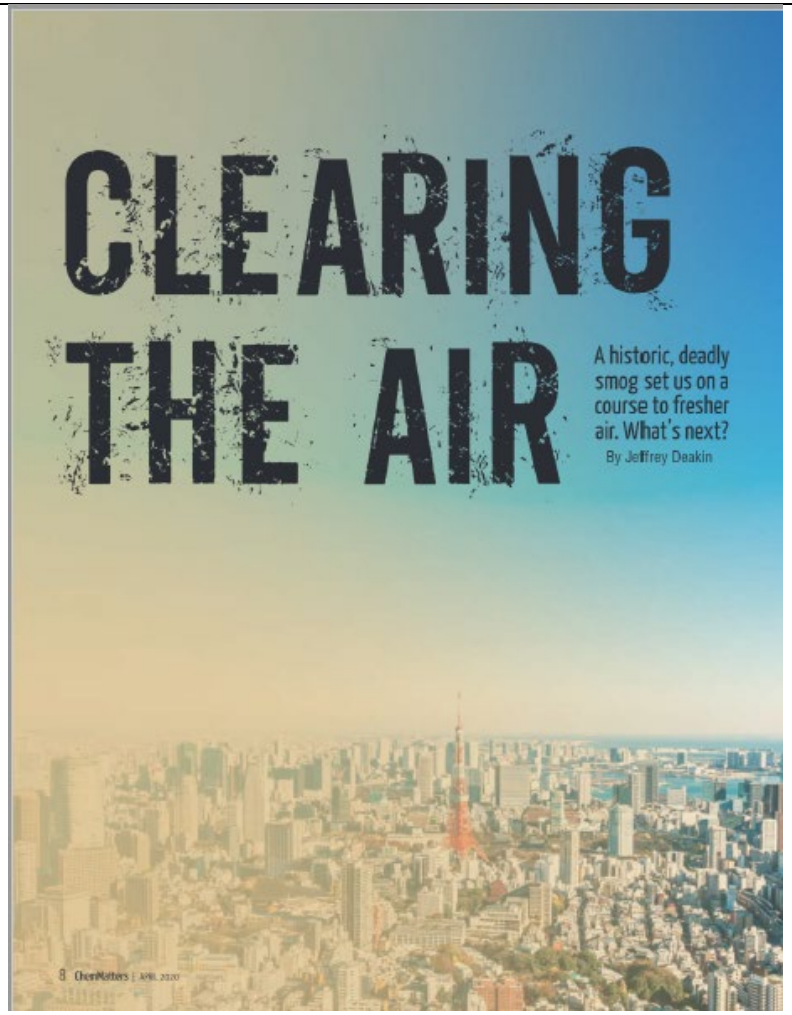
Article Reading # 2: Clean the Air



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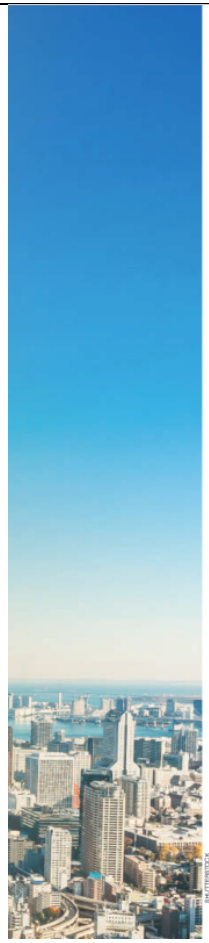

One late October morning in 1948, dense smog blanketed Donora, Pennsylvania, a riverside mill town about 27 miles south of Pittsburgh. Residents were accustomed to haze from the zinc and steel plants and passing trains and boats, but this occurrence was different.

A local physician described what he saw to *The New Yorker* magazine a couple of years after the event. Peering out of his window, he saw the usual sight of a passing freight train. But the smoke it released, rather than rising, spilled down the stack "like a black liquid, like ink or oil, and rolled down to the ground and lay there."

Soon afterward, residents started calling the doctor's office in a panic. They were coughing and couldn't catch their breath. They reported abdominal and chest pain, headache, and nausea.

At the time, health officials didn't know how damaging air pollution could be. But the air was poisoned by particles of zinc, cadmium, and lead, along with hydrofluoric acid (HF), sulfur dioxide (SO_2), and carbon monoxide (CO) from the zinc and steel mills. The Halloween parade and high school football game went on as planned, though spectators said they couldn't see the players through the smog.

By the time a rain fell and cleared the air six days after the smog started building up, 20 people had died. Thousands fell ill, according to the public health study that followed.

It was a wake-up call to the dangers of air pollution. The health crisis helped spur federal legislation to clean up the nation's air. The law evolved over time and ultimately culminated in the Clean Air Act of 1970, which authorized the development of limits on emissions from industry and transportation. More than 70 years after the Donora smog, a sign at a local museum proudly declares, "Clean Air Started Here."

Technologies to control emissions have succeeded in dramatically restricting air pollution. But more work remains to be done. The successful reduction in ground-level ozone pollution—now the substance most often associated with smog—is a prime example of how the value of air quality has changed since Donora revealed its importance. It also highlights the problems that have yet to be fixed.

What is ozone?

Ozone (O_3) is a pale blue gas, an allotrope of oxygen, with a distinct, acrid odor. An allotrope is one of multiple forms of an element that can exist in the same physical state. O_2 is another allotrope of oxygen.

Ozone is found at two different heights in the Earth's atmosphere—one where it's harmful, and one where it's crucial to life. In the lowest layer, the troposphere, which extends from the Earth's surface to an altitude of 10 kilometers (6 miles), ozone is a pollutant that causes health problems. In the stratosphere, naturally occurring ozone acts like a shield, protecting life on the planet from dangerous solar radiation.

Ground-level ozone forms from photochemical reactions between volatile organic compounds (VOCs) and nitrogen oxides (NO_x), which are pollutants emitted from vehicles, power plants, and other sources. VOCs are chemicals, either naturally occurring or synthetic, that evaporate readily at room temperature. Most scents that you smell—pleasant, odd, or stinky—are from VOCs.

Once released in the air, the VOCs and nitrogen oxides undergo a chain of reactions. In the final steps of these reactions, sunlight causes an oxygen atom to split from an NO_2 molecule. The oxygen atom combines with O_2 and forms ozone, as follows:

$$NO_2 + \text{sunlight} \rightarrow NO + O$$
$$O(g) + O_2(g) \rightarrow O_3(g)$$

The ozone issue

The formation of ozone at ground level is problematic because the gas is a powerful oxidizing agent. It can react spontaneously with the atoms or molecules of almost any other substance, including plant and animal tissues, and those reactions can cause harm. Breathing in too much ozone can lead to throat irritation, coughing, shortness of breath, and lung damage.

Usually, ozone levels in the air we breathe are not

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Ozone Shield

Stratospheric ozone, commonly known as the ozone layer, is produced by the interaction of ultraviolet (UV) radiation from the sun with oxygen molecules. The rays' energy is sufficient to break the bond in an oxygen molecule to result in two oxygen atoms:

$$O_2(g) \rightarrow 2\,O(g)$$

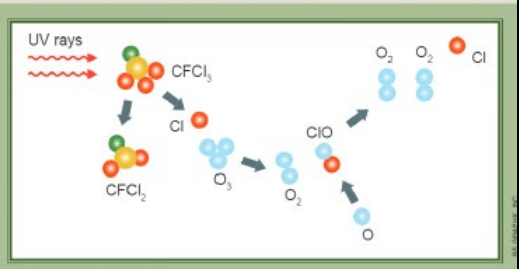
Oxygen atoms aren't stable on their own, so they readily combine with other oxygen molecules to form ozone:

$$O_2(g) + O(g) \rightarrow O_3(g)$$

The ozone layer reduces the amount of harmful UV radiation that reaches the Earth's surface.

A broken shield

Beginning in the 1970s, scientific evidence showed that the ozone layer was being depleted. This reduction of ozone became a serious concern because of its direct impact on human health. Without an intact ozone layer, higher levels of damaging UV light can reach Earth's surface. Typical health issues resulting from too much UV exposure range from eye damage to skin cancer.



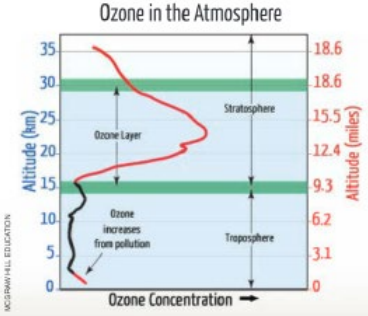
The breakdown of $CFCl_3$ by UV light releases a chlorine atom. The chlorine atom is a free radical because it has an unpaired electron. Chemical species are most stable when electrons are in pairs or part of a chemical bond, so the chlorine atom readily reacts. In the stratosphere, Cl reacts with O_3, causing ozone depletion.

Alarmed by the development of the ozone hole—not a true hole, but rather an area of depleted ozone that forms over the Antarctic every spring (August through October in the Southern Hemisphere)—researchers studied the problem and identified the culprits. Gaseous substances known as chlorofluorocarbons (CFCs) were creating the hole. CFCs were commonly used as solvents, propellant gases in aerosol cans, and refrigerants.

On the mend

To repair the ozone hole, the international community agreed to phase out chemical substances that deplete stratospheric ozone. The United Nations (UN) adopted the agreement, called the Montreal Protocol, in 1987. It is the only treaty, to date, that all 197 UN member states ratified.

Since the agreement was finalized, the ozone hole has been on the mend, though very slowly. CFCs stay in the atmosphere for decades, so the hole is expected to be around for a while. But in 2018, NASA had good news to report: The phase-out of CFCs had succeeded in slowing ozone depletion by 20% since 2005.



harmful. But starting at an average concentration of 0.075 parts per million (ppm) over an eight-hour period, ozone is considered unhealthy, particularly for sensitive groups, including children, people who are active outdoors, and people with asthma.

The good news is that the federal regulations that have evolved since Dono have lowered ground-level ozone over the past three decades.

But there are still areas where ozone is a problem. In 2015, the Environmental Protection Agency (EPA) reported that 197 U.S. counties, hom to about 120 million people, were designated as ozone "nonattainment areas," which means they were in violation of the national ozone standard.

As we head into sun-filled summer months, if you're in one of these counties, you might notice an uptick in "ozone alert days," when health experts recommend that you minimize your time outside.

Because sunlight encourages the formation of ozone, the pollutant's levels are more likely to rise in the summer when there is more direct sunlight for longer periods of time than in the winter. Episodes can also occur in colder months, however, especially in valleys where a phenomenon called temperature inversion is more likely to occur.

Normally, air temperature gets colder with altitude. This is because direct sunlight warms the Earth's surface, and heat energy transfers through conduction to the cooler soil and air just below and above the surface. The warmed, less-dense air rises as cooler, denser air descends. Then the cooler air also

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Nonattainment areas are places that exceed the set limits for ozone pollution.

picks up heat from the sun-warmed surface and rises. This movement of gas molecules creates tiny cells of circulation that warm the air near the surface.

Under certain circumstances, however, the air just above the surface can become cold. This can happen during fall or winter at night when heat from the air is transferred to the cooler soil beneath it. This results in dense, cold air above the surface. Without any wind, the cold air can sit stagnant, as it did during the Donora smog.

A measure of control

In recent years, many urban areas in the United States and elsewhere have logged fewer ozone alert days, which are largely triggered by the reactions of sunlight with vehicle emissions, namely VOCs and NO_x.

The improvement is attributable to legislation introducing strict emissions standards for cars and trucks. One key technological solution that allowed the auto industry to lower vehicular emissions is the catalytic converter. This device lowers ozone-producing NO_x and VOCs, as well as CO, from vehicle exhaust. The VOCs in exhaust are hydrocarbons from unburned and partially burned fuel. Benzene, octane, and formaldehyde are examples of these types of substances.

Despite the progress many countries have made toward reducing ozone pollution, much more can be done. Several reports have found that ground-level ozone is rising in some regions in the world. Because ozone can travel long distances with global air currents, a rise in one location can increase background levels of ozone in other places, offsetting some gains made to cut ozone.

Fortunately, effective technological solutions exist to reduce emissions of NO_x and VOCs, and therefore, ozone. To build upon these successes, a seminal 2008 report on ozone pollution by the Royal Society, a scientific academy in the United Kingdom, called for countries around the world to recognize ozone as a global pollutant, not just a regional one. As other global environmental initiatives have demonstrated, such as restoring ozone to the atmospheric layer where it actually belongs, it could be possible to tackle this ozone problem, too.

Jeffrey Deakin, a former high school chemistry and physics teacher, is a science writer based in the United Kingdom.

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Cleaner Cars

To clean up vehicle emissions, carmakers fit their models with catalytic converters. The technology has been around since the late 1800s, but was put to widespread use in vehicles in the 1970s.

Most modern catalytic converters carry out three reactions at the same time to rid vehicle exhaust of most of its pollutants and those that contribute to ozone formation: nitrogen oxides, carbon monoxide, and unburned hydrocarbons. The reactions are as follows:

1. Reduction of nitrogen oxides:

$$2\,NO_x(g) \rightarrow x\,O_2(g) + N_2(g)$$

2. Oxidation of carbon monoxide:

$$2\,CO(g) + O_2(g) \rightarrow 2\,CO_2(g)$$

3. Oxidation of unburned hydrocarbons such as octane, C_8H_{18}

$$2\,C_8H_{18}(g) + 25\,O_2(g) \rightarrow 16\,CO_2(g) + 18\,H_2O(g)$$

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Article Reading # 3: Measuring Ground-Level Ozone

ACTIVITY

Measuring Grou

Ozone. You hear the word in the news; you hear the word in weather reports during the summer months; you hear the word in ads for swimming pools and spas. And in this issue of *ChemMatters*, you read the word in nearly every article. You might be surprised to hear that the word "ozone" comes from the Greek word *ozein*—to smell. That's the name its discoverer, German scientist Christian Friedrich Schönbein gave it in 1839, a name he thought best described the acrid-smelling gas in his lab.

Schönbein wanted to show that this triatomic form of oxygen (O_3) was a natural part of the atmosphere, not just a laboratory-concocted curiosity. He devised a method to measure ozone that turned out to be both easy to do and sensitive even to low levels of O_3 in the surroundings. His invention is known today as the *Schönbein paper*. You can make a batch of it and try it out for yourself by using the directions included in this article.

Today, scientists are fascinated by the laboratory findings of 19th and early 20th century chemists who used this sensitive paper to record ozone levels in *Schönbein units*. Their records are proving to be particularly useful for determining long-range trends of ozone concentrations in the air we breathe. To make meaningful comparisons, researchers are carefully examining the experimental methods used by these early scientists so that they can duplicate them in current studies—an excellent argument for keeping good laboratory records! You never know who might need the details about how you performed an experiment and obtained your results.

The Schönbein paper records reveal dramatic changes in Earth's atmosphere. Ground-level ozone appears to have increased at least three-fold globally since preindustrial times.

Is this a problem? Ground-level ozone is toxic to living things. Highly reactive O_3 interacts with living tissue, donating oxygen atoms freely in a process known as oxidation—a process that accelerates cellular aging. Breathing too much ozone over time impairs our lung capacity, setting us up for a variety of illnesses, including asthma. (See the *ChemMatters* September 2001 article "Asthma—Attack From the Air".) Other animals and plants suffer, too. Several important crop species respond to today's higher ozone levels with lowered rates of photosynthesis and productivity.

Although the way in which ground-level, or tropospheric, ozone forms is well described, its distribution in the atmosphere and the means to control it are topics of ongoing research and political debate. (See the September 2001 *ChemMatters* article "Ozone—Molecule With a Split Personality".) By all accounts, human activities are responsible for the recent increase in global ozone. NASA's Aura mission will gather important global data for determining the sources and distribution patterns of O_3.

According to science writer Jeannie Allen in an article soon to be published on NASA's Earth Observatory Web site, there is still much to be learned about this toxic gas: "We don't know very much about ozone chemistry at night, nor do we know enough about the transport of gases between the lower and upper layers of the atmosphere. We have a great deal to learn about tropical ozone chemistry. We still cannot predict our chemical weather."

Figure 1. Schönbein color scale.

0–3
Little or no change

Making Schönbein paper

1. Wear **goggles** and a **safety apron** for this procedure. Be sure to wash your hands when you are finished.
2. Heat 100 mL of water in a 250-mL beaker until it begins to boil.
3. In a separate container, mix **5 g of soluble starch powder such as cornstarch** in a **small amount of cold water (about 10 mL)**. Mix to make a slurry. Remove the water from the heat using "hot mitts" and mix the starch slurry into the hot water while stirring.

PHOTO BY TONY FERNANDEZ, ACS

4. After the starch has dissolved, add **1 g of potassium iodide** and stir well. Cool the solution.
5. Lay a **piece of filter paper** on a smooth clean surface and carefully brush the starch/KI solution onto the filter paper using a **small paintbrush**. Turn the filter paper over and do the same on the other side. Apply the starch/KI solution as uniformly as possible.
6. Allow the paper to dry.
7. Cut the dry filter paper into 1-inch wide strips and store them in a ***zip-closing bag*** out of direct sunlight.

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und-Level Ozone

Make and test your own ozone indicator

Schönbein indicator paper is based on the ability of ozone (O_3) to oxidize other substances. To make a batch of your own, you begin by painting a strip of filter paper with a starch and potassium iodide (KI) mixture. Then, if ozone is present, it will oxidize the iodide ion (I^-) in the potassium iodide (KI) to yield elemental iodine (I_2). This elemental iodine in turn reacts with starch to produce a dark blue-black starch iodine complex.

$$2KI + O_3 + H_2O \rightarrow 2KOH + O_2 + I_2$$

$$I_2 + \text{starch} \rightarrow \text{blue starch/iodine complex}$$

4–6
Lavender hue

7–10
Blue or purple

Testing for ground-level ozone

Decide on a variety of locations for exposing the indicator paper strips. Some should be indoors, some outdoors. Then follow these steps for collecting and recording your data.

1. Dip a strip of test paper in distilled water and hang it at a data collection site. Choose a collection site that is out of direct sunlight and away from locations where it might be disturbed. Record the location, date, and time the site was tested.
2. Expose the paper for approximately eight hours.
3. To observe and record test results, again dip the paper in distilled water. Observe the color and determine the Schönbein number using the Schönbein color scale in Figure 1.
4. Determine the relative humidity of the data collection site by using a bulb psychrometer or by consulting local weather data. Round off the relative humidity reading to the nearest 10%.

PHOTO BY TONY FERNANDEZ, ACS

Because high relative humidity makes the paper more sensitive to ozone, you need to correct for this factor.

Refer to the relative humidity number chart in Figure 2. Along the bottom of the chart, find the point that corresponds to the Schönbein number that you recorded. From that point, draw a line upward until it intersects with the curve that corresponds to your humidity reading. To find the ppb ozone concentration, draw a perpendicular line from the Schönbein number/relative humidity point of intersection to the left side of the chart.

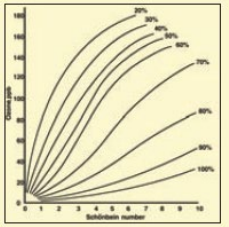

Figure 2. Relative humidity number chart.

Using the Schönbein method

During the 1880s, readings using the Schönbein method peaked at about 10 parts per billion (ppb) in a given volume of air. Today, tropospheric ozone readings average 35–40 ppb around the globe in even the most remote regions. In the United States, summertime levels in suburban and rural areas frequently range from 80 to 150 ppb for several days at a time. Urban levels can exceed those by a wide and unhealthy margin.

After a few trial runs, your class might want to plan a long-term study of ozone levels in your area. You might study the effects of seasons, temperature, and locations. And if you share your findings with *ChemMatters*, we will post your results on our Web site. Contact us at chemmatters@acs.org.

This lab activity was adapted from Project Learn, a program of the National Center of Atmospheric Research, Boulder CO. Another version of the activity appeared in the NSTA publication *The Science Teacher*, December 1995.

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Appendix C

Overview of the Sustainability Focused Biodiversity Curriculum (SBiC)

	Essential Questions	Enduring Understandings	Objectives
Project 1: Valuing Biodiversity	What is the value of biodiversity?	Students understand that the value of biodiversity reaches beyond maintaining healthy ecosystems to achieving and preserving global sustainability.	1. Students will be able to communicate the role of matter cycling and energy transfer in maintaining a bio-diverse ecosystem. 2. Students will use systems thinking principles to interpret and understanding energy transferring and matter cycling. 3. Students will create a visual representation of a food web that can be used to educate the public.
Project 2: Building Biodiversity	How can we measure and increase the biodiversity on our school campus?	Students will understand that biodiversity is variable. It can increase and decrease over time and as a result of natural and non-natural factors. Students will understand that humans have the ability to contribute to and create healthy, bio-diverse landscapes.	1. Students will be able to apply the factors that affect carry capacity and the factors that affect biodiversity to creating a bio-diverse garden on school grounds. 2. Students will be able to set goals, create indicators for success, and implement their project.
Project 3: What's in the Future?	What is the future of our local ecosystem?	Students will understand that science can be used to inform sustainable development, legislation, and progress.	1. Students will be able to apply the principles of natural selection to understanding our changing climate. 2. Students will be able to predict how ecosystems will respond to climate change. 3. Students will take responsibility for their actions and act according to their beliefs.
Project 4: Take a Stand	How can we effectively make change and positively impact complex environmental systems?	Students will understand that they have the power to make environmental change in their community.	Students will feel empowered to create positive change in their community.

PROJECT DESIGN: STUDENT LEARNING GUIDE	
Project 1: Valuing Biodiversity	**Duration: 2 weeks**
Driving Question: What is the value of biodiversity?	
Project Summary (include student role, issue, problem or challenge, purpose, and action taken)	Students will act as natural history museum curators opening a new exhibit titled *The Value of Biodiversity*. The exhibit will focus on the unique biodiversity of the school garden, the relationships and interconnections among species, and the importance of biodiversity to the long-term sustainability of humankind and other living species on Earth. Students will create an engaging exhibit that will interest and educate a diverse public audience.
Driving Question	What is the value of biodiversity? Visit the school garden: Students visit the school garden, or University of Hawaii Botanical garden. They will talk with employees or a professor at the University to better understand the prerequisites and nuances of putting together a successful

	museum exhibit. In their exploration of a museum exhibit, students think about and discuss the following questions: 1) What can one learn from visiting a museum? 2) How is the experience of visiting a school garden different from that of learning in a classroom? 3) What is the goal of building a museum exhibit? 4) How did this exhibit achieve or not achieve your goal? 5) What makes building museum exhibit interesting? Educational? 6) What different mediums (words, pictures, displays, interactive elements, etc.) did you use to build the museum? Which did you find effective? 7) How would you make this museum exhibit better?

Final Product(s)	**Learning Outcomes**	**Formative Assessments**	**Instructional Strategies**
Presentations	1. Students will be able to identify and correctly use a mathematical model to describe the cycling of matter and flow of energy in an ecosystem. 2. Students will understand that on average 10% of the net energy production at one energy level is passed to the next trophic level. 3. Students will be able to calculate the average net energy transfer from one level to the next.	1. Responses to Energy Flow Worksheet 2. Ticket-out-the-door 3. Ecosystem Web Rough Draft 4. Group Check-ins: Ecosystem Web Explanatory Signs	1. Energy Transfer and Matter Cycling PowerPoint 2. Energy Transfer Human Modeling Activity 3. Energy Flow Worksheet
	1. Students can construct their own food web. 2. Students understand what a trophic level is and the relationship between trophic levels. 3. Students can identify producers, primary consumers (herbivores), secondary consumers (omnivores), and decomposers and explain the value of each to the entire food web and ecosystem.	1. Food Web Quiz 2. Ecosystem Web Rough Draft 3. Group Check-in: Ecosystem Web Explanatory Signs 4. Identification of trophic level on herbarium specimen and species accounts.	Food Web and Trophic Level PowerPoint
	1. Students understand that as you move upward in trophic level, only a small fraction of the matter consumed by the organisms is transferred upward. 2. Students understand that the lowest trophic level has the greatest biomass and the most energy. 3. Students understand that the loss of energy through trophic levels results in an ecosystem that can support fewer organisms at higher trophic levels. 4. Students understand the relationship between matter and energy. The energy is then used by organisms to function.	1. Learning Log Response (Matter Cycling): Why is the biomass of primary producers so much greater than the biomass of secondary consumers? Explain your answer in terms of energy and matter flow. 2. Ecosystem Web Rough Draft	1. Energy Transfer and Matter Cycling PowerPoint. 2. Energy Transfer Human Modeling Activity.
	1. Students understand that chemical elements pass through the food web, in and out of the atmosphere, and through the soil and the environment. Chemical elements are combined and recombined along the way. 2. Students can describe what happens to energy that is not transferred to a higher trophic level (growth, maintenance, or	Learning Log Response (Energy Transfer): If only 10% of the matter and energy is transferred upward in trophic levels, what happens to the rest of it? How does this support the idea that matter and energy are conserved through an ecosystem?	1. Energy Transfer and Matter Cycling PowerPoint. 2. Energy Transfer Human Modeling Activity.

	repair and/or transferred to the environment)		
	1. Students will be able to see the whole system, its parts, and their place within the system.	1. System Discussion: Students will generate a list of systems and non-systems, identify the parts of that system, and explain the role of each part in the system. 2. System Concept Map: Students will create a concept map that shows the relationship between their elements of the selected system. 3. Ecosystem Web Rough Draft.	System PowerPoint
	1. Students will demonstrate the awareness of biodiversity to long-term sustainability of humankind and other living species. 2. Students will identify flora, fauna, and geologic formation in the bioregion; describe their interdependence, benefits, and threats associated with our human behavior and how these impact the bioregion and us.	1. Learning Log Response (Valuing Biodiversity): What is the value of having a diverse ecosystem? How does diversity improve an ecosystem? 2. Herbarium Specimen and Species Account	Research conducted for species account and herbarium specimen
	1. Work hard to achieve their goals. 2. Practice and continuously improve their work. 3. Look for challenges that foster learning and growth and that increase capabilities. 4. Articulate their strengths and limitation. Exhibits the drive to discover new territory.	1. Self Evaluation 2. Student Goals	Class Discussion: Why are the following characteristics important to creating a sustainable future? 1. Work hard to achieve their goals. 2. Practice and continuously improve their work. 3. Look for challenges that foster learning and growth and that increase capabilities. 4. Articulate their strengths and limitation. Exhibits the drive to discover new territory.
Project 2: Building Biodiversity			**Duration: 2 weeks**
Driving Question: What is the value of biodiversity?			
PROJECT SUMMARY	The purpose of this project is to collect data about and increase the native biodiversity around the school campus. Students will plan design, and create a space in the Science courtyard that increases native biodiversity.		

Appendix D

Environmental Pre/Post Survey

Demographic information

Name
Gender
Age
Class

Attitudes

The purpose of the following is to understand your attitude towards the environment. Please circle the number below to indicate how strongly you agree or disagree with the statements.

1. I care about the environment.

1 Strongly disagree	2	3 Neither agree/nor disagree	4	5 Strongly agree	I don't know

2. It is my responsibility to take care of the environment.

1 Strongly disagree	2	3 Neither agree/nor disagree	4	5 Strongly agree	I don't know

3. I am aware of environmental issues.

1 Strongly disagree	2	3 Neither agree/nor disagree	4	5 Strongly agree	I don't know

4. I like learning about how people impact the environment.

1 Strongly disagree	2	3 Neither agree/nor disagree	4	5 Strongly agree	I don't know

5. I always think about how my actions affect the environment.

1 Strongly disagree	2	3 Neither agree/nor disagree	4	5 Strongly agree	I don't know

6. My feelings about nature do not affect how I live my life.

1 Strongly disagree	2	3 Neither agree/nor disagree	4	5 Strongly agree	I don't know

7. Nothing I do will change problems in other places on the planet.

1 Strongly disagree	2	3 Neither agree/nor disagree	4	5 Strongly agree	I don't know

8. My relationship to nature is an important part of who I am.

1 Strongly disagree	2	3 Neither agree/nor disagree	4	5 Strongly agree	I don't know

9. Nature is strong enough to handle the bad effects of our modern lifestyle.

1 Strongly disagree	2	3 Neither agree/nor disagree	4	5 Strongly agree	I don't know

10. People will someday know enough about how nature works to be able to control it.

1 Strongly disagree	2	3 Neither agree/nor disagree	4	5 Strongly agree	I don't know

Intended Pro-environmental Behavior

11. I plan to participate in events organized by environmental groups.

1 Strongly disagree	2	3 Neither agree/nor disagree	4	5 Strongly agree	I don't know

12. I would be willing to pay a fee for using disposable plastic bags.

1 Strongly disagree	2	3 Neither agree/nor disagree	4	5 Strongly agree	I don't know

13. I would be willing to pay more in taxes to support renewable energy projects.

1 Strongly disagree	2	3 Neither agree/nor disagree	4	5 Strongly agree	I don't know

14. Many of my everyday decisions are affected by my thoughts on energy use.

1 Strongly disagree	2	3 Neither agree/nor disagree	4	5 Strongly agree	I don't know

15. I would do more to save energy if I knew how.

1 Strongly disagree	2	3 Neither agree/nor disagree	4	5 Strongly agree	I don't know

16. I do NOT care to hear anything more about the energy problems facing our nation.

1 Strongly disagree	2	3 Neither agree/nor disagree	4	5 Strongly agree	I don't know

17. Saving energy is important.

1 Strongly disagree	2	3 Neither agree/nor disagree	4	5 Strongly agree	I don't know

18. There is not much that I can do to help solve the energy problems facing our nation.

1 Strongly disagree	2	3 Neither agree/nor disagree	4	5 Strongly agree	I don't know

19. It is too hard to change my mind about doing things to help conserve energy.

1 Strongly disagree	2	3 Neither agree/nor disagree	4	5 Strongly agree	I don't know

Short Answer Questions

The purpose of the following is to understand some of your answers to the questions above on a deeper level. Please answer the following as completely as possible.

20. Do you think it is important to learn about living things around you* (school, home)? Yes or no, then explain.

21. List up to three things you can do to take care of the environment in (school/home)?

22. What is your motivation to continue environmental behaviors?

Appendix E

University of Hawai'i

Student Consent Form

Cam-Tu Trinh, Principal Investigator

Project title: Fostering Environmental Identity with High School Students

Department of Curriculum Studies, University of Hawaii Mānoa
1776 University Avenue Honolulu, HI 96822
Phone: (808) XXX-5436
Email: xxx@hawaii.edu

Aloha,

I would like to ask you to take part in my research study. The purpose of my research is to examine how you express your environmental identity during the course of learning a sustainability focused biodiversity unit. In this study, I hope to explore how you understand environmental identity at the beginning and at the end of the biodiversity unit. Additionally, I hope to determine how participating in the biodiversity unit impacts your environmental identity. Before you decide if you would like to take part in my study, it is important for you to know that:

- You have a choice whether you want to be a part of the study or not;
- If you decide to take part in this study, you can stop at any time, and
- Your parent or the adult responsible for you must also agree for you to take part in my study.

What activities will you be asked to do?

If you agree to participate, you will not need to do anything differently. The biodiversity curriculum is an accepted and approved curriculum for high school students. The curriculum will take about three months. You will be asked to participate in a study that will be conducted over the course of three months in two phases. In the first phase, you will be asked to complete a 20 minute survey. In addition, some lessons may be videotaped to record general observation and learning strategies used while you engage in different activities. If you choose NOT to participate, you will not be videotaped. All responses from the survey, journal and including all videotaping will be kept confidential as required by law, and only used for research purposes.

The second phase of the study consists of selecting students to be case studies in the research. This phase examines more-in-depth your environmental identity and may involve videotaping as you engage in various classroom activities. You may be asked to participate in focus group three times and each time will take no more than 30 minutes to complete. All responses from the videotaping and focus

group will be kept confidential as required by law, and only used for research purposes. After the research is complete, any tape recordings will be destroyed.

Benefits and Risks: There will be no direct benefit to you for participating in my study. The results of this study might help me, other teachers, and researchers to understand how secondary students express their environmental identity during the course of participation in a sustainability focused biodiversity unit (SBiC). I believe there is little or no risk to you in participating in this project. There may be some risk of loss of privacy due to participation in this study.

Confidentiality and Privacy: I will keep all the study data in a safe place. Only my University of Hawaii advisor, Dr. Tara O'Neill, and I will have access to the information. Other agencies that have legal permission have the right to review research records. The University of Hawaii Human Studies Program has the right to review research records for this study.

I will not record your name or nay other personal information that would identify you in my research records. If you would like a copy of my final report, please contact me at the number listed near the end of this consent form.

Voluntary Participation: Participation in this research project is voluntary. You may choose freely to participate or not to participate. At any point during this study, you can withdraw your permission, stop participating without any loss of benefits. I recognize that I am the researcher in this study and, at the same time, your teacher, I assure you that your participation or non-participation in my research project will not impact your grades, or our teacher-to-student relationship at McKinley High School. I will not be upset or any with you in the slightest, if you decide not to participate, or decide to stop participating in my research project.

If you have any questions about this project, please feel free to contact me at (808) 497-5436 or via email at xxx@hawaii.edu.

Agreement to take part in this study:

Signing your name at the bottom of this form means that you agree to be in this study. I will make a copy of this form for you after you have signed it.

I have read and understand the information above. My questions about project procedures and other matters have been answered to my satisfaction. I know that I can withdraw my participation at any time without consequence.

I agree to participate in this project. I understand that by agreeing to participate, I have not given up any legal rights and that the researchers and the institutions they represent are still responsible for upholding all laws that apply.

Signature of Participant	Print name	Age	Date

If you do not receive satisfactory answer to your questions or have comments or complaints about your treatment in this study, contact:

Committee on Human Studies,
University of Hawai'i,
2540 Maile Way, Honolulu, HI 96822
Phone: (808) 956-5007

Appendix F

University of Hawai'i

Parental/Guardian's Consent for Child to Participate in a Research Project

Cam-Tu Trinh, Principal Investigator

Project title: Fostering Environmental Identity with High School Students

Dear Parent or Guardian:

I am your child's Chemistry teacher at McKinley High School. I am also a graduate student at the University of Hawaii at Mānoa. I am currently working towards my Ph.D. in Education with an emphasis on Curriculum Studies. For my graduate work, I am implementing a sustainability curriculum to promote classroom practices that incorporate critical thinking, and outdoor experiences in support of the environment. With your permission, this research will continue to help me understand student's relationship toward the environment, culture and the community.

Project Description: Four unit lessons will be taught during science period and will focus on the Hawai'i Content and Performance Standards. Group work, hands-on activities, and field trips may be a part of the lessons, which will be videotaped. Videotapings will record the interactions and discussions between student and teacher or student to student.

Lessons along with assignments will emphasize hands-on real world learning experiences in order to help students develop stronger ties to the their community, enhance the student's appreciation for the natural world, and build their commitment to serving as active and contributing citizens. Students assignments will be used as work samples to help me better understanding of how students' environmental idenity is built.

Video Recordings: With your and your child's permission, I will use video recordings to identiy and understand engagement between students/and or the teacher. For example, I may record lessons, which allow students to test the quality of water from samples they collected around the school and community. Recordings allow me to review the interactions between individuals (through conversations and body language) and any engagement students have with the lesson, which in the moment my eyes may have missed. Video recordings will **not** be used beyond this research for any means. As a researcher,

only myself, and my advisor (Dr. Tara O'Neill) will have access to reviewing the video. Transcriptions for the video will be used as data, however, participants in the research will be anonymous and will not be personally identified. Video recordings will be stored in a secured and locked area. I will be the primary source of access to the recordings and all video recordings will be destroyed once the project is completed.

Student participation in this study will involve my observations of their class participation and analysis of their written assignments and class projects. I will also request that students complete a pre- and post-survey on their daily behaviors and attitudes towards the environment. No personal identifying information will be inclued with the research results. Completion of the survey should take no more than 20 minutes. Additionally, I will have three focus group with five student volunteers. Each focus group will meet on the third Wednesday of each month from January to May 2018 and will last no longer than 30 minutes. The focus group will be video taped for the purpose of transcription.

Benefits and Risks: There will be no direct benefits to your child for participating in my research project. The results of this project might help me, other teachers, and researchers learn more about high school students' views on environmental identity. There is little or no risk to your child in participation in this project. I would typically assign these types of assignments and projects even if I were not doing this study.

Confidentiality and Privacy: I will keep all study data secure in a locked filling cabinet in a locked office/encrypted on a password protected computer. Only my University of Hawai'i advisor and I will have access to the information. Other agencies that have legal permission have the right to review research records. The University of Hawai'i Human Studies Program has the right to review research records for this study.

After I transcribe all of the video recordings, I will immediately destroy the tapes. I will not record your child's name or any other personal information that would identify your child in my research records. Instead, I will use a pseudonym (fake name) for your child. If you would like a copy of my final report, please contact m at the number listed near the end of this consent form.

Although we ask everyone in the group to respect everyone's privacy and confidentiality, and not to identify anyone in the group or repeat what is said during the group discussion, please remember that other participants in the group may accidentally disclose what was said.

Voluntary Participation: Your child's participation in surveys and focus group is completely *voluntary*. Your child can choose freely to participate or not to participate. You can choose freely whether or not your child may participate in this project. At any point during this project, you can withdraw your permission, and your child can stop participating without any loss of benefits. I recognize that I am the researcher in this project and, at the same time, your child's teacher. I will ensure that your child's

participation or non-participation in my research project does not impact their grades, class standing, relationship with me, or relationship with McKinley High School.

In order to do my study, I am required by the Hawaii Committee on Human Studies to ask for your written response to my request for your child to participate. Please sign and return the attached page if you agree to allow your child to participate.

Questions: If you have any questions about this project, contact me,

- Cam-Tu Trinh: (808) 497-5436, email xxx@hawaii.edu
- Dr. Tara O'Neill:(808) 956-0415, e-mail at xoneill@hawaii.edu
- Committe of Human Studies, 2540 Maile Way, Spalding Hall 253, Honolulu, HI 96822, Phone: (808) 956-5007, e-mail at uhirb@hawaii.edu.

Please keep the section above for your records.

_____ YES, *I DO agree to allow my child to participate in Ms. Trinh's study*

_____ NO, *I DO NOT agree to allow my child to participate in this study*

I cerity that I have read and understand this letter, that I have been given satisfactory answers to my inquires concerning project procedures and other matters that I have been advised that I am free to withdraw my consent and to discontinue my child's participation in the project or activity at any time without prejudice.

Name of Child (Print): _____

Name of Parent/Guardian (Print): _____

Parent/Guardian's Signature: _____

Date: _____

Appendix G

Focus Group Interview Protocol

Interviewer: _____

Interviewee: _____

Date _____

Opening Script

Thank you for agreeing to conduct this interview with me. The interview should only take between 20-30 minutes. Your contributions to my research study are greatly appreciated.

If it is okay with you, I will record this interview so I can reference our conversation at a later point. I will take some notes during the interview, but I want to focus on our conversation. All transcripts from this interview and any written reports will not include your name. Are you okay with me recording the interview?

Let's get started with the first interview question.

First Focus Group Questions:

1. What comes to mind when you think about the environment? Can you explain why?

2. What experiences, role models, or events have influenced your feelings toward the environment? In what ways have these experiences, role models, or events influenced your feelings?

3. What environmental issues are you aware of? Why did you choose these issues?

4. How did you find out about these environmental issues?

5. What environmental issues do you think are important? Why did you choose these issues?

6. How do you think these environmental issues should be resolved?

7. What actions need to be done to resolve these environmental issues?

8. What environmental issues are important to other people, but not that important to you? Why are these issues not as important to you?

Second Focus Group Questions:

9. What behaviors or actions do you consider to be environmentally friendly? What is it about these behaviors or actions that make them environmental friendly?

10. Which environmental friendly behaviors do you perform on a regular basis? Why do you choose to perform these environmentally friendly behaviors rather than others?

11. What other environmentally friendly behavior(s) would you like to do that you are not currently doing, and what is preventing you?

12. Which environmentally friendly behaviors do you think other people should do? Why did you choose these behaviors rather than others?

13. Which behaviors or actions do you think are especially harmful to the environment? Why did you choose these behaviors or actions?

14. What actions do you do right now that show care for environment? Why is that an important thing for you to do?

15. You are growing into being adults and making more choices for yourself? What choices do you see yourself making in 10 years? What types of things or issues do you think will be a priority for you?

16. You said a lot of interesting things, I just want to know if you want to add anything else? Is there something you wanted to say but you did not get a chance to?

Third Focus Group Questions:

17. If you were going to rate yourself on a scale of one to five, five being really concerned about the environment and one being not at all concerned about the environment, what would you rate yourself? Why?

18. Is there a story you can tell me about something that's happened to you that shows why you think you're a one, a three, a five, etc.? What's the first thing you remember doing that shows caring for the environment?

19. I want you to pick someone (family, friend, anyone) and think about whether that person cares more for the environment then you, how do you know?

20. You talked about people who are good at caring for the environment. Maybe they recycle, turn off the lights, or use reusable water bottles (or use examples participants will give), do you know people that take this a step further and do lots of things that show care for the environment?

Closing Script

Thank you so much for your time. I truly appreciate your contributions to my study. Do you have any questions for me?

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