2020

A PHENOMENOLOGICAL INQUIRY INTO THE TEACHING OF CLIMATE CHANGE

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A PHENOMENOLOGICAL INQUIRY INTO THE TEACHING OF CLIMATE CHANGE

By

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A Dissertation Submitted to the

Graduate School

In Partial Fulfillment of the

Requirements for the Degree of

DOCTOR OF EDUCATION

Benerd College
Curriculum and Instruction

University of the Pacific
Stockton, California

2020

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DEDICATION

This dissertation is dedicated to the globalization of love and the fight against climate change.

ACKNOWLEDGMENTS

Beautiful friends, this is the end. I would like to thank everyone who supported me throughout this long, strange trip. First and foremost is my beautiful and intelligent wife/unofficial editor in chief Sarah, whom I could not have done this without. I would like to offer deep gratitude to my committee members Dr. Nelson, Dr. Starks, and Dr. Jones for the ideas, support, encouragement, and guidance. I would like to specifically affirm Dr. Nelson for the years of support, the stretching of my thinking, the music sharing, and the rich reflective conversations. I would like to thank my family and friends for inspiring me and believing in me. I would also like to specifically thank my grandmother Martha for inspiring the musician in me. I would like to thank my mother Kari, father David, and my grandparents Walter, Martha, Jesus, and Virginia for their support throughout all this. Lastly, I would like to acknowledge the work of all individuals fighting to alter our trajectory toward planetary annihilation. "Keep on rockin in the free world" (Young, 1989).

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Abstract

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The purpose of this study was to explore the ways in which educators address climate change and the impacts of human activity on the environment in conjunction with the Next Generation Science Standards. This study utilized qualitative methods, a phenomenological methodology informed by Moustakas, and a Systems Theory and Ecojustice Education conceptual framework. The central research questions was: in what ways do educators who are implementing the Next Generation Science Standards address climate change and the impacts of human activity on the environment? The supporting research questions were: in what ways do educators who are implementing the Next Generation Science Standards perceive their roles and responsibilities in addressing climate change and the impacts of human activity on the environment? in what ways do educators who are implementing the Next Generation Science Standards interpret the associated Earth and Human Activity standards prior to enactment? and, how do educators who are implementing the Next Generation Science Standards teach climate change and the impacts of human activity on the environment?

Eight participants were purposely selected using criterion sampling. All participants taught in grades six-twelve, had at least five years teaching experience, and worked in the Sacramento Valley region of California. Data collection consisted of interviews, observations, and document analyses. During the data analysis, horizontalization was utilized which led to the

illumination of the following themes: Climate change is an existential crisis, Examination and refinement of pedagogy, Perceptions on Next Generation Science Standards pedagogy, Inquiry-based pedagogical methods, Pedagogical resources, Fostering relevancy to students, and Steps toward an eco-ethical consciousness. The conclusions drawn are: context is key, confusion persists and teachers need guidance and support, adopted curricula and content standards are inadequate, systems thinking and eco-ethical mindsets are vital, teachers are essential for survivability, and more needs to happen. The recommendations from this study are of relevance to policy makers, administrators, curricula and standard developers, teachers, and anyone else interested in mitigating the impacts of human activity on the environment.

Keywords: Climate change, Ecojustice, Pedagogy, Next Generation Science Standards

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CHAPTER 1: INTRODUCTION

> "I'm a bluesman moving through a blues-soaked America, a blues-soaked world, a planet where catastrophe and celebration sit side by side" (West, 2009 p. 4).

All of human existence will someday be condensed into a layer of sediment no thicker than a piece of paper. When stratigraphers look back millions of years from now, will the most extraordinary impact that humans had on this planet be the cause of our own extinction, marked by the end of the Anthropocene epoch? It has long been understood that local and global ecosystems are essential to all life; yet so often humans fail to challenge the deep-seated cultural assumptions that underlie modern thinking, and in effect undermine prolonged human existence (Martusewicz, Edmundson, & Lupinacci, 2014; Plumwood, 2002). As many Westernized habits have become globalized to the point that human demand and activity have vastly altered the composition of Earth's atmosphere, land, water, natural habitats and non-human species (Crutzen, 2002; Kolbert, 2006a; 2006b; 2014), *homo sapiens* will arguably be understood to be the most invasive species in biological history (Burdick, 2006). In fact, the most recent report from the World Wildlife Fund attributes the loss of two-thirds of all wildlife over the last 50 years to human activity (Almond, Grooten, & Petersen, 2020). Considering problems such as this, researchers have highlighted the importance of aligning collective efforts on all fronts to value sustainable relationships between humans, the bio-physical world, and the elements that make up the non-human world (Huckle & Wals, 2015; Macy & Brown, 2014; Martusewicz et al., 2014; McNeal, et al., 2014). If one's realm of responsibility excludes socially equitable treatment of certain groups of humans or other living and non-living beings, then diversity, which largely contributes to the strength and sustainability of communities, is undermined

(Martusewicz et al., 2014). Therefore, eco-ethical and social justice clarity, foresight, and wisdom to make corresponding changes in governance, politics, economics, culture, and thinking is necessary for planetary survival (Orr, 2016). Although concerted efforts to address global and local ecological crises and the associated social justice intersections must come from various areas of society, education is one expanse with the power to foster knowledge and action-oriented concern about the natural world (Martusewicz et al., 2014).

Background of the Study: Prelude in C minor

Dominant and dissonant notes of neo-liberal practices, capitalistic systems, and globalized discourses of modernity characterize the prelude to planetary annihilation with which we currently exist. On a smaller personal scale, California, like many other places, is experiencing climate and ecological changes as evident in data regarding warming, drought, extended wildfire seasons, Alpine zone tree mortality, and northward migration of invasive species (Diffenbaugh, Swain, & Touma, 2015; Glover, 2017; Purzer, Moore, Baker, & Berland, 2014; Stevens, Safford, & Harrison, 2015). In accordance with some of the issues mentioned above, the latest amalgamation of K-12 science education guidelines, known as the Next Generation Science Standards (NGSS), is the first set of science standards to explicitly include climate change (Glover, 2017; Hestness, McDonald, Breslyn, McGinnis, & Mouza, 2014). Moreover, this new set of science standards also includes concepts relating to human impact on the environment and systems thinking. Across several grade levels, the NGSS contains specific Disciplinary Core Ideas (DCIs) related to climate change and the impacts of human activity on the environment (Zee, Roberts-Harris, & Grobart, 2016), while the standards also include emphasis on understanding systems as a Science and Engineering Practice (SEP) (Wysession, 2013). With this updated approach, the NGSS has been described as seeking to impart upon all

students an engaging and relevant science education that will shape how they participate in their world (Pruitt, 2014).

Although these concepts have long been advocated for in education, with specific regards to the NGSS the conception of their inclusion began in 2010 with the Carnegie Corporation of New York's two-part process. This led to the completion of the NGSS in 2013 (Huff, 2016). Throughout the privately funded development, two phases were implemented. Phase one consisted of a partnership between Achieve, the National Research Council (NRC), American Association for the Advancement of Science (AAAS), and the National Science Teachers Association (NSTA). During this phase, the NRC also published a report, *Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics*, which emphasized the need for future innovation and advocacy for mathematics and science to be seen more prominently as 'engines for democracy' (Huff, 2016; Pruitt, 2014; Willard, 2015). While the report lacked detail regarding ecological, environmental, and social justice related issues, it did provide the foundation for the NGSS (Huff, 2016). From this collaboration, *A Framework for K-12 Science Education* was developed in 2012.

Following the completion of this framework, states were encouraged to participate in the next stage of the NGSS development. However, submission of a proposal detailing the ways in which each state would contribute to the development of the NGSS and its implementation was required for participation (Huff, 2016). Twenty-six states were ultimately accepted as lead states; with 40 writers, consisting of K-12 educators, higher education faculty, state science supervisors, practicing scientists, engineers, and researchers (Achieve, 2013; Huff, 2016; NGSS Lead States, 2013). Proceeding the development and adoption of the NGSS, K-12 educators across the country began exploring the NGSS in attempts to deconstruct, design, and implement

science related practices that translate into the classroom (Willard, 2015). Although the NGSS largely consists of scientific concepts carried over from previous education standards, the updated inclusion of climate change, the impact of human activity on the environment, and Science and Engineering Practices (SEPs) that emphasize interacting systems require teachers to include environmentally concerned concepts in their classrooms and instruction.

The NGSS developers have openly asserted that science education is essential to the lives of students, because the challenges they will face will likely require them to make carefully considered decisions on a range of issues, including the environment (Achieve, 2013; Huff, 2016; NGSS Lead States, 2013). This comes as the last century has been characterized by increased dominance and commodification of Earth's natural resources, ecosystems, and groups of people (Bowers, 2001; Kolbert, 2014; Orr, 1997; Plumwood, 2002; Zinn, 1999). Examples of the issues that students and teachers may encounter range from accelerated rises in atmospheric CO2 levels, to the new geologic features introduced and shaped by human activity, the impact of climate change on food, water, ecosystems, and infrastructure, and the decline of living and non-living beings (Glover, 2017). As humans are clearly a major geological superpower, it is imperative that students learn about and question the impact of human activity (Biello, 2015). If we continue to follow this path of capitalistic neo-liberal ways of being, what kind of planet will we leave for future generations? How will future generations learn to care about the relationships between groups of humans as well as their relationships with the natural living and non-living systems and organisms? With the population expected to reach roughly nine billion by 2050, it is an ethical imperative that students not only learn about issues of ecological degradation and intersecting social injustices, but also develop mindsets and connections built on trust, generosity, and fervor for biological diversity, climate sustainability, and the resilience of

Earth's natural and social ecosystems (Klein, 2015; Kolbert, 2014; 2015; Martusewicz et al., 2014).

With the implementation of the NGSS, teachers in certain grade levels will be faced with standards related to issues similar to those mentioned above (www.nextgenerationscience.org, 2018). Considering that the potential influence teachers have on their students can be monumental and widespread, the NGSS developers have described the standards as being designed to support the development of students' understanding of the physical world and the impact of human activity, encourage inquiry, and improve their ability to make reasoned decisions based upon evidence (Glover, 2017; Huff, 2016; Pruitt, 2014; Willard, 2015). As teachers are one of the most important influences on modern day youth (Berkman & Plutzer, 2010; Rodrigues, 2008), addressing the patterns and deeply embedded cultural assumptions that have undermined our social and ecological systems is essential to inspire students to generate change and possible solutions to crises we face (Bowers, 2001; 2010; Lowenstein, Martusewicz, & Voelker, 2010; Martusewicz, 2005; Martusewicz et al., 2014). That being said, this dissertation has sought to explore the ways in which educators address climate change. This includes exploration of the ways in which they perceive their roles and responsibilities in addressing the topic, interpret the NGSS prior to teaching, and the ways they do so in their classrooms.

Statement of the Problem

The complexity associated with educating students about local and global ecological issues has been found to cause educators to struggle with topics in the vein of climate change and environmental racism (Crayne, 2015; McNeal et al., 2014; Monroe, Plate, Oxarart, Bowers, & Chaves, 2017). Research has shown that educators are less likely to include topics with which

they are uncomfortable or unfamiliar in their teaching (Banilower, Heck, & Weiss, 2007; Eidietis & Jewkes, 2011). Moreover, misconceptions, lack of preparedness, and discomfort can transfer inaccuracies to students and lead to the absence of knowledge and learning related to issues such as climate change and the impact of social and cultural human behaviors on the environment in school (McNeal et al., 2014). Similarly, Sterman and Sweeny (2007) had found low conceptual understandings of systems thinking among educators and concluded that current educational practices do not foster an appropriate understanding among students or teachers.

In addition, as a means to maintain global capitalistic competitiveness, the standardized focus of the education system in the U.S. has been argued to further encourage little consideration of ecological responsibility (Louv, 2008, 2011; Nelson & Cassell, 2012; Orr, 1997; & Spring, 2013). Scholars have pointed out this lack of inclusion in mainstream education as being likened, in large part, to the disproportionate amount of power typically held by those who often have much to lose from equitable social, cultural, and economic changes (Lieberman, Golden, & Earp, 2013; Nelson & Coleman, 2012; Spring, 2013; Stone, 2010). Since it's infiltration of mainstream society, the for-profit ideas of capitalism have perpetuated the exploitation of people working within the system and the natural resources of which raw materials are extracted (Martusewicz, et al., 2014). In effect, for-profit corporations, politicians, private investors, and policy makers reap the capitalistic rewards, at the cost of education and our environment (Pappas, 2013; Spring, 2013), despite the majority consensus of climatologists and environmental researchers that many of our systems and habits are no longer sustainable. Although the NGSS contains elements related to climate change and the impacts of human activity on the environment, there has been a limited body of research that has explored and

analyzed (1) how educators perceive and understand their the roles and responsibilities in addressing these issues, and (2) in what ways do they do so in conjunction with the NGSS.

Purpose of the Study

The purpose of this study was to capture and describe the essence of educators' experiences as they plan for, interpret, and implement NGSS related to climate change and the impacts of human activity on the environment. In other words, as the NGSS introduce concepts of climate change and the Earth and Human Impact standards, what are teachers doing—and why?

Research Questions

Central research question: In what ways do educators who are implementing the Next Generation Science Standards address climate change and impacts of human activity on the environment?

Sub-questions:

1. In what ways do educators who are implementing the Next Generation Science Standards perceive their roles and responsibilities in addressing climate change and the impacts of human activity on the environment?

2. In what ways do educators who are implementing the Next Generation Science Standards interpret the associated Earth and Human Activity standards prior to enactment?

3. How do educators who are implementing the Next Generation Science Standards teach climate change and the impacts of human activity on the environment?

Significance of the Study

Researchers have argued that changes in pedagogical content are simply not enough to radically improve long-term sustainability (Nelson & Cassell, 2012, 2016; Nelson & Coleman, 2011); therefore, challenges to the public education status-quo must not only advocate for the inclusion of life-sustaining practices and consider the impacts of human activity on the

environment, but also seek to transform current 'habits of mind' (Bordieu 1985; Martusewicz et al., 2014). Considering this, research in the realm of this study that explores how and why teachers address issues related to climate change and the impacts of human activity on the environment in accordance with the NGSS at this juncture in time has strong potential to inform current practices and inspire changes in teaching. Since there is limited qualitative research that has addressed the specifics of this study, this dissertation will be more than informative, as my goal is not to simply produce knowledge but also inspire changes in attitude, perspectives, and instructional practices.

The current trajectory toward environmental annihilation requires society to focus and share research detailing specific ways in which educators perceive their roles and responsibilities in addressing climate change and the impacts of human activity on the environment, as well as ways in which this translates to their instructional practices. In providing findings on how and to what extent teachers address issues of climate change and the impacts of human activity on the environment, this study adds to the knowledge base among educators as they navigate new terrain related to the NGSS, and informs research related to teacher decisions and practices.

As teachers begin implementing the NGSS it will be important to understand the roles and responsibilities in addressing issues such as climate change and the impacts of human activity on the environment, and the ways in which they do so. In exploring, presenting, analyzing, and discussing roles, responsibilities, and instructional practices of educators as they relate to addressing local and global issues of ecological degradation in the classroom through rich descriptions and analyses, this study has the potential to contribute to the further improvement of more specific courses and professional development, for educators and pre-service teachers alike. The findings may be useful for any teacher professional development,

teacher support systems, or other educators or institutions interested in guiding teachers towards a pedagogy of responsibility, or at the least a more ecologically concerned perspective. This will also inform those interested in the growth of an eco-ethical consciousness or including other life sustaining practices in their teaching. In this regard, this study is relevant to policy makers, advocacy groups, and educators interested in addressing climate change and the impacts of human activity on global and local ecosystems. The analysis and descriptions of teacher perceived roles and responsibilities and the impacts this has on their instructional practices may prove useful for future teacher support and curriculum or standards design. The findings may inspire other educators to reflect upon their roles and responsibilities related to addressing climate change and the impacts of human activity on the environment as well as help to inform practices directed toward creating a restructured society with the urgency of addressing climate change.

Conceptual Framework

Conceptual frameworks serve as the driving force behind studies and investigations. They allow the researcher to better focus their research, data collection, and synthesis. The conceptual framework for this study is a hybrid that consists of Systems Theory and Ecojustice Education as they both work harmoniously with each other. While Systems Theory generally refers to the interdisciplinary study of systems, it is important to note that Systems Thinking generally refers to the analysis approach. Applying Systems theory with Ecojustice Education to the ways I think about human relationships with other groups of people, and the living and non-living systems and beings around us, I acknowledge the need for an extension of justice that includes both the human world and the natural world because everything is interconnected and relational. *Anthropocentric* and *androcentric* views are directly connected to crises with which

we are confronted with as they have positioned certain people and groups as naturally superior to others, as well as positioning humans at the top of a hierarchy of all living and non-living beings (Bowers, 2001; Martusewicz et al., 2014; Nelson & Coleman, 2012). Systems Theory emphasizes the need to recognize the differences and connections between ecologically-centered cultures and dominant, individual-centered cultures (Bowers, 2001; Lupinacci, 2013; Martusewicz et al., 2014). The Ecojustice Education perspective positions Western thinking as having overlooked the importance of aligning behaviors with expressed values and the relationships with other living and non-living beings (Bowers, 2001; Martusewicz et al., 2014). When applying these ways of thinking to the contexts and crises with which we are confronted, we can begin to develop deeper, sustainable solutions to the consequences our habits, systems, and ways of being have had on the world around us (Lupinacci & Heppel-Parkins, 2016; Mackie & Edmundson, 2013). Although this chapter has provided a brief description of the conceptual framework, in order to better understand the ways in which conceptual distinctions and organizational ideas have been made throughout this study, Systems Theory and Ecojustice Education will be further explored in chapter two.

Definition of Terms

Androcentrism: A form of thinking that posits men as naturally superior to women (Martusewicz et al., 2014 p.82).

Anthropocentrism: A human centric form of thinking that views all other living and non-living beings as inferior (Martusewicz et al., 2014 p.81).

Cross Cutting Concepts (CCCs): Concepts that hold true across the natural and engineered world (Willard, 2015). See Appendix F

Disciplinary Core Ideas (DCIs): The fundamental ideas that are necessary for understanding a given science discipline (Willard, 2015).

Discourses of Modernity: Complex exchanges of meaning created by root metaphors. Examples include individualism, mechanism, progress, and commodification/consumerism.

Diversity: The condition of difference that occurs relationally between one thing or idea and anything else (Martusewicz et al., 2014 p. 26).

Ecojustice Education: A framework that recognizes local and global ecosystems as essential to all and therefore places a high sense of urgency on the need to restore cultural and environmental commons while challenging the deep cultural assumptions that underlie modern thinking and undermine local and global ecosystems (Bowers, 1997; 2001).

Performance Expectations (PEs): The set of student learning goals according to the Next Generation Science Standards (NGSS) (Willard, 2015).

Root Metaphor: "Buried ideological sources from which the culture draws strength and reproduces itself inter-generationally, often over hundreds of years." (Martusewicz et al., 2014 p. 72).

Science and Engineering Practices (SEPs): Student centered practices that are based off of those which scientists and engineers use to investigate the world and design and build systems (Willard, 2015).

Chapter Summary

Due to the current state of national education and the environment, this study holds relevance. Considering the lack of research specific to this study, this chapter has discussed the significance of such a study and therefore the need for research in this area. The purpose, research questions, and problems that have been presented here have derived from my role as an

educator, instructional/curriculum coach, and Ecojustice Education advocate. Therefore, this study is founded upon my positionality and Ecojustice Education principles. Considering the nature of this study, chapter two has explored literature and research centered on Systems Theory, Ecojustice education, content standards, environmental education, and climate change. Chapter three details the qualitative methods which have been utilized, chapter four presents the findings, and chapter five is composed of a discussion, conclusions, and recommendations.

CHAPTER 2: REVIEW OF LITERATURE

Introduction: Medley

The purpose of this study is to explore and describe the essence of educator's experiences as they plan for plan for, interpret, and implement the Next Generation Science Standards (NGSS) related to climate change and the impacts of human activity on the environment. The central argument of this chapter is that traditional public education standards have lacked adequate inclusion of the concepts; therefore, with the NGSS including these new additions, there remains a need for qualitative research that seeks to explore how educators address climate change and the impacts of human activity on the environment, perceive their roles and responsibilities in addressing these issues, and interpret the standards prior to enactment.

When a musician performs a collection of preexisting pieces of music condensed into one song it is referred to as a medley. Medleys are often used at the start of extended compositions and include parts, themes, and highlights from existing pieces. As a musician writing this study, I approached this literature much like the composition and performance of a medley. This literature review showcases a medley of pre-existing ideas, themes, and findings from peer-reviewed journal articles, curriculum and educational standards and frameworks, books by authors concerned with similar issues, research handbooks, and theses and dissertations. The central purpose of this medley is not only to advance the argument described previously, but also to provide to look at the landscape and context related to this study. In order to begin to address the research questions, this chapter will commence with an exploration of the NGSS within the context of climate change and the impacts of human activity on the environment. In order to further address the research questions, the following sections will highlight research regarding

teacher instruction related to climate change and the impacts of human activity on the environment. This section will largely consist of an overview highlighting ways in which issues related to climate change and the impacts of human activity on the environment have been included in education (i.e. place-based education, environment education, experiential education, education for sustainability, Ecojustice Education, and traditional standardized education). By exploring the related pedagogical approaches, this section of the literature review will contribute to the background and foundation necessary for understanding the context of this study. The final section, which will provide an overview of my conceptual framework which emphasizes Systems Theory and Ecojustice Education, has been informed by the work of researchers such as Chet Bowers, Rebecca Martusewicz, and Thomas Nelson. The elements of an Ecojustice Education framework that will be addressed in this chapter include the following: (1) A pedagogy of responsibility and an eco-ethical consciousness; (2) diverse, democratic, sustainable ways of being; and (3) dualism, anthropocentrism, hierarchical thinking, and 'ecology of mind'.

Systems Theory and Ecojustice Education as a Framework

Systems Theory is a complex construct that has been explored and expanded upon by many system thinkers and researchers including Richmond, Capra, Bertalanffy, Checkland, and Laszlo. In addition, it is a way of thinking that is necessary for an Ecojustice Education framework. Due to the complexity related to defining Systems Theory, debate has long existed over an exact definition. While differences and debate over precise definitions of Systems Theory exist, Cabrera (2006) has highlighted three, agreed upon, principals found in the literature. The first principal is referred to as "boundary critique." According to Cabrera, in order to systems think, one must set boundaries in order to determine what should and should not be included for consideration. The second principal that Cabrera has suggested is that systems

thinking involves multiple perspectives. Perspectives, therefore, can be understood as that idea of involving multiple stakeholders or that multiple levels of size must be considered. Regardless, the literature is clear that one must view issues from numerous perspectives (Cabrera, 2006). The third principal necessary for understanding the construct of systems thinking is that systems thinking involves placing elements into context.

Linguistically speaking, the word system derives its sense from the Greek verb synhistanai meaning 'to stand together' (Ison, 2008). Building on the ideas presented above, systems thinking refers to thinking about the world through the concept of a system (Checkland, 1999). In this respect, a system is perceived as interconnected elements, as well as a way of thinking about the connections or relationships between elements (Lyneis, 1999). When applied to research and analysis, systems thinking invites the researcher to see complex issues from multiple perspectives, suspend judgment by questioning one's own assumptions, and value insights from various disciplines and alternative ways of knowing. This contrasts with traditional reductionist methods that break down systems into their separate elements. Applying these concepts to the ways in which one thinks about relationships with and within systems, things become understood as interconnected and relational. Thinking this way allows for clarity in understanding the vast array of systems, patterns within these systems, and the ways in which these structures determine the behavior of the systems (Lyneis, 1999). This process of understanding can provide clarity of the ways in which things influence each other within the greater whole. While Systems theory can have applications to many fields of study, it is conducive to the cyclical and interconnected nature of the world in which we live. Furthermore, in capitalizing on the emergence of parallelisms or patterns, systems thinking is conducive to research exploring the complexity in human experiences (Lyneis, 1999 p. 7). In fact, Cabrera

suggests that systems thinking should be understood as "thinking that is informed by knowledge-about-systems" (p. 51). Therefore, for the purpose of this study, systems thinking is understood to be "a conceptual ability, an orientation, and a framework." (Cabrera, 2006).

Ecojustice Education

According to Bowers (2001), Ecojustice Education should frame social and ecological issues of class, race, and gender together to be:

> Responsive to the cultural patterns enacted in the relationships that make up the complex ecologies of the classroom and the larger communities. It should also strive to illuminate environmentally destructive patterns and to reinforce cultural patterns that have a less adverse impact on the environment. In short, an Eco-Justice pedagogy should be understood as a culturally and ecologically responsive form of teaching (Bowers, 2001, p.187)

While education in the U.S. has played a key role in shaping and reinforcing the ways in which humans currently interpret and make sense of the world (Bowers, 2001; Martusewicz et al., 2014; Nelson & Cassel, 2016), Ecojustice Education posits Western culture as consisting of hierarchical perceptions and discourses of modernity that have perpetuated contemporary, taken-for-granted value-hierarchized worldviews and root metaphors regarding concepts such as progress, individualism, science, rationalism, and mechanism (Bowers, 2001; Martusewicz et al., 2014). Furthermore, Ecojustice Education views these hierarchical perspectives as having instilled human-centered cultural habits, inequality, and the acceptance of exploitive political and economic systems. Researchers in the realm of Ecojustice Education have described the advocacy for standardization, accountability, and hierarchical paradigms as having equipped students with ideals shaped by individualism and consumerism, at the expense of social and environmental relationships (Bowers, 2010; Lupinacci, 2013).

Ecojustice Education is an ethical perspective, a framework, and when applied to education, a 'pedagogy of responsibility' (Martusewicz et al., 2014; Wayne & Gruenewald,

2004). At its core, Ecojustice Education is concerned with the intersections of environmental racism, economic domination, non-commodified traditions associated with varying communities, ethnic and cultural groups concerned with ecological and social sustainable way of living, and the responsibility to adapt and rethink our habits and ways of being (Bowers, 2001; Martusewicz et al., 2014; Wayne & Gruenewald, 2004). According to Wayne and Gruenewald (2004), by beginning with the examination of these concerns, Ecojustice Education, "provides endless opportunities for those of us in education to teach toward an expanded notion of justice and toward understanding the politics of ecological themes such as interconnection, interdependence, diversity, limits, and energy dynamics" (p. 7). Therefore, if future generations are to develop life sustaining ways of being, Ecojustice Education principles hold promise for the logical transformation in thought necessary to doing so.

Adding to these ideas, Ecojustice Education activists and practitioners have described Western ways of thinking as having overlooked the importance of aligning dominant human behaviors with the expressed values and the relationships with other humans and nature in order to prepare citizens to develop diverse, sustainable, democratic communities (Bowers, 2001; Martusewicz et al., 2014). In this sense, Ecojustice Education as a 'pedagogy of responsibility' can be understood as a description of practice that is informed and structured by a teacher's commitment to engage students with questions about diversity, democracy and sustainability (Bowers, 2001; Martusewicz et al., 2014; Reid, 2007). Furthermore, the development and pursuit of an 'eco-ethical consciousness,' and 'pedagogy of responsibility' has the potential to transform teacher understanding, awareness, and practice; as educators are encouraged to explore pedagogies that challenge the status quo and address life-sustaining connections between locally

situated contexts of place and engagement in a local indigenous wisdom to strengthen community, which results in the practice of a 'pedagogy of responsibility.'

Continuing along these lines, Bowers (2001) has emphasized the intersections of culture, education, and ecological ideas, with the importance of recognizing and learning from the differences between ecologically-centered cultures and anthropocentric cultures. Furthermore, his work has represented the concern of Ecojustice Education advocates to shed light on non-Western ways of thinking as an approach to recovering our senses and recognizing our membership within the local ecological communities to which we belong (Bowers, 2001; 2006; 2011). In addition, Bowers has also led efforts to call attention to language, root metaphors, and the need to transform dominant patterns of thinking and behaving that have been carried forward and preserved in hegemonic cultural traditions (Bowers, 2001). Overall, Bowers' work has highlighted the ways in which dominant traditions and social inequalities, such as racism or sexism, have been connected to unjust suffering among local and global ecosystems and human instability.

Drawing on the work of Bowers, Martusewicz et al. (2014) have offered the following elements to help define Ecojustice Education: (1) the recognition and analysis of embedded cultural assumptions that undermine local and global ecosystems, (2) the recognition and analysis of patterns of domination that have defined certain groups of humans, as well as the natural world, as inferior, (3) the analysis of the globalization of modernist thinking which has emphasized exploitive habits such as hyper-consumption and commodification, (4) the recognition and protection of diverse cultural and environmental commons, (5) emphasis on decision making that involves those most affected while considering the consequences such decisions will have on the natural world and well-being of future generations, (6) and emphasis

on cultural analysis and community based learning to foster remediation of social and ecological degradation.

Accordingly, Mackie and Edmundson (2013) have summarized this with two main themes. The first is an analysis of the cultural roots of the ecological and social crises, with the understanding that the same forces that have undermined local and international communities, have also contributed to the destruction life sustaining resources. The second theme is the recognition of the importance of replenishing and developing cultural commons necessary to lead sustainable lifestyles (Mackie & Edmundson, 2013). Additionally, Wayne and Gruenewald (2004) have further described Ecojustice Education framework as guiding students to understand and remediate unjust environmental practices connected to social justice and consumerism. Their work has also described and Ecojustice Education framework as recognizing economic domination and exploitation of non-Western cultures for the purpose of maintaining and expanding a hyper-consumptive lifestyle. Therefore, an Ecojustice Education framework recommends the need for the revitalization of non-commodified traditions of different ethnic groups and communities with emphasis on the conservation of ecologically sustainable cultures. In order to transition toward diverse, democratic, and sustainable societies, an overall dedication to reconceive and adapt our lifestyles is necessary (Kolbert, 2015; Macy & Brown, 2014; Martusewicz et al., 2014).

Diverse, democratic, sustainable communities. Democracy and diversity are essential to sustainable communities, as every living organism and system is reliant on a network of relationships (Martusewicz et al., 2014). From humans to micro-organisms, diversity has kept life on Earth functioning. When diversity is abundant, life flourishes. From the perspective of a Systems Theory and Ecojustice Education framework, diversity is the condition of difference

necessary to support all life and creativity, democracy is seen as any system that allows real involvement in the decisions that impact their lives, and sustainable communities are those that support the ability of natural systems to renew themselves (Martusewicz et al., 2014). In developing the idea of democracy as it pertains to Ecojustice Education, advocates have been influenced by Vandana Shiva's 10 principles of Earth Democracy: (1) Ecological democracy: democracy of all life; (2) Intrinsic worth of all species and peoples; (3) Diversity in nature and culture; (4) Natural rights to sustenance; (5) Earth economy is based on economic democracy and living economy; (6) Living economies are built on local economies; (7) Living democracy; (8) Living knowledge; (9) Balancing rights with responsibility; and (10) Globalizing peace, care, and compassion (Shiva, 2006). In addition, Benjamin Barbers' idea of 'Strong Democracy' has been cited as influential due to the emphasis on "decision-making power of local communities" (Lupinacci, 2013, p. 96). With this understanding, Ecojustice Education has situated human communities within and dependent upon the well-being of the complex systems of life (Martusewicz et al., 2014).

Often, sustainability has been used in many contexts. From a Systems Theory and Ecojustice Education perspective, sustainability is both an environmental and a social issue (Pappas, 2013). Along these lines, Medrick (2015) has described two types of SE: Education for Sustainability and Education as Sustainability. Accordingly, the first considers the ways in which teachers educate students on how to achieve global and local sustainable communities. The other considers the means through which teachers educate students to the values, opportunities, and choices necessary to develop and contribute to a habitable society and planet (Medrick, 2015). In conjunction with this thinking, Perry (2013) has described sustainability as, "a complex construct with roots in both the concern for intergenerational equity held by

numerous ancient cultures and the balance of resource use and regeneration within the field of ecology" (p. 47). In addition, Perry (2013) has added that sustainability currently has also come to represent the goal of reversing the environmental degradation caused by humans and the elimination of economic injustice and overconsumption.

On a more specific note, Pappas (2013) has described sustainability as consisting of five main contexts. The first context of individual sustainability refers to the ability to live in a way that creates harmony, interconnection, and an elevated level of awareness in one's "values, thoughts, and behaviors" while increasing "control over one's physical, emotional, social, philosophical/spiritual, and intellectual life" (p. 3). The second context is social and cultural sustainability, which involves the "role of individuals; relationships among social groups; the family; collective behavior; social class, race and ethnicity; medicine; education; and the role of institutions in society that tend to promote harmony among people" (p. 3). Economic sustainability is the third context, which pertains to "profit-making policies and strategies related to the design and development of a process, product, or service" (p. 3). This context questions the economic factors that have influenced the health, standards of living, economic climate, employment, and the influences of corporations on local communities (Pappas, 2013). Another aspect described by Pappas, environmental sustainability, concerns the processes, products, and structures which have had less negative or neutral effects on the Earth's natural ecosystems. Lastly, Pappas has added technical sustainability, which addresses factors related to "the design and manufacture of products" (p. 3) as they relate to a sustainable planet. With an Ecojustice Education framework, the perspective of sustainability considers all the aspects described above, as they relate to the ability to survive with respect to environmental resources and the quality of life.

Ways of thinking. Understanding the world in terms of systems and Ecojustice applies to more than just the physical world. Diverse, democratic, sustainable communities cannot maintain long-term existence if certain components of Western thinking continue to dominate and become globalized. If society is to truly examine the dualistic, anthropocentric, and hierarchical ways of thinking and existing that currently dominate Western thought, historical dimensions must be considered (Lupinacci, 2013). In this regard, counter to the anthropocentric view of human rationality, Bateson (1972) has described the idea of an 'ecology of mind' as an understanding of relationships between humans and other living systems, set within a limited Earthly context. His work has contributed foundational ideas for an Ecojustice Education understanding of the ways in which culture has reproduced meaning through dominant patterns of thought, which have in turn contributed to the current social and environmental crises (Lupinacci, 2013; Martusewicz et al., 2014). In this respect, Ecojustice Education pioneers and theorists have built on Bateson's work to expose the false notion of an autonomous individual and continue to encourage an understanding in which all living and non-living beings are part of complex, recursive systems. Overall, through the acknowledgment of constructed meaning as being relational, interconnected, and built on interpretations of observed experiences and differences, an Ecojustice Education framework is conducive to educators and students addressing the consequences of current cultural habits, while learning to facilitate the implementation of remedial habits that support diverse, democratic, and sustainable communities.

Gender and race. In order to understand ourselves and the impact of human activity on the environment and other living and non-living beings, students must be prepared with critical ecological knowledge and intelligence to deconstruct and assess our history and its influence on

the socialization into dominant mindsets (Lupinacci, 2013; Nelson & Coleman, 2012). Ecojustice Education pioneers and theorists have drawn on the philosophical and ecofeminist work of scholars in the vein of Foucalt, Plumwood, and Warren in order to understand these issues. The work of Foucalt, for instance, has described the need for engagement in historical ontologies of ourselves by reflecting and questioning the construction of knowledge and our acceptance of power relations (Lupinacci, 2013). Ecofeminist scholars, such as Warren and Plumwood, have provided scholarly work that has linked the unjust suffering of women with the degradation and destruction of ecological environments within the context of patriarchal cultures. These scholars have contributed to the development for Ecojustice Education, as their philosophies have highlighted the interconnections of the domination of women, other humans, and the natural world (Plumwood, 2002). From this perspective, gender differences can been seen as created and perpetuated by the ways of thinking and being that have been assigned to biological differences and passed on through interpretations that have been internalized and exchanged through complex systems to be accepted as natural (Martusewicz et al., 2014; Plumwood, 2002). Overall, the work of these scholars and others alike have suggested that, in order to recover from the current social and ecological atrocities, light must be shed on the silenced historical truths in a way that recognizes patriarchal structures as having forwarded the androcentric versions of human history (Abram, 1996; Lupinacci, 2013; Martusewicz et al., 2014; Plumwood, 2002; Warren, 2000).

According to an Ecojustice Education framework, democratic and sustainable communities cannot maintain themselves if they are situated with hierarchized ways of thinking and being with regards to other humans and the natural world (Martusewicz et al., 2014). Although many researchers have acknowledged race as a social construct influenced by

discursive practices, hierarchized perspectives have continued to underlie mainstream society. With this in mind, an Ecojustice Education framework recognizes that value hierarchies have perpetuated logical domination, which has contributed to the trajectory of planetary annihilation (Martusewicz et al., 2014). In addition to drawing attention to issues related to the environment, an Ecojustice Education framework also seeks to highlight issues, such as the disproportionate location of poor families and people of color in proximity to a toxic environment (Martusewicz et al., 2014). From incinerators and hazardous waste facilities, to pollutants linked to cancer, respiratory ailments, skin diseases, and birth defects, to high quantities of lead still found in housing, soil, and water, this framework recognizes the need to address environmental and social problems.

In further relation to the impacts of human activity on the environment, an Ecojustice Education framework is concerned with exploitation and degradation carried forth by 'Western industrial models of economic development' (Lupinacci, 2013). As these 'discourses of modernity' have been globalized, Martusewicz et al. (2014) have explained that industrialization and participation in the global market has come to be seen as a necessary improvement over other ways of living with these cultures being forced to 'modernize' or 'develop'. An Ecojustice Education framework seeks to highlight the mainstream perspectives of globalization as having ignored ways in which rich, industrial countries dominate and benefit far more from the destruction of the environment and local communities, and has therefore led to the need for a more community-based, self-reliance model that celebrates reciprocity, mutual care, and sharing (Martusewicz et al., 2014). While some researchers, educators, and politicians have argued the necessity of increasing economic productivity for the U.S. to be competitive globally, an Ecojustice Education framework recognizes that these goals are often connected to the roots of

wide spread cultural and environmental degradation (Mueller & Bently, 2007, 2009). Therefore, it is necessary to seek to foster human–nature relationships in order to reduce the impacts of human activity and sustain local ecosystems (Mueller & Bently, 2007; 2009).

Education as a pedagogy of responsibility. Education is an essential element in the response to the current path of planetary annihilation (Martusewicz, Edmundson, & Lupinacci, 2014; Nelson & Cassell, 2012; Nelson & Coleman, 2012; Weart, 2017), as research has demonstrated that education has the potential to foster an understanding of life sustaining concepts and encourage mind-shifts and changes in attitudes and ways of being (Martusewicz, et al., 2014; Wals & Corcoran, 2012). Numerous researchers and publications have reiterated the importance of education that encourage changes in attitudes and behavior, attends to emotional sense-making, and provides opportunities to make sense of and address the impacts related to human activity and climate change (Bowers, 2001; Orr; 1997; 2002; 2017; Lieberman, 2013; Wals & Corcoran, 2012). For instance, Orr (2002) has stated that:

> The crisis we face is first and foremost one of mind, perception, and values. It is an educational challenge. More of the same kind of education can only make things worse. This is not an argument against education but rather an argument for the kind of education that prepares people for lives and livelihoods suited to a planet with a biosphere that operates by laws of ecology and thermodynamics (Orr, 1997 p. 27).

In this frame of thinking, it is paramount that educators and students engage with each other in ways that explore the causes and consequences of current global cultural and social behaviors on Earth's ecosystems and climate.

Environmentally and Ecologically Concerned Pedagogies

Outside of the realm of traditional standardized public education, certain pedagogical practices and educational frameworks have remained at the forefront in the advocacy for environmental, ecological, and socially just education. The characteristics of these pedagogies

of ecological concern and responsibility have developed to encompass: (1) the appreciation of the natural world; (2) critical analysis of the effect of human actions on the environment, social relationships and practices, and the influence of dominant views such as the media and other institutions, and consumer capitalism; and (4) the examination of ways in which humans can help solve environmental problems caused by anthropocentric perspectives and habits while fostering sustainable ways of being (Disinger & Monroe 1994; Gilbert, 2003). The next section will provide an overview of pedagogies concerned with environmental justice and responsibility, and although many categories and sub-categories exist, emphasis will be place on the most prominent. These will include Environmental Education (EE), Education for Sustainable Development (ESD), Sustainability Education (SE), Place-Based Education (PBE), Experiential Education, Ecoliteracy, and Ecojustice Education.

Environmental Education (EE): The Tonic

In music theory, the tonic is the first note of the diatonic scale and therefore the tonal center. The tonic center of ecologically concerned pedagogy is environmental education. The notes of EE provide support for melodies and harmonies to build upon. In 1762, Jean-Jacques Rousseau's publication *Emile* maintained that education should include a focus on the environment. It would be nearly 200 years later, at a meeting of the International Union for the Conservation of Nature in Paris in 1948, before the term Environmental Education is used for the first time in a professional public context by Thomas Pritchard, Deputy Director of the Nature Conservancy in Wales (McCrea, 2006). The first international effort to define EE, however, was derived from the Belgrade Charter in 1972. During this conference, EE was described as education with the goal of fostering awareness and concern about the environment and its associated problems while also and which has the knowledge, skills, attitudes, motivations and

commitment to work individually and collectively toward solutions to current problems, and the prevention of new ones, (Hungerford, Peyton, & Wilke 1980). Furthermore, the Belgrade Charter categorized EE into two types: formal and non-formal. Formal EE was considered academic instruction that took place at the pre-school, primary, and secondary levels, as well as in professional teacher training courses and environmental courses in institutions of higher education. On the other hand, non-formal education was that which occurred outside of traditional academia. This might include educating different demographics of the general public through informal educational opportunities, employee training programs, after-school youth programs, community grassroots campaigns, and mass dissemination of information from television, radio and print news sources.

As history has shown, EE has developed as a response to a growing public awareness of the rapidly deteriorating state of the environment and the belief that an informed public will more likely make enlightened lifestyle decisions in the interest of their families, communities and nation (Linke, 1980; McCrea, 2006; Stohr, 2016). Studies have suggested that due to the complex meaning and content of EE, depending upon the context of application, a universally agreed-upon definition has remained nonexistent. However, studies have shown that teachers who have adopted EE practices in their classrooms have come to include a wide range of ecologically centered education with an underlying attempt to provide students with knowledge and understanding of the natural living and non-living ecological systems (Fien, 1995; Martusewicz et al., 2014). In addition, some have included the additional purpose of fostering an appreciation for nature and the outdoors (Fien, 1995; Martusewicz et al., 2014). Studies along these lines have highlighted the implementation of EE as a means to foster changes in behavior

that support and advocate for responsible environmental consideration (Saylan & Blumstein, 2007).

Environmental education (EE) at home. Considering the absence of nationally mandated EE standards, California state authorities independently developed a comprehensive, applicable model for state schools (Education and the Environment: Strategic Initiatives for Enhancing Education in California, 2002). Under the Governorship of Gray Davis, Assembly Bill 1548 (2003), made California the first state to enact a legislative program for formal EE and established the California Office of Education and the Environment (COEE) with the purpose to foster the development and integration of EE principles into state primary and secondary school curriculum (Stohr, 2013). Continuing along these lines, Assembly Bill 1721 (2005), which was signed into law by Governor Arnold Schwarzenegger, provided additional funding for the California Education and the Environment Initiative (EEI). This initiative embraced a seven step mandate: (1) development of Environmental Principles and Concepts (EPCs); (2) development of a kindergarten through grade 12 model curriculum (now referred to as the EEI Curriculum); (3) alignment of the EEI Curriculum and its underlying EPCs to California's existing academic content and student achievement standards; (4) approval of the EEI Curriculum by the California Board of Education; (5) provision of statewide, electronic access to the EEI Curriculum and supplemental materials; (6) cooperation and coordination of state educational agencies (i.e. Board of Education, Office of the Secretary of Education, CDoED, Curriculum Development and Supplemental Materials Commission) and the California Natural Resources Agency; and (7) incorporation of the EPCs into statewide textbook adoption criteria by CDoEd. Pursuant to this mandate, the state developed a set of five primary principles and supplementing concepts (EPCs) to guide development of the EEI Curriculum.

During the 2007-2008 school year, 19 schools across California encompassing approximately 200 teachers and 4,700 students tested and completed EEI Curriculum (Stohr, 2013). The pilot phase resulted in positive feedback from both educators and students, and valuable insights regarding classroom application and methodology allowed for minor adjustments prior to submission of the EEI Curriculum to the state Board of Education for final approval (Stohr, 2013). The EEI Curriculum received unanimous approval for implementation in early 2010, after an extensive review by the Curriculum Development and Supplemental Materials Commission under the auspices of the state Board of Education. It was determined that California's K-12 EEI Curriculum provided a comprehensive approach to environment-based learning, as the 85 approved EEI units comprised included traditional EE concepts such as geology, lifecycles, climate change, and adaptation, and sustainability-based themes. Although California's EEI policy has provided an example of how to integrate EE *about* the environment into the existing standards-based model of public education, it is not a mandate of local schools and school districts to adopt the EEI Curriculum.

Place-Based Education (PBE)

For over a decade, the idea of Place-Based Education (PBE) has grown in popularity among educators who believe in the relevance of place as it relates to education and sustainability (McInerney, Smyth, & Down, 2011). PBE has evolved as a multidisciplinary experiential form of education that seeks to connect one's place with one's self (Smith, 2002; Sobel, 2004). Therefore, teachers of PBE have encouraged students to understand the relationships between human and natural living and non-living beings; often through projects designed around a specific place (Martusewicz et al., 2014). PBE practitioners have also sought to provide students with a sense of agency by acknowledging them as producers of knowledge

and encouraging active participation as contributing citizens (McInerney et al., 2011; Rodriguez, 2008). Another important element of PBE that practitioners have included in their teaching has been exposing students to community-engaged learning as a means to provide them with experiences and knowledge necessary to democratically develop solutions to social and ecological problems (McInerney et al., 2011; Smith & Sobel, 2010). Community-based learning and curriculum in this sense posits one's place as fundamental to learning, because it connects the classroom with issues taking place in the community (McInerney et al., 2011).

Research has suggested PBE has the potential to not only help students develop more meaningful connections to their communities and the natural world, but also foster strong academic achievement in a time of standard-based education and teaching to the test (McInerney et al., 2011; Sobel, 2004; Shure, 2016; Smith, 2002). Furthermore, practitioners of PBE have argued that by engaging students at all ages in the process of understanding and analyzing local issues, students will develop new ways to understand and make meaning of global and ecological issues they are likely to encounter in the future (McInerney et al., 2011; Smith, 2002; Smith & Sobel, 2010; Sobel, 2004). PBE practitioners seek to revitalize the commons and foster learning that encourages understanding the relationships between local commons and the related ecosystems, and addresses environmental issues. Moreover, a review of the literature suggests emphasis on two underlying themes; (1) cause and effect relationships of economic, social, and ecological problems with local and global phenomena; and (2) addressing the hegemonic and hierarchical factors that contribute to poverty, exploitation, and oppression (Bowers, 2002; Furman & Gruenewald, 2004; Gruenewald, 2014; Martusewicz et al., 2014; McInerney et al., 2010; Smith, 2002; Smith & Sobel, 2010; Sobel, 2004).

Sustainability Education (SE)

Although the concept of sustainability may have been first articulated in the early 1980s, it has deep and complex roots connecting to the intergenerational equity held by numerous ancient cultures and the balance of resource use and regeneration within the field of ecology (Nolet, 2009; Perry, 2013). In the Agenda 21, the United Nations (UN) stated that education plays a central role in any sustainable development for our future (Du Plessis, 2002). Broadly used, sustainability has been described as a balance among various human systems that influence, and are influenced by, the natural environment while meeting the needs of the present without compromising the ability of future generations to meet the needs of their own (Nolet, 2009; Keeble, 1988). Given the complexity of this idea, the Center for Ecoliteracy has identified four primary guiding principles for education for sustainability: (1) nature is our teacher, (2) sustainability is a community practice, (3) the real world is the optimal learning environment, and (4) sustainable living is rooted in a deep knowledge of place (Stone, 2010). Teachers including Sustainability Education (SE) in their classrooms have been shown to focus on more than just the study of natural systems (how they function and how to manage them) (Abrams, Palmer, & Hart, 1998), as they incorporate topics and themes related to social, political, cultural, and economic systems, in an effort to help students recognize the complex relationship between humanity and the natural world. SE practitioners have also sought to facilitate examination of ideological principles and values often found in Western society (e.g., the concepts of dualism, anthropocentrism, progress, and economic growth) (Stone, 2009). There is also an element of helping students develop new ways of thinking, feeling, and behaving (Coates, 2008).

In the context of schooling, Education for Sustainable Development (ESD) has represented the most widely applied brand of EE and SE. Whereas traditional EE has

predominately maintained an environmental focus, ESD has sought to take the educational concept a step further—enhancing EE rather than replacing it completely. In practice, ESD has sought to encourage changes in behavior that contribute to a more sustainable future in terms of environmental integrity, economic viability, and a just society for present and future generations. In this regard, it is important to acknowledge two fundamental international studies which have focused on pre-service chemistry student teachers and teacher trainees (Burmeister & Eilks, 2013a) and experienced in-service chemistry teachers in Germany (Burmeister, Schmidt-Jacob & Eilks, 2013). Both studies focused on the participants' knowledge about sustainability and ESD, their ideas for implementing ESD in the classroom, and their personal attitudes towards ESD. Both studies found the participants to have a persistent lack of theory-based knowledge concerning sustainability (e.g., the three-pillar model and the definitions in the Brundtland report) as their understandings of sustainability was often limited and stemmed primarily from the mass media, rather than from their teacher education programs.

Like traditional EE however, no universal definition of ESD currently exists. Although numerous efforts to enact SE have been made around the world, a single, replicable model has remained nonexistent. Sterling (2004) has attributed this actuality to the emphasis environmental and SE places on diversity. Similarly, McKeown-Ice (2000) acknowledged that diversity is a key component of environmental and SE and explained that a single, replicable model of SE would be "entirely inappropriate [given its highly localized nature]" (p. 12). Without a model to follow or adapt, educators looking to enact SE are left to decide for themselves what this orientation towards education and the school curriculum should look like in their own contexts.

Experiential Education

Experiential education has, at times, been referred to as outdoor education. Practitioners of which have adopted approaches to instructional practices and curriculum that have sought to help students develop positive feelings and emotions towards the outdoors (Martusewicz et al., 2014). Like other environmental education approaches, experiential education centers on helping students understand the ways in which Earth's natural ecosystems function; however, the emphasis on the idea that happiness and positive views toward learning about the natural world will not only provide a deeper understanding of the natural world and the relationships necessary to create sustainable ways of living, but will also foster a deeper understanding of oneself typically sets it apart from other approaches (Martusewicz et al., 2014). Experiential education practitioners have included the likes of teachers, camp counselors, corporate team builders, therapists, environmental educators, guides, instructors, coaches, and mental health professionals. This approach has often been utilized in conjunction with many disciplines and settings such as PBE, Project-Based Learning (PBL), Global education, EE, and service learning.

Environmental and Ecological Literacy

Like enharmonic notes or scales, Environmental literacy and ecological literacy are often used interchangeably and can be understood as multi-dimensional approaches that encapsulate similar ideas (environmental principles with emphasis on preparing students to act responsibly toward nature) (Boehnert, 2015; Schume, 2016). Practitioners of environmental literacy and ecological literacy have sought to foster understandings of the inter-relationships between humans and the environment, while cultivating compassion towards all forms of life (Boehnert, 2015; Roth, 1992; Schume, 2016). Like other branches of EE, researchers have described this approach as recognizing the need for students to perceive and interpret the health of

environmental systems, then take appropriate action to maintain, restore, and revitalize those systems. Teachers of ecological and environmental literacy have helped students recognize the commonalities of all organisms as a means to move away from anthropocentric perspectives and more towards the view of humans as members in a wider, interconnected system of living and non-living beings (Boehnert, 2015; Goleman, Bennett, & Barlow, 2012). While no universal definitions of ecological and environmental literacy have officially been adopted (Yavetz, Goldman, & Pe'er, 2009), previous research has highlighted five major components often cited as essential: (1) developing empathy and love for all living and non-living beings, (2) embracing sustainable ways of being, (3) understanding the far reaching implications of our actions and ways of being, (4) anticipating unintended and unforeseen consequences, and (5) recognizing the interconnections and inter-reliance of all beings as members of complex web of life (Boehnert, 2015; Goleman et al., 2012).

Ecojustice Education

Although the branches of EE have some similarities with Ecojustice Education, practitioners have contended that the way ecology is defined by environmental education in general is problematic (Martusewicz et al., 2014):

> One of the main problems in this approach is with the way that ecology is defined, for the most part, as the scientific study and management of natural systems assumed to be outside of human communities. Intersections among human social problems and ecological problems are generally ignored in the curriculum (p. 14).

In practice, however, it is impossible to reduce Ecojustice Education to a set of techniques. According to Bowers (2001), Ecojustice Education seeks to be "responsive to the cultural patterns enacted in the relationships that make up the complex ecologies of the classroom and the larger communities" (p. 187). Furthermore, in the classroom, this approach has sought to guide students to recognize environmentally destructive practices and habits, while celebrating cultural

patterns that have had a less adverse ecological impact (Bowers, 2001). Martusewicz et al. (2014) have argued that a 'pedagogy of responsibility' must be grounded in an Ecojustice Education framework, in which teachers seek to develop an 'eco-ethical consciousness' amongst their students to include social, cultural, and environmental sensitivity, awareness, and knowledge (Reid, 2007). Furthermore, practitioners of this approach have sought to develop a deeper awareness among students of cultural and ecological diversity, as well as an understanding that every part of the natural world must be considered (Reid, 2007).

Despite the dominance of traditional standards-based education, research has indicated a growing interest in the principles related to Ecojustice Education as a framework for teaching, redefining schooling, and promoting local communities (Bowers, 2001, 2004, 2006; Lowenstein et al., 2010; Martusewicz, 2005; Martusewicz et al., 2014; Mueller, 2009; Nelson, Cassell, & Arnold, 2013). In Ghana, for instance, Mueller and Bently (2009) pointed out that teachers had implemented a more culturally relevant and environmentally responsive curriculum at the secondary level. Similarly, educators working in places such as Canada, Ghana, Kenya, Malawi, the Philippines, and the U.S., have taken to supplementing curriculum with materials that celebrate the importance of traditional knowledges and skills as they relate to sustainability (Aikenhead, 2006; French, 2011; Jegede, 1995; Kroma, 1995). Examples of activities have included soap-making projects, de-worming campaigns, coconut and mahogany reforestation projects, dental care, composting, herbal gardening, erosion control projects, waste segregation, and community history projects (Aikenhead, 2006; French, 2011; Jegede, 1995; Kroma, 1995; Mueller & Bentley, 2009).

Prominent Ecojustice Education pioneers have highlighted ways in which educators concerned with environmental issues continue to work to strengthen the relationships between

community and the natural ecosystems. For example, Martusewicz et al. (2014) have described examples of grassroots efforts and community relationships that continue to be fostered through education. In these cases, local communities have worked to revitalize the commons, make use of empty lots, restore old buildings, develop parks, and cultivate numerous citywide gardens (Martusewicz et al., 2014). More examples range from students testing soil and teaching residents how to decide if their soil is safe for planting, to participation in the self-sufficiency and moral reciprocity of teaching each other how to build and maintain compost bins, to exchanging seeds and seedlings (Martusewicz et al., 2014; Mueller & Bently, 2009). In addition, Martusewicz et al. (2014) have further highlighted programs and models that have begun to make progress. These programs range from the Sunnyside Environmental School in Portland, Oregon, to the Nsoroma Institute in Detroit, Michigan, to the Southwest Michigan Stewardship Coalition, to Food for Thought senior seminar at Souhegan High School in New Hampshire (Lupinacci, 2013b; Martusewicz et al, 2014). The objectives of all these programs have been to encourage students to see their relationships with the society, the economy, and the environment in a way that incorporates local knowledges and provides opportunities for teachers to make environmental education relevant to all.

If one is to implement an Ecojustice Education framework at the primary and secondary levels, Bowers (2001) has offered his own set of suggestions on how one might accomplish this. First, as the starting point for learning from viable and just communities, and understanding how many marginalized groups are dependent upon intergenerational responsibility, he has suggested having students study intergenerational relationships, activities, and technologies in the dominant and minority communities that have not been commodified (p. 263). Secondly, teachers can work to find ways to educate students to understand principles of simplicity and how they can

contribute to a quality of life that cannot be measured in monetary terms (p. 264). Another important aspect that educators should consider is fostering interactions among students and elders followed by discussions on the difference between elder knowledge and the information found in places like their textbooks (p. 264). As students develop these ways of thinking and learning, teachers could educate students on the principles of ecological design described in Van Der Ryn and Cowan (2007) and how to apply them in problem solving issues associated with different environmental and cultural concerns (p. 264). The work of Bowers has suggested that teachers should seek to also guide students to investigate environmental racism and hyper-consumerism as an impact on cultural groups and ecosystems (Bowers, 2001).

Curriculum Standards and Frameworks

Although many researchers have argued that education must be part of the global response to climate change and other related issues (Nelson & Coleman, 2012; UNSESCO, 2013), specific inclusion of climate change and the impacts of human activity on the environment have been virtually absent from national public education content standards until the development of the NGSS (Shepardson, Roychoudhury, & Hirsch, 2017). However, this is not to say that these concepts have not been encouraged or included in education. In 2006, in a clear attempt to address climate change and environmental destruction at the education level, a partnership between the National Oceanic and Atmospheric Administration (NOAA) and the American Association for the Advancement of Science (AAAS) titled Project 2061, funded a workshop to discuss the need for a common set of curriculum guidelines to be used at the local, state, and national levels. The resulting efforts of this partnership led to a broader collaboration through the U.S. Global Change Research Program to coordinate and produce *Climate Literacy: The Essential Principles of Climate Sciences guide* (McCaffrey & Buhr, 2008).

This guide presented a framework of principles and concepts with the purpose of fostering sustainable communities concerned with the protection of Earth's ecosystems and resiliency to climate change. Within the guide, underlying emphasis was placed on understanding of the Climate's influence on humans and society, as well as the impacts of human activity on the climate and the environment. These principles and concepts described the importance for individuals and communities to know and understand facets of Earth's climate, impacts of climate change, and approaches to adaptation or mitigation (National Oceanic and Atmospheric Administration, 2006). In addition, these sets of guidelines and principles were also meant to assist educators who wish to address similar issues in meeting the requirements of content standards in their science curricula (National Oceanic and Atmospheric Administration, 2007).

Building on the development of the aforementioned guide and recognizing the need for understanding the extent to which pedagogical science standards across the country align with the principles of climate literacy, the NOAA commissioned a study by Hoffman and Barstow in 2007. Their study sought to review and compare the principles and concepts recommended by the Climate Literacy framework with current state curricular standards in all 50 states, thus producing the first detailed national picture, for a given point in time, of the degree to which such perspectives are incorporated in standards. Hoffman and Barstow, (2007) primarily analyzed K-12 Earth science standards with the goal of understanding the degree to which state standards addressed key principles. While their study found alignment between state standards, and approaches and perspectives articulated by the National Science Education Standards (e.g. inquiry-based learning and system-based perspectives), only 35 of the states directly included the perspective of Earth as a set of interacting systems. While the report highlighted great variation

among state standards' inclusion of related concepts, the overall results of the report revealed a lackluster alignment with the principles of climate literacy across the U.S. Furthermore, Hoffman and Barstow (2007) revealed an extensive lack of states having thoroughly integrated essential components of climate, weather and oceans studies into their curriculum, therefore suggesting a need for significant improvement. Although 20 states articulated environmental literacy perspectives, seventeen states were depicted as having inadequately addressed environmental literacy concepts. Furthermore, Hoffman and Barstow (2007) concluded that while some standards included minimal alignment with the principles of climate literacy, 30 states failed to directly address the concepts in their state standards. In addition, the ocean literacy principles and concepts that were formulated in 2005, were largely missing from most states' standards.

The Next Generation Science Standards (NGSS)

Until the formal adoption of the NGSS, teachers and schools had not been required to address issues such as climate change and the impacts of human activity on the environment. With the national adoption of the NGSS, this is no longer the case as these issues are now expected to be a part of a 'three dimensional' approach to science education. The three dimensions of this approach consists of scientific content, which is referred to as Disciplinary Core Ideas (DCIs), practices that scientists engage in to acquire evidence and construct meaning, referred to as Science and Engineering Practices (SEPs), and concepts that transcend science disciplines, referred to as Cross-Cutting Concepts (CCCs) (NRC, 2012). Within the NGSS, climate change and the impacts of human activity on the environment have been represented as a specific set of DCIs and therefore considered fundamental (NRC, 2012). In order for concepts and ideas to be considered a DCI, they must meet the following criteria: hold comprehensive

importance within or across science and engineering disciplines, provide a key tool for understanding or investigating complex ideas and solving problems, relate to societal or personal concerns, and are conducive to being taught over multiple grade levels at progressive levels of depth and complexity (www.nextgenerationscience.org, 2018). The DCI's of most relevance to this study specify that students understand the impacts of human activity on the environment, the contributions to climate change, and thinking processes necessary to pursuing possible solutions (www.nextgenerationscience.org, 2018).

Within the context of the DCIs concerning climate change and the impacts of human activity on the environment, the NGSS specifies that students at the primary and secondary levels are expected to: (1) articulate solutions that will diminish the impact of humans on land, water, air, and/or other living things in their local environment; (2) analyze and connect information about ways individual communities use science ideas to protect Earth's natural resources and environment; (3) construct arguments supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems; (4) ask questions to clarify evidence of the factors that have caused a rise in global temperatures over the past century; (5) create simulations to illustrate the relationships between management of natural resources, the sustainability of human populations, and biodiversity; (6) evaluate or refine technological solutions that reduce the impacts of human activity on Earth's natural systems; (7) analyze geoscience data and results from global climate models to make an evidence based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems; and (8) use a computational simulation to illustrate the relationships between Earth's systems and how those relationships are being modified due to human activity. In a cross comparison of the NGSS and the Essential Principles of Climate Literacy, Busch and

Roman have suggested that in an ideal context, students would be presented with conceptual information about all of the seven principles, including the link between humans and current climate change by the time they completed both high school Biology and high school Earth Science courses (Busch & Roman, 2017). However, at this stage of research development, details on the extent to which students actually receive instruction of this nature remains unclear.

Understanding climate change and the impacts of human activity on the environment requires thinking in terms of systems (Achieve, 2013; NRC, 2012). The NGSS views systems thinking as an antidote to fragmentation. Within the seven CCCs that undergird the NGSS, systems thinking is presented as a fundamental idea necessary for understanding many aspects of science (Achieve, 2013; NRC, 2012). Although there has been limited research related to teacher utilization of systems thinking within the context of NGSS implementation, a study by Sterman (2007) has provided insight into the ways in which systems thinking has been taught. In this study, Sterman (2007) found low conceptual understandings of systems thinking among educators and concluded that current educational practices do not foster an appropriate understanding among students or teachers. In addition, some educators found the idea of systems thinking daunting, in part because the term was understood to denote many different things. In this respect, business and education writer Art Kleiner has reiterated this point with the statement that, systems thinking has been used, in the last two decades, to refer to a confusing array of tools, methods, and practices (Senge, Cambron-McCabe, Lucas, Smith, & Dutton, 2012). Although systems thinking and systems theory has grown to include a large body of knowledge from many areas of research; the central idea can be understood as the recognition of interconnections as relevant and necessary for understanding (Ison 2008; Stratchen, 2009). In relation to the importance of system-based constructs in understanding the overarching planetary

architecture, Nelson and Cassell's (2012) have recommended a framework that recognizes the world as:

> A complex, multi-tiered, deeply interwoven system of natural and human elements all interacting with one another at various levels of operation and all operating within the bounds of system limits; limits with regard to resources available to the system, operating nodes functioning within the system, and the movement of resources and energy through the system including information and knowledge. (p. 71).

Clearly, taking a systems thinking approach has important implications for pedagogy and decision making and practices. Thinking systemically entails several shifts in perception or emphasis, especially for those whose intellectual grounding is the Western scientific, analytic tradition. These shifts are not either/or alternatives, but rather movements along a continuum that can lead to different ways to teach, evaluate, govern, and effect institutional change.

The NGSS approach to systems thinking has been rooted in the general study of systems and asks students to apply a systems lens at various levels and across contexts. Similar to Bertalanffy (1968) and Laszlo and Krippner, (1998), systems thinking within the NGSS, has been articulated as a means for students to understand and analyze the interconnectedness of the world around them. In relation to the climate change and Earth and human impact DCIs, the system thinking CCCs are meant be applied to thinking about the ways in which students can respond and exist sustainably, while striving to meet the needs of living and non-living beings.

Teaching Climate Change and the Impacts of Human Activity

All things considered, standards, textbooks, and other literature can only provide guidance for teachers to address these issues. In a review of literature, Monroe, Plate, Oxarart, Bowers, and Chaves (2017) analyzed 49 pieces of research related to climate change education interventions. Their analysis revealed four common themes associated with the interventions: (1) purposeful engagement in deliberative discussions, (2) opportunities for students to interact

with scientists, (3) addressing misconceptions, and 4) implementation of school or community projects (Monroe et al., 2017). In the Six America's Study (2011) by Lieserowitz, Maibach, Roser-Renouf, and Smith, results indicated that the more 'concerned' about climate change an educator is, the more likely they are to address these issues in their classrooms. Along these lines, Liu, Roehrig, Bhattacharya, and Varma (2015) indicated that teacher attitudes and knowledge related to issues associated with climate change influenced the ways in which their instructional practices addressed these concepts. Liu et al. (2015) further suggested that while teachers may often believe that the impacts of human activity on the environment will lead to devastating consequence if left alone, yet, when it comes to identifying which aspects of climate change should be taught in the classrooms, confusion persists.

Studies such as Nation (2017) have sought to explore teacher beliefs about climate change in order to better understand why they make certain instructional decisions. However, considering the current stage of NGSS implementation at the national level, there is a need for research exploring how educators perceive and understand their roles and responsibilities within the new standards and the ways in which they in turn address the content and practices. More specifically, as teachers will be expected to serve as liaisons between issues and concepts related to climate change and their students, emphasis in this study has been placed on how teachers perceive and understand their roles and responsibilities and in what ways do they do so. Therefore, continuing along these lines, the following section will explore ways in which educators in the U.S. have approached climate change, ecological degradation, and the impacts of human activity on the environment.

Climate Change and the Impacts of Human Activity Are Complex

Climate change and the impacts of human activity on the environment are complex topics with rapidly developing science, technology, and the potential for controversy. Depending on the grade level, course topics and instructional methods, research has shown that there are numerous facets to consider when seeking to address climate change and the impacts of human activity on the environment (Roychoudhury et al., 2017; Shepardson et al., 2009). Considering the complexities associated with teaching students about such, studies have shown that educators often tend to struggle with related topics (Crayne, 2015; McNeal et al., 2014; Monroe et al., 2017), as teachers are less likely to include topics with which they are uncomfortable or unfamiliar in their teaching (Banilower et al., 2007; Eidietis & Jewkes, 2011). With the NGSS directing teachers to address newly incorporated elements of climate change and the impacts of human activity on the environment, current research regarding teacher ability and readiness to address these issues suggests that they may still be underprepared to do so in their classrooms (Lambert & Bleicher, 2013; Leiserowitz et a., 2011; Herman & Clough, 2017)

One important and determinant prerequisite for effectively teaching about climate change is one's degree of climate literacy. Research has indicated that climate literacy among U.S. citizens has predominantly remained inadequate for effective engagement (Herman & Clough, 2017; Herman, 2015; Leiserowitz, 2010; Leiserowitz et al., 2014). More specifically, research has indicated that teachers hold deficiencies in knowledge regarding the consequences of climate change and solutions to global warming (Herman & Clough, 2017; Lambert & Bleicher, 2013; Leiserowitz et al., 2011). Research has also suggested that related deficiencies have existed in the understanding and instructional practices of science teachers (Herman & Clough, 2017). Similarly, Rutledge and Mitchell, (2002) also found that educators have held misconceptions

regarding standards of confidence for scientifically supported ideas and maintain unnecessary levels of uncertainty before accepting an idea and moving toward appropriate action.

Climate Change and Human Impact Can Be Controversial

Several studies have sought to understand ways in which public education in the U.S. has addressed issues related to climate change (Johnson & Holzer, 2011; Monroe, Oxarart, & Plate, 2013; Petrinjak, 2011; Wise, 2010). One commonality among these studies has been the suggestion that tensions can arise due to the controversial nature of climate change. In this respect, high school science teachers in Bunten and Dawson (2014) expressed preference to restricting classroom instruction to well-understood topics of minimal controversy. Bybee (1993) suggested that classroom inclusion of controversial topics is largely dependent upon the beliefs and intentions of teachers. Due to the controversial nature associated with teaching about climate change, studies have suggested that political and public beliefs and misunderstandings can cause teachers to avoid teaching about climate change, present alternatives to the scientific consensus, and misrepresent the position of the scientific consensus as scientifically controversial (Berbeco, Heffernan, & Branch, 2017; Nation, 2017).

Along these lines, the National Center for Science Education (NCSE) in conjunction with Pennsylvania State University sought to better understand the ways in which public schools across the U.S. educate students about issues related to climate change (Plutzer et al., 2016a). Their study was directed at exploring the number of students receiving instruction related to climate change and global warming, the relevant topics and scientific principles being taught, teacher preparedness to effectively address issues related to climate change, and the extent to which non-scientific ideas and ideologically motivated reasoning permeate public school classrooms (Plutzer et al., 2016).

Similarly, in a 2014 study, researchers at Pennsylvania State University and the National Center for Science Education (NCSE) undertook the first nationally representative survey of science educators focused on climate change (Plutzer, et al., 2016a). Data was collected from 1,500 science teachers in public middle and high schools across all 50 states and sought to cover areas that had been overlooked by previous studies. This study considered the classes and topics being taught, the strategies adopted in teaching about climate change, state's science standards and standardized tests, the textbooks and supplementary materials being used, teachers' personal views on climate change, teacher preparation, training, and continued education, and personal backgrounds including ethnicity, religion, and politics.

The researchers concluded that there was evidence of science teachers addressing climate change with their students. Teachers reported presenting concepts, such as the greenhouse effect and the carbon cycle, that are essential to understanding climate change. They also reported discussing observable consequences of climate change, such as sea level rise, and possible responses to mitigate and adapt to climate change, such as improving the efficiency of technology. Within the context of this study, only a few teachers reported encountering pressure not to teach climate change.

Although studies have suggested a willingness of teachers to attempt to address the complex issues related to climate change and the impacts of human activity on the environment, several complex factors have been shown to influence the accuracy and acceptance of teachers in doing so (Herman, 2015). Wise (2010) has suggested that the degree of inclusion of instruction related to climate change is related to the level of community and school administration acceptance and encouragement. Although the NGSS have included DCIs that seek to engage students in learning about climate change and impacts of human activity on the environment,

Ranney (2012) has suggested that people living in the U.S. are less likely to accept controversial issues such as climate change when compared to peers in other nations. Rutledge and Mitchel (2002) have further suggested that lack of classroom instruction around controversial topics is influenced by lack of understanding of the principles and scientific evidence related to these topics. The level of public acceptance has been suggested to also influence student understanding in ways that increase the perpetuation of misunderstandings (Liu et al., 2015).

Knowledge and Understanding

With regards to teacher knowledge and understanding, Nation (2017) sought to explore the impact of teacher beliefs regarding climate change on instructional practices and student outcomes. Findings from this study indicated that the more informed a teacher is about climate change, the better the quality of classroom instruction and student outcomes (Nation, 2017). Although multiple studies have suggested that teachers have been addressing issues related to climate change, Plutzer et al., (2016a) highlighted that many teachers have not done so well with it. While a small number of participants in their study expressed avoiding the topics related to climate change as a way to avoid controversy, for those that did not, one in three reported having emphasized natural causes as contributing to climate change. This notion, however, is contrary to the scientific evidence and consensus on the causes of climate change. Regardless of having accepted the consensus view or not, most teachers maintained a misunderstanding regarding the proportion of scientists in agreement that Global Warming and climate change have been largely caused by human activities.

In other studies, Herman (2015) and Herman and Clough (2016), acknowledged that large proportions of science teachers held inaccurate notions of how reliable scientific knowledge is developed and comes to be accepted by the scientific community, while perceiving

the validity of climate science to be primarily determined by controlled experiments. Likewise, in studies by Wise (2010) and Sullivan, Ledley, Lynds, and Gold, (2014), the majority of teacher participants supported teaching two sides of climate change controversy, with many doing so based on the incorrect notion that both sides are valid science perspectives. Roychoudhury et al., (2017) has suggested that misconceptions held by many science teachers may actually be hampering their understanding, acceptance of, and teaching of climate change science, and thus impeding students' understanding of, and willingness to take action on, climate change. Similar to other studies, Wise (2010) has suggested, that the degree of inclusion of instruction related to climate change is related to the level of community and school administration acceptance and encouragement.

Herman and Clough (2017) further discussed issues that contribute to the impediment of teachers' misunderstandings. Their research has highlighted a perception among teachers that controlled experiments are the most appropriate way to develop and substantiate science ideas, that good scientists and the workings of science can and should be objective, that science leads to absolute certainty and that public action is not warranted until such certainty is established, and that scientific ideas become apparent from and are unambiguously supported by data. In addition, they suggest that teachers may experience misunderstandings regarding the development, character, and role of models in science, the differences between private and public science, the interdisciplinary nature of certain scientific research and how interdisciplinary support bolsters confidence in conclusions (Herman & Clough, 2017).

Appropriate understandings related to the issues mentioned above have been described as necessary to teach students about climate change and other aspects of ecological degradation caused by human impacts (www.climate.gov, 2018; Roychoudhury et al., 2017). According to

Plutzer et al. (2016b), almost one third of teachers that addressed issues related to climate change in their study portrayed the issue as being caused by mainly natural occurring phenomena. Similarly, Roehrig, Bhattacharya, and Varma (2015) found that while many teachers in their study showed a similar degree of concerns about climate change, they did not share specific beliefs about humans' roles and responsibilities in relation to climate change. Similarly, Leiserowitz et al., (2014) concluded that over a third of the U.S. general public believed meaningful dissent exists among the scientific community regarding the occurrence of climate change and its link to human activities. Along similar lines, the National Survey of American Public Opinion on climate change found Americans to be highly divided on claims that scientists are manipulating climate research for their own interests (Rabe & Borick, 2012).

Given the misunderstandings and deficiencies highlight by previous research, research in the vein of Herman and Clough (2017) has suggested that educators focus on accurately portraying the nature of science (NOS) which includes emphasis on the overwhelming scientific evidence supporting the conclusion that human activity is the cause climate change. Accordingly, the term 'nature of science' has been used to refer to the core values and assumptions that are characteristic of science knowledge (Herman, 2010). This includes emphasis on the epistemological and ontological foundations of science, the ways in which scientists interact socially, and the communal role that science can play (Clough 2006). In classrooms at the primary and secondary levels, NOS inclusion emphasizes the idea of 'what is science and how does science work?' Although the ideas associated with NOS have been described as "crucial for effective science teaching, deep learning, and responsible citizenship" (Herman, 2010), previous research has highlighted inadequate, inaccurate, and ineffective inclusion at the primary and secondary levels.

Another factor that has impacted teacher knowledge and teaching about climate change is a lack of curriculum. Bentley, Ebert, and Ebert (2007) has suggested that teachers may opt out of teaching about climate change due to curriculum constraints. In Nation (2017), the use of a strategically designed curriculum allowed teachers to gain better understandings of how to teach climate change. Participants in this study indicated that the inclusion and availability of the curriculum also helped provide a place within their day for climate change. With regards to the NGSS, however, although schools and administration must support the standards, a true NGSS curriculum remains elusive and nonexistent.

While curriculum can play an important role in teaching, research has emphasized that simply adding a curriculum is not adequate as teachers must also be well prepared in their understandings prior to implementation of a curriculum (Nation, 2017). Studies have echoed this idea as many science teachers have felt their science coursework insufficiently prepared them to teach about climate change (Backhus & Thompson, 2006; Herman & Clough, 2017; Wise, 2010). With regard to the ways in which teachers address climate change and the impacts of human activity on the environment, the lack of adequate knowledge may cause teachers to be influenced from public media sources and curriculum materials, which are often rife with inadequacies and inaccuracies (Choi, Niyogi, & Charusombat, 2010; Herman, 2015; Hestness et al., 2014; Herman & Clough, 2017; Sullivan et al., 2014). Anderson and Helms (2001) and Hattie (2009) have suggested that teachers remain the most important factor for educational reform. What teachers think, believe and know affects their teaching. These factors are therefore important when it comes to effectively and successfully reforming teaching practices. Any educational reform and implementation can only be successful if teachers` beliefs, their *a priori* knowledge and their attitudes are seriously taken into account when implementing reforms

(Haney, Czerniak & Lumpe, 1996; Nespor, 1987). If teachers lack the preparedness, confidence, and motivation to teach issues related to climate change and ecological degradation in accordance with the scientific consensus, it will not happen. Based on the current literature related to this study, it is reasonable to suggest that misconceptions, level of preparedness influenced by the lack of proper teacher preparation and curricular resources, and discomfort of controversial and unfamiliar topics has the potential to transfer inaccuracies to students and lead to impeded knowledge on many fronts (McNeal et al., 2014).

Discussion

The complexity associated with educating students about climate change and the impacts of human activity on the environment has been found to cause educators to struggle in certain capacities (Crayne, 2015; McNeal et al., 2014; Monroe et al., 2017). Educators may be less likely to include topics with which they are uncomfortable or unfamiliar with in their teaching (Banilower, Heck, & Weiss, 2007; Eidietis & Jewkes, 2011), and misconceptions, lack of preparedness, and discomfort can transfer inaccuracies to students and lead to the absence of knowledge and learning related to climate change and environmental education in school (McNeal et al., 2014). Similarly, studies have found low conceptual understandings of climate change, systems thinking, and other related ideas among educators and concluded that previous educational practices have not fostered an adequate understanding among students or teachers. This research has suggested educators must be better equipped with knowledge of climate change, systems thinking, and other controversial issues in order to address concerns of ecological degradation (McNeal et al., 2014).

Regardless of the importance of addressing issues related to climate change, many educators have struggled with related topics (Crayne, 2015). Studies have likened the inherent

difficulty and struggle in conveying the information necessary to fostering an adequate understanding of climate change among students to similarly charged topics, such as Sexual Education and Evolution (Crayne, 2015). This is because socially and ecologically just pedagogies may present challenges to both teacher and student, not only due to the complexities associated with such topics, but also the complex social and political factors that have come into play (Crayne, 2015). Political and social controversy has not only increasingly existed at the state level with continued dispute over the content of education standards (Bidwell, 2014; Spring, 2013), but also at the local level, as teachers, administrators, and parents negotiate whether and how to include potentially controversial topics in schools (Crayne, 2015; Reardon, 2011). Therefore, research has shown these problems to cause teachers to be unsure of how to address potentially controversial issues (Crayne, 2015; Reardon, 2011).

The omnipresent motives that have kept environmental and socially just education in the U.S. on a similar path for decades, have left little room for any kind of ecologically responsible curriculum (Orr, 1997; Bowers, 2001; 2010 Spring, 1998; 2008; 2013; 2016). In effect, education in the U.S. has often reflected certain political, hierarchical, and dominant *anthropocentric* and *androcentric* perspectives, minimizing the inclusion of any meaningful concern or understanding of the root causes of current ecological and cultural crises (Bowers, 2001; 2010; Martusewicz et al., 2014; Spring; 2013). Whether it be technology, standardized testing, the ideas of progress, individualism, dualistic perspectives toward nature, or the capitalistic promise of increased profits or earnings, researchers have suggested that these dominant influences and motivations have ingrained ideological beliefs and root metaphors into much of society (Bowers, 2001; Martusewicz et al., 2014; Spring, 2013). In response, many institutionalized education systems have done little to promote the mindsets necessary to

question or confront the ecological crises we face and instead have focused on standardized tests and in-cohesive curriculum (Martusewicz et al., 2014; Mueller, 2011; Orr, 1997; Spring, 2013). These dominant influences have contributed to teachers at the elementary and secondary levels feeling overwhelmed with the need to teach to the test and produce data driven results (Longo, 2010; Popham, 2001; Volante, 2004). Because of this, educators have felt as though there is not enough instructional time in the day to include deeper thinking pedagogical practices that shy away from the outdated ways of old (Longo, 2010; Popham, 2001; Volante, 2004).

In addition, often when schools, teachers, curricula, and educational standards have attempted to address environmental and ecological issues, focus has ubiquitously been on the symptoms related to Earth's vital signs and less on the root causes (Orr, 1997). Students may often learn about distant places, such as the rain forest, or general concepts, such as the water cycle; while these topics are important, students rarely learn about the social or natural habitats in their own community or the current habits that have impacted local and global ecosystems (Louv, 2008). If educators are to help mend this disconnect from local ecosystems and commons, many of the current pedagogies in place must be reconsidered and deconstructed (Shepardson, 2009).

Although the developers of the NGSS hail the standards as a step away from certain past tribulations in education, little research exists to confirm this. Indeed, the Earth human impact and climate change standards are new and speak to the recognition of human activity as affecting global and local ecology, a gap in the related literature and research persists.

Chapter Summary

As history has demonstrated, the establishment of human supremacy over other species and the environment has led to anthropocentric justification of dominance that has since

reproduced itself in many facets of life, including the U.S. education system (Edmundson, 2013). Educational researchers have suggested that allowing dominant hegemonic forces to widely dictate education, environmental policy, and therefore the ways the associated intersections are taught in U.S. schools has not only instilled these patterns of behaviors but also impacted the ways in which teachers address these issues (Martusewicz et al., 2014; Spring, 2013). With the advancement of the NGSS, public science education standards in the U.S. have come to include concepts related to climate change and the impacts of human activity on the environment. Understanding these concepts can help foster thinking that perceives the local and global ecosystems as essential to all life. Elements of the NGSS appear to allow for science education that challenges the social and cultural behaviors that have undermined the living and non-living systems, as there is language that encourages teachers to help students recognize and restore environmental commons and develop sustainable ways of being. While the literature presented in this chapter has been guided by the research questions of this study, little research has focused on understanding the ways in which elementary educators address these concepts against the backdrop of NGSS implementation. While much literature exists regarding creation of the NGSS, little studies have explored the lessons, practices, and ways in which educators bring to life these concepts in their classrooms in conjunction with the standards.

CHAPTER 3: METHOD

Form

The structure of a musical composition is its form. As ideas expand and develop, the form unfolds over time. Form creates unity; and, knowing the form prior to composing the piece allows one to stay focused within coherent parameters as their song develops. This chapter will describe the form of this study and, therefore, the methodology and research methods that have been used to capture and describe the essence of educator's experiences as they plan for, interpret, and implement the Next Generation Science Standards (NGSS) related to climate change and the impacts of human activity on the environment. First, this chapter will begin with the purpose of the study, research questions, and description of phenomenological research. Second, the chapter will describe the study design and setting and participant selection, data collection, and data analysis procedures. Third, this chapter will describe the role of the researcher, validity and trustworthiness, positionality and biases, and limitations and assumptions.

Description of the Study

This study has incorporated characteristics of qualitative research. The intended purpose of a qualitative research is for the researcher to draw conclusions from the findings, to advance the field (Patton 2003). A qualitative methodology was chosen based on the purpose of this study. Due to the complex exchanges between teachers' implementation of curriculum and their reasons for doing so, a variety of data including interviews, observations, and document analysis has been collected to best capture the essence.

In order to describe the essence of the participants' experiences as they plan for, interpret, and implement NGSS related to climate change and the impacts of human activity on the environment, this study has included qualitative phenomenological analyses. According to phenomenology, essences are the core meanings that are mutually understood through an experienced phenomenon (Patton, 2002). Therefore, interviews, observations, and document analysis were used.

Considering the purpose of this study was to describe the essence of the participants' experiences as they plan for, interpret, and implement NGSS related to climate change and the impacts of human activity on the environment, I intended to recruit educators representing various contexts. The primary sources of data were generated mainly from document analysis, in-depth, standardized open-ended interviews, and observation notes (Chan, 2010; Cohen & Crabtree, 2006; Patton, 2002). The interview structure allowed for probing for further information (Creswell, 2013; McMillan & Schumacher, 2010; Patton, 2002) and each interview was conducted for approximately one hour. A total of 10 interviews were conducted in person and 6 were conducted via a digital platform due to concerns over the spread of Covid-19. Triangulation, as described in Creswell (2013), included interview transcriptions with notes (see Appendix B), analysis of supporting documents, and observations notes.

Purpose of the Study

The purpose of this study was to capture and describe the essence of educator's experiences as they plan for, interpret, and implement NGSS related to climate change and the impacts of human activity on the environment. When it comes to addressing climate change in the context of schooling, this study sought to explore what teachers are doing and why.

Research Questions

Central research question: In what ways do educators who are implementing the Next Generation Science Standards address climate change and impacts of human activity on the environment?

Sub-questions:

1. In what ways do educators who are implementing the Next Generation Science Standards perceive their roles and responsibilities in addressing climate change and the impacts of human activity on the environment?

2. In what ways do educators who are implementing the Next Generation Science Standards interpret the associated Earth and Human Activity standards prior to enactment?

3. How do educators who are implementing the Next Generation Science Standards teach climate change and the impacts of human activity on the environment?

Phenomenology

According to Patton (2015), "qualitative researchers using a phenomenological inquiry framework should immerse themselves in its historical evolution" (p. 117). Therefore, in describing phenomenology as a methodology, this section will also explore its roots and historical evolution. Alternative to positivism, phenomenology emerged at the end of the 19th century largely as a means to solve crises related to positivisms inability to answer questions being asked in the human sciences (Merleau-Ponty, 1945; Patton, 2015). The philosophies and theoretical foundations that emerged out of this paradigm shift sought to highlight the uniqueness of the human experience, consciousness, and perception (McPhail, 1995; Sixsmith & Sixsmith, 1987). This shift toward phenomenological thinking is largely associated with Hegel and Husserl. The philosophical and theoretical foundations of phenomenology pioneered by Hegel and Husserl can be seen as having roots in the work of Immanuel Kant, who distinguished between objects as phenomena and objects as noumena (things-in-themselves). While Hegel,

and Husserl can be understood as early phenomenological thinkers, differences therein lie in their reactions to Kantian phenomenology (Moran & Magri, 2017). In Hegal's work, *Phenomenology of Spirit* (1807), phenomenology is described as an approach to philosophy that begins with an exploration of the phenomena as a means to fully grasp the spirit that is the phenomena (dialectical phenomenology). The work of Husserl, however, which was also informed by Brentano, presents phenomenology as reflective study of the essence of consciousness as experienced from the individual perspective. Furthermore, the work of Husserl referenced the Kantian distinction between *noumenon* and *phenomenon* in his argument of the existence of two kinds of reality: Noumenon and phenomenon (McPhail, 1995). According to Husserl's framework, Noumenon is being in reality and therefore the most optimal way to describe the natural world. Phenomenon on the other hand, is the appearance of reality in consciousness and therefore the best way to describe the human sciences.

A Return to the Lived World

Although Hegel and Husserl have been understood to be important foundational phenomenological thinkers, Husserl has often been portrayed as the founder of phenomenology (McPhail, 1995; Sadala & Adorno, 2002; Earle, 2010). Phenomenology, according to Husserl, is a return to the lived world where people have unique experiences. A phenomenon, in this context, should be described rather than explained. In addition, this approach warrants that the causal relationships be found by the researcher. Phenomenology, therefore, recognizes that there exists a lived world of experiences as well as subjects who have experiences. Central to Husserl's framework is the concept of using consciousness to understand the world which he calls *intentionality of consciousness.* From this perspective, all human actions and experiences have meaning. Additionally, in order to prepare one for the critical examination of the

phenomenon before individual, interpretive beliefs factor in, one must consider *eidetic reduction.* This concept refers to one's ability to bracket ideas, attitudes, and experiences regarding a particular phenomenon (Earle, 2010). Lastly, Husserl's framework emphasizes the *constitution of meaning* as a way to identify the essences of the human lifeworld. In this context, essences are the mutually shared meanings that are experienced in relation to a phenomenon.

Heidegger, Merleau-Ponty, Moustakas, and Beyond

This perception of phenomenology as pioneered by Husserl has been furthered by the work of Heidegger and those in the vein of Merleau-Ponty and Moustakas. German philosopher and student of Husserl, Heidegger's perspective was one that denounced the intentionality of Husserl in favor of *Dasein*, "the meaning of being in the world" (2010). Furthermore, his work highlighted the concept of *temporality* which suggested that existence and being can happen in the past, present, and future (Earle, 2010). Another concept that Heidegger denounced in opposition to Husserl is the idea of bracketing and reduction. Understanding, he argued, is not possible without presuppositions (Earle, 2010). In Heidegger's perspective of phenomenology, the work of Schleiermacher is referenced as a means to reintroduce the hermeneutic circle. A concept that allows for a relationship between pre-understanding and understanding (Earle, 2010). In this context, pre-understanding is the knowledge that one has by simply being in the world and therefore cannot be eliminated through bracketing or reduction. Rather, a researcher of this nature attempts to understand the lived experiences of others by first examining their "own *forestructures* of 'the things themselves' prior to moving from the whole to parts and then back to whole in a reciprocal way" (Earle, 2010, p. 288).

Another pivotal philosopher in further developing Husserl and Heidegger's phenomenological ideas was the French Philosopher Merleau-Ponty. He argued that "not only is

phenomenology the rigorous search for essences, but additionally, it is a philosophy that sees people in a world preexistent to any reflection" (Sadala & Adorno, 2002, p. 286). With the perspective that we exist in a pre-given world, Merleau-Ponty's phenomenology is considered existentialist. Therefore, people exist in the world and it is from the world that a person can learn about themselves (Earle, 2010). Lastly, Merleau-Ponty's existential phenomenology deals fundamentally with humans in the pre-given world, the conditions of limitation of living in a "pre-given" world, and their ability to choose their actions and thoughts (Earle, 2010).

Continuing along these lines, Clark Moustakas and Max van Manen have provided two different sets of methodological guidelines by which to carry out a phenomenological study (empirical, transcendental, or psychological phenomenology vs hermeneutical phenomenology) (Creswell, 2006). While their work draws on that of the aforementioned philosophers, their approaches differ and therefore for the purpose of this study, the work of Moustakas has been used to inform the methodology. This choice was made due to the systematic steps for data analysis and development of textural and structural descriptions.

Research Design

Phenomenology, in simple form, is the study of lived experience (Creswell, 1998; Moustakas, 1994; Patton, 2002); however, it is important to keep in mind that rigorous phenomenological research is more than just a synthesis of participant's interviews. Phenomenology as a research design necessitates that the participant experiences be described in a way that effectively communicates their ways of seeing things (Donalek, 2004; Patton, 2002; McPhail, 1995; Sixsmith & Sixsmith, 1987). Furthermore, phenomenological research seeks to allow for participants to uncover their own categories and to understand their experiences (McPhail, 1995). Therefore, phenomenological research begins by describing a situation

experienced in daily life as the researcher obtains descriptions of whatever there is in front of a person's eyes and not of that thing's existence (Moustakas 1994). In this regard, Moustakas has recommended that the researcher attempt to suspend judgement and set aside their experiences as much as possible to achieve epoche (bracketing) because a researcher's duty is not to impose preselected categories upon the participant, but to allow participants to engage in their own meaning-making structures and construct their own meaning (Moustakas 1994). In order to do so, I began by describing my own experience with the phenomenon as an attempt to bracket out my views prior to describing the participants' experiences with the phenomenon. By attempting to set aside preconceived notions, the researcher is better able to work with the description of the phenomena and place it in epoche'. *Epoche* is the essence of the experience, and therefore what is sought by the researcher. By placing the phenomenon in epoche, the researcher is able to search for the essence of the phenomenon and therefore the very nature of what is being questioned. In this regard, it was important and necessary to distinguish my role of *nonparticipant observer* but recognize that it was necessary to take on a participative role during the interviews to ensure that I understood the lived experiences of the participants (Creswell, 2013).

Participant Selection Strategies

According to Creswell (2007), research along the lines of this study requires that the problem be understood from the perspective of several individuals in order to get to common or shared experiences of the phenomenon. More specifically, Creswell has recommended that phenomenological studies recruit three to nine participants. Therefore, for the purpose of this study, eight educators in the secondary grade levels were recruited using purposeful, criterion sampling. Initially, I began by exploring school websites to science teacher emails. I emailed

over 200 science teachers at local middle and high schools. During this same time period, I reached out to contacts that I have made. In addition, I explored social media websites and teacher groups as a means to identify potential participants. With every teacher that I emailed, I sent them a copy of the informed consent form (see Appendix A). During this time, I utilized purposeful, criterion sampling. Ultimately, the goal behind these recruitment strategies was to identify participants with the intent of informing the research problem, purpose, and questions within this study. Because educators across the country are in transition to implementation of NGSS which includes explicit language concerning climate change and the impacts of human activity on the environment, it is essential to understand the uniqueness of teachers who are addressing these standards. Therefore, in order to ensure that the participants have lived the experience of the phenomena, the following qualifying criteria was required: (1) having taught for a minimum of five years; (2) currently be positioned in a public or charter school where they teach grades six-12; (3) currently be positioned in a public school located in the Sacramento Valley region of California; (4) having implemented climate change and Earth and Human Impact Disciplinary Core Ideas (DCIs); and (5) have no social or professional relationship to myself.

In order to minimize the affect my presence as an educator, coach, or doctoral student had on the responses, I chose participants to whom I had no relation. Gender and age were not necessary to consider for the participant criteria. With regards to the identities of the participants, it was necessary to use pseudonyms as some may consider issues surrounding climate change education and the ideas expressed to be controversial.

Data Collection Strategies

Qualitative phenomenological research is not only interpretive and naturalistic, but must also seek to capture the essence of the lived experiences through reflective practices (Moustakas, 1994). In addition, phenomenological research as informed by Moustakas is transcendental, empirical. Following the approach of Moustakas requires the researcher to collect data from individuals who have experienced the phenomenon with the goal of producing a composite description of the essence of the experience for all the individuals.

Patton (2002) states that the only way researchers can understand the lived experiences of the participants is to get close to the phenomenon by becoming immersed in the shared information. Therefore, participant interviews, observations, and document analysis played a key role in data collection. When conducting research in the vein of this study, the use of multiple sources of information led to achieved triangulation. Triangulation consisted of in-depth and detailed data collection processes involving multiple sources of information rich in context (i.e. interviews, observations, and document analysis) (Creswell, 2012; Knafl & Breitmayer, 1989). The purposes of utilizing these types of documents was to bring out the stories of the participants experiences with the phenomenon at question in order to develop clear, full descriptions and understanding of the phenomenon. The documents and materials which I collected, referenced, described, and analyzed include observation notes and supporting teaching documents.

Once participants were identified as willing to take part in this study, a meeting time was scheduled at their convenience and at a mutually agreed upon location for the first of two interviews. Prior to meeting, it was made clear that at any time during the interview process, participants will be allowed to stop an interview for any reason. All interviews were scheduled

at the convenience of the participants and followed an interview protocol (see Appendix C). After the first interview was conducted, an instructional observation and second interview was scheduled at the convenience of the participants. The second interview was scheduled within approximately one to two weeks of the observation so as to keep the experience fresh in the mind of the participants and myself. The criteria for the observation was that the content must be of relevance to this study as perceived by the participant. During the observation, I took notes utilizing the categories on my observation note page (see Appendix C). The note page consists of four sections designed to help capture specific facts, quotes, phrases, summaries of conversations, and materials used. During this process of observational note taking, the goal was to bring out participants' voices. Throughout the observation I jotted down notes and immediately after the observation I reflected on the experience using the reflection note page in my observation protocol. The purpose of multiple interviews was, not only to increase trust and relational capacity, but to allow for reflection on the observation and ample time to explore the experiences in detail. Initial interviews were scheduled for approximately one hour to two hours, using a standardized open-ended interview protocol designed to maximize opportunities for participants own words to be conveyed without the influence of leading questions (Chan, 2010; Cohen & Crabtree, 2006). According to Creswell (2013), open-ended questions allow the participants to voice their experiences without the constraint of other perspectives or past findings, while open-ended responses allow participants to create the options for their response. During the interview process, I was prepared to elicit probes in the event that more information was needed, points needed clarification, or expansion upon an issue is warranted (Creswell, 2013; Krefting, 1991). In the context of this study, probes are understood as sub-questions used to clarify or encourage the elaboration of information as needed, as described in Creswell (2013).

In order to address the research questions, a structured open-ended interview protocol was developed (see Appendix B). The interview questions were designed to help understand the participants' experiences regarding the phenomena. Prior to use with the participants in this study, I pilot tested the interview protocol with two colleagues in order to strengthen the protocol and provide me with a chance to practice using it before official use. By piloting the protocol, I was able to gain a better understanding of the types of probes that might be necessary for eliciting depth. Once the interview protocol was tested, I made minor adjustments accordingly and prepared for use with the participants. The purpose was to elicit responses regarding their experiences with addressing climate change and the impacts of human activity on the environment in accordance with NGSS. The goal of the questions were to focus attention on collecting data conducive to developing a textural and structural description of the experiences (Creswell, 2006; Moustakas, 1994). Participant interviews were audio-recorded and transcribed verbatim to allow for a sentence by sentence examination conducive to the development of themes. After interviews were transcribed, they were offered to participants to allow for opportunities to validate the data from the previous interviews and participate in member checking. Member checking is a participant validation technique used by researchers to improve the validity and credibility of qualitative research and can be conducted at different times within the timeline of the study (Creswell, 2007).

Data Analysis Strategies

Following the recommendations of Moustakas, once the researcher has identified the phenomena to be studied, bracketed out one's own experiences, and collected data from participants who have experienced the phenomena, data analysis can begin (Moustakas, 1994). At this juncture, Moustakas (1994) has recommended horizontalization in which the analyst goes

through the data, highlighting 'significant statements', sentences, or quotes, which provide an understanding of how participants experienced the phenomenon. Once I reached this phase, I sought to use the data to develop clusters of meaning into themes (Creswell, 2006). Data was examined by reading through transcriptions, observation notes, and document analysis notes. Simultaneously, I made notes and comments of my own in my journal. Moustakas has suggested that researchers attempt to examine data from multiple angles and perspectives in order to identify hidden meaning. Therefore, I repeatedly listed to the interviews, read through the transcriptions and observation notes, and explored the documents to do so.

In examining the data reflectively and from multiple angles and perspectives, themes can be allowed to immerge which give meaning and structure to the phenomenon (Earle, 2010). Therefore, as I reviewed the data common themes were identified using logical inferences (Sadala & Adorno, 2002). As common themes emerged, I chose illuminating phrases from the data to capture the essence of the meaning of the phenomenon. Thematic coding was appropriate for the study as it allowed me to identify common themes within and across the qualitative data collected, and categorize it to create a framework of thematic ideas about the data (Gibbs, 2007; Nation, 2017). The combination of significant statements and themes were then be used to develop the textural descriptions of what the participants experienced and structural descriptions of the context or settings that influenced how the phenomenon was experienced (Creswell, 2006). Simultaneously, I wrote about my own experiences and the contexts and situations I believed to have been an influences (Moustakas, 1994). Following the development of the structural and textural descriptions, a composite description was written that presented the overall essence of the experience (Creswell, 2004; Moustakas, 1994). According to Creswell

(2006), this description should focus on the common experiences of the participants and leave the reader with a sense of deeper understanding of what it is like to experience the phenomenon.

Validity and Trustworthiness

Creswell (2013) states that, "Validating findings means that the research determines the accuracy or credibility of the findings through strategies such as member checking and triangulation" (p. 258). Johnson and Christensen (2012) refer to validity as the extent by which an instrument measures what it is intended to measure. Throughout this study, the following verification procedures were employed to help ensure trustworthiness: (1) researcher positionality clarification and portrayal of 'participant as observer'; (2) the purpose of this qualitative study and the interview questions were made clear and provided; (3) use of thick and rich description; and (4) triangulation of the information (Creswell, 2012; 2013; Lincoln & Guba, 1982; Knafl & Breitmayer, 1989).

The participants' rights were considered first and participation was presented as voluntary, with the allowance to halt participation in the study at any time without repercussions. As data was collected, it was shared with the participants to allow them the opportunity to discuss and clarify. This member checking also allowed them to contribute new or additional perspectives on the issue under study. The use of triangulation helped corroborate the data and thus helped ensure accuracy by drawing on multiple sources of information (Creswell, 2013). By including the participants in member checking, which is the process of allowing the participants to check the findings for accuracy, validity and trustworthiness was further ensured. In addition, the use of field notes and journaling has also contributed to the validity of this study.

Role of the Researcher

As an educator and curriculum/instructional coach, it was important to consider my personal motivation for this research study. Building on just over a decade of teaching experience at various grade levels and schools, as well as five years as an instructional/curriculum coach, one of my goals from this study was to better understand how educators perceive their roles and responsibilities in addressing issues related to climate change and the impacts of human activity on the environment against the backdrop of NGSS implementation, and in what ways do they do so. As a curriculum/instructional coach to teachers, I believed that this knowledge would help inform the ways in which I support my teachers.

While my role was largely that of non-participant observer, for the purpose of this study, I took on a participative role during the interview process as recommended by Sixsmith and Sixsmith (1987). During this process, I sought to achieve what Patton has described as 'empathic neutrality', so as to find a balance between being overly involved and remaining too distant. The reason for striving for this was to avoid clouded judgement or reduced understanding (p. 50). This approach was necessary in order to remain neutral and prevent the interviews and observations from being filtered through the views of the interviewer or observer (Creswell, 2013). Furthermore, I took on the role of the composer, conductor, and the instrument as I interviewed, analyzed, and interpreted data throughout the study. As researcher, my role was that of the composer who makes decisions on the scope and methodology (form) of a piece; as the instrument I sought to bring out the voices of the ensemble; and as the conductor, my role during participant selection, data collection, and data analysis is to attempt to unify the ensemble,

maintain tempo, listen critically, and shape the sound (i.e. participating in the negotiation, discussion, and expression of the participants' experiences).

Researcher Positionality

In qualitative research, researchers must be aware of their own positionality, experiences, and other factors that may influence the study; therefore, I chose to make my assumptions explicit (Cohen & Crabtree, 2006). At the heart of it all, I am an educator and musician. Therefore, I viewed my role of qualitative researcher much like that of being a musician; the chord structures, progressions, and ability to improvise that often characterize music are similar to characteristics of a qualitative research approach. I believe that good music and good research are composed of rich rigor, sincerity, credibility, resonance, significant contributions, and meaningful coherence. In addition, my ability to improvise and navigate a piece of music without pre-thought out fully-orchestrated scores was much like the way I approached this qualitative study without fully knowing what the outcome will be. In both cases, the beauty and significance was in the unawareness of what could happen along the way, and where I would go next. The excitement in not knowing where improvising and jamming will lead is much like that which I believe qualitative researchers may experience and must be prepared for. Regardless of harmony or the strike of a chord that doesn't quite work, the potential for something so organic is powerful.

In addition to being an educator and musician, I also consider myself a social reconstructivist with strong opinions and advocacy regarding the need for social and environmental justice and education. Rather than perpetuating the status quo, social reconstructionist educators see themselves as agents of social change who recognize the need to empower humankind as informed and rational social actors (White, 2005). I believe that, in

order for change or social reform to occur, educators must be willing to entertain drastic changes in pedagogy and ways of thinking about their practice so that students are educated accordingly. For the purpose of this study, I have acknowledged that I have these predispositions that guide my thinking and reality and therefore must be aware of, and make explicit, these beliefs so as to not let them cloud my interpretation of the data. However, I approached this study with the idea of remaining open to any contrary evidence or beliefs that may emerge as I proceeded. In this sense, I sought to achieve empathetic neutrality throughout this study (Meriam, 2001; Patton, 2002).

Phenomenological research, allows for the incorporation of the researcher's beliefs into the data and therefore the ability of the researcher to become familiar with the phenomenon as it relates to their own lived experiences (Donalek, 2004). Having taught across grade levels for over a decade, coached teachers for five years in grades four, five, and six, and been involved in school administration, I have a diverse background in education. During the latter part of my career I have placed strong emphasis on the importance of principles and pedagogical approaches related to an Ecojustice Education framework. Within my school, classrooms, and interactions with teachers, I have advocated for positive environmental practices that emphasize diverse, democratic, sustainable ways of being. In addition to my interest in environmental issues and social reconstructionism, my involvement in the NGSS Train the Trainer certification and conference put on by the NSTA during Fall of 2017 has contributed to my understanding, subjectivity, and biases. Furthermore, I have received certification and training through a cognitive coaching program provided by my school district. This training helped me to develop interview, paraphrasing, and analysis skills which proved to be beneficial to this study. As far as my personal philosophies, I believe it is important for teachers to encourage positive eco-ethical

behaviors and perspectives among their students; therefore, I strove to remain aware of this stance as I participated in this research study. This involved me thinking about the research assumptions and becoming conscious of what values, attitudes, and concerns I brought to the research (Hesse-Biber, 2010, p. 60). I reflected on my own subjectivity throughout the study as a way to help better understand how it is affecting the research process and data collection. I constantly journaled my thoughts and ideas as well as remained open to new learning.

Assumptions

As a phenomenological study, there was the assumption of this study that there would be an essence or essences to the shared experiences. Furthermore, phenomenological research in itself brings assumptions with it regarding consciousness (McPhail, 1995). It is assumed that consciousness is temporal and the key to human experiences, experiences are perceived holistically, and the cultural world is a creation of human meaning (McPhail, 1995). This study incorporated my beliefs and therefore, as a means to prevent my predispositions and positionality from having shaped the findings too drastically, I made these explicit (Patton, 2002). In order to reduce the influence of my positionality, I avoided falsification of information, dishonesty, and/or deceptive practices. In holding myself to high ethical standards, I remained up-to-date with related research, strove for accuracy and credibility, understood and explored the limitations to this study, and depicted the narratives and experiences of participants with as much accuracy as possible.

As one of my primary roles in this study was to be the main instrument for data collection and analysis, it was necessary to acknowledge that I am only human and seek to remain aware of any positionality, perceptions, or other ways of being that may influence the reporting. Therefore, constant reflection was necessary to remain objective. Although it was imperative to

assume that my positionality and values may impact the outcome of any study (Merriam, 1998), I attempted to bracket these by explicitly describing them as fully as possible. As this study was intended to produce thick and rich descriptions and analyses, it was assumed that the emergence of themes would arise. Lastly, an additional assumption to the study was that the participants would be honest and forthcoming of valuable information and the meanings I derived from them were that which was intended.

Chapter Summary

Phenomenology can have significant contributions to research seeking to understand the essences of shared experiences (Patton, 2002). Therefore, qualitative phenomenological methods were employed. While there are necessary components to phenomenological research, there is not a set of prescribed techniques for conducting phenomenological research (McPhail, 1995). Phenomenological methods are evaluated by their ability to improve understanding of human meaning making within the context of the study and therefore for the purpose of this study, data collection methods included interviews, observations, and document analysis. These methods were chosen based on their potential to allow me to listen to the data and come to understand the essence of the lived experiences. Therefore, I interviewed and conducted analyses in order to understand the shared essence of teachers. Purposeful, criterion sampling was be used to elicit participants for this study. Document analysis, and open-ended, semi-structured, one-on-one interviews were conducted (Chan, 2010; Cohen & Crabtree, 2006; Creswell, 2006). In addition, thematic analyses were used, as well as open coding to help divide the data into sections which then contributed to the emergence of themes.

CHAPTER 4: FINDINGS

Introduction

From August 2019 to May 2020 I met with and interviewed with eight educators in grades six through 12, observed five classroom activities and lessons, and examined numerous documents and websites that were referenced and shared by the participants. During the time of this study, the world has become an increasingly vulnerable place to exist. In addition to the new norm of perpetual record breaking temperatures, fires, warming and acidifying oceans, Arctic and Antarctic melting, and unnecessary loss of living and non-living beings and systems, the Covid-19 pandemic has further complicated life on this planet. At the start of this study 238 teachers were emailed inquiries into their participation in this study, 47 replied, 18 specifically mentioned teaching climate change, 15 said they don't address climate change, and eight qualified. Between September 2019 and February 2020 we met individually in person, in classrooms, coffee shops, and a health bar. However, as the Covid-19 virus took hold in local communities, safety concerns prompted us to meet from our homes through a digital meeting platform for the remaining portion of the study.

Data Collection

This inquiry into the teaching of climate change was intended to understand the ways in which educators address the topic. The intended purpose of this study was to capture and describe the essence of educators' experience as they plan for, interpret, and implement NGSS related to climate change and the impacts of human activity on the environment. In other words, I wanted to know what were teachers doing—and why? In order to describe the essence of what it means to address climate change and the impacts of human activity on the environment in

conjunction with the NGSS, interviews, document analysis, and observational data were used. The following research questions served as the focus of this study:

Central research question: In what ways do educators who are implementing the Next Generation Science Standards address climate change and impacts of human activity on the environment?

Sub-questions:

1. In what ways do educators who are implementing the Next Generation Science Standards perceive their roles and responsibilities in addressing climate change and the impacts of human activity on the environment?

2. In what ways do educators who are implementing the Next Generation Science Standards interpret the associated Earth and Human Activity standards prior to enactment?

3. How do educators who are implementing the Next Generation Science Standards teach climate change and the impacts of human activity on the environment?

Throughout this study, I approached the data collection much like the musician in me preparing for a 'jam session'. Interview questions were prepared and presented to the participants much like a chord chart used to present the basic harmonic and rhythmic information for a song. The questions, much like chord changes, were the same, yet each interview was unique. As the interviews progressed, it was necessary at times to probe for clarification and depth, reminiscent of a call and response between two musicians.

Once all data was collected, horizontalization as recommended by Moustakas (1994) was used in order to reveal themes. The interviews were printed out and read numerous times. Text was highlighted based on common ideas, and then cut them into chunks and short phrases. These pieces of text were sorted into closely related categories and grouped together until themes became clear. These groups were based on common information that captured the essence. Prior to, and during, the data collection, bracketing was used to minimize biases. To do this, I

engaged in discussions and journaling centered on exploration of my biases, past experiences, and prior knowledge related to the topic of this study. As data was collected and any biases or preconceived notions arose, I made note. Once the data was organized and coded, 10 overarching themes emerged.

Participant Profiles

Using purposeful criteria sampling, nine educators from various schools in the Sacramento Valley Region of California were selected to participate in this study. However, as the Covid-19 virus spread, one participant withdrew. At the time of this study, all participants taught in grades six through 12 and expressed having consistently addressed climate change and the impacts of human activity on the environment in conjunction with the NGSS. In addition, all participants had a minimum teaching experience of five years. Pseudonyms were chosen to represent the participants and first appear in the headings along with the grade level and content area they teach. The headings for each participant also include a descriptive characteristic that stood out during the interviews. The overall purpose of the participant profile section is to add context help make meaning of the participants' stories.

Michelle (High School Earth Science and Astronomy): A Happy Accident

I first met Michelle through a contact of mine at the Center for Mathematics and Science Education at a local university. As a curriculum coach, I had developed a professional relationship with one of the center's science consultants and decided to reach out, inquiring as to any teachers she was aware of who addressed climate change in conjunction with the NGSS. As it turned out, this contact had led professional development related to climate change for a cohort of 18 teachers, whom she graciously reached out to for permission to share their email with me.

All granted permission, but only one was comfortable with the prospect of participating. That's where I met Michelle.

Michelle is a high school Astronomy and Earth Science teacher for students in grades nine through 12. She is informed, composed, and dedicated. She considers her school an "upper middle class kind of culture" and "incredibly diverse." She works with students of varying language and learning levels and has approximately 38-42 students in a class at a given time. "I teach a lot of upper level English language learners so I have kids from Ukraine, from China, from Japan, from Vietnam, the Philippines, and I have kids from Afghanistan and from Iran."

She has participated in a range of professional development and education around climate change and geology. In college she earned degrees in geology and climate change, and received a fellowship through Rutgers University to study climate change with emphasis on how the ocean changes in response to climate change. During this fellowship, she published an article in which she and a lead scientist explored the Pacific current in Australia and discovered sedimentary evidence of a paleo current north of Tasmania. Further along these lines, she has experience working in field paleontology, as well as studying the paleo-climatology of lakes through chemical isotope chemistry in order to understand how past climates have changed in lake sediment. When I inquired as to her path to education, she described teaching as an accidental career that had roots to her work tutoring children in math while she worked in a program organized by the university. After college, while working with a paleontological consulting company, the 2007/2008 recession hit and she lost her job. This change in circumstances prompted a return to college to further study geology, climate change, and earn her teaching credential.

Jude (Sixth Grade Multiple Subjects): A Summer Camp Kid

I discovered Jude while watching online interviews of recent teachers who were awarded teacher of the year. He had been awarded the honor for his work with sixth grade students. In his interview, he was charming, witty, and knowledgeable. A simple online search of his school led me to his email information and when I emailed him the details of this study, he seemed instantly intrigued and excited to participate.

Jude is a sixth grade multiple subject teacher and instructional coach at an elementary school, where his weeks are usually split evenly between coaching and teaching. He works with a high population of Hispanic and Hmong English language learners. The school has a high percentage of students qualifying for free and reduced lunch as well. Jude absolutely loves his students and his practice, "everyone that I tell I teach sixth grade to they're like, *oh no sixth grade? They're horrible and moody.* No, to me they're just normal humans and you know, they're really fun."

His educational background includes experience in psychology, chemistry, and a Master's Degree in education from the University of California Berkeley. In addition, he is an instructional coach with Tier two GLAD certification. He was also recently awarded teacher of the year by his school district for his work with sixth grade students and teachers. His career in education stems from his first jobs working in a summer program at a local elementary school, and then for the school's afterschool program which led opened the door to volunteering in classrooms where he discovered his calling.

Lucy (Middle School Math and Science): A Philomath

I happened across Lucy as I had just began exploring school websites for possible leads. Through email correspondence, we decided to meet at a local coffee shop near her residence. As I waited outside at a small table, she pulled up on her bike.

Lucy is a math and science teacher for sixth and seventh grade students at a local middle school composed of affluent families with high ethnic diversity. She described student population as affluent, first and second generation Americans with highly educated parents (educated in their native language). She is quiet, reserved, yet self-assured and knowledgeable. She loves to learn. She also has previous experience teaching eighth grade and working with socio-economically disenfranchised students. She has been involved in various professional development opportunities related to the NGSS and environmental education, such as Project Wet, Project Learning Tree, and the Forestry Institute for Teachers. She described teaching as a calling and explained that originally, she was on track to a career in the medical field but after being enrolled into medical school and working at a pathology lab "things just didn't feel right". During our interview, she recalled a moment while attending a school performance with her sister:

> My sister was a nanny for a little girl and I went to the school show with her. I was in the school setting and sitting in the auditorium and was like, wait a minute, this is where I was supposed to be.

Something about the environment spoke to her and that seemed to be the moment that she knew she needed to be a teacher. "It felt like what I was supposed to do." Soon after, she applied for her teaching credential and within a year, was in the classroom where she has been ever since.

She told me that the highest compliment she ever received was from a challenging student, "I really hate science, but I really like your class."

Pam (Sixth and Seventh Grade Science): A Steward to the Environment

Pam is science teacher for students in sixth and seventh grade. I met her soon after meeting Lucy and much in the same way. A simple exploration of her school's website led me to the staff directory where I found a link to her profile and classroom website. Her school is designated Title One, due to a high percentage of students qualifying for free and reduced lunch. Her students hail from a myriad of ethnicities, cultural backgrounds, and language levels. In addition, she described some of the students as having emotional trauma from their socio-economic surroundings. As I got to know Pam, I saw that she is spunky, caring, and confident. She explained to me that she was inspired by her parents to pursue a career in education. She has earned her teaching credential and Master's Degree and spent time in Taiwan and Japan studying education for sustainable development through the Fulbright exchange program. She began teaching as a substitute teacher and then para educator where she eventually became a classroom science teacher. Since becoming a teacher, she has partaken in a number of programs, such as Project Wet. She has worked on curriculum development through a program called Facing the Future and has earned grants from SMUD, PG&E, BP, and the Coastal Commission for her school. She has also spent time attending conferences and speaking on climate change. Other notable projects include her work with the International Student Carbon Footprint Challenge, the development of a traffic garden, various water conservation initiatives, and organized litter clean-up. She is a steward of the community and during our interview she related her personal way of being to the parable of the Kings Highway:

> Do you know the parable of the Kings Highway? The king's highway was something that we share in our family. *The king invited his subjects to come to his palace and they had*

> *to travel a certain road. And so they got there and there was a large pile of debris and rocks in the way blocking the point. That got in their way and hindered their traveling. But some people went around. There was one person who moved all of that away and then he found some treasure. So they got there and at the end of the day, a lone traveler crossed the finish line and walked over to the King, who was tired and dirty, and he addressed the king with great respect and handed him the gold that he found. I stopped along the way to clear the pile of rocks and debris that was blocking the road. The chest of gold was under it. Please have it returned to its rightful owner. Well, you are the rightful owner the King said. But oh no, I've never had that kind of money. The King says yes, you earned this gold. You won my contest. He who travels the road best is he who makes the road better for those who will follow.* So that's the way I feel. That's how I feel about this.

Maxwell (Middle School Science): A Social Justice Advocate

I met Maxwell much in the same way as Lucy and Pam. After searching 40 school websites, I came across his teacher page, emailed him, and he was the second teacher to confirm through this approach. Maxwell is a middle school teacher with an educational background in ecology and outdoor education. He is the youngest in this study, hip, humble, and maintains a deep advocacy for environmental and social justice. He has studied population ecology, community ecology, entomology, and hepatology. His desire to enter teaching stems from witnessing his mother teach. As a child, seeing his mother "in her element" inspired him to pursue a career in education. After college however, he felt the calling to 'work for the world' and joined the Peace Corps, where he gained experience teaching abroad. In the years that followed, he pursued a Master's Degree in Environmental Education, taught at an outdoor education program, and currently teaches science to students in grades six and seven. The middle school that he works at is located in a low socio-economic community and hosts a large immigrant English Learner (EL) population. They also have a large refugee population with many students coming from Afghanistan, Iraq, and Iran. In addition, he spoke about students who are homeless or considered foster youth as being another demographic at his school.

Regardless, he takes teaching in stride and always seems to find a way to advocate for the disenfranchised.

Rocky (Sixth Grade Science): A Reformed Agnostic Buddhist Once Removed

Rocky and I met after I noticed his name and school on the California Department of Education website listed in a section detailing the history of adoption of NGSS for California. He was one of 27 members named as part of the Science Expert Panel. His name jumped out to me because I recognized the school district as being local. Following that, an internet search of his name followed by the word 'teacher' brought up the URL for his school and an article that he wrote comparing the two NGSS models of implementation. Immediately upon learning of the details of this study, he was intrigued. When he and I sat down for our first interview in his classroom he was wearing a custom NGSS t-shirt he had made.

Rocky is a sixth grade science teacher to say the least. During the course of this study, Rocky had been working with 90 "advanced students", 70 "regular Ed students", 15 special education students, and three students who were receiving Tier three interventions for emotional disturbance. His school is an International Baccalaureate (IB) middle school and host to a variety of students with diverse ethnic backgrounds, the majority of which are Latino, African American, Pakistani, and Asian. He is on the verge of retirement with a wealth of varied experiences related to education. He has degrees in biology and environmental ethics. He is cheerful, well-informed, and gracious. Aside from teaching middle school students, he has an extensive background in leading professional development and presenting at conferences such as the California Science Teachers Association. His passion for teaching goes beyond sixth grade as he has worked with, and mentored, new teachers in various contexts; was involved in the original California NGSS committee (the science expert panel) tasked with developing the dual

models of NGSS implementation (integrated model and discipline specific model); has participated in Adopt a Watershed through the Environmental Protection Agency (EPA) and Project Wet and Project Wild through the association of Fish and Wildlife; has written various grants, published articles, and has participated in curriculum development and piloting.

He refers to himself as a 'reformed agnostic Buddhist once removed' and believes deeply in the power of science literacy. His path to teaching has roots connected to his father, his time as a boy scout, and his experience serving as a park ranger where he became involved in outdoor environmental education. Several times throughout our interviews he summarized his teaching philosophy with a quote from John Dewey, "If we teach today's students as we taught yesterday's, then we rob them of tomorrow." This quote was on the shirt he wore for our first interview.

Julia (Sixth Grade Science): A Constructivist and "Big Earth Science Nerd"

Julia is a sixth grade math and science teacher at a high performing charter school. I happened across her as I was doing research for the school I work at. At the time of this study, my school was in the midst of a transition to Standards Based Grading and therefore I had been looking into schools that had already made this transition. I came across Julia's school when its name appeared at the top of internet searches centered on schools that have adopted Standards Based Grading (SBG) practices. As I explored the school website, I decided to email the science teachers with regards to this study.

Julia is funny, boisterous, logical, and passionate. She has three years of experience teaching in third grade, 10 years of experience teaching fourth grade, and was in her second year in sixth grade when we sat down for our first interview. When asked to describe her students, her positivity was infectious:

> So it's a beautiful, really cool mix of kids. In my morning class I have six kids with an IEP, five kids that are GATE, um few on 504s, one English Language Learner, and my afternoon class is six GATE, one EL, four kids with 504s.

The enrollment at her school during this time was 919 students with 34 percent qualifying for free and reduced lunch (slightly above the local district average):

> Our demographics are crazy cool. I don't know if you know this, but [the school's zip code] is one of the most diverse zip codes in the entire nation. And so, we have something like 47 languages on our campus.

She considers herself a constructivist whose primary passion is science with emphasis on ecology, geography, and geology. She also has an extensive background in outdoor education and science professional development as mentioned during our interview, "If there's an opportunity for outdoor PD that goes over many days, I've either done it or am looking for a way to do it." The list programs includes Project Wet, Project Wild, Project Wild Aquatic, the Buck Institute, and the Forestry Institute for Teachers. Further along these lines, she has been involved with the Wetlands Institute for the last four years, is a fellow at the Monterey Bay Science Teacher Institute for Project Based Learning, and has additional certification as a California Naturalist and Nature Bowl Coach through the department of Fish and Wildlife.

While she prides herself in being a good teacher, she never saw it as a calling. Rather, she described teaching as a career choice that stemmed from necessity and the will to earn a degree, given that her family's financial situation and cultural capital were not conducive to supporting her beyond the junior college level. Left with few options, she discovered a free ride scholarship that required her to teach after college. Upon graduation, her hesitancy to move into teaching prompted her to live in the mountains in Sequoia National Park where she gained an intimate appreciation for human kind and the natural world. "Eventually I realized that I needed health insurance and that's the reason I'm a teacher today. Sounds awful but it pays the bills."

Fall 2020 will mark the start of her 16th year teaching and her first year as the preliminary science teacher for the new high school division of her school that is set to open.

Rita (Eighth Grade Physical Science): Old School

I was introduced on to Rita through Pam. At the start of my email exchanges with Pam, she introduced me to Rita. After several exchanges, Rita confirmed participation. Rita is a physical science teacher for eighth grade students, with a background and degrees in environmental education, climate change, and the Forestry Service. She works with a range of students from diverse backgrounds and ethnicities at a designated Title-One school. Rita understands the power of empathy, she is deeply knowledgeable in science and wise to the world. She has attended a multitude of professional development throughout her career from a range of programs such as Project Wet, the Forestry Institute, and NGSS. She is an active member of the Sierra Club and has strong feelings toward climate change and other environmental issues. During one of our interviews, she told of one of her earliest environmental advocacy triumphs (closure of a nuclear power plant). While studying geomorphology, she and her colleagues discovered that a local nuclear power plant was situated on a fault line. After devoting extensive time and energy to expose this, the plant was shut down to the credit of Rita and her friends.

Spotlighting climate change is a constant for her. She believes that climate change is a topic to be infused into everything she does. As she says, “It doesn't matter what the topic is. I've always made sure that I bring that up.” In fact, during our virtual interview when she referenced Covid-19, she said, “You know, the only silver lining, the only silver lining about this virus is there is less pollution in the atmosphere. People are not driving cars.”

Table 1
Participant Descriptors

Participant	Grade Level	Content Area	Years in Education
Jude	Sixth Grade	Multiple subjects	Seven years
Julia	Sixth Grade	Earth Science and Astronomy	16 years
Lucy	Sixth and Seventh Grade	Math and Science	12 years
Maxwell	Seventh and Eighth Grade	Science	Five years
Michelle	Ninth – Twelfth Grade	Earth Science and Astronomy	Six years
Pam	Eighth Grade	Physical and Honors Science	10 years
Rita	Sixth - Eighth Grade	Physical, Life, and Earth Science	13 years
Rocky	Sixth –Eighth Grade	Earth and Physical Science	29 years

Themes: 'Digging in the Crates'

The phenomenon of addressing climate change and the impacts of human activity on the environment in conjunction with the NGSS is complicated and multifaceted. The profiles described previously were meant to provide a glimpse into the participants' backgrounds and lives in order to ad context. The following presentation of evidence is meant to contribute to a deeper understanding of the participants' experiences. The goal of phenomenological research is for the participants to uncover their own categories and to understand their experiences (McPhail, 1995). Therefore, the goal of this study was not to impose preselected categories upon the participants, but rather to ask questions that foster meaning-making structures conducive to effectively communicating their experience (McPhail, 1995, p. 163). By examining the data through a Systems Theory and Ecojustice Education framework, seven broad themes emerged.

This systematic analysis of the data led to the emergence of the following themes: climate change is an existential crisis, examination and refinement of pedagogy, perceptions on Next Generation Science Standards pedagogy, inquiry based pedagogical methods, pedagogical resources, fostering relevancy to students, and steps toward an eco-ethical consciousness. Although the themes that appear in this study are distinct and prominent recurring ideas, subjects, or topics related to the ways in which the participants address climate change and the impacts of human activity on the environment, a Systems Theory framework acknowledges multiple connections within and across themes.

Climate Change Is an Existential Crisis

Teaching climate change in conjunction with the NGSS is complicated and multifaceted. For the participants in this study, teaching of climate change and the impacts of human activity on the environment involves deep recognition. Recognition in this sense refers to the acknowledgement that climate change must be addressed, human activity is the most afflictive factor, and educators are at the front lines with the duty to address related issues. Throughout this study, participants referred to climate change as an existential crisis and although terminology varied at times, each participant spoke with a sense of urgency, ferocity, and responsibility.

Recognition of climate change as an existential crisis is a major watershed moment, and therefore a primary motivating factor for their decision to address the topic. In addition, this acknowledgment has also informed how the participants address the topic. As I asked participants to speak about what they know about climate change and the importance as it relates to them, common sentiments emerged. When Jude was asked about it he explained, “It’s something that we can no longer ignore.” He feels as though climate change is on par with

universal health care and therefore, “something that must be addressed!” Jude believes we are at a crucial moment in human existence:

> How many hurricanes have to hit and how many people have to die for it to be something that we do something about? Even looking at the amount of animals that have died off recently and looking at the coral bleaching. We have irreversible problems coming.

Accordingly, Jude understands that climate is changing and human actions are clearly the cause. He emphasizes the release of methane and carbon dioxide into the atmosphere as major causes of human driven climate change. He predicts that civilization will continue to experience increased natural disasters, glaciers melting, and oceans rising. If society does not act immediately, he believes that many cities will be left underwater. As he spoke about the visible effects, he went on to say:

> We’ve had what, more level four level five hurricanes in the last couple years. Ever year is the hottest year on record, there are floods, California is on fire, California had the seven year drought… So I think we’re seeing some of these effects. The coral reef is dying, the acidities of the ocean are increasing and we’re gonna have thousands if not millions of refugees.

On several occasions throughout the interviews, Maxwell referred to climate change as “the most important thing.” He believes the situation is dire:

> It’s incredibly important. I personally am making choices to lower my impact as much as possible. I'm trying to make sure that I'm contributing as little as possible to the changing climate. So it's I mean, for me, it's the most important issue. And, I always tie climate change with humanitarian things because as climate change gets worse, humanitarian issues are getting worse as well. They're connected. It's not separate things. You know, access to water, access to food, access to health care? That’s all connected to climate change. So yeah, for me, climate change is the most important thing.

As our interviews continued, Maxwell often spoke about the multifaceted connections, factors, and impacts. For example:

> I know the effects of climate change. You know, I studied ecology, I've seen. It's affecting micro ecosystems in certain places. But I also know the general trends of temperatures are getting hotter in general even though it might be cold over here. You know, the temperatures on the globe are getting warmer. It's snowing here but that

> doesn't mean that global warming, climate change doesn't exist. And, you know, a lot with climate change is just all these different pieces of pollution and plastics, you know? The more plastics we're using, the more fuels we're taking out, the more fossil fuels we're taking out the more greenhouse gases are coming out. Methane. Cows are releasing more methane and that's a greenhouse gas as well. All of it building up. I mean, there's just so many different pieces.

The other participants expressed similar outcry. Julia spoke about to climate change with equal furor as "the existential crisis of our time!" and "we're losing our planet!" Pam spoke about it as more important than any other crisis when she said, "Well, climate change is going to affect us on a much greater scale." The threat was reiterated with Rocky, "So what do I know about climate change? I know it's the most existential potential threat to our society, culture and world civilization as we know it." Furthermore, "I think climate change is possibly one of the most dire potential threats for our society. I mean, it's enormous. I wouldn't call myself an expert, but I'd call myself as knowing more than most people." He then went on to relate climate change to extinctions and societal collapses of the past:

> I mean, dinosaurs did not die from the meteor. Dinosaurs died because a meteor hit causing climate change. The ones where the meteor hit died but it caused rapid climate change and it was more than one meteor as we've learned. So climate change is what did them in. When you look at civilizations that collapsed like the Anasazi, it was climate, not global climate change, but localized climate change that caused them to collapse. Why did different societies collapse? Because of environmental degradation, in a sense it wasn't climate change it was environmental degradation. That's what ends society.

As Rocky spoke about climate change, he spoke about the impacts around the world and shared several experiences related to his travels, "And it's everywhere. When I go to Alaska the glaciers are disappearing." As he continued he explained:

> I had to go to Alaska a couple years ago to see [climate change], because that's the greatest place to see climate change. Because the degrees of climate change are more than the percentage you can read for worldwide changes. Its five degrees! The last ice age was five degrees different and Alaska's already at five degrees different on average!"

His concern and heartbreak was expressed several times throughout the study as he referred back to Alaska with comments such as, “The entire forest is changing here. It’s changing right now.

All participants spoke about climate change as existential and dire. Rita believes it something that she needs to address and bring awareness to constantly. For Michelle, her awareness and concern was apparent. As she spoke about climate change, she used hypothetical questions such as, “why aren’t we planning how to mitigate those?” or “why aren’t we thinking of ways to mitigate impact?” Several times throughout the interviews she referred to schools and students as being on the “front lines.” For example, when asked to describe what she knows about climate change, Michelle said:

> I feel like the front line of doing anything about climate change is in the schools. The scientists have done a lot of research, the research says it’s happening, and humans are the reason it’s happening. The evidence is pointing to climate change, its occurring, and humans are the ones who are largely responsible for making it occur at an accelerated rate. Climate is gonna change no matter what, that’s kind of what climate does. I mean, we’re coming out of an ice age and it’s gonna warm up but humans are impacting it by making it warm up more faster than normal.

As I spoke with Lucy, she often demonstrated recognition as an individual:

> I think it's pretty important as an individual just because I'm aware of what's going on and someone who likes to be out in nature and who lives in a very quickly growing town. When I see them, you know, chop down a bunch of oaks to put up, you know, 60 houses on a seven acre lot it breaks your heart. And then, for my students, I think middle school is especially as a place where you start to plant the seeds for who you're going to be as an adult so I try get those kids to notice where they live and appreciate where they live and how their choices and actions affect their environment.

Lucy, like others in this study, emphasized climate change as something that has always naturally occurred, however, the difference being human innovation and technology has led to more than we can manage. When asked to describe what she knows about the topic she said, “Climate change, as I understand it, it's always happened over the history of the earth. But with

our, you know, success I guess as a species, our innovations and technology have put more out there than we can manage." In addition, she went on to say:

> I know that it's strongly driven by humans and it's always occurred, but with the human impact it's really accelerated. I mean I look around where I live and where my kids live, my students, and I can see just the growth.

In exploring the issue of climate change with the participants, I experienced a wealth of information and high level awareness as I asked them to discuss what they know about climate change. Regardless of backgrounds, schools, or grade level, teachers in this study believe that the existence of human kind is contingent on remediation of degradation caused by human centric activities and habits. To the participants, this recognition prompts a call to action.

In recognizing climate change as an existential crisis, the participants' keep their beliefs active and at the forefront of their teaching. Based on their interviews, they believe that in order to best instill the importance of addressing the existential crisis that is climate change and the impacts of human activity on the environment, constant exposure, discussion, and reflection with students is necessary. To do this, participants described imbedding the topics into other content areas and discussions with regularity. Teachers shared examples of texts and assessments that have an underlying theme related to the impacts of human activity and environmental sustainability. As the only multiple subject teacher, Jude spoke about integrating and imbedding topics related to climate change into his Language Arts. He begins with students reading an article titled, "What is climate" and move through texts and activities centered on severe weather. He described, "We have some comprehension questions and we have a climate versus weather video. And then we read climate change makes blizzards worse. That's our bridge into the second week, which is more on the severe weather." The students go on to read, write, and

discuss more on climate change and the greenhouse effect with emphasis on, “why are these sever weather happening? What’s causing them? And what can we do?”

For Maxwell, “as far as climate change goes, I mean, this is something that we’re constantly learning about.” Rita emphasized imbedding climate change into everything as her primary way to address the issue. “It doesn't matter what the topic is. I've always made sure that I bring that up. If I'm talking about acids and bases as you saw, I talk about the acidic ocean, ocean acidification.”

With regards to Michelle, Rocky, and Rita, teaching Astronomy has been another content area for them to further imbed climate change. For example, Michelle spoke specifically about addressing climate change when they learn about topics such as carbon cycling and Rita specifically spoke about acids and bases being one way she brings it in. Regardless of the participant, climate change was described as something that is a single entity as well as taught within and across various content areas and topics. After interacting with the participants through this study, a single sentence from Rita sums up the general perspectives of this group, “I want to save the planet, so I always stick it in there somewhere.”

As I began to understand the participants’ beliefs and perspectives regarding their roles and responsibilities related to addressing climate change and the impacts of human activity on the environment, it was clear that they desire to address the topic with fidelity, depth, and urgency. As participants discussed and shared the content covered, they emphasized the responsibility of teaching students that carbon cycles and the release of greenhouse gasses from burning fossil fuels as major factors that have led to a rise of Earth’s surface temperature. For instance, when Maxwell addresses climate change, he said, “I tend to talk about how the general trends of temperatures are getting hotter in general, even though it might be cold over here.” He

went on to further describe the goal of his Earth's Systems Unit as helping students deepen their understanding of the atmosphere, biosphere, geosphere, and hydrosphere and how they're all connected to each other. For him, fossil fuels is a good way to tie them all together. This was further confirmed when I observed him teaching, as he referenced during the final interview:

> When you saw me we were kind I was trying to get them engaged and then led into breaking it down. The first thing we talked about is what fossil fuel is. So we talked about how fossil fuels are formed, we did a couple experiments where they put gummy worms between bread and they put pressure on it and then left it there and they could see like its crushed down.

Along similar lines, when it comes to climate change, Pam spoke of teaching students the nature of greenhouse gasses, that offsetting one's carbon footprint can be done by human behavior, and that sea levels and temperatures are rising. She described this in an activity she was planning to do when I came in to the classroom. "We'll do the actual greenhouse gas demonstration with the Saran wrap, large Saran wrap, the world, and describe certain human activities that increase the amount of CO2 and show how it gets to a certain point and comes back." For Lucy, the focus on factors that contribute to climate change was mentioned when she was describing the goal in her unit as fostering an understanding that carbon dioxide and methane are major factors in temperature rise.

When Jude addresses climate change the students "look at global temperatures and factors that have caused the rise of global temperatures of the last century." During the final interview with Jude, I asked about his goals and he spoke about a desire for students to understand the factors that give rise to climate change and that human activity is largely the cause:

> I want them to walk away with the understanding that humans are causing the Earth to get warmer. And that has that has an effect on the Earth. Through, through all these severe weathers. Right. So we're seeing a rise in level four and level five hurricanes. Right. Like, we're seeing more drought. We're seeing, you know, hotter summers and

> colder winters. Right. Like we're seeing this huge change in this huge impact. And humans are responsible. But I also want them to walk away with the idea that, like, there are things that we can do. Right. Like there are there are things that we can do to help mitigate. Like things are bad, but like we can start to mitigate if we start now. And I think generally that's what I want them to walk away with.

For Michelle, teaching climate change is twofold. First, it follows along similar lines as what Maxwell and others described, "We start teaching them what a system is and what the spheres are and how you describe an interaction." From there, they move into the different parts of Earth's systems and eventually culminate with a research project wherein they choose human impacts and research how it is affecting all the different spheres and systems. In the end, they will have learned about greenhouse gasses, what climate change is, and how these factors interact and impact all Earth's spheres. With regards to another set of activities she explained:

> And then they learn about the reflection, absorption, storage, and redistribution. In this one we focus on the atmosphere and then in term two we start talking more about the oceans and how the land can you know, heat up faster but it doesn't store heat as well as the oceans. And then changes in the atmosphere due to human activities have increased carbon dioxide concentrations and effect climate. And then developing possible solutions when they do they're [school site] floods thing.

In addition to addressing climate change as a separate unit, Michelle tends to interweave the factors that contribute to climate change into her Astronomy lessons. One example she gave was when she spoke about teaching carbon cycles:

> We had just learned about carbon cycling so we talked about how carbon was stored in different reservoirs and how it moves between the reservoirs. After that I felt like they were kind of ready to learn what happens if we have too much carbon in one reservoir and how that could affect the other spheres which we had already learned about.

Similarly, Rita and Rocky spoke about bringing climate change in to astronomy by relating it to the atmosphere on Venus. Rocky describes Venus as "Earthlike" and "greenhouse gas gone mad" and Rita goes into depth about the effect on Venus to facilitate student awareness of the impacts humans are having on earth. To this she explained:

> I go in great detail about Venus and the greenhouse effect and carbon dioxide in the atmosphere and what it looks like. And then I bring it to Earth and I talk about what we're doing here on Earth**,** how we're cutting down the rainforest and about the oxygen depletion and all of that.

Of the documents that Rocky shared, one was a research activity that was broken up into three parts. Part one was centered on environmental impacts, computer models, historical data or economic costs. This part challenged students to explore and discuss the evidence they found to indicate Earth is warming and the causes with emphasis on human activity. The second part emphasized choices (personal, local, state, federal, and international). For this, students explore and discuss choices humans have for responding to global climate change, the pros and cons associated with the differing choices, the effects these choices have on the economy and public policy, and the impacts these choices will have on lifestyles and the technology human's use. The third section of this research activity addressed recommendations for the United Nations member countries, the U.S.A. or California (i.e. policy recommendations, state and federal laws enactment, environmental impacts).

Another example came from one of the activities Michelle shared. It was a research project of which the prompt is:

> For the last 12,000 years, the Earth's climate has been slowly warming as part of a natural climatic cycle between glacial (ice ages) and interstitial (no ice) time periods. However, over the last century the rate of global warming has begun to increase at a rate which is faster than has ever been recorded before for an interstitial period. What is causing this accelerated warming? What is the evidence that it is occurring? What are the effects, and how will it impact you, and your community?

As I explored the documents and observed teachers, activities and assignments along these lines were frequent. Participants spoke about teaching content and addressing climate change in the classroom with the common understanding that human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors that contribute to climate

change and reduction of the impacts of human activity will require preparing students with knowledge and awareness of climate science and other kinds of knowledge.

Examination and Refinement of Pedagogy

As participants' spoke about climate change and their roles and responsibilities being to teach the topic with fidelity, feelings of doubt and conflict were expressed regarding society's response to climate change as well as the curriculums' responses. Given the high concern for all existence on Earth, participants expressed the need to examine and refine their practices. As a byproduct of their inclination to examine and change practices, participants often integrated supplemental resources and material into their teaching. The decisions to do so were based on prior experiences and teacher competency, exploration of alternative practices, and moral and ethical consideration. From this, all participants spoke about the drive and rationale to seek opportunities for growth, deconstruct practices, and identify areas in need of change. Julia justified the need to pull from a variety of resources, "there's nothing really good that's out there that will walk you through it in a way where you're going to have enough tools in your tool kit to be able to help kids make sense of it." She went on to add, "I've been involved in so many institutes and I've jumped in, and I've tried it, and I've built some of my own stuff. It's gone great. And some of it has been terrible." In this sense, she believes that in order to address climate change with fidelity one must seek alternative resources and take risks. For Rocky, he believes that he can learn from every experience and these experiences will often influence his instructional practices or thinking. For example, "At this point in my career I have so many bags of tricks and stuff that it's more of what am I into right this second." His efficacy and knowledge from over 29 years of teaching has contributed to a flexible approach to teaching in which he is making decisions and adjustments with regularity.

Along these lines, Julia believes in teachers as designers, “My curriculum that I teach is my curriculum. The only thing that I have to do is share common assessments and give benchmarks at the same time. But every path you take to get there is yours.” She spoke often about reflection and continuously striving for the best learning opportunities for her students which often led to development or refinement of her own lessons and activities.

When Michelle spoke about planning, she spoke about confidence to take discretion with the NGSS Science and Engineering Practices (SEPs):

> I use discretion but I don’t just do one, at least three or four depending on what it is we are doing in class. Could be *cause and effect*. Like, more greenhouse gasses means it gets hotter. And then *stability and change* by forcing the climate to change faster than it normally would.

Efficacy to make decisions was common among participants. For example, when Lucy discussed priorities related to planning, she spoke about the putting the needs of students first which she believes is not always the case when it comes to curriculum. She explained, “Whenever I prepare to teach anything, I always think about what's best for the students that I have right now.”

For Jude, internal examination of his biases is important aspect of addressing climate change, “I have to ask myself, do I need to step back from my personal view? Do I need to present a more objective view and let them make their own decisions?” When Maxwell spoke about reflection and metacognition, he shared similarities as he expressed his avoidance to be perceived as a “knowledge giver”. To him, continual reflection is important to ensure that he is modeling behaviors, and providing students opportunities, that foster self-created knowledge and learning through inquiry and discovery.

As interviews progressed, internal resources such as metacognitive thinking, reflection, efficacy, and creativity were demonstrative of their propensity to examine and refine their

pedagogical practices. They spoke of their thought processes and rationale for making instructional and curricular decisions, as well as overcoming adversity. When participants expressed encountering challenges, their ability to overcome adversity was linked to the need to examine and change practices. With this regard, participants spoke about overcoming challenges and adversity associated with the NGSS, their curriculum, climate change, time constraints, 'nay-sayers' or 'deniers', pressure, lack of adequate resources, language and learning deficiencies and gaps, and distance learning.

The tendency to examine and refine practices extends beyond the self. When Rocky spoke about challenges with the curriculum and other teachers, it was often centered on inadequate or missing components of Nature of Science (NOS). "They miss the Nature of Science on several occasions, I found that. And then that doesn't do justice to the standards. It doesn't do justice to what science is all about, in my opinion." He has expressed this concern to publishers, trainers, and anyone else who will listen. "That's a piece that's undercooked in the NGSS" Considering this, he went on to note that he will often spend much of the first quarter on the NOS.

Julia spoke about overly complicated curriculum and disconnect between the curriculum developers and student cognition which has influenced her decisions to alter suggested activities. "The essential problem isn't NGSS. The essential problem is brain development." She touched on this further when she was reviewing the curriculum and sharing her concerns with me:

> It's like this is so complicated. Are you kidding me? My sixth graders cannot look at that. Let me just introduce to integers. This scale is way beyond their ability to connect to this. These are freakin cool, like these graphs are amazeballs. As an adult looking at average global sea surface temperature from a 1880 to 2015, I can see the line. I know what that means. No sixth grader knows what that means. What's the difference between this? They don't know the idea of upper and lower limits.

To account for this deficiency, Julia has altered her pacing and brings in supplemental material. She spoke extensively about providing meaningful opportunities to explore and discuss data sets from graphs, charts, investigations, and simulations.

As Maxwell spoke about examining his teaching practices, he described self-reflection based on concern and pressure from staff and his innate desire to integrate deeper concepts such as race. "[Students] are more aware of things than a lot of staff and teachers are. With staff, I would say the biggest push back is around race. Talking about Race, discussing racial issues." To this, he spoke about sometimes feeling unsure of what exactly he is allowed to say:

> I definitely noticed that a lot of administration thinks that climate change is just science. That's all it is. And when you start thinking about social things like race they're like, *wait a second. You're going out of your zone. You don't teach that.*

However, he believes that racial and social injustice is connected to climate change and therefore, it is his duty to help students come to see the connection. Although the connection to race is not explicitly stated in the standards, he believes it is his duty to shed light on the relationships. "You can't separate the two. By separating the two, I'm doing an injustice. I'm hurting these kids by separating it." Regardless of the pressure, he remains focused on his role and responsibility to address the social and environmental aspects of climate change.

The need to examine and refine pedagogical practices has led to a number of learning experiences and opportunities as well as an accumulation of knowledge. As the participants accumulate and develop deeper understandings, they tend to refine their practices and approach their instructional practices and content with fluidity and flexibility. Through constant reflection and learning, they are always evolving and seeking ways to improve.

In this sense, they maintain an ever evolving accumulation of knowledge and experience rooted in their formal education, professional development (trainings, workshops, and

conferences), personal learning (book studies, documentaries, discourse) and lived experiences. As participants spoke about their efficacy to address climate change and the impacts of human activity on the environment in conjunction with the NGSS, they consistently referenced the learning they have gained from their past experiences as having influence them.

Throughout the study, Michelle and Lucy referred to their work with the Informal Science Education Enhancement (iSEE) as a major contributing factor to development of their understanding. According to Michelle:

> It was more or less a program to teach the teachers how to teach the Next Generation Science Standards. So I was a part of that for two years and then we lost the funding for that. Every summer we would go for a couple weeks of professional development and they would give us examples of lessons that we could use and then we would develop lessons in a group.

She also spoke about her affiliation with the Sacramento Area Science Project (SASP) prior to iSEE, "I went to SASP which was similar to iSEE except it was for all the teachers in the area. It was just like summer professional development about what NGSS is, how to teach it, how to incorporate engineering." While not directly related to climate change, it did provide her with the internal resources necessary to understand how to approach teaching climate change within the context of the NGSS.

While participants referenced a variety of professional development, Project Wet, Project Learning Tree, and the Forestry Institute for teachers were common among Rocky, Lucy, Julia, Pam, and Rita. Lucy first mentioned the influence of Project Learning Tree and Project Wet as she spoke about previous professional development:

> I've done a couple with Project Learning Tree and Project Wet. Just this past summer there was a Forestry Institute for Teachers, which they ran out in Plumas County. It was a week in the woods where we talked about just educating kids about forests. And a big part of that was conservation and stewardship. It's wonderful. They're all wonderful. I don't know if you are familiar with Project Learning Tree or Project Wet? They've been

> doing stewardship and conservatorship for decades and they offer free programs but you can pay to get credits if you need to.

Similarly, during our first interview Julia explained:

> I've attended the week long Forestry Institute for Teachers up in Sonoma. You spend a week working with loggers and Cal Fire and Rangers and constituents that live in the woods and just learn about the ecology and the geology and the fire, and the ecology of our forests, and the potential impacts there. But, I've also received training through your Project Wet, Project Wild, Project Wild Aquatic, and Project Learning Tree.

As the participants have sought out and participated in training and professional development related to the NGSS, they have developed a deeper understanding. In addition, they described continually learning about the nuances and elements of the NGSS, and therefore have developed personal activities that have been adapted to align with the standards and their personal beliefs.

Perceptions on Next Generation Science Standards Pedagogy

In order to address climate change and the impacts of human activity on the environment in conjunction with the NGSS, it is reasonable to suggest that one must have knowledge of the factors that contribute to climate change as well as the standards and framework. In the context of this, conceptual understanding involves awareness of the connections between climate change, the impacts of human activity, and the NGSS, as well as an understanding of how to practically implement the standards and address climate change. Aside from Jude, who speculated that his district's lack of NGSS training was dependent on the curriculum once the piloting phase has completed, in one way or another, every participant spoke about the three dimensional approach learned through NGSS trainings. However, despite trainings on the framework, Jude still feels comfortable with the standards. Pam's background, on the other hand, shares commonalities to most participants as she expressed:

> I've had training, I've read books, I've been in book studies, I feel comfortable with the concept. When NGSS was just starting. My interest was to go to conferences and present about NGSS and how that tied to some of the things I was doing.

During the first interview Rocky highlighted his work with the Expert Science Panel as the reason for his elevated understanding of the NGSS and framework:

> So the framework committee was focused on how to implement. We basically were the editors, not the writers, but the editors. The writers would send it in and we would edit. It was interesting. I learned a lot and gained a lot. I know that I know the NGSS and the framework better than most because of what I did not because of who I am.

Despite various and different professional development and training around the NGSS, participants shared commonalities in their understanding and demonstrated conceptualization of the framework and topics.

With specific regards to the NGSS, three dimensional understanding was highlighted by the participants as they described knowledge of the relationships between the Disciplinary Core Ideas (DCIs), the Science and Engineering Practices (SEPs), and the Cross Cutting Concepts (CCCs). These commonalities included understandings of the DCIs, SEPs, and CCCs, as well as the ways in which they are meant to be interwoven. When talking about what they know about NGSS, many participants referred to the DCIs as the 'what' and SEPs as the 'how' as Rocky explained, "So, when you're thinking about it, the DCIs are all about the 'what' of science and then the science and engineering practices is the how (how are you going to teach this). And that is a unique shift, especially for high school." Julia reiterated this, "The DCIs are what scientists know, the SEPs are what they do, and the CCCs are how they think."

When Michelle spoke about awareness of the three dimensional elements of NGSS, she explained the DCIs as "the things the kids actually have to know", the cross cutting concepts as the things that connect everything together, and the SEPs as "the practices that kids should be

doing everyday". She added that the performance task is how you want students to demonstrate mastery at the end.

Regardless of the participant, each demonstrated an understanding of the ways in which the DCIs, SEPs, and CCCs are connected. They see these elements as connected and equally important to providing a robust science education experience. To them, the DCIs are the content (the what), the SEPs are the practices that students engage in (the how), and the crosscutting concepts are the concepts that cross all content areas.

As participants spoke to their understanding of, and experience with, the NGSS, they described a recognition of the differences between the current science standards and the previous ones. To this, they often mentioned an emphasis on phenomena, storylines, new content such as climate change and the impacts of human activity. However, the biggest difference between the NGSS and the pervious standards that the participants expressed was an inquiry and engineering focus versus route memorization. The participants in this study believe that recognition of the shift from direct instruction and memorization to inquiry and exploration is imperative when it comes to addressing the standards. Rocky referred to it as "inquiry with a purpose." Jude made the comment, "Looking at the NGSS standards they're so much more interesting and complex and they expect different things from the students like creating models." When Maxwell mentioned the shift, he referred to a larger emphasis on making connections and exploration, "for science teachers that's kind of our job now, is making sure that were connecting it to things and it's not just like can you recite these things, that's not what it is." According to Michelle:

> The old way, we memorized facts and this kids had to memorize the facts on the state tests. This way is a lot better because we're teaching kids how to think critically which is a skill they're gonna need. They don't need to memorize how many different types of galaxies there are, they need to be able to think through a problem to solve it. I think that NGSS standards address that. We've gone from like spoon feeding kids the answers toward inquiry based teaching.

This perception seemed common among all participants; however, Maxwell brought up the point that this shift has not only made it a challenge for teachers to get used to but students have also had to adjust, “Kids are so used to being fed this stuff. So it's also a change for them. You know? I can go in and ask a bunch of questions, but they're like, ‘what's the answer?’ but I'm not going to give you the answer.” He went on to distinguish that the NGSS also emphasizes teaching students the skills necessary to experience the science. Along these lines Julia stated:

> Students shouldn't be learning about science. They should be learning science. And in the past, the way the old standards were written, they were learning about science. Here are facts that exist, let's learn them and then a lab or an inquiry was kind of a side dish.

Jude’s perception was similar as he emphasized conceptual understanding.

> There’s the whole learn by doing philosophy of like, they’re doing something and while they’re doing this they’re learning about it. I think that’s great. I feel like standards before common core and the standards before Next Gen were almost like a checklist of *'can they say that? Did they do that? Did they read about this?'* It wasn’t necessarily about, like, conceptual understanding and now I feel like our standards are more about the conceptual understanding of things. There’s less of them but they’re broader so there’s more to them to kind of teach.

As he spoke about the differences, he also addressed the addition of climate change into the NGSS:

> Part of our job is to teach standards and with it being in the standards there are people that will follow the standards and so whether or not they personally believe in climate change. I feel like having it as a standard will be a reason that they have to at least teach it and mention it and I think the more we’re talking about it, the better off we’re going to be. I like that it’s there because I feel like it’s gonna force people to make sure that they’re doing it. I think that’s a good benefit.

He believes that the addition of climate change is similar to that of Sexual Education and other controversial topics. Jude retains hope that teachers will begin addressing the issues with fidelity but expressed having recent encounters with teachers who are unsure how or what to teach when it comes to climate change.

As the participants have come to recognize the shift away from direct instruction and rout memorization to a focus on facilitation, guidance, and inquiry. Overall, pparticipants often spoke highly of the NGSS due to a perceived shift to inquiry based learning and the addition of climate change.They recognize that their roles as educators has shifted and therefore they have adapted. Along these lines, they believe that this recognition is imperative to addressing the standards and climate change.

As our interactions progressed and participants spoke to their understanding of the NGSS, emphasis was placed on fostering scientific thinking among students. Although all participants described students learning to think like scientists, the teachers often expressed that their goal is not for students to necessarily pursue a career in science, but rather for them to be able to make informed decisions based on evidence. The participants recognize science as one way of knowing, rather than the only way of knowing.

In accordance with the NGSS, the participants believe that students must be able to think like scientists because, as Michelle put it, “They’re the ones who have to deal with the problem.” Often times, she explained, in class she can be heard saying phrases such as, “Scientists think this…” In class, the participants often refer to the overwhelming scientific consensus as well. According to Rita, “What is it, 97% of scientists believe that climate change is a problem?” Jude mentioned, “Scientists are not trying to dupe us. This isn’t a huge conspiracy.” When on the topic of planning, Julia said that teachers should be thinking, “What do, as scientists, [kids] need to know and what do they need to do?” In this regard, she places an emphasis on teaching her students to think like naturalists, ecologists, and geologists.

For Rocky, the depth of ignorance in science saddens and motivates him to foster scientific thinkers as he made comments such as, “I keep pushing science literacy because

scientific illiteracy is rampant at the highest levels of our country." In his classroom, the school year begins with a unit called, "How we think as a scientist" because, as he explained, "to get them to climate change and to be scientifically literate they need to think how a scientist thinks." Later he reiterated this when he said, "Thinking like a scientist is more important than a bunch of random data that's shoved in their head."

When Michelle was asked to describe an activity in her classroom she shared:

> They're developing and using models, they're using climate models. They use mathematical and computational thinking. They do some calculations but they're also manipulating some of the climate models. For constructing explanations and designing solutions, they're coming up with their explanation of what the effects of climate change are throughout.

She then continued to describe the activity where students are tasked with figuring out to save the school from flooding:

> They have to design the solution. At least the start of the engineering cycle. And then they're looking at a lot of data from data tables and graphs, so scientific knowledge based on empirical evidence. And then they're analyzing data as well.

Several times during the interviews with Maxwell, he spoke about what teaching students to think like scientists looks like in his classroom. One example with regards to climate change was when he described systems thinking and understanding the relationships between stability and change:

> Its talking about the systems we want to make stable, you know we want to make all of our spheres stable but their constantly changing by our actions. So getting kids to see how our action affects the stability of cycles and that also leads into cause and effect. The things that we do you, see the effects every day. Ok, we're drilling for oil, that oil gets released in the water, what does that do? Animals die, it gets into the water we drink, you know, so cause and effect is big. Kids are able to pick up on *their actions leads to this action*. And then, patterns, I feel like patterns is infused into everything. I'm trying to constantly get them to see that there are patterns everywhere. You can find a pattern in everything, and then analyzing that pattern, why does that happen, what changes the pattern. I think that's really important as well.

Maxwell stated that “Climate change is a huge phenomenon that can be broken up into a lot of pieces and it can be really digestible that way.” In accordance with the NGSS, participants described phenomena as central to science, engineering, and understanding climate change and the impacts of human activity on the environment. In order to help students conceptualize and understand climate change, all participants spoke about anchoring learning with phenomena. For participants, phenomena ranged from photos, videos, and texts to demonstrations and observations. They spoke about specific websites where educators can access various examples of phenomena for teaching, but most participants explained that they prefer to find their own examples everywhere. Throughout the study, participants spoke about the importance of students exploring diverse and meaningful phenomena through the lenses of various SEPs and CCCs. For example, rather than simply reading and learning about genetic and environmental factors that impact plant growth, students in Julia’s class will design investigations that emphasize patterns or cause and effect to explore the phenomenon of toxic algae bloom in Lake Temescal. When Maxwell spoke about phenomena, he stated, “Phenomena is really the key” and proceeded to share an example of how students begin with an overarching phenomenon and then explore smaller connected phenomena:

> Coastal erosion, that's our big phenomenon. So once we go through three lessons, we'll come back to it and say, *OK, using our knowledge, we're going to assess how can we do this engineering solution performance assessment?* And then broken into it, it's usually broken into three or four lessons and each lesson in the curriculum consists of observing phenomena, smaller phenomena, and then a couple investigations. The observing phenomena are usually less focused on climate change. They're usually very, very specific to what we're learning.

For Lucy, phenomena could be an image, a demo, or a noticing of some kind followed by a question to the class of “what's going on here?” When it comes to phenomena, the possibilities are endless. During this part of our interview, Lucy demonstrated this when she grabbed a cup

that was sitting on the table and said, “I found this cup sitting out overnight and let's look at what's inside of it. What’s going on here?” Michelle addressed phenomena when she spoke about the ‘hooks’ of her lessons, “I use google a lot for phenomenon. I try to find interesting pictures or video clips. Or if there is something that the kids can observe that I can think of I use that.” When I went in to Michelle’s classroom to observe, she began an activity with a short video clip highlighting sea level rise in the Republic of Kiribati before the class moved on to exploring carbon cycling with relation to the atmosphere and climate change.

For Jude, teaching climate change often begins with students designing pizza box greenhouses and then asking questions and making observations as different factors are introduced or removed. This phenomenon will lead to discussions and research on “green roofs and different things people are doing and better public transit”. This will culminate with students developing research projects emphasizing “strategies to combat climate change.” In Rocky’s classroom, he described an example of how he might use phenomena to help students understand the impact of Greenland melting:

> You take some water and you put two sticks across there like Popsicle sticks and you put an ice cube. This is a setup. You put it aside and come at the end of the period and then you have ice in water sitting there. You measure the height of the water and very quickly and easily it shows, when they get done, ice and the water melts and it's like at the same level. The ice that's sitting up there on land on these Popsicle sticks went into the ocean, the water went up.

One grave lesson that came out of this was that once the ice has melted, there is no way to freeze it back.

Throughout the interactions with Rocky, he often emphasized engaging students with phenomena. At the conclusion of his first interview, he gave me a pair of black squares that he has used to demonstrate the phenomenon of heat transfer. He explained, “With a heat thing I do I pull out these black squares. One’s made from foam plastic and ones made from anodized

aluminum. And they look just alike." He then directed me to the table. "So they play with them and then write a bunch of observations about them. Don't really care. But a bunch of observations because I want them to notice them." After asking me to make observations like he would his students (one square was obviously heavier and cooler) he placed a round plastic ring on each of the two black squares, "OK. Got your observations?" Then he placed a piece of ice in the center of each ring and asked which would melt the ice cube quickest. The ice that was placed on the dense, cold block melted noticeably quicker, thus demonstrating how energy can be transferred more quickly through conduction depending upon the material of the surface.

Participants believe that by focusing investigations on compelling phenomena, students are engaged in ways that help them identify with science as a means of understanding and improving real world contexts. Regardless of participant, when it comes to planning, phenomena is always one of the first things to consider and often referenced as the hook or anticipatory set of the lesson or activity. To that, Rocky says, "I want something grabs them by whatever that is that you want to call and gets their attention in that brain."

Inquiry Based Pedagogical Methods

To the participants, an important element to consider when addressing climate change is inquiry based methods. In order to understand the impacts, causes, and potential mitigations of climate change students must be engaged in practices that center on inquiry. Throughout this study, participants spoke often about having students ask and answer questions, define problems, use phenomena, recognize patterns, plan and carry out investigations, engineer models, analyze and interpret data, make claims, use evidence to reason, engage in mathematical and computational thinking, communicate results, and collaborate. According to Jude:

> You have to ask questions from time to time and sometimes you have reject things that you're being told if there's evidence. If there's evidence, and I use that word a lot,

> evidence, evidence, evidence. Is there evidence to support or does this evidence that you're seeing conflict with what they're saying and can you make your own conclusion based on that?

While observing Maxwell, he would say things such as, "there's no scientists that ever succeeded thinking there's one right answer!" In Pam's classroom on any given day, she might be heard saying things such as, "Science is all around us. You explain this. Explain that. You've got to ask questions. You've got to figure it out." When observing her, one could hear little bits and phrases such as, "Now you're talkin! You're asking good questions!" In Lucy's class, phrases such as, "prove it" were common. In Julia's classroom the term *I cubed* is commonly referred to when analyzing data. First "I see" refers to making an observation, second, "it might mean" refers to student inferences, and third, "I wonder" refers to students asking further questions or drawing conclusions. In class, she explained, an example student response might be, "The data showed… It might mean… because …"

Another example arose when I was looking over teaching documents with Julia and she described teaching kids 'HLPA', pronounced *helpa*. She explained, "So given a graph, first thing you do is you run it through HLPA. And that's the language we use, *run it through HLPA*. Where are the highs, where are the lows, what are the patterns, what are the anomalies?" Furthermore, "Any time we do a graph for data or look at anything, the first thing we do run a HLPA. You don't give it to them. They have to create or create the learning."

As Jude spoke about classroom activities, he described an emphasis on making models, asking questions, and disciplinary discussions:

> For the conversations part, we teach create, clarify, fortify, and negotiate, as conversations skills. We teach them how to generate ideas, that's create, and then clarify we break into three parts of paraphrasing, building on, and prompting, so we kind of coach them on how to ask questions, when to ask questions and why to ask questions, and when you need to stay on topic and when its ok to switch topics. Then we fortify which is bringing in your evidence to support your ideas.

Similarly, in Lucy's class, model making, running simulations, designing diagrams, and using evidence to support is common. During the observation of Lucy, the classroom was a hum of activity as students worked in groups, explored the Albedo Effect with lux meters, noted their findings, and held discussions. She spoke about design and budgetary constraints which required students to sacrifice certain elements for other elements. For example, during our interview she explained, "Whenever I do an engineering, like anything hands on, I always gives the kids constraints. Usually it's limited to materials and asking me a certain amount questions."

Maxwell described a focus on collaboration and systems thinking several times. At one point he related the purpose and benefit of collaboration to efficiency and explained how he might explain it to students:

> I may focus on this one piece and this other scientist may be focusing on this other piece and we talk to each other to see how our pieces interact with each other in order to build the bigger picture of things.

When Julia spoke about classroom activities she described:

> We have our guiding questions and we have their observations and we have pictures and models and diagrams. And no one kid's looks the same as any other kid's because they are their notes. We lead with Cal Academy of science and scientific sketching. Nobody's looks like anybody else's. We make predictions, test results and... I mean, we're doing science. And none of the labs we do have guaranteed outcomes right? They have to record their own data, they have to construct models, they have to do all of the things that scientists do.

During Rita's classroom observation, students began with what she calls "brain food." As the activities proceeded to get underway, students were engaged in research centered on ocean acidification. Students were exploring the pH scale and acids and bases. As I observed back and forth discussions between the students and teacher, students were making connections between the ocean and 'us' while drawing conclusions related to the introduction of CO2 into the

atmosphere from the burning of fossil fuels. As conversations deepened, the topic shifted to why these types of actions are problematic.

As Rocky spoke about classroom activities that foster science literacy and thinking like scientists, he stated, “Patterns are everywhere.” And then proceeded to elaborate:

> They look for patterns and they look for cause and effects, relationships, systems. They look from a systems point of view. So getting students to think about that, then they're thinking scientifically and that will help reduce some of these problems that we have I believe in the world today.

With regards to inquiry based methods, every participant highlighted the strategy referred to as Claim Evidence and Reasoning (CER). As participants spoke about fostering scientific thinkers and inquiry based activities, they spoke about a specific approach to teaching students to make claims and use evidence to reason that they referred to as CER. When Pam spoke about CER in relation to her class she described put it in the context of research, “They have to do all the research. You provide the tools. But they come up with their claim, their reasoning, their evidence, CER, and then they're to discuss that back and forth.” She also drew attention to the connections between the NGSS evidence statements and CER as she referenced planning for the activity I observed:

> I was just looking the DCI up, *earth and human activity and questions to clarify evidence of the factors.* Remember we talked about evidence, claim and reasoning? There's evidence statements and so if anything, we try to teach students to look at some of the evidence there and how to verify that that is absolutely clear evidence. And then they can make their claims and their reasoning beyond that.

Maxwell described CER along similar lines and highlighted activities that do not have predetermined outcomes, “I stress that I'm not trying to get a right or wrong answer from you.” During this part of the interview he went on as though he were speaking directly to his students, “It’s not that you're not giving me the answer I want to hear. You're giving me the answer you think makes sense. You can tie it together and that's what matters.” He further explained, “I’ll

tell them, ok, we're answering this question. They answer it. I say, here's your claim, here's what I saw, and here's why I think it." According to Julia CER is, "Make a claim, present your proof, explain it." She went on to say that the "students are writing CERs" anytime they are expected to construct an explanation in her class. To this, she gave a recent example of an assessment that prompt that stated, "Assume Oakland had a very rainy winter followed by a hot summer. What would you expect to happen for the plants?" She described how students referred to their data table from Lake Temescal's toxic algae blooms and their experience with the simulation as they discussed cause and effect and the environmental impact. Similarly, as Michelle was discussing an activity she mentioned CER as well:

> They ask the questions the first day and then when we come to the answers they fill in the evidence and answer where they found it. Then I have another sheet which is like a CER model where I make theme us the question answer evidence to create like the claim evidence and reasoning.

With regards to the documents that Michelle provided, there were multiple references to CER. One of the documents she provided, for example, asked students to create CER and model statements and then translate that to letter to the governor. The details of the assignment were as follows: describe what climate change is and what causes it, reference at least three types of evidence which supports climate change is taking place, describe at least three effects of climate change and three impacts predicted to affect their local community, and detail solutions that might help mitigate.

When CER came up with Rocky, emphasized the importance of the reasoning aspect and added, "For students to become scientifically literate they need to be able to look at their own choices and change positions if needed." And during our first interview he had mentioned using a web-quest that "is all about claims and reasoning."

In some form or another, every participant spoke about the use of CER to address climate change and the impacts of human activity. For many, CER is a way to help students who enter their classrooms at the start of the year conditioned to automatically assume that there is only one correct answer expand their thinking.

Throughout the interviews as participants discussed addressing climate change in conjunction with the NGSS, they highlighted the use of Global climate models and computer driven models for forecasting weather, understanding climate, and projecting climate change. They also related these practices to the things scientists do. When teaching climate change, participants spoke about using geoscience data and results from climate models to help students make evidence-based forecasts regarding the rates of climate change and impacts to Earth's systems. One way that Lucy does this is through the use of the online program called PhET Interactive Simulations. Through this program her students "run the sim and either collect data from the sim or just notice things about what happens with the greenhouse gases as they work through the sim." While explain a project along these lines Michelle said:

> What I have the kids do is look at the sea level rise which is like five point five to seven point six meters and they use this online simulation site to figure out if their house or the school is under water.

She went on to explain that she uses the West Antarctic ice sheet collapse as a phenomenon to help illustrate this. As she is typically does so, she will involve the students in running simulations and exploring historical data to draw conclusions or make inferences based on questions such as, "what would happen if it doesn't collapse and we cut back carbon? What would happen if we don't cut back carbon and it doesn't collapse? And what happens if it does collapse?"

Julia spoke often about data sets and simulations, “Climate change is seen in patterns. It's not day to day weather, its trends over time. And that involves data.” As she went deeper into classroom activities, she spoke about a project along similar lines:

> We did a really cool one. We were analyzing Lake Temescal and toxic algae blooms and were looking at the genetic and environmental factors that lead to it. And as part of this, we bring in the simulations that are freakin amazing.

During the activity, the students went on to look at environmental effects on plant growth and in order to do so she explained that they used data tables illustrating the historical record of toxic algae blooms in lake Temescal in combination with the data and experience from the earlier simulation.

When Jude was discussing his Greenhouse Pizza box activity, he mentioned using simulations and historical data to help understand trends in global temperature increases. He explained:

> We have a Web site that we use that kind of like a fun clickable model that takes them, you know, back 100 years and they can kind of see the rise in temperature. And so that was a really cool sim that we used so that they can get that visual of, *look what the world was like a hundred years ago temperature wise. Now, look what's happening in 2019 compared to the amount of gas in the atmosphere.*

During the interviews and observations, descriptions such as these were common. For example, during the final interview with Pam, she spoke about her students along these lines. “They’re looking at geoscience data, the results from the climate models and connecting it. They're doing these models.” This seemed to encapsulate all classrooms that I entered for the purpose of this study.

When Jude and Maxwell spoke about inquiry based practices, they referenced specific Guided Language Acquisition Design (GLAD) strategies. GLAD strategies are a comprehensive set of strategies designed to foster language, literacy, metacognition, and awareness for students.

One such example came when Jude highlighted the Expert Groups strategy:

> With weather we do one of the GLAD strategies called expert groups. And so we'll basically break the kids up into groups and they'll each get assigned a severe weather and they'll make PowerPoint slides on it and they present to each other. And then the rest of the class has what's called a 'Process Grid' and they'll take that and they note take about all the other severe weathers that they did not research. In the end they all become experts on one severe weather and then they have to present to each other to share that information.

Jude and Maxwell referenced the GLAD Expert Groups strategy as conducive to helping students learn to think like scientists. The purpose of this strategy is to teach students skills for analyzing information and explaining their results. The strategy begins with the class of students separated into groups. The teacher then pulls one member from each group to form an 'expert group'. This small group of students is guided by the teacher to analyze information and draw conclusions with emphasis on one element of a bigger topic. Once the small group session is complete, students return to their original groups to disseminate information and share their learning. Each time an 'expert group' is called together, it is a different set of students and a different element of the bigger topic. For example, if students in Matt's class are learning about Earth's spheres, each 'expert group' might focus on a different sphere.

Another element of connection that participants placed emphasis on was the idea of bridging the content for students with various language proficiency levels and lower cognitive abilities. This involves strategies to target the needs of the various types of learners. In exploring an issue like climate change with their EL students and emerging students, several teachers spoke about the importance of GLAD strategies for fostering language, literacy, metacognition, and awareness for students.

Jude described emphasis on a particular strategy, "We do *Pictorials* on like the greenhouse effect and we go into fracking". In fact, several times throughout the interviews,

Jude, Julia, and Maxwell referenced three specific GLAD strategies (Pictorials, Expert Groups and Cognitive Content Dictionary). According to Jude, "the GLAD style of teaching makes front loading all the language that much more easier for them to reference and use." As a certified Tier three Project GLAD trainer, I have personal knowledge and experience with this program. As he spoke about his use of the GLAD Pictorial strategy, I completely understood what he meant. The Pictorial strategy is designed to foster metacognition and understanding while frontloading language for EL students. The end result of the Pictorial is a visual representation. When implementing GLAD strategies teachers utilize various levels of questioning depending on the language proficiency level of the students.

Within the realm of inquiry based practices, participants spoke about inquiry based assessments. According to the participants, assessment in this context is formative, summative, and observational. For Julia, "Everything we do is project based. All of our assessments are integrated within the bigger projects. Whatever it is we're working on." During one of our interviews, Julia shared an assessment which spoke to this:

> So the culminating project for this one, which is our assessment, is two parts. Ready? The first part is a Group Project, *create an advocacy video that describes the human impact on your chosen organism and gives a potential solution.* And then the individual project is *create a solutions evaluation that compares and evaluates the different solutions presented.* And the list of organisms include magpies, shorebirds, Finnish farm birds, salmon, whooping cranes, humming birds, caribou, lilac spider orchids, and glacier release. The checklist of criteria for the individual project is a description of the problem facing all of the organisms, including criteria and constraints for solving this problem. So obviously, there you're seeing the engineering process, scientific background, helping your audience, understanding the problem, including cause of the problem and evidence that supports the cause and effect relationship. So there you're seeing the CCCs. Whether you think this problem was caused by a sudden change or gradual changes that have accumulated over time. So, again, we're looking at the CCCs, argument for why global warming poses a threat to organisms. Including how all organisms, behaviors and structures.

Assessments in the context of this study came in a variety of forms. It could be summative, formative, or just observational. Teachers use quizzes, writing samples and prompts, investigations, and "exit tickets". Regardless, every participant spoke of open ended assessments, project based assessments, and assessment based on teacher observation. Several participants spoke about Language Arts assessments with content aligned with or addressing climate change. When participants assess students on learning related to climate change it is more often based on the drawing conclusions from evidence and exploring possible solutions. For example, assessment in Lucy's class often focuses on "demonstrating what [students] can do. So making a model or you know, *here's a model and tell me what you can from it*."

Pedagogical Resources

As participants spoke about addressing climate change, they spoke about an accumulation, utilization, and application of resources related to a variety of common external sources. These resources fall into the following categories: (1) packaged curricula, (2) teacher resource websites, (3) networks of educators, (4) scientific sources, and 5) other supplemental material.

Within the area of external resources, participants spoke of various curricula that were being piloted, had previously been piloted, or had been adopted. Often, it was noted that while the curricula had some strong elements, they also had plenty of weaknesses and therefore participants sought out and integrated elements from various curricula. Lucy spent a whole year examining and piloting curriculum, of which she now uses three to pull from (Inspire, Amplify, Green Ninja). As we spoke throughout the study, she described incorporating investigations and lessons from each of the curricula.

For Maxwell, the packaged curricula that he tends to utilize are called STEMscopes, PCI and Green Ninja:

> So we did Green Ninja, which was focused on climate change. That was built in. It's a really awesome curriculum and I was fortunate enough to get to draw some of my stuff from them so I kind of get to piece that into my curriculum a lot. And then the STEMscopes was another one which I like as well. It was inquiry and focused on, you know, activities in labs. And then the one we chose was PCI, which is more work books focused. It's kind of like NGSS light. For teachers who aren't quite ready to go into NGSS.

Rita, and Rocky use elements of their schools' adopted curriculum (Amplify). Pam uses elements of Amplify as well, but her instruction is also largely informed by the Facing the Future curriculum. For Julia, her preferred curriculum to supplement with is the SCALE curriculum, developed at Stanford University. She referenced this curriculum several times as being an ideal curriculum for her to work with, "I love the SCALE curriculum. I think it's a great framework. It's a great skeleton to hang a bunch of other things on." In addition she said:

> All the information is there. It's not, going to be pretty or fancy, you're not going to have a lot of cool labs and demos and all that stuff with it but it's a curriculum for people who don't have a science background and who have limited resources.

Although various "packaged" curriculum were described by each participant as integral resources to address climate change, one was consistent (Project Wet curriculum). When I began the study, I had familiarity with Amplify, Stemscopes, and some of the other 'state adopted' curriculum; however, until I began this study I had was not familiar with Project Wet, SCALE, Facing the Future, or Green Ninja. Participants provided material and resources from each curriculum, but Julia gave me a complete copy of the Project Wet Curriculum and Activity Guide 2.0.

Throughout the interviews and observations, education related websites were another type of external resource that the participants discussed and demonstrated utilizing. For

Maxwell, *"*I also like using Teaching Tolerance. They have more of a focus on environmental racism but a lot of it is based on climate change. So, bringing in lessons about that as well." Lucy discussed PHET as, "a whole data base of online simulations" and Michelle referred to her local school district's science website as a primary resource because of the comprehensive collection of material developed by teachers in collaboration with iSEE. TUVA labs is a resource site that was unique to Julia. This site is designed to provide students tools to explore and manipulate data through graphing and charts. As a multiple subject teacher, Jude often places emphasis on cross curricular approaches and spoke about resources that are conducive to this. With that regard, he explained that, "We pull articles from Readworks or NewsELA on the greenhouse effect as supplemental resources." To this, every teacher in this study referenced using NewsELA, and/or Readworks at some point. In fact, during my conversation with Julia she explained that she tries to use NewsELA because, "it has more current things and they'll take like a Guardian article and they'll rewrite it in kid friendly so we can still do more current events but not be using a text book from like 2002." Google Suites were among other digital resources many participants referenced. They spoke about teaching students to collaborate and work with Google Docs, Google Sheets, and Google Classroom on research projects and group work, especially as the Covid-19 virus evolved. Teachers Pay Teachers was another website that most participants mentioned using as a data base of teacher created resources for free or purchase.

Many participants also discussed the websites for Project Learning Tree and Project Wet as valuable resources offering training opportunities as well as units and lessons centered on environmental education. As I explored the sites the participants discussed, I came across several collections of learning resources ranging from activities and demonstrations to various visual aid resources and articles.

Aside from curriculum and physical resources, networks of educators were perceived as a valuable resource. Collaboration and networking has played a key role in the ways in which climate change is addressed. This often was connected to professional development or other learning opportunities and cohorts. When talking about an activity he does, Rocky said, "And so I stole it from somewhere else in Project Wet and then changed it a little bit. It's a different bend." For Maxwell, "it's a lot of connecting with other teachers at my school and asking like, what are your ideas?" Regardless of subject or content area, Maxwell sees value in working with all teachers:

> I'll usually connect with the math teacher and see what it is they're working on and try to tie it in a little bit. And I think that's a little bit nicer because then the students are learning it in both classes.

When Pam described her networks of support she stated, "My supporting entities were the green schools, the air quality people, the waste management people, the water people, the coastal, see those are all supportive entities."

For every participant, collaboration, whether it be their grade level team or outside educators, was consistently referenced. As Michelle spoke about the iSEE program, she highlighted this idea:

> Every summer we would go for a couple weeks of professional development and they would give us examples of lessons that we could use and then we would develop lessons in a group. A cohort with other teachers. And then we would pick two teachers to try it out and we would all go to their classrooms and observe (I got picked both times to teach it), and then we would write it up and share it with the district.

The major networks of influence for Rocky include the Expert Science Panel, the National Science Teacher Association (NSTA), and other cadres. Furthermore, he, like many in this study, tends to see himself as a 'kid in a candy store' with regards to these networks, "I'll either develop my own stuff or go, wow, he had a great idea I want to do that and I'll steal it."

Pam referenced partnerships with the Coastal Commission and the Green Schools Conference as networks. Julia spoke about her collaboration with teachers from various fellowships, such the Project Based Science Teacher Institute out of the Monterey Bay Aquarium. As the only multiple subject teacher in this study, Jude emphasized working with Project GLAD to develop cross-curricular lessons and units related to climate change and the impacts of human activity on the environment. Regardless of the participant, collaboration and networks have played key roles in informing their instructional practices and the ways in which they address climate change and the impacts of human activity on the environment in conjunction with the NGSS.

For many of the participants, scientific resources were discussed as an integral element in the teaching of climate change. Sometimes, this was in the form of resources and materials necessary for labs and investigations, while other times it was websites such as NASA, the National Network for Ocean and Climate Change Interpretation (NNOCCI), the National Oceanographic and Atmospheric Administration (NOAA), the Environmental Protection Agency (EPA). According to Michelle, NASA has "a huge collection of climate data from their satellites." For Rocky, "NASA is great but it's dense." Regardless of perception, NASA is an integral scientific resource to use when studying climate change with students.

The EPA was also mentioned as a resource but as I probed deeper, the general consensus is that the website has become outdated. Rita, Pam, Rocky, and Julia spoke directly about the EPA's decline in reliability. For example, as I spoke with Rocky about student research, he expressed:

> The EPA used to be a great site for seventh grade information. All that disappeared. I'm talking about all this stuff. It all disappeared. And so we had a little discussion about the EPA and how it's changed quite a bit. They don't have to check with me if they use NASA or NOAA.

Aside from digital scientific resources, participants spoke about physical scientific resources necessary for their labs, experiments, and investigations. These were often beakers, scales, measuring tools, and things of that nature. When I observed Lucy teach the Albedo Effect within the context of climate change, she had students working with lux meters. As for Rocky and Michelle, when I went in to observe them, I noticed various tools and laboratory equipment but neither referenced them during our interviews. Rocky however, did often demonstrate and explain how to turn regular items into scientific tools for demonstrating phenomena.

Throughout this study, participants made reference to the variations in cognitive ability, lived experiences, and academic and language development among their students. They also made reference to the differences between the NGSS and the 'old standards'. In order to address climate change in a meaningful way and in conjunction with the NGSS, participants spoke about utilization of supplemental and differentiated material. As they did so, they often spoke about the importance of visual aids and realia (objects and material from everyday life) with regards to climate change and the impacts of human activity on the environment. Maxwell addressed this when he was discussing his approaches, "I've used videos a lot. Usually, I bring in a little news clip sometimes or like videos from YouTube. Just anything like that." This was apparent during the observation with Maxwell for instance, when he brought in clips concerning fracking and mountain top removal to prompt further discussions about the impacts fossil fuels and fracking have on all Earth's spheres.

Jude spoke about using as many political videos or videos of politicians talking about climate change as he can find to help students, "see this is an issue that everyone's talking about." Lucy spoke about videos on coral bleaching and the effects on other systems. One film

that many participants referenced was Al Gore's *An Inconvenient Truth*. Rocky, Maxwell, Rita, Pam, and Julia referenced the documentary as a video they've shown or show clips from. Overall, participants shared a number or other supplemental material based on the uniqueness of their students.

Fostering Relevancy to Students

As teachers in this study described their instructional practices around this topic, fostering relevancy was a constant theme in which participants referred to purposeful, meaningful learning that connects. On a deeper level, the purpose of fostering relevancy and connections to climate change is to make the content accessible for students, help them understand the connections within and across systems and humans, and foster an appreciation for the natural world.

When participants spoke about fostering relevancy, finding ways to highlight and draw connections were described as an integral element. In order for students to take ownership and feel empowered as change makers, they need to understand their roles and responsibilities and therefore their relationship to climate change. As Rocky spoke about the importance of relevancy he related his success with it to personal strategies that he's "developed over 29 years of teaching" and described, "They want to learn so they want to buy into but you just have to provide something that's interesting because if it doesn't peak their interest, you're going to lose 'em." For him, teaching involves connections to humor, classroom community, and real world experiences because, "You can have all the knowledge in the world. But if you can't communicate it in a way that the students can appreciate it, it's not gonna work." When Jude spoke about connections, he emphasized locality and disconnect between outdated examples:

> And anytime we can keep things current I feel like the engagement goes up and the participation goes up. No one wants to read out of their text book from something that

> was like 20 years ago. It's just not interesting to be a part of. But if it's current, like this is happening right now, they're usually more willing to participate.

He went on to elaborate:

> But like when we teach the severe weather and we teach climate change, we teach human impact. Like it directly impacts their lives now. So, like, we showed them the floods. Last year I showed the group during this lesson, like Nebraska was under water. Right now Nebraska is under water and we looked at photos for a while about like Nebraska being under water. And they're kind of like wide eyed like, this is happening right now. And I'm like not trying to scare you to think like the worst ending. It's just something that's so relevant to our lives.

As his discussion continued, he spoke about the power of connecting the climate change and the impacts of human activity to California's fires and droughts.

When Rita addresses climate change and the impacts of human activity, her primary goal is to start with the heart:

> When I talk about it, I do pull on their heartstrings a little bit because, you know, like you talk about the sea animals and the plastic and that that gets to them. That's the one thing I think that will really pull on their heartstrings, when they see things like that and hear about things like that. That makes a difference. I have many kids that want to, you know, be marine biologists. They'll tell me and I feel like it does. I feel like it makes a difference and they don't necessarily come and tell you about it. But, you know.

Along these lines, Lucy explained that her teaching emphasizes connections to students to help them relate and hopefully take ownership:

> Well, I've been teaching middle school for, this is my 12th year, and one of my favorite things about that age group is that they're at that point in their life where they really do start to notice the world around them, and it's a really good time to get them thinking about those things and get them on a path. So, it's easier to teach if the kids are invested. It's easier. If they're engaged, they're not going to be behavior problems.

One approach that Maxwell takes is relating climate change to universal, every day, real world experiences. One example arose when he was specifically discussing the topic of connections:

> You know like plastics, every student has interacted with plastics so they're connected to it. You know, every student has interacted with fossil fuels in some way so their

> connected to it and they feel that, *oh I can talk about this because I've ridden in a car, I've used the heater before*. It helps to build that student connection to everything you're doing. And I think they recognize that it's relevant to them to. It think science sometimes has a problem with how students don't always think it's relevant to their life.

As the participants spoke about fostering relevancy, making connections was a constant. One area was helping students relate to and connect with advocates and stewards of relatively the same age. As Julia spoke about this during our first interview, she shared some of the articles and texts she uses to help students connect to activists:

> There's one in here about this woman named Erika who helped fight against a pipeline being built through her city. And we liken that to the Dakota Access pipe line, and we link it to other events that are happening as like *be aware that this is a thing.* We often ask what can you do as a person? So we read about these different activists. Like, here's what examples of what you can do look like when you get older to go and combat climate change. Real people that are making a difference. I'd like to bring in what's her name, Gretta…? Because you know, she's young and she's a student and she's their age-ish plus a couple years. So just showing them that this is an issue and you can be involved and you can make a difference. And not just to be a preachy hope guy, but really, help them understand we can do something about this. Individual people can make a difference is also a thing.

Pam often addressed the need for things to peak and connect to student's interests as she described examples of projects she's done. She said that although they may not initially be interested in the academic aspect, you can hook them by connecting it to them. She spoke about bike riding as an interest to her students and therefore a way to connect:

> I wrote a grant for 100 storm drains and to buy 100 of those adhesive stickers. And to maintain those storm drains around our school we got a bike grant and we have 37 bikes and we ride our bikes to clean up the creeks.

Often during the interviews, Maxwell would talk directly to his students. In one such instance he demonstrated how he attempts to help students make connections:

> I tell them a story a lot. *You know, a lot of people follow by example. If you choose to do this, other people are going to follow because they see you doing it. So lead by example. If you think this is important, start doing it and people will follow you. Maybe not everyone, but people will follow you and those people are gonna make a difference.* I always use the example about meat and factory farming and just saying like, studies

> come out saying that if every person in the U.S. cut down their meat consumption than it would lessen the methane carbon dioxide by a huge number. And that's just two days out of the week, everyone in the U.S. just not eat meat. That's all it would take to lower it a huge number. So like little things like that. And every person is capable of cutting it out for 2 days. Every little change it does make an effect. You know, obviously we want big changes but a lot of us don't have control over that so we gotta do what we can do.

The participants in this study spoke about the power of Place-Based Education (PBE) centering learning on nature and local issues. Michelle often relates her lessons to their local neighborhood and city, as earlier examples have mentioned. She spoke about connecting climate change to recent fires in this regard, "I look at like what's going on. With the fires last year, we talked about human impacts on fires and how that affects the environment and climate change." During another part of the interview when she was describing classroom activities she share an example that spoke to this idea:

> There's a paper that came out maybe three or four years ago that talked about how high sea levels will rise if the west Antarctic ice shelf collapsed. They listed the cities, and the flood risks. And [our city] was one of them. I give them the date table and they have to look at the minor carbon cuts vs if we cut a lot back. How would that effect where we live.

Maxwell also mentioned using the local fires as a means to address climate change and the impacts of human activity on the environment.

Lucy gave several examples where she described facilitating students to walk around campus and notice things such as, "little bits of erosion from a leaky drain pipe" or "a field that had been plowed over." She hopes that these types of noticing's will lead to deeper awareness of the environment around them and eventually to bigger community projects.

As Maxwell spoke about connections to locality he highlighted ways in which he connects issues related to agriculture and immigrant populations in California to climate change and the impacts of human activity on the environment:

> We did story of food. And a piece of that, that I liked to rope in, was not just where is it coming from but who is it coming from. *Who are the people picking those strawberries that you get? Those aren't the people that you often think of because you think of the big company that's selling it. But there are, you know, immigrant labor that's going in there and getting paid like no money.* Starting to make those connections as well of like *who is responsible for what stages of your food*?

As Rita discussed ways she addresses climate change, she described deepening students' understanding by drawing attention to connections between human activity and the natural world:

> And so when you talk about and related it, like I said, they see animals or power affecting children and famine perhaps with climate change and they do understand it. That's where I think like I said, if you pull on their heartstrings, they get it.

During this time Rita went on to share an example that spoke to this:

> I did the oil spill lab. And I do things that I like to relate to oil spills every time. One was on density. I was teaching density so I talk about how oil floats on the ocean and so we talked about tankers out there in the ocean and if they spill, what happens to the sea animals? And we show them videos and clips and they do an oil spill lab.

When Julia spoke about teaching the content and making it relevant, she often emphasized the importance of students interacting with phenomena in nature:

> It's the only thing that matters right? And I say that because a lot of kids believe nature is a place you go. It's Yosemite, it's Death Valley, its Hawaii. Nature is a place you go. And that kind of thinking leads to people who are disengaged with local environments. And there's a big divorce between, especially kids, what they think of as nature. They don't feel connected to their environment, they don't. They don't see nature here.

Whether it be something as simple as taking students outside to the fields behind the school and to nearby creeks to attending overnight or weeklong excursions into nature, all participants spoke about nurturing connections to, and relationships with, nature. Participants expressed power in connecting students to nature because these types of interactions foster a love for the natural world and in turn advocacy and stewardship. Jude, for instance, takes students on a week-long trip to the Mendocino redwoods:

> We stay there for a week and it's on conservation so we'll go like tide pooling and we'll talk about food waste and like the effects of food waste. Like, when we think of food waste we think of like throwing food away but we don't think about the waste in human energy from like the farmers farming. We don't think about the waste of them trucking it to a place. And we don't think about the waste of us driving to the store to buy it.

As he spoke, it was clear that this was an issue he is passionate about as he was pounding on the table as he spoke:

> We don't think about the waste of the energy used to cook it. We don't talk about the waste in all these different areas of how the food went from being grown to getting to your table and how much energy and how much resources went into that for you to just throw it away. And then we talk about the gas that's being released from food that's just kind of sitting there and how that can be a problem for the atmosphere as well and contributing to the greenhouse effect. So that's kind of what we do with our unit on climate change and our field trip.

Rocky spoke about helping students develop an appreciation for nature because he believes it is a key component to fostering meaningful advocacy and stewardship:

> Because once you start to appreciate things in the nuances, then you are concerned about it. Once you take ownership and realize, hey, I'm part of nature. Because in our society we've kind of become separate from it. Plastic and that. So, getting kids more in touch with nature is an important piece so we always push a camp. That's at least something small we can do.

In order to help students realize their potential to make a difference, participants emphasized messages of hope rather than 'doom and gloom.' When it comes to engaging students, optimistic perspectives is crucial. Lucy strives for students to feel optimistic and empowered to act. She, like many participants in this study, expressed "avoiding the heavy burden of climate change and cutting the kids out before they even have a chance to feel like they can do something". She went on to clarify:

> I don't want to make it into sunshine and daisies, but finding a way to make it, I don't want to say palatable but actionable because it's just such a great problem that it's more than a child should be asked to take on.

As she continued, she explained an important element to consider when addressing climate change with her students is, “finding ways to empower the kids versus just, you know, feeding them, this whole doomsday message of the world's going to end.”

Rocky mentioned avoidance of “doom and gloom” several times and instead emphasized, “I give them hope”. As students learn about climate change and the impacts of human activity on the environment, Rocky explained:

> As their awareness goes up, their concern goes up. And then my job is to watch that, because if it goes up too high, it can become a doom and gloom type situation. And I don't want that to occur.

Many participants mentioned witnessing students become overwhelmed which prompts them to encourage the students to step back and put things in a different perspective. To this, Maxwell put it, “They get overwhelmed and there’s definitely comments of, *oh man were in trouble, were screwed*. And I always try to address that and say, *step back for a second. I get it.”* Rita spoke about positive messaging fostering hope through empathy and connection to student emotions. One example she gave as a recent oil spill lab designed to build awareness, connect to student interests, and help them understand that people can make a positive change. “That’s what I do” she said as she continued:

> They come through and you see it. Like I said, they see animals or power affecting children and famine perhaps with climate change. They do understand it and that's where I think, like I said, if you pull on their heartstrings, they get it. Nourish that.

During Pam’s first interview she spoke with regards to modeling hope and encouragement and related it back to the parable she shared with me at the start of the study:

> You can’t do everything, but you can do something. And I think, by example, I try to encourage my students to. I think picking up a piece of trash can make a change when you have a hundred fifty kids clean up the schoolyard yard and you literally see what that trash is. I believe that individuals can make change and make a positive change and reduce the number of plastics that go out in the ocean. All of those things, they may not

> directly be involved with climate change, but we are stewards of this Earth and we need to do the best we can and not have an, *I don't care* attitude.

Maxwell addressed this idea several times at length when he spoke about his desire for students to feel empowered and optimistic which he believes can be quite challenging for students:

> I'd say probably the hardest part is thinking about how them as an individual fit into this. Climate change is a huge thing but to them as an individual, how does their life fit in that? It's hard to think of big systems things and think of yourself as individual when there's eight million people in the world almost. It's like, I'm one person, does what I do really matter? Am I really affecting things?

He went on to explain that he does not typically encounter student disbelief in climate change, but rather a bigger challenge is helping students to understand the next step actions they can take and feel empowered to do so:

> The problem isn't getting them to recognize that it's happening, its *ok let's take steps to think about what we can do*. They don't feel empowered. They don't feel like they can do much because they're kind of a slave to their situation. There are powerful people who don't believe in it and its controlling them. I'd say, what's difficult that I want to work more on is getting them connected and feeling like, *'ok I have these ideas, I want to fight for them, how do I do that.'*

Maxwell believes that one way he can do this is to help students get more connected with the local political figures who have connects to legislative decision making and writing.

When the participants in this study spoke about fostering relevancy they described imbedding, facilitating various connections, and optimism. They spoke about the power of empathy, optimism, and connections to shift perspectives. Participants recognize that communities flourish when diversity and diverse perspectives are prevalent and celebrated; student perspectives and voices should be considered and heard; and life sustaining practices should be the end goal.

Throughout the study, participants spoke about English Learners (ELs) and students with various academic proficiency levels and cognitive capabilities. To this, several participants spoke about targeted small group instruction, humor, positivity, and community building. During the interview with Rocky, he spoke about an article he was working on titled, *Reality check: NGSS in a difficult classroom.* To him, this requires, "essentially developing a climate for culture in your classroom that students appreciate and that connects." He went on to say that this approach might be described as "NGSS light" and a "choose your battles" type of approach. By this he means that teachers may find that they have to slow down, simplify, and focus on bigger ideas and more scaffolds conducive to inquiry based learning. Further along these lines, other participants spoke about students with social emotional needs, disabilities, and anger issues. Often, this requires community building, careful thought as to how one frames the topics and activities, scaffolds, and targeted intervention. Regardless, the participants spoke about the need and desire to engage all students in equitable learning around climate change.

Steps Toward an Eco-Ethical Consciousness

Throughout this study, participants spoke with a sense of urgency and deep obligation. They spoke as stewards and advocates for humanity and the planet. When exploring their goals and perceived roles and responsibilities, participants spoke about the need and desire to foster an appreciation for, and connection to nature; an awareness of their role in the world; and the thinking and know-how to advocate for change and sustainable ways of being. In this regard, every participant spoke heavily on fostering advocacy, stewardship, and critical thinking. The participants' desire for their students to understand that there are things they can do now and as adults to help mitigate the impacts of human activity; in order to do so, however, students must be exposed to thinking and practices that are conducive to combating anthropocentric ways of

being. When speaking about her students, Rita expressed, "I just want them to become empathetic. I want them to understand that, you know, we have a fragile planet and everything relates to it. Everything we do, everything we think about." For students at the middle school level, Lucy believes it is important to plant the seeds that will lead to healthy and positive local communities:

> So if I can get those kids to notice where they live and appreciate where they live and how their choices and actions affect their environment. I hope that they can then become adults who care about the choices that they make and educate their kids for the choices that they make because I think getting the kids aware of their choices and how they act as consumers and people on our Earth, hopefully they can make choices that are gonna help. I want the kids to be aware of who they are as a person and then where they are.

Recognition of the need to protect the health and welfare of the planet and the systems that exist on it is related to thinking critically. Change and awareness often stems from critical analysis and therefore the participants believe that students must learn to think critically about the larger social, political, and economic systems and connected modes of thought.

When Jude spoke about critical thinking, advocacy, and awareness of our relationships and the impacts of our actions, he emphasized the importance of fostering a sense of skepticism when appropriate. For him, this is a challenge because many of his students enter his class with the perception that what he says is truth:

> If anything I have more of a problem of them just taking the things I'm saying as truth. So like getting them to be critical thinkers and to think like, *hold on hold on, is this actual, does this really contribute to that?*

He often spoke about fostering critical thinking and building awareness of the impacts of our systems and actions:

> Cutting down trees for like grazing and farmland is a huge, the meat industry is a huge contributor to greenhouse gasses you know? And so like getting them to ask questions and push back a little I would like because that shows their critical thinking. The worst part for me, I think, is like that flaccid acceptance of like 'yeah, yeah, yeah, he's saying it so it must be true'.

Maxwell wants his students to think critically and draw their own conclusions. Several times during the interviews, he spoke about exposing students to various perspectives. He believes that part of teaching students to think critically about climate change involves understanding the perspectives of others and having the skills to make informed decisions and rebuttals. He stresses that, "people will say false things all the time" and many people will blindly believe those falsities so one of his goals is to help students learn how to make informed decisions based on evidence.

One of Rocky's primary goals for students is to foster long-term thinking, awareness, and a call to action, "There's too much short-term thinking. So my goal in my students is some long term thinking. So I've decided my big goal is long term thinking. That's why I'm into climate change." As the interview progressed, he continued to speak about his desired impacts and described:

> So the impact is getting students to take actions, apply it to their community service, and make real world examples so that they can not only become informed, which is one aspect of science, but also to take action in their lives.

Similarly, Michelle described:

> In general, I really want students to be independent and critical thinkers. I want to help them develop that. And then, I want them to know how to communicate their ideas with others in multiple settings and I want them to be successful in life when they leave high school.

As Michelle spoke about facilitation, she made statements such as, "I'm not here to tell you there's only one way to do it because science is all about looking at the evidence and using that." and "I just want them to be successful in life. My goal is to give them the skills to do that". She also spoke about the desire to deepen and build awareness of climate change and the impacts of human activity on the environment. She wants students to have the skills and

understanding to look at evidence and draw accurate conclusions, “giving them the skills to think critically through the evidence”. As far as climate change, she believes:

> My goals for the kids are that they understand what the greenhouse effect is and that more carbon in the atmosphere means that it can store more heat. And then, that they understand that we are putting these gasses that do that in the atmosphere. Hopefully they look at the data and come to their own conclusion that climate change is real. What is it, 99.8% of all scientists believe in it? They’re not just making it up. So my goal is, I hope that they believe in climate change but at the same time, you know, I want them to be able to think independently and make their own decisions because that’s what they’re going to have to do in the future.”

At the end of the interview with Lucy she restated her perceived role as one of guidance and facilitation:

> I feel like my role is to try to guide the kids in the right direction but I also want to just give them the skills to make their own decisions. I feel like in science, questioning things is good so I think it’s ok if kids don’t necessarily believe what you want them to believe but just giving them the skills to make their own decisions so that whatever they do end up believing they are informed. I just want to help them think critical for themselves. What they think is on them.

As participants went on, they often shared examples of advocacy, stewardship, and critical thinking through reflections of past activities. As Lucy spoke, she reflected on an environmental action project she participated in with her seventh grade students:

> It was environmental action project and so you get them to identify areas of need in our community and then come up with a solution. So, it could be something as simple as noticing, *hey the trash blows all into this corner here* and the solution could be, you know, *we'd go over there, pick it up*. Or, you know, *birds are losing their habitats* and *let's put up some bird boxes*. But it was more real for the kids because they could see it and they could do something about it. And it gave them that foundation of being kind of a global citizen. I actually had a couple of students write up their whole project and then go and sponsor a community park in the neighborhood.

Later, as she was explaining more regarding her goals, she spoke about critical thinking. She places a high emphasis on helping students learn to be knowledgeable about the world, understand the impacts they can have, be able to make informed decisions, and maintain skepticism when appropriate.

As Julia addressed her core values, she emphasized stewardship and cultural competence as the goal of all instruction:

> One of our core values is stewardship. That's the goal of all instruction that I do. It doesn't matter the subject, it's that the kids take the learning that we do in class and apply it. Right? Isn't that what every teacher wants? You don't just teach it and learn it. You live it. It's been really cool. I've seen impact from our instruction outside the classroom. I have groups of kids who, pre-Covid-19, would go out spontaneously with each other and clean up the creek on the school because it's something that they noticed or I had kids who were testing the waters for their science fair projects or kids who are teaching their younger brothers and sisters about the species that are around because they've studied it in class. Just giving kids the language of advocacy and stewardship.

As she spoke about her goals of fostering stewardship, she continued to describe students reading about different environmental activists and exploring "What they're doing to lessen their carbon footprint." Expression of stewardship were common when interacting with Julia and during our final interview she detailed plans that were derailed by the Covid-19 pandemic. Had it not been for the cancelation of onsite classes due to fears over the virus, she was planning for the class to "follow a specific species and show how climate change is affecting that species." Further elaborating:

> We'd gone out in our field adjacent to the school, and they had taken some observations. We looked at migration routes of birds coming through the Pacific Flyway, and each picked a species to talk about what things that species needs. Created some cards around it so that they had this information and we went back out into the field and they had to see if currently those conditions were ideal for their birds and determined if their birds could survive in our field with our creek going through it or if not, what was missing. Then we we're gonna tie that into the activity they were going to do with these species that are outside of our hyper local geographic area, which are the ones that are embedded in the unit.

For Pam, stewardship and advocacy center on environmental and water quality awareness:

> And we also pick up trash. We just finish participating in the Coastal Commission. It's called a school yard cleanup. They do a coastal cleanup but because we're inland, we did the cleanup so that our trash doesn't get in the streams and the rivers to the ocean. But for

> the last 13 years, I've done everything on water quality because that's something I want students to understand.

Everything she said harkened back to the parable of the king's highway:

> When we ride the bikes, I tell the principal when we come through we'll clean up any trash we find on the way to the park. When we're in the park, we clean up the trash. Clean up the cigarette butts, we do the water. And we come back and I check all the storm drains, the grant I wrote this time was 100 storm drains. We're gonna monitor 100 storm drains. There's 30 on this campus. And then there's some on the way in the neighborhood. So I'm going to come up with 100 storm drains and we're gonna monitor those during the year of this grant.

Pam believes her role is to teach by example, provide accurate information, direct them to legitimate resources, and help them learn to discern between what is factual from what is not because, as she believes, "those are tools they need for life."

Maxwell, much like the others, described staying away from closed thinking and described himself as "trying to avoid falling into the role of knowledge giver." Rather, he believes in guidance. For example, when he spoke about goals, he emphasized, "My job is to give them the big skills. For example, the ability to analyze resources, the ability to take in information and make their own thoughts. Make their own conclusions. Those are probably the two biggest things." He says he is indifferent as to whether or not students enter a career in science as long as they develop into informed human beings. "What matters is that they're learning to take in the information, come up with legitimate conclusions, and then make choices based on that." He gave the following example:

> When it comes to big corporations, I try to talk about perspectives and ask kids like, *why do you think we have so much plastic?* And also, *why do you think it's so hard to stop using this stuff? Why do you think it's so hard to stop using fossil fuels?* Giant corporations have ingrained it into our lives. So I try to get them to like be critical of what you're consuming. Think about these big companies that are controlling things.

During our final interview Maxwell spoke more about his goals. At one point he emphasized the importance of students having a combination of presentation skills and the ability to critically assess information in order to advocate for the causes they believe:

> My biggest goal is to get them to a stage where they have life skills that they will be able to use. Being able to present something is a big one. Like, I want them to be able to present. I want them to be able to analyze resources, analyze where they're getting information from, and I want them to be able to create proposals and be able to use those to affect change. So I think that those are three things that I really want to focus on. And those are processes where you need science, you need science to be the base of that, but they're skills that whether you're a scientist or not, you're going to use them where ever you go.

As Maxwell spoke, he also made references to drawing students' attention to connections between social and environmental disenfranchisement. To this, he spoke about indigenous communities, immigrant populations, and other groups of downtrodden being impacted most from climate change. He was not alone in these sentiments, as participants expressed emphasizing the idea that there will continue to be uneven and unfair consequences associated with climate change. As Michelle was sharing and explaining some of the documents she brought to our interview she explained, "Last time I taught this, I added that climate equality or climate justice piece and I had kids realizing that change can be racist and doesn't affect everyone the same."

Although it is unclear whether or not humans will be able to positively alter our current trajectory, all participants in this study believe in the power of optimism, hope, stewardship, advocacy, and critical thinking. They believe that their students are on the front lines and must be equipped with the knowledge, know-how, and experiences to change the trajectory of our path towards self-annihilation. To do this, educators must seek to foster diverse, democratic, sustainable thinking and behaviors.

Summary of Findings

This chapter has organized and presented the findings as themes with relation to the ways in which educators address climate change and the impacts of human activity on the environment in conjunction with the NGSS. The themes the emerged are: Climate change is an existential crisis; examination and refinement of pedagogy; inquiry based pedagogical methods; perceptions on Next Generation Science Standards pedagogy; pedagogical resources; connecting climate change to students; and steps toward an eco-ethical mindset.

Climate change is an existential crisis: The participants described climate change as an existential crisis. With recognition of climate change as an existential crisis, participants expressed the need to address climate change constantly and through various methods. Furthermore, with this perspective, participants expressed the need to emphasize factors that contribute to the global rise of temperatures with emphasis on human activity.

Examination and refinement of pedagogy: The participants described the propensity and need to examine and refine their content and pedagogical methods based on experience, new learning, and the desire to address climate change with fidelity. Participants often integrated supplemental resources and material into their teaching and integrated bigger ideas. In addition, they expressed the desire to seek opportunities for growth, deconstruct practices, and identify areas in need. Participants demonstrated metacognitive thinking, reflection, efficacy, and creativity as they described the examination and refinement of their pedagogy.

Perceptions on Next Generation Science Standards pedagogy: The participants expressed common perceptions regarding pedagogical approaches for implementing the NGSS. Within their perceptions they described the three-dimensionality of the NGSS, their understandings of

the DCIs, SEPs, and CCCs, and a shift to inquiry based science. In addition, the participants focused on helping students learn to think like scientists and utilize phenomena to drive inquiry.

Inquiry based pedagogical methods: In alignment with the shift to inquiry based science, participants described inquiry based pedagogical methods. These methods included opportunities for discourse and asking/answering questions, defining problems, using phenomena, recognizing patterns, planning and carrying out investigations, engineering models, analyzing and interpreting data, engaging in mathematical and computational thinking, communicating results, and collaborating on research. In addition, each participant spoke about use of the strategy commonly referred to as CER which stands for Claim, Evidence, and Reasoning. This strategy was described for use when teaching students to make claims and use evidence to reason. Additionally, participants spoke about the use of a comprehensive set of strategies designed to foster language, literacy, metacognition, and awareness for students with low language proficiency levels called GLAD (Guided Language Acquisition Design) strategies.

Pedagogical resources: In order to address climate change and the impacts of human activity in conjunction with the NGSS participants spoke about specific pedagogical resources. The resources that were described included packaged curricula, teacher resource websites, networks of educators, scientific sources, and other supplemental material. Throughout the interviews, participants often noted short comings or disconnects within the state/school adopted curricula led them to integrate supplemental resources and elements from various curricula.

Fostering Relevancy to Students: As teachers in this study described their instructional practices around this topic, fostering relevancy was a constant theme in which participants referred to purposeful, meaningful learning that connects. When participants spoke about fostering relevancy, finding ways to highlight and draw connections were described as an

integral element. This includes connections to climate change, nature, local environments, other groups of humans, and within and across systems. The participants also spoke about fostering relevancy to students with language and academic deficiencies, and emotional trauma.

Steps toward an eco-ethical mindset: The participants spoke about the desire to teach students to think critically and act as stewards and advocates for humanity and the planet. Participants spoke about the need and desire to foster an appreciation for, and connection to nature; an awareness of students' roles in the world; and the thinking and know-how to advocate for change and sustainable ways of being. Participants described empowering students with optimistic perspectives, awareness of connections to other humans or systems, and thinking that is conducive to working towards a solution to the existential crisis.

Based on the findings from this study, addressing climate change and the impacts of human activity on the environment is about education, informing, warning, persuading, mobilizing and solving this critical problem. At a deeper level, addressing climate change in the classroom is shaped by different experiences, mental and cultural models, and underlying values and worldviews. It requires proper understanding and various resources and methods. It begins with recognition and curiosity among learners and culminates in the creation and communication of deep learning and environmental impact.

CHAPTER 5: DISCUSSION, CONCLUSIONS, RECOMMENDATIONS

Coda

The purpose of this study was to capture and describe the essence of educators' experience as they plan for, interpret, and address the Next Generation Science Standards (NGSS) related to climate change and the impacts of human activity on the environment. The discussion that follows is intended to address the research questions which served as the focus of this study:

Central research question: In what ways do educators who are implementing the Next Generation Science Standards address climate change and impacts of human activity on the environment?

Sub-questions:

1. In what ways do educators who are implementing the Next Generation Science Standards perceive their roles and responsibilities in addressing climate change and the impacts of human activity on the environment?

2. In what ways do educators who are implementing the Next Generation Science Standards interpret the associated Earth and Human Activity standards prior to enactment?

3. How do educators who are implementing the Next Generation Science Standards teach climate change and the impacts of human activity on the environment?

The proceeding discussion will respond each question in accordance with the data and literature that is related to the findings. The supporting research questions will be answered first, followed by the central research question.

Discussion

Supporting Research Question: In What Ways Do Educators Who Are Implementing the Next Generation Science Standards Perceive Their Roles and Responsibilities in Addressing Climate Change and the Impacts of Human Activity on the Environment?

Findings from this study, as well as in previous literature, suggest that addressing climate change in the classroom is shaped by different experiences, mental and cultural models, underlying values and worldviews, and other external factors. In previous studies, such as Bryan (2012) and Nation (2017), findings suggested that although understandings of climate change influence teacher beliefs about the topic, these beliefs do not necessarily impact instructional practices or lead to inclusion of climate change in their teaching. The findings from this study, however, suggests that the participants' understandings of climate change has influenced their beliefs and informed their instructional strategies and, therefore, the ways in which they address the topic with students. Perhaps this is due to a combination of two things. First, anthropocentric climate change recognition is now included in the national and state science standards known as the NGSS; secondly, due to the participant's strong opinions, concern, and experiences related to climate change and other environmental issues, their beliefs are active and operational during teaching. Throughout this study, the participants often expressed high concern for informing students on climate change and referred to the NGSS as providing further motivation for their inclusion of climate change and the impacts of human activity into their teaching.

The perspectives and experiences of the participants in this study have informed the ways in which they perceive their roles and responsibilities with regards to climate change. The participant beliefs expressed in this study are in line with the findings from studies such as

Lieserowitz, Maibach, Roser-Renouf, and Smith (2011), which suggest that the more concerned one is with the issues, the more likely they are to address it. Furthermore, this is also in alignment with Liu, Roehrig, Bhattacharya, and Varma (2015) and Hunter and Markman (2016), which suggest that teacher attitudes and knowledge related to issues and topics influenced and impacted their instructional practices the most when the teachers' beliefs were active and operational at the time of teaching.

The participants in this study believe they have an ethical responsibility to address climate change in meaningful ways. As educators, they see themselves as change makers and models. They believe that it is their responsibility to exemplify the behaviors and teachings they believe necessary for remediation. The participants expressed with certainty the belief that it is their responsibility to open minds, stretch thinking, challenge behaviors, and inspire awareness and action. Given the pressure of time constraints, inadequate curriculum, and high stakes testing in combination with the vast diversity that exists within classrooms, they believe addressing climate change is challenging, but there is no other choice if humans are to alter the course away from planetary annihilation.

Teaching climate change involves more than simply reading the standards and teaching the described content. The participants in this study believe that educators and students must not only be aware of the urgency of climate change; one must connect with it and be allowed opportunities to explore the complexity, conflicting viewpoints, and intersections of environmental, social, political, democratic, and other ramifications. The participants in this study spoke about the responsibility of teachers to think in terms of systems, perceive climate change as an existential crisis, address conflicting viewpoints and multiple perspectives while maintaining alliance with the scientific consensus, and understanding of wider ramifications and

intersections. Within this study, the educators tended to view themselves as acting on a higher calling because they believe the crises to be dire. The participants believe that educators must play a major role in educating the youth as a means to shaping future responses and actions. In this sense, they see themselves as facilitators, guides, and leaders of the charge from the classrooms. They perceive their role as inspiring change and critical thinking to help students develop the skills necessary for diverse, democratic, sustainable thinking and being.

With regards to fostering critical thinking, participants generally emphasized one element of their responsibility to be providing opportunities for students to engage with, and explore, multiple perspectives on climate change. Much like previous literature, when addressing "both sides" of climate change, the participants understand "both sides" as referring to two perspectives on climate change: climate change is caused, in large, by anthropocentric human activity or it is not. Wise (2010) and Sullivan, Ledley, Lynds, and Gold, (2014), highlighted teachers as supporting the teaching of "both sides" of climate change; however, the participants in their studies demonstrated the tendency to remain neutral and therefore promote the incorrect notion that both sides are equally valid scientific perspectives. Regardless of one's acceptance of the scientific consensus on climate change or the fact that human actions continue to cause a deterioration of Earth's natural resources and systems, previous research has suggested that the belief of whether or not one should remain neutral with regards to issues such as climate change varies from teacher to teacher (Liu 2015; Nation, 2017: Oulton, Dillon, & Grace, 2004) due to the perception that climate change is a controversial topic.

The findings from this study, as well as from more recent studies, suggest that teacher perspectives may be shifting (Nation & Feldman 2020). The participants in this study expressed belief that anthropocentric climate change is perceived by many as controversial and the data

inconclusive; however, this was not a deterrent for the participants to teach in alignment with the scientific consensus as they often referenced a wealth of examples to support their stance. While the participants in this study support acknowledging "both sides", they recognize validity in the scientific consensus and not in the alternative. The participants in this study emphasized a "both sides" approach to climate change because they believe it is important for fostering students' scientific inquiry and communication skills necessary for informing others. After all, they believe it is their responsibility to prepare students for informing, warning, and enlightening others.

Supporting Research Question: In What Ways Do Educators Who Are Implementing the Next Generation Science Standards Interpret the Associated Earth and Human Activity Standards Prior to Enactment?

Addressing climate change and the impacts of human activity on the environment is complicated and incredibly important. Within the context of the NGSS, this becomes even more complicated as students are expected to: (1) articulate solutions that will diminish the impact of humans on land, water, air, and/or other living things in their local environment; (2) analyze and connect information about ways individual communities use science ideas to protect Earth's natural resources and environment; (3) construct arguments supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems; (4) ask questions to clarify evidence of the factors that have caused a rise in global temperatures over the past century; (5) create simulations to illustrate the relationships between management of natural resources, the sustainability of human populations, and biodiversity; (6) evaluate or refine technological solutions that reduce the impacts of human activity on Earth's natural systems; (7) analyze geoscience data and results from global climate models to make an

evidence based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems; and (8) use a computational simulation to illustrate the relationships between Earth's systems and how those relationships are being modified due to human activity (Achieve, 2013; NRC, 2012). Considering the complexity of the standards, participants in this study use discretion and supplemental material. The participants in this study enact strategic informed discretion with regards to the reality of climate change and the NGSS. They interpret the standards with the purpose of making meaningful choices for instructional practices and content. The participants in this study generally demonstrated confidence to make decisions based on their experiences, education, and sense of urgency. Although they perceived themselves as having the background knowledge and experience to make meaningful decisions, their perceptions of others tended to align with previous research which has found variances in teacher preparedness and efficacy to do so on a larger scale.

Rather than interpreting all the NGSS as a set of daily standards, the participants referred to most elements as expectations for the end of instruction. When unpacking the standards, they begin with the end goal as described in the Disciplinary Core Ideas (DCIs), Performance Expectations (PEs), and the evidence statements. The participants described the Disciplinary Core Ideas (DCIs) as the content for students to learn, the Performance Expectations (PEs) as the goals, and the evidence statements as providing additional details regarding the concepts students should know. Given the end goal, the teachers identify the appropriate Science and Engineering Practices (SEPs) and Cross Cutting Concepts (CCCs). They understand the SEPs to be the ways in which students engage with, and explore, the content and the CCCs as lenses with which students use to explore the DCIs. The SEPs and the CCCs inform how they teach and the activities in which they engage students. In some instances, the participants incorporate the

recommended SEPs and CCCs for a given DCI, however, more often than not, they include the ones they believe to be most important with relation to their learning goals and targets. An example of what this might look like would be: teachers engaging students in learning centered on greenhouse gasses (DCI: ESS3.D) by Asking Questions and Defining Problems (SEP) while looking at the topic through the lens of Stability and Change (CCC). Based on the NGSS framework and previous literature (Achieve, 2013; NRC, 2012; Shepardson, Roychoudhury & Hirsch, 2017) the participants' interpretations of the components are in alignment with the NGSS which describes the DCIs as the scientific content, the SEPs as the practices that students engage in to acquire evidence and construct meaning, and the CCCs as the cross-curricular concepts which transcend disciplines (Achieve, 2013; NRC, 2012). However similar in interpretation, the participants in this study take liberty with the language of the standards and include intersections of race, politics, activism, and stewardship.

During the planning phase of their teaching, the participants interpret the standards prior to enactment through four lenses:

- Learner needs and accommodations
- Lesson coherence
- Student engagement
- Climate change is an existential crisis

When participants interpret the standards based on the needs of their students, the teachers differentiate instruction and consider the necessary accommodations and modifications to help ensure access for all learners. Rocky, for instance, described his approach for students with specific learning disabilities or emotional trauma as, "NGSS light." Julia, on the other hand, described her students' cognitive and academic abilities as cause to differentiate instruction and emphasize exploration of data sets. Others, such as Rita and Pam, referenced keeping their students' interests in mind when developing lessons in alignment with the NGSS. As

participants interpreted the standards prior to lesson planning and pacing development, they described a focus on lesson coherence. Due to their perception of the NGSS as a set of goals and expectations rather than daily standards and a pacing guide, the participants seek to structure their activities and lessons in ways that build and maintain coherence from one lesson to another, from one class to another, and year to year. Choices are made based on their understanding of the students' background knowledge, previous experiences, and the teachers preferred sequencing. Sequencing of lessons is based on a combination of the suggested pacing in their adopted curriculum, their understanding of brain development, and their knowledge of climate change. The third lens, student engagement, is based on the participants' belief that engagement is a crucial element to consider when interpreting standards and planning for lessons. Through this lens, participants look for ways to bring the DCIs to life. They look for real and exciting phenomena, personal stories and examples, and hands-on inquiry based activities. They look for games and hands on activities that allow for conceptual understanding, practical application, and procedural fluency. As participants interpret and deconstruct the standards, they also maintain a sense of the reality of climate change and the need for mitigation. They believe that climate change is perhaps the most threatening existential crisis humanity has ever faced. Interpreting the standards through this lens inspires them to foster connections, urgency, hope, and deeper awareness during instruction. In addition, they are inspired to go beyond the standards and curriculum to include aspects of advocacy and stewardship, much in line with previous recommendations (Lieberman, 2013; Martusewicz, Edmundson, & Lupinacci, 2015).

Supporting Research Question: How Do Educators Who Are Implementing the Next Generation Science Standards Teach Climate Change and the Impacts of Human Activity on the Environment?

Vast numbers of educators across the United States are required to implement the NGSS. Within the standards, teachers are now required to address newly added topics such as climate change and the impacts of human activity on the environment. Although previous literature has recommended climate change as an interdisciplinary topic (Beach, Sharf, & Webb, 2020), often when educators in previous research have been portrayed as teaching climate change and the impacts of human activity on the environment in accordance with standards, it is done in Earth Science classrooms or in Environmental Education programs and courses (Plutzer, McCaffrey, Hannah, Rosenau, Berbeco, & Reid, 2016a; Shepardson & Hirsch, 2020). To the participants in this study, however, teaching climate change is interdisciplinary and cross curricular. Similar to the recommendations of Beach (2017), the participants described climate change as a topic to be addressed and included in science, social studies, language arts, and math classes through inquiry, discussion, and writing. Due to the hands on and inquiry based nature of the participants' instructional practices, teaching climate change involves students exploring informational texts, practicing cognizant reasoning, developing arguments from evidence, engaging in persuasive writing, and using models and simulations. There is also an element of Place-Based Education as teachers connect topics to locality and community.

More specifically with regards to 'how' educators teach climate change, the findings from this study emphasize 11 components that bear similarities to previous research:

- Engagement of students in inquiry based learning
- Engagement of students in Place-Based Education
- Teaching students to think like scientists
- Utilization of supplemental material

- Emphasis on hope and positive messaging
- Drawing attention to, and highlight, vast connections and cause and effect relationships
- Exploration of factors that have caused rises in global temperatures
- Exploration of the ways in which humans have tried to remediate the impacts from their activity
- Fostering advocacy and stewardship
- Interdisciplinary inclusion
- Three dimensional learning

These 11 components bear similarities to those highlighted by Monroe, Plate, Oxarart, Bowers, & Chaves (2017) which revealed four common themes in teachers addressing climate change: (1) purposeful engagement in deliberative discussions, (2) opportunities for students to interact with scientists, (3) addressing misconceptions, and (4) implementation of school or community projects. In addition, the findings from this study showcase the inclusion of elements commonly associated with environmentally concerned pedagogies as described by (Disinger & Monroe, 1994; Gilbert, 2003; Martusewicz et al., 2014; Stone, 2010).

Central Research Question: In What Ways Do Educators Who Are Implementing the Next Generation Science Standards Address Climate Change and Impacts of Human Activity on the Environment?

Educators play an essential role in the fight against climate change. With the addition of climate change and impacts of human activity on the environment included in the NGSS, science teachers have been drafted, in a sense, as leaders of the frontline; however, this is not to assume that teachers across the nation are in fact addressing the issues. Although the participants in this study spoke to the ways in which they address climate change and the impacts of human activity on the environment, most also expressed concern with the lack of inclusion of climate change among colleagues and other teachers. When Michelle spoke about her college experience and credential program, for example, she made multiple references to teachers pushing back against climate change because they didn't believe in it. Jude explained that even though the inclusion

of climate change into the standards are "forcing teachers to teach something," his experiences have led him to believe that other teachers may not be doing it with the fidelity, accuracy, and the necessary understanding. In addition, he explained that he has encountered teachers who perceive climate change as controversial and confusing. Julia described similar perceptions and feels that complicated topics like climate change tend to "scare a lot of teachers away, especially at the lower grades." As further evidence, she described examples of her previous students returning to visit her and expressing that they miss science the way they experienced it in her class. As a mentor for new teachers, Rocky had similar experiences. He has worked new teachers and noticed unease and a lack of appropriate understandings. With regards to veteran teachers, Rita and Pam spoke in general terms about many of them being set in their ways and not addressing climate change because they prefer to stick to what they know and, what Pam referred to as, the "old style" of teaching science. These perceptions share similarities to Liu, Roehrig, Bhattacharya, and Varma (2015) and Plutzer et al. (2016b) in that my participants suggested that while some of their colleagues believe that the impacts of human activity on the environment will lead to devastating consequence if left alone, when it came to identifying which aspects of climate change should be taught, confusion persists. This is not surprising given the variance in; teacher familiarity and understanding of the NGSS and climate change; students within and across grade levels; adopted and recommended curricular lessons, topics, and instructional methods; and acceptance of scientific conclusions based on factual data.

Although the participants' experiences with, and perceptions of, other teachers echo similarities to Liu et al. (2015), the findings from this study demonstrate that certain educators in grades six through 12 do address climate change and the impacts of human activity on the environment; however, consistency and fidelity among many outside of this study remains

unclear. Although the participants in this study perceived inconsistencies in the fidelity with which other teachers address climate change, the actions of those in this study include commonalities regarding approaches, content, resources, and knowledge. This is similar to Monroe, et al. (2017). In classrooms and contexts where this is happening, this study, as well as previous literature suggests, that inquiry, informing, warning, persuading, learning, and mobilizing are common themes that educators perceive as necessary to help solving this critical problem (Disinger & Monroe, 1994; Gilbert, 2003; Martusewicz, et al., 2015). When broken down further, the findings from this study emphasize four common overarching ideas which will be explored further: (1) recognition of what is at stake and acting with a sense of urgency, (2) a blended approach with elements of environmental education pedagogies, (3) three-dimensional understanding, and (4) thinking in terms of systems.

Recognizing what is at stake and acting with a sense of urgency. Research suggests that teacher perceptions, beliefs, and knowledge affect their teaching (Bybee, 1993; Haney, Lumpe, Czerniak, & Egan 2002) and the findings from this study speak to this. For the participants in this study, addressing climate change in conjunction with the NGSS begins with recognition of climate change as an existential crisis. The teachers in this study teach in accordance with the NGSS, however, recognition of climate change as an existential crisis informs their instruction, planning, actions, and goals. The participants in this study address climate change with a strong sense of urgency that is informed by their recognition of climate change as an existential crisis. In addressing climate change and the impacts of human activity on the environment in this sense, the participants have highlighted the importance of fostering critical inquiry into the problems, factors, and causes.

Addressing climate change with the ferocity and urgency which the participants in this study do so, is in opposition to previous research exploring public school teachers and inclusion of climate change. Plutzer et al. (2016b), for instance, found that one third of teachers in their study that addressed issues related to climate change perceived and portrayed climate change as being caused in large by natural occurring phenomena. Similarly, Roehrig, Bhattacharya, and Varma (2015) found that, although many teachers in their study displayed concern about climate change, many were unsure about humans' roles and responsibilities in relation to climate change.

Previous studies have demonstrated that while teachers often understand that human actions have impacts on the environment and climate change, many often fail to adequately address it in the classroom (Plutzer et al., 2016a). The participants in this study, however, address climate change as an existential crisis and therefore impress upon students the urgency and reality of anthropocentric climate change as it relates to planetary annihilation.

A blended approach with elements of environmental education pedagogies. Addressing climate change and the impacts of human activity on the environment requires diverse, meaningful, wide ranging, approaches. As the teachers in this study address climate change and the impacts of human activity on the environment, they apply a hybrid approach with elements that align with models of Environmental Education including Education for Sustainable Development (ESD), Place-Based Education (PBE), Experiential Education, and Environmental Literacy/Ecological Literacy. The aligned characteristics include: (1) the appreciation of the natural world; (2) critical analysis of the effect of human actions, social relationships, practices, and dominant views such as the media and other institutions, and consumer capitalism; and (3) the examination of ways in which humans can help solve environmental problems caused by anthropocentric perspectives and habits while fostering sustainable ways of being (Disinger &

Monroe 1994; Gilbert, 2003). As the participants spoke about, and demonstrated, the ways in which they address climate change, these three elements were consistent and critical.

As teachers address climate change and the impacts of human activity on the environment in accordance with the NGSS, it is predominantly done within science classrooms and with science curriculum in grades six-12 (Plutzer et al., 2016a; Shepardson, et al., 2017); however, that is not to say that teachers of other content areas do not follow suit. Jude, Maxwell, Julia, and Lucy clearly demonstrated this as they described an infusion of climate change into language arts, social studies, mathematics, and science. Regardless, the participants in this study tend to address issues related to climate change with regularity and through various means. Often, their strategies and goals shared similarities to practitioners of other environmental education pedagogies. In a sense, one might consider addressing climate change as an act of defiance of the status quo.

Familiarity with the Next Generation Science Standards. With consideration to the science standards and content, participants emphasized factors that contribute to the rise in global temperatures; the impacts of human activities on the environment; the impacts that rises in global temperatures have or will have; and the measures that humans have taken or take to mitigate climate change. In addition, they utilize a three dimensional approach that includes the Disciplinary Core Ideas (DCIs), the Science and Engineering Practices (SEPs) and the Cross Cutting Concepts (CCCs). This is directly aligned with the NGSS (NRC, 2012). Furthermore, participants all described teaching that is in line with the NGSS inquiry approach (NRC, 2012). In this, they described emphasizing phenomena, evidence based reasoning, hands on exploration, and research. With the implementation of the NGSS comes a shift away from traditional direct instruction and rote memorization to inquiry based learning. When the participants in this study

address climate change and the impacts of human activity on the environment in accordance with the standards, they maintain a focus on inquiry. In this sense, they address the crises, causes, impacts, and potential solutions through discussions, research, projects, and experiences with nature and their environment.

Systems thinking. When addressing climate change and the impacts of human activity on the environment, The NGSS views systems thinking as an antidote to fragmentation. Within the seven CCCs that undergird the NGSS, systems thinking is presented as a fundamental idea necessary for understanding many aspects of science (Achieve, 2013; NRC, 2012). The participants in this study address climate change through a systems thinking perspective in which they recognize climate science, engineering capabilities, and other kinds of knowledge (i.e. knowledge of human behavior, indigenous practices) as connected and imperative for wise decisions and practical application. Furthermore, outside of the standards, the participants address climate change and the impacts of human activity on the environment in ways which include recognition that populations will continue to experience uneven and unfair consequences. Thinking in terms of systems, for example, was described by Maxwell as a reason he includes social justice elements and seeks to empower students to become involved in climate change and environmental justice. Overall, the participants utilize systems thinking, similarly described by Bertalanffy (1968) and Laszlo and Krippner (1998), as a means to foster student understandings and perceptions of the interconnectedness of themselves and the world around them.

Conclusions

Addressing climate change and the impacts of human activity on the environment is an important, multifaceted necessity. According to the NGSS Executive summary, the three-dimensional approach is designed to minimize the need to unpack the standards prior to

implementation (2013); however, the participants in this study expressed confusion among colleagues and, at times, for themselves. Addressing climate change with fidelity and in accordance with the standards is difficult, and at times overwhelming, but it must be done. As this study was meant to explore the ways in which educators address climate change and the impacts of human activity on the environment, certain elements found within the literature were validated by my participants. However, there were also areas where the participants differed from the findings in previous literature. The following set of conclusions are drawn from the answers above.

Context Is Key

Context seems to play an integral role in addressing climate change and the impacts of human activity on the environment. Knowledge and experience can be made more meaningful by the context with which it is developed. Determining and referencing the appropriate context for one's student population is an important element in addressing climate change with fidelity. The context provides the framework which climate change is addressed. Within this study, effective contexts included emphasis on the NGSS as well as other practices common to Environmental Education; efficacy toward developing students' understanding of systems and the interrelationships between humans and the natural world, as well as with other groups of humans; diverse opportunities to engage with data, simulations, nature, and multiple perspectives; cognitive and developmentally appropriateness; the potential for stewardship, advocacy, and optimistic thinking; and practical relevance.

Confusion Persists and Teachers Need Guidance and Support

Climate change is an incredibly complicated topic to teach. Add the parameters of the NGSS and it becomes more so. Based on the findings from this study and previous literature, it

is reasonable to suggest that teachers need support and guidance. Although every participant in this study addressed climate change and the impacts of human activity on the environment with regularity, deficiencies and gaps in knowledge persisted among them and among participants in previous studies (Nation, 2017). This complexity has the potential to cause confusion and inconsistencies in teaching. Furthermore, based on previous literature, as well as the findings in this study, inconsistencies with inclusion and understandings will potentially inhibit the ways in which teachers address the issues.

Throughout the study, the participants referenced confusion about the standards; although they perceived themselves to be knowledgeable of climate change, they were not so confident in the knowledge of others. Regardless, they attributed their self-efficacy to address climate change as being informed by professional development, their education, and their life experiences. In addition, they also described personal influencers and guides such as their parents, previous teachers, coaches, and science professionals. Considering the information mentioned above, it is reasonable to suggest that without proper support and guidance, confusion and inconsistencies are likely to persist.

Adopted Curricula and Content Standards Are Inadequate

Curriculum is often understood as the lessons and academic content taught in schools. Nation (2017), for example, demonstrated that the use of a strategically designed curriculum has the potential to foster better understandings of how to teach climate change in teachers. As public school teachers, however, the participants are required to use California approved school adopted curriculum for implementing the NGSS. Unfortunately, every participant expressed a level of discontent and dissatisfaction with the state adopted curriculum and standards. These sentiments contributed to the decisions to included elements of programs such as Project Wet,

Project Wild, and SCALE. The findings in this study highlight a lack of emphasis among state adopted curricula on connections to nature, real opportunities for stewardship and activism, connections made to the uneven and unfair consequences of human activity and anthropocentric thinking, and student background knowledge and brain development.

At the time of this study the state approved curriculum consisted of Accelerated learning, Activate learning, Amplify, Delta education, Great Minds, Green Ninja, Houghton Mifflin, McGraw Hill, National Geographic Learning, Pearson Education, and Teachers' Curriculum Institute. A review of the material provided by the participants in this study highlighted potential for misconceptions regarding the greenhouse effect and doubts regarding the scientific conclusion that climate change is primarily human driven. In addition, marginalized perspectives of those such as feminist and indigenous people on climate change were nearly non-existent. This observation bears similarities to Roman and Busch (2016), who conducted an analysis of middle school science text books and found that the language often expressed uncertainty along the lines of human caused climate change. With dominant curriculum developers seemingly influencing the ways in which educators are allowed to address climate change in conjunction with the standards, one must question whose curricula are teachers actually using? And whose truth are students actually internalizing? In recognizing the importance of meaningful instruction centered on climate change, the participants in this study supplement the curriculum rather than solely adhering with the school/state adopted curriculum. However, this is not to generalize that others are making the same moral and ethical decisions to defy the status quo, supplement, use discretion, and educate for a bigger purpose.

Systems Thinking and Eco-Ethical Mindsets Are Vital

Systems thinking and eco-ethical mindsets are necessary for addressing the challenges that humans face if we wish to sustain life (Orr 1997). When we recognize our interconnectedness with the natural world and understand our current ecological state, we know that we must do something. If students are provided opportunities to learn to think in terms of systems, the potential to develop a deeper understandings of climate change and the impacts of human activity on the environment seem to become more likely. Given the dire nature of our current climate situation and the importance of recognizing the connectivity within and across systems, systems thinking is vital. In order to develop an eco-ethical mindset and understand the interconnected relationships with nature, the significance of climate change, systems thinking is necessary (Martusewicz, 2015: Orr, 1997). If it is our goal to empower future generations to become eco-ethical thinkers willing to fight for democracy, sustainability, social equality, and new economic policies and practices, systems thinking is a necessary component.

Teachers Are Essential for Survivability

Teachers are needed to play an essential role in the struggle against climate change, as they have the power to inspire thinking that is essential for meaningful responses to the current path towards planetary annihilation (Martusewicz, et al., 2014; Nelson & Cassell, 2012; Nelson & Coleman, 2012; Weart, 2017). The findings from this study, as well as those from previous research, suggest that education has the potential to foster an understanding of life sustaining concepts and encourage mind-shifts and changes in attitudes and ways of being (Martusewicz, et al., 2014; Wals & Corcoran, 2012). For example, teachers at all levels have the potential to influence thinking by using literacy to critique multiple sources of information, comprehend various perspectives, create alternative discourses, and inspire possibilities for hope and

activism. In fact, this study as well as numerous research and publications have reiterated the importance of education that encourages changes in attitudes and behavior, attends to emotional sense-making, and provides opportunities to make sense of and address the impacts related to human activity and climate change (Bowers, 2001; Orr; 1997; 2002; 2017; Lieberman, 2013; Wals & Corcoran, 2012).

The dramatic trajectory of our path towards self-annihilation requires action from all angles; therefore teachers have an important role to play in shaping understandings, mind sets, and action regarding climate change. The looming severity of the current climate situation requires eco-ethical ways of thinking and being, which requires teachers to consider new ways of educating students. More than ever, teachers must play a crucial role in fostering strong personal and affective understandings of, and commitments to, the most looming existential threat we have faced in modern times.

More Needs to Happen

With new realities come the necessity of new paradigms (Kuhn, 1970). Given our current reality, it is time to figure out how to solve the problems we face. More than 97 percent of actively publishing climate scientists agree that the climate change we are experiencing is predominantly caused by human activities; in a review of more than 69,000 peer reviewed science articles, Powell (2015) discovered that only four rejected the notion that climate change is primarily caused by humans. In addition, the NGSS are the first set of required national science standards to explicitly include climate change and the impacts of human activity on the environment; however, deficiencies still exist. Simply put, more needs to happen. While the participants described addressing climate change, they also expressed concerns regarding the adequacy of their curriculum and ways in which their colleagues address the issues. Julia

likened this to teachers being afraid of science, Rocky likened this to lack of proper training, and Jude likened this to the complication of the topic and standards. Clearly, it should come as no question that a paradigm shift in the ways we perceive climate change and our actions is necessary. The damage from soaring temperatures and inequality should tell us that a fundamental shift toward survivability must be the primary goal. Educators at all levels must alter the ways in which they generally educate the youth and think about their position as means to promote a survivability shift toward repair, security, and protection. As stated earlier, by not addressing climate change with fidelity and in multiple ways, we are allowing silence to normalize unsustainable systems and ideologies, which will continue to have disastrous consequences for everyone and everything.

Recommendations

It is time for a paradigm shift in education to a pedagogy of responsibility that includes a holistic emphasis on Environmental Education and eco-ethical thinking. In order to fully address the crises, educators, policy makers, curriculum developers, and professional development must transcend current practices and strive for a pedagogy of responsibility. The efforts of these combined forces should be centered on the responsibility to lead and impact social change related to issues of sustainability and survivability. Clearly we have reached a critical juncture in human existence where all life on Earth as we know it is at stake. Therefore, as a means to combat climate change and the impacts of human activity through education, this section will offer recommendations for policy, content standards development, curricula development, teacher professional development, practice, and research.

Recommendations for Policy

At the national and state levels, policy makers can play a prominent role in bringing about change by focusing direction. Therefore, I recommend a widespread emphasis on holistic eco-ethical education and environmental practices at all levels of instruction. This requires a shift away from the current anthropocentric human capital perspectives which have dominated societal and educational policy, to one that emphasizes eco-ethical thinking and Environmental Education approaches. Rather than a continued focus on education for economic growth and meeting the needs of the labor market, there must be a widespread shift to education for diverse, democratic sustainability. In developing this idea I recommend policy makers look to Vandana Shiva's 10 principles of Earth Democracy which prioritize people and nature above capitalistic commodification and profits.

Recommendations for Content Standards Development

The NGSS requires that climate change and the impacts of human activity be addressed in certain grade levels and classes; however, they are also incomplete. Scholars have emphasized that paths toward justice are best understood from the perspectives of the marginalized; however, within the standards and adopted curricula, there is a lacking of marginalized perspectives and communities. If educators are to address climate change in meaningful ways, the standards and curricula must include feminist perspectives, gender inequalities, and marginalized communities because often personal stories shape and are shaped by the current climate crisis as there is inequality at the roots.

I propose amendments to the standards and frameworks that emphasizes the interrelationship of humans with nature and other groups of humans, and challenges anthropocentric and other hierarchized modes of thinking, discourses of modernity, and

economic development that have contributed to crises plaguing Earth's natural systems and placed us on this path to planetary annihilation. This includes an emphasis on educating students on the political, social, and economic conditions that have led to the degradation of many components of the natural world; problem solving for survivability and sustainability; eco-ethical responsibility and action. Although the NGSS includes emphasis on climate change and the impacts of human activity, the Disciplinary Core Ideas (DCIs) and the Science and Engineering Practices (SEPs) could be strengthened by inclusion of Shiva's 10 principles to Earth Democracy.

Recommendations for Curricula Development

In accordance with the findings, I propose several considerations for curricula development. The participants in this study have placed emphasis on the need for more curricular alignment with nature of science (NOS) and systems thinking that connects climate change to issues of social justice and human activity. While it is important for curricula to include increased emphasis on NOS, I propose curriculum developers embed textbooks and curricula with eco-justice related principles to include increased emphasis on globalizing peace, love, and eco-ethical responsibility.

In addition to emphasizing the globalization of peace, love, and eco-ethical responsibility, curriculum should include activities and lessons that emphasize the study of the intergenerational relationships, activities, and technologies in both dominant and marginalized communities. Furthermore, rather than maintaining an ubiquitous focus predominantly in science curricula and classrooms, more emphasis on interdisciplinary ways of organizing curriculum and the content standards to include the following:

- Systems thinking and Ecojustice Education
- The effect of population growth on Earth's natural systems and living and non-living beings
- The adverse impacts of air pollution, energy production and consumption, global climate change, diminished ecological and biological diversity, water quality and ocean degradation, over-consumption of natural resources
- The adverse impacts of hierarchized modes of thinking and discourses of modernity
- Practices that foster advocacy and stewardship for the natural world
- Indigenous culture and knowledge
- Narratives and experiences related to communities of color and poverty

Recommendations for Teacher Professional Development

There is research available regarding how teachers' beliefs about climate change affect their classroom practice and the findings from this study as well as from Nation and Feldman (2017) suggest that teacher understandings and experiences influence their beliefs about climate change. Findings from this study suggest that the combination of climate change being included in the NGSS, teachers recognizing climate change as an existential crisis, and experiencing meaningful and motivating teacher education and professional development can translate to an increased desire for more inclusion in the classroom. Therefore, I recommend deconstruction and refinement of teacher professional development and preparation programs so that there is an increased emphasis on raising deep awareness and concern among teachers and new generations of students. I propose increased workshops, professional development, and teacher education that seeks to increase teacher awareness by offering teacher education courses on climate change awareness and pedagogical practices for addressing environmental issues. Programs and professional development must strive to illuminate environmentally destructive patterns, reinforce actions, behaviors, and thinking that minimizes or eliminates adverse impacts on the environment. For practical examples I recommend exploration of material provided by Project Wet, Project Wild, Project Aquatic, and Green Ninja.

Recommendations for Practice

Educators have an incredible opportunity to be at the forefront of social change on the issues of sustainability and survivability. The findings of this study have prompted recommendations for practices and transcending the status quo in, and beyond, science classrooms. The following are 12 recommendations for practice within classrooms where science is taught:

- Foreground climate change as the most existential crisis facing life on Earth
- Adopt and maintain a systems thinking-based perspective
- Foster solidarity with, and empathy for, the oppressed and exploited
- Strive for social and environmental justice
- Envision and enact transformational changes through individual and collective action, advocacy, and stewardship
- Provide inquiry based learning opportunities
- Address, and seek to foster an understanding of, the causes and impacts of climate change at global and local levels with emphasis on the uneven and unfair consequences
- Embrace Place-Based Education (PBE) practices to create relevancy to students by fostering connections to one's locality and nature
- Address the efforts to mitigate climate change as well as those seeking to perpetuate the problems
- Embrace the valid conclusions of climatologists, other scientists, environmental experts, researchers, simulations, climate data, and indigenous populations
- Make pedagogical adjustments with developmental appropriateness in mind
- Strive for a balanced inclusion of hope and the grim realities of anthropocentric climate change

While the recommendations above are intended for classrooms where science is taught, I also recommend that educators across content and grade levels perceive climate change as an interdisciplinary topic to bridge content areas. Means by which this can be done include reading, writing, speaking/listening, and digital media production and research. Educators of English Language Arts should engage students in textual exploration, close reading strategies, and comprehension development utilizing literature that centers on climate change. They should consider topics related to climate change to teach language development through the use of Guided Language Acquisition Design (GLAD) strategies. Teachers of English Learners can use

leveled texts, Pictorials, and plan collaborative activities centered on marginalized communities to create a sense of cultural affirmation and inclusion. Further along these lines, teachers should consider engaging students in disciplinary and interdisciplinary discussions to address ethical and moral questions portrayed in fiction and non-fiction. In mathematics classes, teachers can engage students in predicting and describing climate change as the inclusion of related topics into mathematics classes may present the opportunity to make predictions based on climate models, simulations, and other data.

In history classes, students should reflect on important social and political aspects of climate change. These educators should promote inquiry into unequal roles of humans in adversely shaping the Earth in the Anthropocene Age that began in the nineteenth century. In addition, essential questions should include 'who causes global warming and who suffers first and most?' and, 'how is climate change being addressed by individuals or governments?' Teachers and schools must provide opportunities for students to grapple with these moral dilemmas in order to recognize the importance of transforming unsustainable status quo systems, to reduce dependency on fossil fuel, and to restructure current agricultural practices. In addition, teachers of nutrition and health classes should consider emphasis on plant based diets as a means to further reduce greenhouse emissions.

In recognizing that human caused climate change is an existential crisis, educators such as those teaching social studies must concern themselves with the exploitation and degradation carried forth by the industrialized models of economic development, globalized discourses of modernity, hierarchical thinking. After all, the participants have recommended that education centered on climate change and the impacts of human activity on the environment must include inclusion of the ways in which wealthy, industrialized countries and groups of people dominate

and benefit far more from the destruction of the environment and local communities. Educators in all disciplines must recognize and bring recognition to the idea that there are, and will continue to be unfair and uneven consequences should they remain silent on the issue. For educators seeking practical ideas and examples, I recommend "EcoJustice Education" by Martusewicz, Edmundson, and Lupinacci.

Recommendations for Research

This study has sought to understand the ways in which educators who are implementing the NGSS address climate change and the impacts of human activity on the environment. While the findings have yielded valuable insights and information, the findings could be strengthened by future research. With NGSS implementation gaining momentum across the nation, researchers should consider exploring the ways in which educators address climate change through various qualitative and quantitative methodologies so as to add to the developing body of research around this topic and inspire others. The participants in this study teach in the Sacramento Valley area of California, however, research duplicating or along the same lines but conducted in other areas of the United States would prove insightful as it would present the opportunity to compare the ways in which educators address climate change in various locations.

Future research duplicating this study in more diverse settings and classroom assignments as well as across various methodologies would prove valuable. As studies seek to build upon the findings presented here or continue in the realm, I offer several recommendations for research along these lines, across various methodologies. One methodology that should be considered is case study research as described by Stake (1995). With a methodology such as this, the exploration of a real-life case or cases over time have the potential to provide insight into the impacts of sustained practices. With an in-depth case study, researchers could study teachers

and/or students over a period of time. This could be as teachers participate in sustained professional development over a period of time, implement a curriculum over time, or follow students over the course of a school year. Case studies seeking to dive deeper into professional development, teacher experiences, and the ways in which climate change is addressed or experienced over time and across cases could utilize any of the following research questions to guide the study: In what ways do environmentally concerned professional development programs impact the ways in which educators address climate change? In what ways do curricula and educational standards address stewardship and advocacy? How does curricula influence the ways in which educators address climate change? In what ways are educators prepared to address climate change?

Narrative research is an additional methodology that would benefit the body of research should studies be connected utilizing them. Because Narrative research comes in a variety of forms, for the purpose of research in the area of this study, the detailed stories and lived experiences of individuals with an important story to tell would prove beneficial. In this case, I recommend an oral history of individuals whose personal work has influenced academia with relation to the topics discussed in this study. Historical perspectives of individuals who have much to offer by sharing their stories and life experiences can provide a valuable understanding of a topic such as addressing climate change in academia (Boone, Tucker, & Meisenach (2000). Therefore, Narrative research that considers perspectives in the vein of ecofeminist scholars such as Val Plumwood, Vandana Shiva, or Rebecca Martusewicz may prove enlightening. When considering this avenue of research, one could utilize the following research questions: In what ways do leading experts and scholars describe their experiences and knowledge with relation to the development of eco-ethical ethical consciousness? What knowledge and experiences do

leading experts and scholars hail as essential to developing an eco-ethical consciousness? What knowledge, experiences, and resources do leading experts and scholars hail as essential to addressing climate change in education?

Descriptive and comparative quantitative research is an area that would add to the scope and body of research should a similar study be conducted. A quantitative study that utilizes survey data could add an element of statistical understanding related to the implementation of instructional practices, strategies, topics, standards, and curricula. By including a survey, there is potential to uncover widespread common practices, goals, and understandings. A study of this nature could also provide insight into the relationships between certain populations and the ways in which they address climate change. Furthermore, one could also investigate correlations between the NGSS, professional development, and teacher inclusion of climate change and the impacts of human activity on the environment in their teaching.

For quantitative studies seeking to broaden the scope and contribute further to the development of research in the area of this study, the following questions are offered as recommendations for consideration: How is climate change represented in curricula? How does professional development address climate change in the classroom? What impacts do the Next Generation Science Standards have on teacher beliefs about climate change? What impact does the context of professional development have on teacher self-efficacy and preparedness to address climate change? In addition to that which has already been recommended, future research should consider the exploration of curricula inclusion of marginalized perspectives. Research questions along the lines of a study such as this could include: What proportion of science curricula is inclusive of marginalized perspectives? What representation do marginalized perspectives have in science curricula?

Recapitulation

This study has explored the ways in which educators who are implementing the NGSS address climate change and the impacts of human activity on the environment. The findings of this study have yielded recommendations for practice, policy, curriculum development, teacher development, and further research. In doing so, this study has contributed to the limited body of research surrounding the teaching of climate change in conjunction with the NGSS. The experiences, beliefs, and practices provide insight into the complexity of addressing climate change in accordance with the NGSS. This intricacy makes it a particularly challenging topic to approach no matter the educational setting, however, the participants in this study have demonstrated that the urgency of addressing climate change is far too important to gloss over. The minds of students are ready for nourishment and it is the teacher's responsibility to help students realize their potential to alter the trajectory toward self-annihilation that humans have place ourselves on.

Like a bluesman singing of real life tragedy, it is my hope that this song will inspire strategies for survival and coping among educators and educational leaders in ways that translate to practical application, contribute to eco-ethical practices and thinking, and encourage a shift to believing in education as pedagogy of responsibility. I believe that with new modes of thinking and being, we can inspire students to challenge dominant ideologies and systems. We live on an astonishing planet that is fundamentally more glorious than any of the other options for which we head; however, if we continue to make the same 'business as usual' decisions rather than drastically seeking to slow the invasiveness of the human species, our magnum opus will be the destruction of life as it once was known.

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APPENDIX A: INTRODUCTION LETTER TO POTENTIAL PARTICIPANTS

Dear [Participant's name],
My name is Daniel Diego. I am a doctoral student in education at the University of the Pacific (Stockton, CA) under the supervision of Dr. Thomas Nelson. My purpose for contacting you is to discuss the possibility of you being a participant in a research study exploring the teaching of climate change and the impacts of human activity on the environment. For this study, I am looking for participants that have addressed climate change at the classroom level. The time frame for this study will be over the course of the 2019-2020 school year.

The Study: This is a qualitative, phenomenological study seeking to describe the ways in which educators who are implementing Next Generation Science Standards (NGSS) address the issues of climate change and other impacts of human activity on the environment.

Who am I looking for?
Educators who address climate change and are willing to partake in three interviews, one observation, and provide supporting teaching documents. Participants must be located in a school in Northern California.

Interviews and Observations: Each interview will last approximately one hour. The interviews and observation will be conducted at a time a place of your choosing and will be audio-recorded. In addition, a follow up interview may be scheduled should more clarity be needed (in-person or telephone). The focus of the interviews will be on your beliefs, experiences, and strategies in teaching climate change and/or the impacts of human activity on the environment. All audio files of the interviews will be stored in a secure location and destroyed within two years of completing the study.

Document Analysis: I am requesting that participants bring any teaching documents or resources they use to teach. This might include, but are not limited to, items such as lesson plans, handouts, study guides, quizzes, assessments, labs, and anything else that has informed your teaching).

Confidentiality: Pseudonyms will be used to maintain confidentiality. Pseudonyms will be assigned to participants, schools, districts, and any other name involved in this study. Information and documents will be stored and kept confidential in a locked filling cabinet of which only I will have access to. The findings of this research may be published, however, to assure your confidentiality, any information regarding your identity, school site, or school district will not be published without the use of pseudonyms.

Risks: There are no foreseeable risks, immediate benefits, or discomforts associated with participation of this study. Participation is voluntary, pseudonyms will be used, and there will be no penalty or repercussions for choosing not to participate in this study or for choosing to withdraw from the study at any time.

The findings from the study would be of great value to educators, curriculum developers, instructional coaches, administrators, and any other stakeholders interested in the ways in which teachers address climate change and the impacts of human activity against the backdrop of Next Generation Science Standards implementation. It would be my pleasure to discuss the potential of your participation in this study further. Please let me know if you have any questions and I will respond within 24 hours of your questions. If this sounds like something you are willing to participate in, please let me know.

Thank you for your time,
Daniel Diego
d_diego@u.pacific.edu
(916) 532 4930

Dr. Thomas Nelson,
tnelson@pacific.edu

APPENDIX B: INFORMED CONSENT FORM

[Participant's Name],
You are invited to participate in a research study on the teaching of climate change and the impacts of human activity on the environment. Participation is voluntary, and there are no immediate benefits for participation. My name is Daniel Diego, and I am a doctoral student at the University of the Pacific, Benerd School of Education (Stockton, CA). You were selected as a possible participant in this study because of your reply to my initial letter and inquiry. The purpose of this study is to describe the ways in which educators address climate change and the impacts of human activity on the environment. Your participation will involve two audio-recorded interviews which will last approximately one hour. Additional interviews may be needed for clarity. You will also be observed in a teaching context by myself and asked to complete a short post observation reflection form. Financial compensation will be offered for any travel expenses to conduct an interview or expenses incurred through document transfer. Any information that is obtained in connection with this study and that can be identified or associated with you will remain confidential and will only be disclosed with your permission.

The foreseeable risks or discomforts associated with participation of this study are minimal. These possible risks or discomforts include:

- The possibility of emotional trauma and anxiety caused by being observed while teaching.
- The loss of confidentiality and its repercussions for your employability and representation.
- Physical risk involved primarily in transportation to and from the interview setting.

To minimize the risks, the preventative measures I will take include:

- I will use pseudonyms for names of all participants, schools, districts, and all other individuals involved.
- There will be no penalty or repercussions for choosing not to participate in this study or for choosing to withdraw from the study at any time.
- All data will be stored in a password protected hard drive which will be stored in a locked storage cabinet in my personal home office.
- All data will be destroyed within two years after the study is completed.

If you have any questions regarding the research or study at any time, please contact me at (916) 532–4930 or email me at mrdiegoeducator@gmail.com. You may also contact my doctoral advisor Dr. Thomas Nelson at the University of the Pacific at tnelson@pacific.edu. For questions regarding your rights as a participant in this study, please contact the Research and Graduate Studies Office at the University of the Pacific at, (209) 946-7367. For questions or concerns in the event of a research-related injury, please contact your regular medical provider and bill through your normal insurance carrier, then contact the Office of Research & Graduate Studies.

Your signature below indicates the following:

- You have read the information provided in this letter and understand the content.
- You willingly agree to participate in this study but may withdraw your consent and discontinue participation at any time without penalty or repercussions.
- You are not waiving any legal claims, rights, or remedies.
- You will receive a copy of this form for your records.

SIGNATURE: _____ DATE: _____

APPENDIX C: INTERVIEW PROTOCOL

Interview # 1 Background, pre-observation
Welcome, thank them for choosing to participate in this study. Introduce self and review study. The purpose of this study is to capture and describe the essence of educators' experiences as they plan for, interpret, and implement NGSS related to climate change and the impacts of human activity on the environment. What are teachers doing and why? The purpose of this interview is to help gain a sense of your background. Please elaborate.

1. Tell me about how you got into teaching.
2. Tell me about your education. Have you taken any course related to climate change, other environmental issues, if so, please describe them?
3. Describe your students to me.
4. Tell me about your experience and understanding with NGSS.
5. What do you know about climate change?
6. How important is the issue of climate change to you? Follow up if needed: Is that different from the impacts of human activity on the environment?
7. Describe for me a typical NGSS climate change lesson or activity.
8. What materials and resources do you use during the planning phase of lessons and activities and what materials and resources do you use when actually teaching students?
9. What teaching strategies do you use when addressing issues related to climate change and the impacts of human activity on the environment?
10. What aspects of climate change or the impacts of human activity on the environment do you think are most difficult to teach or address? Follow up if needed: What aspects do you think are most difficult for students to understand? Are there any aspects that you do not address and if so, why?

Prior to the upcoming observation, is there anything I need to know or anything I should be aware of coming in?

Schedule interview #2: 1.) Remind participant of the purpose of interview #2 (to go deeper into the teaching of climate change and the impacts of human activity on the environment), 2.) Request that the participant come prepared to discuss the lesson to be observed, 3.) Schedule interview #2 and make arrangements to schedule an observation, and 4.) Request that participant brings teaching documents used for the lesson and any other documents or things used in general.

Interview #2 (Post-Observation) Part A:
Sub-question: In what ways do educators who are implementing the Next Generation Science Standards perceive their roles and responsibilities in addressing climate change and the impacts of human activity on the environment?
For the next part of this interview, I'd like to ask you a series of questions designed to inform my sub-research questions. Some regarding the observation and some regarding teaching in general. Please be specific and elaborate.

1. Tell me about the lesson (think about the objective, flow, student preparedness, student engagement and other details) and why you choose to teach it at this phase in your students' learning?
2. Tell me about the reasons and rational for selecting the resources and materials used during the lesson.
3. If you had opportunity to teach this lesson again, what revisions would you make to it and why?
4. Describe the connection and alignment to NGSS. Follow up: Tell me about the SEPs, CCCs, or DCIs used?
5. What impacts have the addition of climate change in the NGSS had on your teaching?
6. What impacts have you seen from teaching or addressing climate change and the impacts of human activity on the environment on your students?
7. What goals do you wish to accomplish in the classroom?

Interview #2 (Post-Observation) Part B:
Sub-question: In what ways do educators who are implementing the Next Generation Science Standards interpret the associated climate change and Earth and Human Activity standards prior to enactment?
Now, I would like you to tell me about how you interpret the standards.

1. When preparing for, or teaching and addressing, climate change?
2. What do you think about when preparing for, or teaching the standards?

For this part of the interview I would like to look over the standards with you. For each standard, I would like to read it and describe to me what it means to you. I may ask you to 'tell me more' about certain aspects. (see Appendix E)

APPENDIX D: OBSERVATION NOTES

Observation Notes

Date: Participant: Topic: Document ID:

Specific facts and things observed by the researcher
Quotes, phrases, summaries of conversations during the lesson heard by the researcher
NGSS connections observed by the researcher (DCIs, SEPs, CCCs, inquiry, phenomena, etc.)
Materials used

Reflection to be done by the researcher after the observation

APPENDIX E: NGSS STANDARDS FOR INTERVIEW PART B

MS-ESS3 Earth and Human Activity

MS-ESS3 Earth and Human Activity

Students who demonstrate understanding can:

MS-ESS3-1. **Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.** [Clarification Statement: Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).]

MS-ESS3-2. **Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.** [Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).]

MS-ESS3-3. **Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*** [Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).]

MS-ESS3-4. **Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.** [Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]

MS-ESS3-5. **Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.** [Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Asking Questions and Defining Problems
Asking questions and defining problems in grades 6–8 builds on grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models.
- Ask questions to identify and clarify evidence of an argument. (MS-ESS3-5)

Analyzing and Interpreting Data
Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.
- Analyze and interpret data to determine similarities and differences in findings. (MS-ESS3-2)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.
- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (MS-ESS3-1)
- Apply scientific principles to design an object, tool, process or system. (MS-ESS3-3)

Engaging in Argument from Evidence
Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).
- Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-ESS3-4)

Disciplinary Core Ideas

ESS3.A: Natural Resources
- Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (MS-ESS3-1)

ESS3.B: Natural Hazards
- Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3-2)

ESS3.C: Human Impacts on Earth Systems
- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3)
- Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3),(MS-ESS3-4)

ESS3.D: Global Climate Change
- Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. (MS-ESS3-5)

Crosscutting Concepts

Patterns
- Graphs, charts, and images can be used to identify patterns in data. (MS-ESS3-2)

Cause and Effect
- Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. (MS-ESS3-3)
- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS3-1),(MS-ESS3-4)

Stability and Change
- Stability might be disturbed either by sudden events or gradual changes that accumulate over time. (MS-ESS3-5)

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World
- All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ESS3-1),(MS-ESS3-4)
- The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-ESS3-2),(MS-ESS3-3)

Connections to Nature of Science

Science Addresses Questions About the Natural and Material World
- Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes. (MS-ESS3-4)

Connections to other DCIs in this grade-band: **MS.PS1.A** (MS-ESS3-1); **MS.PS1.B** (MS-ESS3-1); **MS.PS3.A** (MS-ESS3-5); **MS.PS3.C** (MS-ESS3-2); **MS.LS2.A** (MS-ESS3-3),(MS-ESS3-4); **MS.LS2.C** (MS-ESS3-3),(MS-ESS3-4); **MS.LS4.D** (MS-ESS3-3),(MS-ESS3-4); **MS.ESS2.D** (MS-ESS3-1)

Articulation of DCIs across grade-bands: **3.LS2.C** (MS-ESS3-3),(MS-ESS3-4); **3.LS4.D** (MS-ESS3-3),(MS-ESS3-4); **3.ESS3.B** (MS-ESS3-2); **4.PS3.D** (MS-ESS3-1); **4.ESS3.A** (MS-ESS3-1); **4.ESS3.B** (MS-ESS3-2); **5.ESS3.C** (MS-ESS3-3),(MS-ESS3-4); **HS.PS3.B** (MS-ESS3-1),(MS-ESS3-5); **HS.PS4.B** (MS-ESS3-5); **HS.LS1.C** (MS-ESS3-1); **HS.LS2.A** (MS-ESS3-4); **HS.LS2.C**

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

MS-ESS3 Earth and Human Activity

(MS-ESS3-3),(MS-ESS3-4); **HS.LS4.C** (MS-ESS3-3),(MS-ESS3-4); **HS.LS4.D** (MS-ESS3-3),(MS-ESS3-4); **HS.ESS2.A** (MS-ESS3-1),(MS-ESS3-5); **HS.ESS2.B** (MS-ESS3-1),(MS-ESS3-2); **HS.ESS2.C** (MS-ESS3-1),(MS-ESS3-3); **HS.ESS2.D** (MS-ESS3-2),(MS-ESS3-3),(MS-ESS3-5); **HS.ESS2.E** (MS-ESS3-3),(MS-ESS3-4); **HS.ESS3.A** (MS-ESS3-1),(MS-ESS3-4); **HS.ESS3.B** (MS-ESS3-2); **HS.ESS3.C** (MS-ESS3-3),(MS-ESS3-4),(MS-ESS3-5); **HS.ESS3.D** (MS-ESS3-2);(MS-ESS3-3),(MS-ESS3-5)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS3-1),*(MS-ESS3-2),*(MS-ESS3-4),(MS-ESS3-5)
RST.6-8.7	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-ESS3-2)
WHST.6-8.1	Write arguments focused on discipline content. (MS-ESS3-4)
WHST.6-8.2	Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-ESS3-1)
WHST.6-8.7	Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-ESS3-3)
WHST.6-8.8	Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-ESS3-3)
WHST.6-8.9	Draw evidence from informational texts to support analysis, reflection, and research. (MS-ESS3-1),(MS-ESS3-4)

Mathematics –

MP.2	Reason abstractly and quantitatively. (MS-ESS3-2),*(MS-ESS3-5)*
6.RP.A.1	Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. *(MS-ESS3-3),(MS-ESS3-4)*
7.RP.A.2	Recognize and represent proportional relationships between quantities. *(MS-ESS3-3),(MS-ESS3-4)*
6.EE.B.6	Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. *(MS-ESS3-1),(MS-ESS3-2),(MS-ESS3-3),(MS-ESS3-4),(MS-ESS3-5)*
7.EE.B.4	Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. *(MS-ESS3-1),(MS-ESS3-2),(MS-ESS3-3),(MS-ESS3-4),(MS-ESS3-5)*

APPENDIX F: MATRIX OF CROSS CUTTING CONCEPTS IN THE NEXT GENERATION SCIENCE STANDARDS

6 – 8	9 - 12
Patterns: Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.	
Macroscopic patterns are related to the nature of microscopic and atomic-level structure. • Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems. • Patterns can be used to identify cause and effect relationships. • Graphs, charts, and images can be used to identify patterns in data.	• Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. • Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. • Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system. • Mathematical representations are needed to identify some patterns. • Empirical evidence is needed to identify patterns.
Cause and Effect: Mechanism and Prediction: Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.	
• Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. • Cause and effect relationships may be used to predict phenomena in natural or designed systems. • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. • Systems can be designed to cause a desired effect. • Changes in systems may have various causes that may not have equal effects
Scale, Proportion, and Quantity: In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.	

• Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. • The observed function of natural and designed systems may change with scale. • Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. • Scientific relationships can be represented through the use of algebraic expressions and equations. • Phenomena that can be observed at one scale may not be observable at another scale.	• The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. • Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. • Patterns observable at one scale may not be observable or exist at other scales. • Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. • Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth)
Systems and System Models: A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.	
• Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. • Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. • Models are limited in that they only represent certain aspects of the system under study.	Systems can be designed to do specific tasks. • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. • Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.
Energy and Matter: Flows, Cycles, and Conservation: Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior.	
• Matter is conserved because atoms are conserved in physical and chemical processes. • Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. • Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). • The transfer of energy can be tracked as energy flows through a designed or natural system.	• The total amount of energy and matter in closed systems is conserved. • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. • Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. • Energy drives the cycling of matter within and between systems.

	• In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.
Structure and Function: The way an object is shaped or structured determines many of its properties and functions.	
• Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function. • Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.	• Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. • The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.
Stability and Change: For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.	
• Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale. • Small changes in one part of a system might cause large changes in another part. • Stability might be disturbed either by sudden events or gradual changes that accumulate over time. • Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.	• Much of science deals with constructing explanations of how things change and how they remain stable. • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. • Feedback (negative or positive) can stabilize or destabilize a system. • Systems can be designed for greater or lesser stability.

APPENDIX G: PARTICIPANT DESCRIPTORS

Participant	Grade Level	Content Area	Years in Education
Jude	Sixth Grade	Multiple subjects	Seven years
Julia	Sixth Grade	Earth Science and Astronomy	16 years
Lucy	Sixth and Seventh Grade	Math and Science	12 years
Maxwell	Seventh and Eighth Grade	Science	Five years
Michelle	Ninth – Twelfth Grade	Earth Science and Astronomy	Six years
Pam	Eighth Grade	Physical and Honors Science	10 years
Rita	Sixth - Eighth Grade	Physical, Life, and Earth Science	13 years
Rocky	Sixth –Eighth Grade	Earth and Physical Science	29 years

APPENDIX H: CURRICULA

Name	Grade Levels Covered	Content Emphasis	Developed by
Amplify Science	Sixth - Eighth	Science	Amplify
Facing the Future	Sixth - Eighth	Science	Green Schools National
Green Ninja	Sixth -Eighth	Science	San Jose State University
Inspire Science	Pre K - Twelfth	Science	McGraw Hill
PCI Reading Program	Kindergarten - Adult	Multiple subjects for students with developmental and significant learning disabilities	Wieser Educational
Project Wet 2.0	Kindergarten - Twelfth	Water Education	Project Wet Foundation
Project WILD	Kindergarten - Twelfth	Wildlife-based conservation and environmental education	Association of Fish and Wildlife Agencies
SCALE Science	Sixth -Eighth	Science	Stanford Graduate School of Education
Stemscopes	Kindergarten - Twelfth	Science	Accelerated Learning Inc.
Teaching Tolerance	Kindergarten - Twelfth	Identity, diversity, justice, and action	Southern Poverty Law Center

APPENDIX I: ACRONYMS

CCC	Cross Cutting Concepts
CER	Claim Evidence Reasoning
DCI	Disciplinary Core Ideas
NGSS	Next Generation Science Standards
PBE	Place-Based Education
PBL	Project Based Learning
PE	Performance Expectation
SEP	Science and Engineering Practices