ABSTRACT

GUTIERREZ, KRISTIE SUSAN. Investigating the Climate Change Beliefs, Knowledge, Behaviors, and Cultural Worldviews of Rural Middle School Students and their Families During An Out-of-School Intervention: A Mixed-Methods Study. (Under the direction of Dr. Margaret R. Blanchard).

In a recent nationwide survey, 63% of American adults believe that there is global warming, yet 52% received a 'grade' of 'F' on climate change knowledge and beliefs. Climate change is a politically-charged topic in the 21st century. Even for those who support the 97% of scientists who assert that climate change is occurring, many are still uncertain about the role that humans play in this complex process. This mixed-methods study examined the climate change beliefs, content knowledge, worldviews, and behaviors of rural middle school students and their families in four rural, high poverty school districts in the Southeastern United States (US). The students, who ranged from 5-8th grades, were part of an after school STEM Career Club program that met for two hours, six times per semester. STEM Club students (N = 243) and selected students' families (n = 15) interacted with climate change activities and materials in the student clubs and in an at-home intervention. Quantitative pre- and post-intervention surveys were used to measure any changes in climate change content knowledge and beliefs as well as participants' worldviews. Qualitative audio data gathered from at-home intervention activities with students and their family members, as well as during family dyad interviews, was coded using the Determinants of Behavior framework that reflected climate change awareness, during and post-intervention. This embedded mixed-methods design with climate change education was designed to reflect place-based examples in these rural, southeastern US communities, and to empower families to see the relevance of this global issue, consider their role, learn more about climate science, and take actions locally.

Initially, a large percentage of students believed that global warming is occurring (69.5%) and is occurring at least in some part due to human influence (69.3%). Students had learned significantly more total climate change knowledge, post-intervention. Analyses of variance (ANOVA) found a significant main effect for gender; males improved significantly more than females on the content knowledge test. Significant gains in content knowledge could be traced to engagement in specific club activities. The vast majority (73.3%) of students held egalitarian worldviews, while students were almost equivalent on the individualism (48.8%) /communitarian (47.7%) worldview scale. Student worldviews correlated to responses on the affective items of the survey, but did not predict students' climate change content knowledge. Findings from this study suggest that significant gains in climate change content knowledge can be attained through short-term out-of-school interventions, but not climate change beliefs. For rural, low income families, knowledge talk was most common (26.6%), followed by discussion of behaviors (11.5%), and talk regarding the seriousness of the problem (10.6%). Seventy-two percent of the participants (n = 18; 9 students, 9 adults) were coded as individualistic egalitarian. Changes in climate change content knowledge from pre- to post-intervention were greatest in the students and parents who were highly engaged in the at-home family intervention, indicating that parents and students can benefit from climate change interventions in their own homes.

Investigating the Climate Change Beliefs, Knowledge, Behaviors, and Cultural Worldviews of Rural Middle School Students and their Families During An Out-of-School Intervention: A Mixed-Methods Study

by
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BIOGRAPHY

I was born in North Carolina and educated in the K-12 public education system in North Carolina. For ten additional years I attended three of the University of North Carolina system universities for my post-secondary educational degree and taught science courses ten years in four public high schools throughout North Carolina and four semesters as a biology lab teaching assistant at North Carolina State University. Both my parents, Neil and Carolyn MacDonald, and only sibling, Scott MacDonald, were educators in the public schools in North Carolina. If there were a specific gene for "educators" or a way for education to be "in your blood," then I would have it. My attraction to education lay dormant in my educational pathway as my love of science overwhelmed my undergraduate self. It was not until I finished my BS in Biology at UNC-Chapel Hill that this latent call to be an educator appeared. I finally figured out the way to marry my attraction to all things STEM with my skillfulness as an educator. Thus, I immediately began my journey toward Secondary Science Education certification and Science Education Master's degree at UNC-Wilmington. I remember thinking then, even before I had stepped foot in a high school classroom on the other side of the desk, that I would one day begin the steps to become a professor in Science Education. I can remember telling my advisor at the time, Dr. Dennis Kubasko, that one day I wanted to have his job…or at least a job like his!

After ten years in the classroom, with the support of my husband and son, Giovanni and Gianni Gutierrez, I began my three year, full-time journey at NC State in the Science Education Ph.D. program to make that dream a reality. I was at the point in my career where this was the most logical step. I had completed my M.Ed., achieved National Board Certification, received Teacher of the Year at my school and did not feel as if there were many more steps I could take

to further my career. Those who know me best know that I enjoy challenges and must continually work to better myself.

In my undergraduate coursework, my focus was in life sciences and chemistry. However, my graduate coursework has been mostly in ecology, earth, and environmental sciences. Within the last year of graduate coursework, my interest in science funneled into topics related to the atmosphere, climate, and climate change communication. As climate change is an extremely salient topic in the world today, it is important for individuals to be scientifically literate and aware of the current and future impacts of climate change in the region. In the future, I would like to continue to develop relationships with students, parents, and teachers in communities and advance STEM content to help prepare our future STEM workforce and those who will prepare our future STEM workforce through science education methods course instruction.

ACKNOWLEDGMENTS

The funding for this research was made possible by NSF-ITEST grant DRL-1433747. With the deepest gratitude I would like to thank my committee chair and apparent (at least as deemed by my four-year-old son) 'best friend,' Dr. Margaret Blanchard. (I *must* hold Meg in high regard and in frequent conversation, if my son, Gianni, perceives Meg as such an integral part of my life.) I appreciate the trust and confidence that she had in me to bring me on board as the research assistant on the STEM Career Clubs project. The Science House at NC State has been my work base for the last year and a half and I would like to thank Dr. Jason Painter (PI) and Scott Ragan for their continued support, as well as other faculty and staff members working with the STEM Club Project: Dr. DeLeon Gray, Dr. Cameron Denson, and Braska Williams, Jr. Additionally, I want to especially thank my fellow science education doc student and graduate assistant, Kylie Hoyle (A.K.A. "the new Kristie" who was, previously, "the new Meredith"). She has served as my support, confidant, and friend through the trials and tribulations that is the 'Year of the Dissertation.' Everyone I have mentioned to this point has been willing to stay just a little later after a club meeting to help interview families, deliver intervention goodie bags to the clubs, travel to a club meeting in my place so I could get just a few more hours of writing done, or act as my hands when I was at a conference and could only virtually attend a STEM club parent meeting. I would be remiss if I did not thank all of the teachers, administrators, and district leaders in our STEM Career Club districts each of whom have played an integral part in this research from collecting consent forms, leading club activities, collecting at-home intervention materials, and ensuring that students have completed surveys. I am thankful that you did not begin blocking my emails—my many, many emails. Those favors and sacrifices have not gone unnoticed. I am grateful that I am able to work with awesome educators whose

mission is student success over personal acknowledgment. I look forward to continued relationships with the members of this team for many years to come.

If Meg thought she was going to get away with only a couple of lines in the first paragraph, she doesn't know my bulky writing style as well as she thought. Well…I am sure she does by now, after the numerous drafts she has reviewed to help get this dissertation in the shape you see today. Not only has Meg seen me through the length of this dissertation process as my committee chair, she has taught me the ins and outs of academia from research, to conferences, to publications, and even some of the not so glamorous required duties of academia. She has always kept it "real" and I respect her unwavering dedication to her work and to her family. But thankfully it has not been all work and no play. I will miss our occasional summer afternoon pool days after a grueling morning of coding or writing those summer research proposals, and our long car ride conversations to and from our STEM Club Meetings, and PD sessions. For all of this, and more, I am eternally grateful.

I have also been privileged to have a supportive dissertation committee who has helped me to grow in various ways as a professional. I would like to thank Dr. Catherine LePrevost for guiding me through the process of scientific academic writing, from inception to publication of my minor exam. She has consistently provided valuable feedback on my writing and has been a great colleague and friend. Dr. Patricia Simmons invited me to intern in her undergraduate science methods course in order to gain insight and experience working with pre-service teachers. She has provided valuable suggestions to help guide my dissertation proposal into the research stage. Finally, I was extremely lucky to get to work with Dr. Miriam Ferzli in the Biological Sciences Department at NC State University upon my arrival in the science education Ph.D. program. As a teaching assistant in biology labs, I was immediately impressed by her

professional demeanor, obvious mastery of her subject area, and her use of innovative teaching strategies in both her traditional and scale up classrooms. Her rigorous course requirements and the high standards that she consistently sets for her students are elements that I will take into my own courses as I enter the world of academia. I would like to thank each of my committee members for their unwavering support and flexibility through this arduous dissertation process.

Over the last three years in the science education program at NC State University, I have had the privilege to learn and grow through my interactions with members of my cohort. I am thankful that the Science Education Ph.D. program fosters unique diversity and encourages us to use each other as "more capable peers." To each of you who have impacted my learning trajectory, I thank you and look forward to crossing paths with you in the future: Alonzo Alexander, Osman Aksit, Courtney Behrle, Emily Cayton, Katherine Chesnutt, Gina Childers, Elysa Corin, Stephanie Grady, Kathleen Gray, Rebecca Hite, Kylie Hoyle, Huei-Chen Lao, Lindsay Lewis, Sarah Luginbuhl, Mariana Pereya, James Sanders, Rebecca Stanley, Sam Wheeler, and Jared Williams. A special acknowledgment goes out to fellow doctoral student, Dell Tolin, who has been my go-to 'statistics guru' through this dissertation process; thank you.

This dissertation would never have been possible without the unwavering support of my family. When I made this decision to go back to school for my doctorate, it was going to be all or nothing. We were living in Charlotte, NC and knew that this commitment would require me to resign my high school teaching position and uproot my family closer to NC State in Raleigh, NC. We were supported in this decision by my father-in-law and mother-in-law, Jesse and Rita Gutierrez. When needed, Rita dropped everything for several weeks and flew out from California to help take care of our son during the day, so that my husband and I could continue

working and I could finish classes. Jesse and Rita have always had kind and supportive words and prayers to help me finish this path I started on three years ago.

My parents, Neil and Carolyn MacDonald, have always been supportive of higher educational opportunities and have done everything, and I mean EVERYTHING, in their power to help me make it through these last three years. When a big paper is due—"*Gianni, you're going to be staying at Mac and MeMaw's today"* (my dad and mom, Gianni's grandfather and grandmother); I have to be in Raleigh by 7:45 for an 8:00 lab—"*Gianni, Mac will be here when you wake up to get you dressed and ready for school*"…you get the idea. I have to have been born to the most selfless parents a child could ask for. For everything they have done and continue to do for me and my family, I am wholeheartedly appreciative.

Finally, the last three years, and particularly this final year, has required a lot of sacrificed family time. No one said that this process would be easy, but I feel as if I owe the biggest thank you's to my husband, Giovanni Gutierrez, and my son, Gianni, for rolling with the punches. Weekends were no longer a time for rest and family time often had to be postponed. Gianni has learned to tell people that "*Mommy is a scientist*" and that "*She is almost done with her big paper*." He has even added into his prayers for God to "help mommy's big paper write itself—automatically" …I have no idea where he got that from! He has been such a strong supporter for such a small boy. I am happy that he looks at me with admiration for what I have accomplished, but I am definitely ready to have my family back. My husband has learned to live in a small town but yearns for the day we move back to the 'big city.' He also had to change jobs because of the move and became the primary breadwinner for the family for the last three years. Each time I was tasked with a creative product for a class project or needed sections of audio data cropped and compressed…well, anything digital or artistic, he was always there for me. He has

been my cheerleader (and yes, I've seen his high school Powder Puff football pics) and my main support system when I did not know if I could keep going. He has also been my solid rock through this station in our live journey…for this, and so much more, I thank you and I love you! I began this journey because I was at a point in which I needed a motivational boost in my career trajectory and wanted to open more doors for myself and my family. I end this part of the journey having set a positive example of work-ethic for my son, gained many valuable professional experiences, and having established awesome personal and professional relationships for the future.

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CHAPTER ONE

Introduction

Worldwide, people still experience daily and seasonal variation in temperatures and precipitation (weather), but have a hard time discerning regional long-term patterns over 30 or more years (climate) from day-to-day or year-to-year fluctuations (Leiserowitz, 2012). There has been a substantial gain in the last decade in the number of Americans who "believe" that climate change is occurring; however, the extent to which climate change is occurring, who or what the main contributors to climate change are, and the amount of content knowledge about climate change is still variable in the American population at large (Leiserowitz, Maibach, Roser-Renouf, Feinberg, & Howe, 2012). In a Gallup poll of Americans from 1998-2014, between 62% and 75% of those surveyed thought that global warming was happening or would happen in their lifetime, but only 25% to 40% believed it would pose a serious threat to their way of life (Jones, 2014). In a study conducted by the *Yale Project on Climate Change*, Leiserowitz, Smith, and Marlon (2010) found that while about 63% of Americans believe global warming is happening, only 8% of Americans scored an *A* or *B* on climate change knowledge, with the majority (52%) receiving an *F*.

Efforts to introduce the scientific evidence, mitigation strategies, and adaptation of climate change into the K-12 classroom is underway (Bofferding & Kloser, 2014). One goal of the Next Generation of Science Standards (NGSS Lead States, 2013) is to emphasize global climate change at all secondary education levels through the *Earth and Science* core ideas. The NGSS standards designed for middle school state:

> 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 (NGSS, 2013 p. ESS3.D).

These progressive standards have been adopted in approximately a quarter of the United States; however, there are some states that have reservations, especially those with strong positions against teaching more controversial topics, including climate change (Robelen, 2013).

The Science of Climate Change

Climate refers to the long term weather patterns occurring over a region within a 30-year window (KSC, 2015). Global climate change takes into account various parameters that fall under the umbrella of 'climate' such as the average temperature, amount of precipitation, and occurrence of severe weather events. The trends in these environmental parameters are currently fluctuating and are predicted to continue changing, affecting regions of the world differently. Anthropogenic global warming (AGW), warming due to the activity of humans, has occurred due to the excessive use and release of greenhouse gases. These gases are primarily carbon dioxide, methane, and nitrous oxide, released through the combustion of fossil fuels in the industrial and transportation sectors (Shepardson, Niyogi, Choi, & Charusombat, 2011; Stocker, Qin, Plattner, Tignor, Allen, Boschung, Nauels, et al., 2013). These gases trap radiation from the sun, increasing the average global temperature, much like a greenhouse traps radiation from the sun, creating a warm, sunlit environment for plant growth. Over the last century, the annual average global temperature has continued to rise, causing an increase of surface air temperatures over land and oceans (Stocker et al., 2013). Anthropogenic global warming is now considered to be a driving force in melting polar icecaps and glaciers and causing sea level to rise 17 cm in the last century (Anderson, Boesch, Burkett, Carter, Cohen, Grimm, Hatfield, et al., 2009; Church & White, 2006; Stocker et al., 2013). Average global temperature has risen (especially over the last 20 years), oceans have warmed about 0.3^{o}F since 1969, and the acidity levels in oceans has

increased by 30% since the beginning of the industrial revolution (NOAA, 2015; Anderson et al., 2009; Levitus, Antonov, Boyer, Locarnini, Garcia, & Mishonov, 2009; Stocker et al., 2013).

Anthropogenic climate change will create serious problems for human health, economics, and the security of resources and safety (Melillo, Richmond, & Yohe, 2014; Stocker et al., 2013). For example: temperature extremes and seasonal shifts have caused an additional strain on the energy infrastructure, farmers have had to reassess crop type and land use as droughts have caused a reduction in crop yields, lightning strikes have increased wildfire incidences, and sea level changes have caused salt water intrusion and increased storm surges (Anderson et al., 2009). Drought, seasonal changes in growing seasons, and increased temperatures are expected to affect breathing and lung function due to an increase in air pollutants, allergens, and breathable ozone (Portier, Tart, Carter, Dilworth, Grambsch, Gohlke, Hess, et al., 2010). Portier et al. (2010) also assert that agricultural food supplies will be affected by the increasing blasts, rusts, blights, and rots that are affected by climatic conditions which drive prices up. Anxiety and emotional stress in populations affected by increases in extreme weather events due to a changing climate are expected to rise (Berry, Bowen, & Kjellstrom, 2010). Additionally, the habitat reach of vector-borne or zoonotic diseases (spread between animals and humans) are expected to expand due to the changing climate (Portier, et al., 2010). Climate change is a global issue; yet, it affects individuals and families in a personal way at the local and regional level. Given these impacts, it is essential to communicate scientific information in meaningful ways to students and their families.

Climate Change Communication Challenges

Climate literacy is a movement to introduce the public to the importance of understanding the Earth's climate, the impacts of climate change, and to outline the various

approaches to mitigating and adapting to climate change (United States Global Change Research Program, 2009). It is challenging to introduce climate change curricula into K-12 classrooms today (Robelen, 2013). However, it can be even more challenging to convey climate science to adults in a scientific and compelling manner (Sterman & Sweeney, 2007). Regional, state, and local communities have their own unique challenges related to climate literacy. For example, in the southeastern United States, approximately 40% of adults were found to be disengaged, doubtful, or dismissive toward climate change, which was comparable to the reported national average (Leiserowitz, Maibach, Roser-Renouf, Feinberg, & Howe, 2012). Interestingly, when these statistics were broken down by state, the percentage of individuals who were disengaged, doubtful, or dismissive was higher, at 45-50% in several southeastern US states (Adams, Monroe, Plate, & Wojcik, 2011).

Climate communicators have a tough job, due to preconceived notions of individuals, whose experiences with the topic of global climate change comes from a wide variety of perspectives (Moser, 2010). Thus, it is important to understand frameworks by which to approach one's audience that incorporate economic development, personal health, morality and ethics, scientific uncertainty, and conflict and strategy (Nisbet, 2009). Recently, research efforts in K-12 schools related to climate change have become more prevalent and national polling organizations continually contact American adults for their thoughts on human-induced global warming (McCaffrey & Buhr, 2009).

Public apathy toward climate change has been blamed on the idea that the public was not well-enough informed about the science behind climate change (known as the *knowledge-deficit* model) (Kahan et al., 2012). Kahan et al. found contradictory evidence; individuals' interests, and not scientific understanding, contributed the most to their personal perception of climate

change risk. Kahan et al. determined that individuals often form beliefs that match their scientific understanding but also align their beliefs with people "with whom they share close ties" (i.e., parents, friends, religious leaders) (p. 732).

In work by Stevenson, Peterson, Bondell, Moore, and Carrier (2014), the researchers recommend that ethnicity and gender should also be considered when developing climate literacy interventions. Non-White adolescents and female adolescents in the Stevenson et al. study were more likely to accept anthropogenic global warming as true as compared to White and male adolescents. The student population within this study is vastly different than the current study. While both populations are similar in geography as both are located in the Southeastern US there are significant differences in the demographic makeup of the student populations. Three out of the four schools in the current study are Title I schools (signifying high percentages of low income students), while the Stevenson et al. study had a ratio of Title I schools more reflective of the study state. Additionally, only 15.6% of students in the Stevenson et al. study were African American, as compared to 53.9% in the current study.

Theoretical Framework

The theoretical framework for the basis of this study, the Determinants of Behavior (DOB) Model, was created by Patchen (2010). Patchen's model (Figure 1.1) was informed by other popular environmental behavior models including the Theory of Planned Behavior (TPB) (Ajzen, 1991), Value-Belief-Norm (VBN) Theory (Stern, 2000), Structural Model (Grob, 1995), Appraisal Theory (Scherer, 1999), and others related to habit, identity, knowledge, influences, and behaviors of others. Patchen found that these different, established theoretical frameworks addressed many similar components of environmental behavior. He found that "none of them alone is adequate to encompass the wide range of research findings concerning such behavior

and specifically behavior at countering climate change" (p. 49). This newly generated framework relies heavily on the TPB and Appraisal theories (Patchen, 2010).

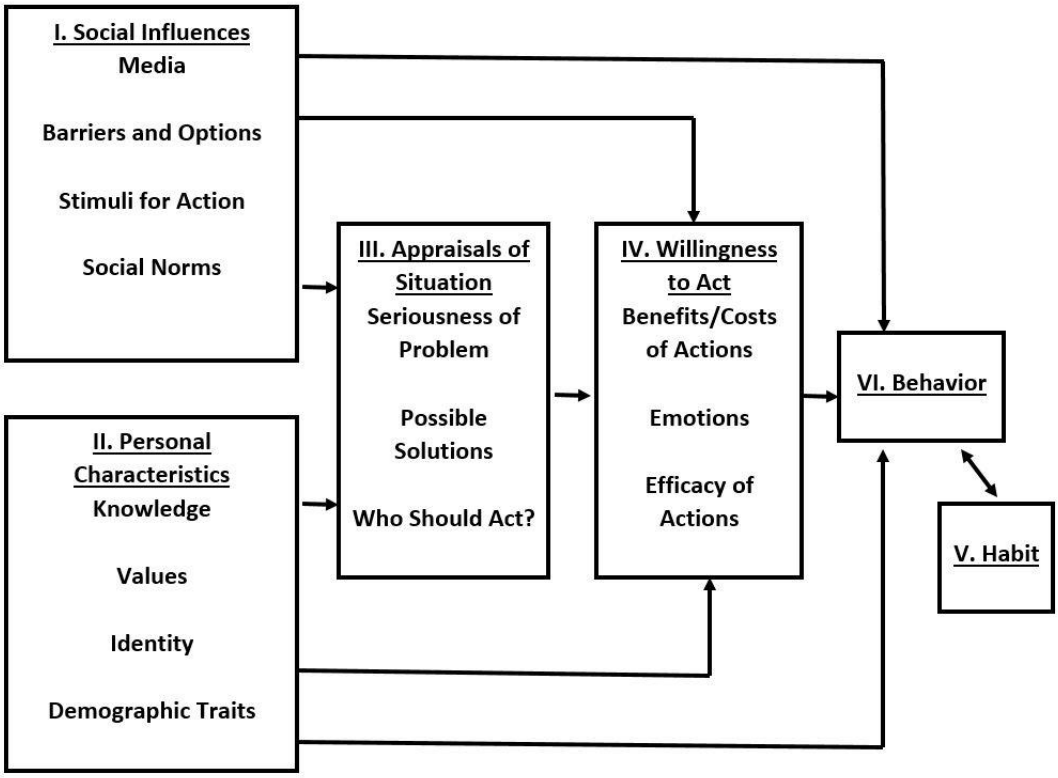

Figure 1.1. Adapted from the Determinants of Behavior (DOB) model of climate change (Patchen, 2010), Roman numerals added.

In order to fully understand the theory leading to the development of this broad framework, it is essential to first gain insight on the two main frameworks that influenced the current model: The Theory of Planned Behavior (TPB) and Appraisal theories. The TPB asserts that human behaviors are dependent on one's motivations and intentions and on a person's ability to have control over his or her behavior. The original TPB developed by Ajzen (1991) is has been altered throughout the years to address additional components of behavior, including beliefs (i.e., behavioral, normative, and control) and actual behavioral control. In an updated model shown in Figure 1.2, there are six identified components that lead to an individual's

formation of intentions (an indication of an individual's readiness to behave in a certain way), which then may lead to actual changes in behavior (observable response by the individual), based on whether or not the behavior can actually be controlled by the individual (Ajzen, 2006).

(1) *Behavioral beliefs*: The individual's belief in the probability that the behavior will actually lead to a given outcome.
(2) *Attitude toward the behavior*: The degree to which the individual either positively or negatively values the behavior, given the strength of their behavior beliefs regarding whether the behavior will result in the expected outcome.
(3) *Normative beliefs*: The perceived belief of the individual that the behavior will align with important individuals in his or her life (e.g., spouse, parents, family, friends).
(4) *Subjective norm*: The perceived social pressure to behave in a certain way; often heavily influenced by normative beliefs.
(5) *Control beliefs*: The perceived factors that may assist or impede performance of a behavior.
(6) *Perceived behavioral control*: The individual's perception of the difficulty or ease of performing the behavior successfully, and influenced by their control beliefs. (Ajzen, 2006)

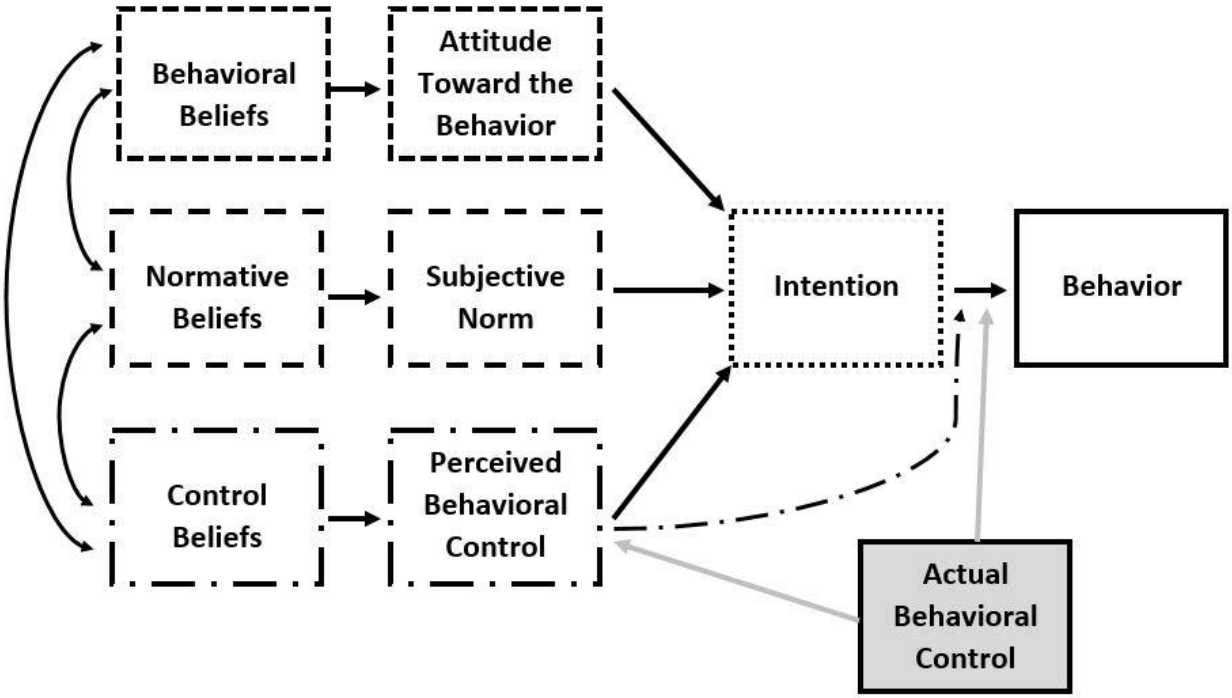

Figure 1.2. Updated version of the Theory of Planned Behavior (TPB) diagram (Ajzen, 2006).

Additionally, Patchen's (2010) DOB model was heavily influenced by Scherer's (1999) Appraisal Theory model. Scherer asserts that "emotions are elicited and differentiated on the basis of a person's subjective evaluation or appraisal of the personal significance of a situation, object, or event on a number of dimensions or criteria" (p. 637). The appraisal theory purports that we appraise or evaluate things continually and then assess them based on known criteria. Following that assessment, individuals will feel emotions based on the appraisals. Lazarus (1991), who worked with earlier versions of the Appraisal Theory, acknowledged that individuals assess how personally important an event is (primary appraisal) and then determine their ability to do something about the situation (secondary appraisal). The Appraisal Theory is integrated into Patchen's model (see Figure 1.1) in both the middle sections of the model, "Appraisals of the Situation" and "Willingness to Act."

The DOB model (Patchen, 2010) also includes factors that were not explicitly included in any one model from previous environmental behavior work. The DOB model is thorough and descriptive in its diagram. The model shows the unidirectional influential relationship between the majority of the constructs within the model; however, there is a bidirectional relationship between behavior and habits. Patchen explains that the habits (the repetition of the same behaviors) will also be affected, in the long-term, by the same factors that lead to behavioral changes.

Purpose Statement

The purpose of this study was to provide rural middle school students and family members with researcher-designed climate change interventions and to assess the extent to which climate change content knowledge, beliefs, and behavior are altered following the interventions. There is a wealth of literature concerning climate change literacy and beliefs in K-12 classrooms that

explores teacher-student interactions (e.g., Busch, 2014; Mutiso, Kibett, & Obara, 2015; Ojala, 2015). However, this study took place in informal settings (i.e., after school STEM club, within family homes) and included family members. By involving the family, the study aimed to first assess and then impact the knowledge, beliefs, and behaviors of students and their families regarding climate study design.

The involvement of students and their parents/guardians in climate change interventions sought to personally connect families to local climate change effects and mitigation strategies and encouraged them to develop a personal perspective to climate change education. An embedded mixed methods design was used. First, quantitative data was collected to gain an understanding of climate change content knowledge, beliefs, and worldviews of both participating students in an after school STEM Career Club and their parents/guardians. Post measures allowed the researcher to measure any changes from the intervention. This design also collected qualitative data to understand how parents and guardians communicated with their children about climate change. Audio data helped to triangulate content knowledge, beliefs, worldviews, and behaviors of students and their parents. Students (N = 96) from four middle schools in rural districts in the southeastern United States participated. All parents of these students were invited to participate in further out-of-school interventions with their children during an evening parent meeting and, for a random subset of families, at-home activities. The range of data collection methods employed provided rich, contextualized data to better understand the participants' beliefs, knowledge, worldviews, and behaviors related to climate change. This study not only informed the researcher about the knowledge and beliefs of this rural population, but also provided insight into ways to promote the relevance of climate change to this population.

Research Questions

For rural middle school students and their parents in the southeastern US engaged in a climate change intervention:

1. Are there changes in students' beliefs and content knowledge about climate change?
2. What are students' worldviews and what factors (i.e., school, grade, gender, ethnicity, and religious beliefs) most correspond to students' worldviews?
3. What are the relationships among students' climate change beliefs and knowledge, worldviews, and demographic factors?
4. What underlying factors are most often addressed by families while watching at-home climate change documentaries and during interviews?
5. How do parents and their children talk about climate change during the at-home intervention and through interviews?
6. Does the level of engagement during the at-home intervention relate to family change in climate change beliefs and content knowledge?

Summary

In this first chapter, climate change was introduced as the topic of study, the importance of the study for parents/guardians and students was examined, the theoretical framework and purpose of the study was introduced, and research questions for this study were outlined. Chapter 2 reviews all of the pertinent literature that is essential for this study. Chapters 3 and 4 are compiled as full manuscripts, ready for journal submission, each including a targeted abstract, introduction, literature review, theoretical framework, research questions, methods, results, and conclusions. Chapter 5 synthesizes the conclusions of the two unique manuscripts from Chapters 3 and 4 to paint an overall picture of the information and insight gained from the

holistic study. Lastly, implications for the development of intervention activities for middle school students and their parents will be examined, along with ideas for future research.

CHAPTER TWO

Literature Review

Climate Change as a Global Issue

There are no national or international borders that can contain climate change impacts. Often it is the most vulnerable populations, who are least able to combat climate change and who have contributed the least to greenhouse gas emissions, that are most likely to be the most negatively impacted (Nema, Nema, & Roy, 2012; Obama, 2014). In November and December 2015, the United Nations held a conference on climate change (COP21) in Paris, France. Over 25,000 people were involved with the conference, including "150 Heads of State and Government from around the world (including Barack Obama from the US, Xi Jinping from China, Narendra Modi from India, and Vladimir Putin from Russia)" (COP21, 2015, p. The world at Le Bourget, para 2). This conference brought together 188 countries in their commitment to reduce greenhouse gas emissions. It was substantially more than the 30 countries who committed to the Kyoto Protocol in 1997. At the UN Climate Change Summit in 2014, United States President Barack Obama stated,

> "…there's one issue that will define the contours of this century more dramatically than any other, and that is the urgent and growing threat of a changing climate. … No nation is immune. … We cannot condemn our children, and their children to a future that is beyond their capacity to repair. Not when we have the means—the technological innovation and the scientific imagination—to begin the work of repairing it right now" (Obama, 2014).

Adults and individuals within the current workforce are responsible for beginning work toward a more sustainable future through technological advances in clean energy, carbon emissions reduction, and adoption of national policies relative to climate change mitigation. However, it is equally important to begin involving youth, at an early age, in the future movement of climate

change mitigation through STEM education, behavior changes in their homes and communities, and involvement in public climate change mitigation outreach opportunities (NRC, 2012).

Climate Change Science, Misconceptions, and Knowledge and Beliefs Constructs

Climate Change Science

There are four major environmental factors related to climate change: temperature, precipitation, sea level, and extreme weather. The geographic range and extremity of these changes are variable worldwide. There already is historical evidence to support the assertion climate change has been, and is, currently happening. In addition, scientists predict that the changing climate will continue to have lasting effects on the future of our planet for the foreseeable future. These changes will impact the health, economics, and security of nations worldwide and will have increasingly severe impacts on already vulnerable populations (i.e., the impoverished, geographically isolated, the young and elderly) (Shepard & Corbin-Mark, 2009).

The Intergovernmental Panel on Climate Change (IPCC) (Stocker et al., 2013) documents that in the last 50 years, daily minimum temperatures have increased faster than the daily mean or maximum temperatures. Since 1970 there have been increasing numbers of days above 95°F and nights above 75°F, and decreasing numbers of extremely cold days (Kunkel, Karl, Brooks, Kossin, Lawrimore, Arndt, Bosart, et al., 2013). Atmospheric modeling programs predict that major climatic effects, such as El Nino events caused by an increase in anthropogenic global warming (AGW), are projected to increase (Cai, Borlace, Lengaigne, van Rensch, Collins, Vecchi, Timmermann, Santoso, et al., 2014). Major cities have reported increases in heat-related deaths relative to an increasing number of 95°F and above days since the last quarter of the 20th century (Sheridan, A. Kalkstein, & L. Kalkstein, 2009). There also

have been seasonal changes in regions around the world negatively affecting crop variety and production in areas where crops historically flourished (Backlund, 2009).

Trends in precipitation are anticipated to fluctuate dramatically at the regional scale; while some areas will frequently flood, other areas will be in severe drought. The IPCC has data showing that incidences of flooding, as well as drought, have increased substantially in the last three decades (Parry, Canziani, Palutikof, van der Linden, & Hanson, 2007). These alternating conditions can cause secondary problems when drought and intense thunderstorms contribute to an increase in soil runoff and erosion, affecting crop yields (Riha, Wilks, & Simoens, 1996). Rural areas covered by forest and dense agriculture may be slightly better suited for flooding conditions due to the pervious land cover, as compared to the impervious cover of urban environments, such as road pavement and concrete sidewalks (Sheppard et al., 2011). Flooding, as a result of an increase in heavy rains or tropical events, as well as sea level rise, may impact water and sewage treatment facilities and waste lagoons (Portier et al., 2010). These events will also introduce waterborne pathogenic microorganisms, including protozoa, parasites, bacteria, viruses, amoebas, and algae (Batterman, Eisenberg, Hardin, Kruk, Lemos, Michalak, Mukherjee, et al., 2009).

Changes in sea level due to rise, storm surge, and salt water intrusion related to the changing climate is occurring along coastlines worldwide. Along the eastern coast of the US, models have shown that there is a heightened Atlantic hurricane surge in warmer conditions and that it is further exacerbated by sea level rise (Grinsted, Moore, & Jevrejeva, 2013). Home and infrastructures will be lost to individuals in these coastal communities and insurance in these areas are expected to rise (Leurig & Dlugolecki, 2013). As affected coastal regions are losing land and homes to sea level rise, former potable fresh water wells have become unusable due to

intruding saltwater (Ammon, Barnes, Cadavid, Carnes, Hoppes, Irizarry-Ortiz, McBryan, et al., 2009; Carter, Jones, Berry, Burkett, Murley, Obeysekera, Schramm, et al., 2014; DOT, 2002). Saltwater intrusion will affect the irrigation potential of agricultural ventures, decreasing crop production potential in affected areas (Jones, Hatch, Murray, Jagtap, Cruise, & Yields, 2001). Also, mental and stress-related disorders (e.g., post-traumatic stress disorder (PTSD), grief, depression, anxiety, sleep difficulties, social avoidance, and alcohol or drug abuse) among individuals affected by extreme weather along the coast have been found to increase (Silove, Steel, & Psychol, 2006).

Extreme weather event (e.g., hurricanes, tornadoes, winter storms, thunderstorms) frequency and extremity are expected to vary regionally. The frequency in the number of tropical storms and hurricanes is not projected to increase; however, the storms that do form will increase in intensity (i.e., Category 4 and 5 storms) (Knutson, McBride, Chan, Emanuel, Holland, Landsea, Held, et al., 2010). Thus, there may be even greater economic repercussions for those living within the paths of these storms (Knutson et al., 2010). The conditions that lead to strong thunderstorms and subsequently, tornadoes, are expected to increase with atmospheric warming; however, predictions are less clear on whether the frequency or severity (i.e., F3-F5 tornadoes) will increase (The National Academy of Sciences and the Royal Society, 2012). Climate change not only will alter globally averaged surface temperature, but also changes in atmospheric circulation. Thus, occasionally stronger winds from polar regions will still continue to cause colder than average winters and winter storms in some regions (National Aeronautics and Space Administration (NASA, 2016).

Direct relationships between human health and cold temperature are not as blatantly pronounced as compared to hot temperatures; thus, linking cold weather and death rates has been

more difficult to determine (Laschewski & Jendritzky, 2002). However, power outages with winter storms are often associated with decreased air quality in homes as a result of carbon monoxide and particulates from wood and coal-burning stoves and fire places, as well as gas or diesel generators (Bond, Streets, Yarber, Nelson, Woo, & Klimont, 2004). Lastly, the frequency of severe thunderstorms has increased in regions over the last few decades due to increases in wind shear and humidity (Kunkel et al., 2013). The resultant lightning strikes have increased the frequency of wildfires, which affect wildlife habitat, home and infrastructure loss, and air quality (Carter et al., 2014). Decreased air quality can exacerbate asthma, respiratory allergies, and airway diseases, reducing lung function (Portier et al., 2010).

Climate Misconceptions

Leiserowitz et al. (2010; 2011) indicated "important information gaps in knowledge and common misconceptions about climate change and the earth system" for both adult and teen populations (2011, p. 5). Although certain disciplines have shifted to the term, 'alternative conceptions,' the fields of climate science and climate communication still use the term 'misconception.' Thus, 'misconception' will be used throughout this text to refer to knowledge that is at odds with scientific knowledge. Climate change literacy among middle school students and their parents or guardians can be challenging for communicators due to the misconceptions, risk perceptions, and cognitive and affective barriers of individuals (Stevenson, Peterson, Bondell, Mertig, & Moore, 2013). Lombardi, Sinatra, and Nussbaum (2013) note that many people view human-induced climate change as implausible. The authors contend that, in order to change these conceptions as people learn about climate change, individuals will need to make plausibility judgments that are both critical and reflective about scientifically accepted models of

climate change. Only then will individuals be able to make a significant conceptual shift in their climate change understanding and beliefs.

Mitigation aims to reduce the impacts of climate change, whereas *adaptation* helps populations cope with the impacts of climate change (Laukkonen et al., 2009). Bofferding and Kloser (2014) found that even after engaging middle school students in an instructional unit about climate change mitigation and adaptation, several student misconceptions remained. The terms *mitigation* and *adaptation* were often still conflated, even though students showed stronger environmental system (earth-climate system) knowledge and pro-environmental action (behaviors) knowledge. Students often mistakenly believe that global warming is caused by particulate air pollution and that ozone depletion is the driving factor in global warming, as opposed to the warming of the atmosphere due to the increase in greenhouse gases (e.g., carbon dioxide, methane, nitrous oxide, water vapor), as supported by scientific evidence (Shepardson et al., 2011). Shepardson et al. also found that students do not perceive that global warming nor climate change have any real, perceived consequences in their own lives.

Along the same lines, Bodzin, Anastasio, Sahagian, Peffer, Dempsey, and Steelman (2014) investigated climate change knowledge in urban 8th grade students and found a lack of student understanding about weather and climate concepts, the composition of Earth's atmosphere and greenhouse gases, and anthropogenic sources contributing to climate change. Bodzin et al. suggest specific recommendations for implementing curricula to help address climate change related misconceptions. These include exploring temperature and precipitation trends over a 50-60-year period, integrating human impact on the carbon cycle, and investigating the implications of human population increases and sea level rise. McCaffrey and Buhr (2009) also found climate change misconceptions problematic and recommended that effective mental

models and strategies can overcome these misconceptions and should be integrated into teacher professional development. They also explained the need to equip educators with the proper resources (e.g., current and accurate tools and resources) to be able to explain climate change topics.

Knowledge and Beliefs Constructs

Climate change content knowledge and beliefs have been an active areas of research in the United States and worldwide. Both adults and K-16 students have been surveyed and polled to gain insight into the depth of their climate change knowledge and their associated climate change beliefs. Most recently, Leiserowitz and his fellow researchers on the Yale Project on Climate Change Communication surveyed adults and teenagers (13-17) to access their knowledge of climate change. The instrument they used also addressed beliefs about anthropogenic climate change as well (Leiserowitz et al., 2010; Leiserowitz, Smith, & Marlon, 2011). Results from both the adult and teen surveys indicated "important information gaps in knowledge and common misconceptions about climate change and the earth system" (Leiserowitz et al., 2011, p. 5). Interestingly, climate change trust for scientists and scientific organizations was relatively high, but respondents self-reported a lack of understanding of climate change. In a recent study, Bolsen et al. (2015) found that the ideological divide over the cause of global warming "gets significantly larger dependent on the respondents' knowledge about politics, energy, and science" (p. 271). For example, 90% of energy scientists believe there is global warming but still 19% express uncertainty about humans' role in the process. There also is a political divide in the United States; "Democrats and liberals are more likely to accept the scientific consensus regarding the reality of global warming, while conservatives and

Republicans are significantly less likely to express a belief that is consistent with the scientific consensus on this issue" (Bolsen et al., 2015, p. 286).

Climate Communication, Framing, and Worldview Construct

Climate Communication

Individuals perceive climate change risks differently. Early work by McDaniels, Axelrod, and Slovic (1995) found that ecological risk perceptions vary in relation to five factors: impact on species, human benefits, impact on humans, avoidability, and knowledge of impacts. Research participants organized 65 items according to how much potential risk they involved including natural disasters, technologies and their applications, human practices that may be seen to have negative environmental impacts, and human beliefs and political/social systems. On this instrument, individuals ranked climate change as having a potentially important impact on humans, not easily avoidable, and having little knowledge of its impacts. Leiserowitz (2006) found that the American public has a moderate risk perception of climate change. This is due, for the most part, to their perceptions of its danger to geographically distant people, places, and non-human life. However, in a more recent study by Shao, Keim, Garand, and Hamilton (2014), the authors found that those who have experienced negative impacts of the changing climate, such as increased summer heat or drought, are more likely to perceive the risk and severity of global warming. Their study also indicates that demographic factors such as age, gender, and race influence risk perception; youth, women, and racial minorities were more likely to indicate higher concern about global warming. Risk perceptions are important to consider when predicting people's behavioral intentions (Mead et al., 2012). However, the researchers concluded that knowledge and general environmental beliefs also play integral roles in predicting

positive environmental behaviors such as reducing their carbon footprints or supporting environmental programs through tax increases.

Gifford, Kormos, & McIntyre (2011) identified barriers for pro-environmental behaviors related to climate change including structural (e.g., poverty and climate-averse infrastructure) and psychological (e.g., limited cognition, perceived risks, social norms). These behaviors may include reducing their carbon footprints by minimizing bottled water and plastic bag usage, carpooling, or increasing carbon sinks by planting trees (Bofferding & Kloser, 2014; Bolderdijk, Gorsira, Keizer, & Steg, 2013). Semenza, Hall, Wilson, Bontempo, Sailor, and George (2008) urge changes in governmental policy to help eliminate economic, structural, and social barriers to behavior change. Some of the barriers most often cited in the Semenza et al. study include: not knowing how to change behaviors, not believing that one person's change would make a difference anyway, and not having enough money and time to make changes. Steg, Bolderdijk, Keizer, and Perlaviciute (2014) stress that pro-environmental actions need to be made more "convenient, fun, cheaper, or less effortful as to make such actions more attractive" (p. 105).

Not only do barriers exist for behavior change, but there are information barriers for climate change communicators (Nisbet, 2009). In order to break through these barriers, Nesbit insists "messages need to be tailored to a specific medium and audience, using carefully researched metaphors, allusions, and examples that trigger a new way of thinking about the personal relevance of climate change" (p. 15). In many cases, frames are not effective unless they align with their audience's preexisting interpretation of climate change (Nisbet, 2009). Nisbet also asserts that the world continues to become increasingly connected and news sources (e.g., cable television, internet news, social media), both reliable and unreliable, are abundant. Popular news sources have begun to cover climate change stories more frequently; however,

public readership has shifted from news outlets "such as the *New York Times* and *Washington Post*" to more social forms of communication such as Facebook and Twitter (Nisbet, 2009, p. 15).

Age appropriate effective teaching and learning strategies are essential to stimulate changes in students' knowledge, beliefs, and behaviors. Lombardi et al. (2013) stress the importance of teaching students the skill of collaborative argumentation, when individuals "work together to compare, critique, and revise conceptions" (p. 53). Students also need to build their skills in weighing evidentiary data. Chin and Buckland (2012) introduce a specific model of instructional scaffolding called the model-evidence link (MEL), in which students make arguments by weighing conflicting evidence. Argumentation skills are encouraged and expected for K-12 students in the Common Core standards (2012) and Next Generation Science Standards (2013). Teaching students the skills necessary for building their own scientific understanding from materials is an important learning strategy for climate change education (Sadler, 2011). Stevenson et al. (2013) also found students' relationships with the outdoor environment and pro-environmental attitudes and behaviors can be strengthened with time spent outdoors.

When working with populations, especially when addressing controversial issues such as climate change, it is important to examine demographic factors and the relationship between school and home cultures specific to the population of study (Adger, Barnett, Brown, Marshall, & O'Brien, 2012; Leiserowitz, Maibach, Roser-Renouf, Smith, & Dawson, 2012). Woolley, Strutchens, Gilbert, and Martin (2010) found that greater use of reform-based practices and higher teacher expectations and standards increased the motivation of all students, but particularly African American students. Further, the relationship the student has with his or her teacher directly related to student success.

Research by Stevenson et al. (2013) suggest that minority groups who experience more constraints to natural area access and who are less exposed to the natural environment may demonstrate substantial gains in pro-environmental attitudes and behaviors through exposure to novel natural outdoor experiences. Recognizing that different cultural groups interact with nature at different frequencies and often for vastly different purposes is essential to understanding an individual's relationship with environmental topics such as climate change (Stevenson et al., 2013). Additionally, race/ethnicity should be examined in relation to differences in parental involvement (Bower & Griffin, 2011). Barbarin, McCandies, Coleman, and Hill (2005) found that African American families traditionally spend more time in home-based activities as compared to White families. The formation of parent groups has been especially successful increasing parental involvement with African American families because a group setting allows parents to collectively learn, advocate, and form support networks in a social setting (Martinez-Cosio, 2010).

Rural regions of the United States can pose unique challenges for residents and students. There is no one, true definition of rurality; however, for this research, rural will be defined similarly to the United States Bureau of the Census (2010)—"the U.S. Census Bureau identifies a rural area to be one in which there are less than 2,500 people and all undesignated areas not identified as urban centers." Unfortunately, simply being geographically remote is often not the only issue as "approximately 10 million persons, or 16.3 percent of the rural and small town population, live in poverty. Nearly one-quarter of people in poverty live in rural areas" (Duncan, 2012, p. 1). Many of these rural regions lack resources and opportunities for economic growth. Educational opportunities may be the only way for many rural residents to break free of the persistent poverty that plagues certain regions of the United States including Central Appalachia,

the Lower Mississippi Delta, the southern Black Belt, the Colonias region along the U.S.-Mexico border, and Native American lands (Duncan, 2012). Even though rural populations are characterized by geographic isolation, Burnell (2003) emphasizes the importance of connectedness and personal relationships in these communities. It is perhaps even more essential to connect one's rural identity with locality and connection to place (Semke & Sheridan, 2012). Petrin, Schafft, and Meece (2014) speak to the tie that many rural students have to their communities and many "achievers" are either expected to or desire to return to their home towns following post-secondary education. Their research also indicates that economic opportunities, and not community poverty, is often the strongest factor motivating rural students to be either a 'leaver' or a 'stayer' after high school. This may influence students' decisions to pursue post-secondary educational opportunities in STEM or other areas of study. In regards to educational roadblocks in rural education, teacher turnover is often high in rural regions and high quality teacher professional development is often scarce, potentially impacting student success in rural schools (Blanchard, LePrevost, Tolin, & Gutierrez, 2016).

Climate Change Communication Framing

It is important to understand the proper frames by which to approach one's audience. Table 2.1 from Nisbet (2009) describes various climate communication frames. A message frame is defined by Chong and Druckman (2007) as a type of communication (e.g., words, images, or phrases) whose main purpose is to relay information about a topic or an event to its targeted audience. It has been argued that it is impossible to address the issue of climate change with complete neutrality or without some personal context (Hulme, 2009). Nisbet asserts that it is necessary to present one's audience with the proper conversational frame based on what is known about their overall demographics (i.e., gender, age, political affiliation, religious beliefs,

highest educational level), worldview (i.e. hierarchical/egalitarian and individualist/ communitarian), and cultural influences.

Table 2.1

Climate Change Frames Typologies with Brief Descriptions taken from Nisbet (2009, p. 18)

Frame	Defines science-related issue as…
Social Progress	"A means of improving quality of life or solving problems; alternative interpretation as a way to be in harmony with nature instead of mastering it."
Economic development and competitiveness	"An economic investment; market benefit or risk; or a point of local, national, or global competitiveness."
Morality and ethics	"A matter of right or wrong; or of respect or disrespect for limits, thresholds, or boundaries."
Scientific and technical uncertainty	"A matter of expert understanding or consensus; a debate over what is known versus unknown; or peer-reviewed, confirmed knowledge versus hype or alarmism."
Pandora's box/Frankenstein's monster/runaway science	"A need for precaution or action in face of possible catastrophe and out-of-control consequences; or alternatively as fatalism, where there is no way to avoid the consequences of a chosen path."
Public accountability and governance	"Research or policy either in the public interest or serving special interests, emphasizing issues of control, transparency, participation, responsiveness or ownership; or debate over proper use of science or expertise in decision-making ("politicization")."
Middle way/alternative path	"A third way between conflicting or polarized views or opinions."
Conflict and strategy	"A game among elites, such as who is winning or losing a debate; or a battle of personalities or groups (usually a journalist-driven interpretation)."

Gifford and Comeau (2011) found that women were more likely to support climate change mitigation efforts and felt greater environmental concern, despite scoring lower on related content knowledge questions. In contrast, older participants responded with a greater intent to act in pro-environmental ways but did not feel as if they were equipped or competent

enough to do so. Men were found to be more responsive to framing than women, overall; thus, in television stations with a predominantly male audience, motivational messages, rather than sacrifice messages should be played. Motivational messages involve solutions and visions to problems rather than highlighting things that must be given up, or sacrificed, for climate change mitigation. For a mixed audience, the authors recommend that motivational messages are used over sacrifice messages, in order to reach the broadest portion of the overall audience. Additionally, messages intended for older audiences should strive to build confidence in older populations' capacity to induce climate change mitigating behaviors (i.e., showing how to go about buying new energy efficient appliances, adjusting the thermostat a few degrees up in the summer and down in the winter, and how buying local foods can help mitigate climate change), whereas messages for younger audiences should focus on ways to enhance positive mitigation behaviors (i.e., explaining potential efficient car options and green home options as they begin to earn capital and can financially afford to act in a more pro-environmental manner). While younger individuals may find the mitigation strategies for the older population to be useful as well, younger populations may be more apt to make certain changes in their long-term habits and behaviors over older individuals.

Frames help to organize central ideas, allowing communicators to condense complex issues, such as climate change, to give greater emphasis to the parts of the message that are most salient and meaningful to one's target audience (Nisbet & Mooney, 2007). Spence and Pidgeon (2010) also examined various outcomes of using a gain vs. loss frame dichotomy. Similarly to Gifford and Comeau (2011), when climate mitigation was framed more positively in a gain frame, the audience's sense of personal and societal efficacy was high. The take away message from Spence and Pidgeon's work (2010) is that focusing on potential mitigation efforts ("gain

frame advantage") proved to be a more successful frame than dwelling on the impacts of mitigation inactivity or the losses due to inaction. An additional player in climate framing research is uncertainty. Morton, Rabinovich, Marshall, and Bretschneider (2011) examined the positive vs. negative frame dichotomy with regard to levels of uncertainty in our changing climate. They determined that even if one expresses higher uncertainty toward the existence of climate change, positive or negative framing can dramatically change the audience's perceptions and intentions to act. Higher uncertainty along with a negative frame (loss frame) decreased intentions to behave in environmentally conscious ways; whereas, the same high uncertainty paired with a positive frame (gain frame) created stronger intentions to act in environmentally conscious ways.

Myers, Nisbet, Maibach, and Leiserowitz (2012) further examined how framing climate change in terms of both public health and national security would affect adult audiences in the U.S. A stronger emotional reaction was elicited through the use of a public health focus, which generated substantial support for climate change mitigation and adaptation. However, using concerns about national security to try to stimulate changes in the mitigation and adaptation strategies of participants did not produce changes and even elicited unintended anger in audience members, many of whom were doubtful about or dismissive of climate change.

Worldview Construct

Kahan, Jenkins-Smith, and Braman (2011) developed a short scale to determine basic factors related to an individual's view of the world. In this simplified version of cultural worldview, the authors focus on two dichotomies of how people may see the world they live in: egalitarian vs. hierarchical and communitarian vs. individualist (as shown in Figure 2.1, Kahan, 2012). As shown on the vertical axis, a person who is strongly egalitarian believes in equity for

all, whereas someone with a more hierarchical view believes that human society should be constructed in levels, with some levels holding higher importance than others. Along the horizontal axis is the communitarian vs. the individualist continuum. A person who has a strong communitarian view of the world would support a more cooperative societal structure, whereas an individualist believes that the needs of one are more important than the needs of the whole. Kahan et al. (2011) and Kahan et al. (2012) use these worldview continua in conjunction with other constructs such as scientific literacy, scientific understanding, and numeracy (how people comprehend quantitative information) to determine if science and mathematics content knowledge are significant contributing factors in climate change risk perceptions.

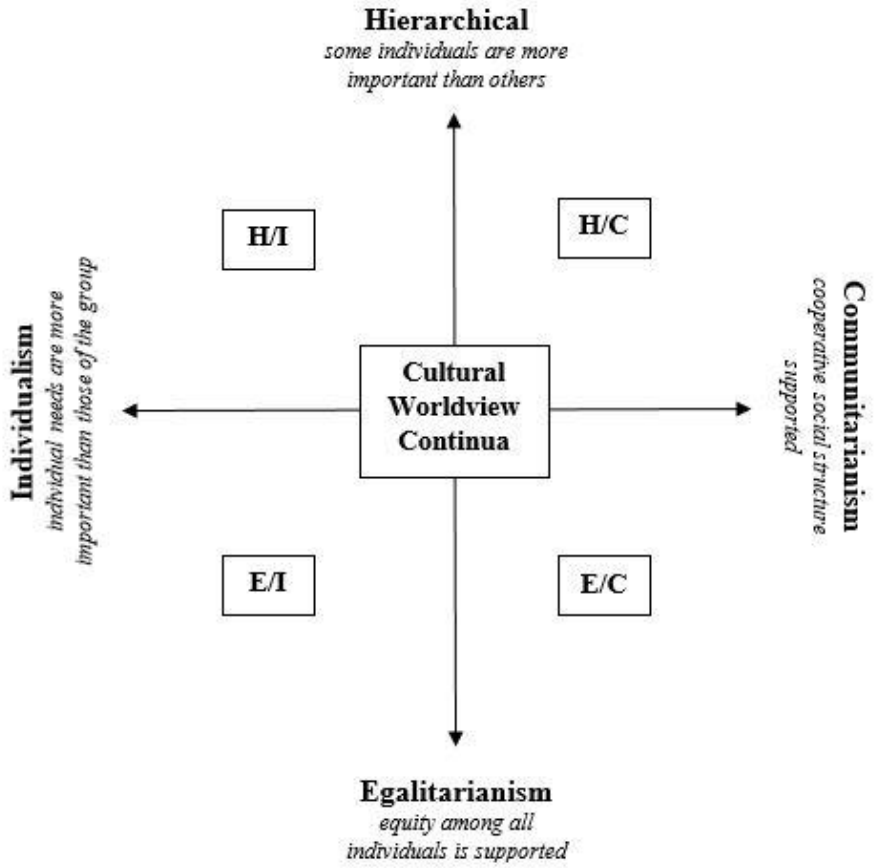

Figure 2.1. Adapted from Kahan (2012) worldview continua (individualist vs. communitarian and hierarchical vs. egalitarian).

Kahan et al. (2012) found that higher science literacy and numeracy scores are associated with a small decrease in the perceived seriousness of climate change risk. However, more importantly, they found that with most lay individuals, the strongest factor influencing climate change beliefs is the individual's relationship to his peers. Thus, cultural worldviews are strongly influenced by one's social group and, in many cases, individuals will consciously or subconsciously try "to avoid dissonance and their group standing" by 'fitting in' with others holding their same worldviews (e.g., a hierarchical individualist). Other researchers have adapted worldview survey statements and examined the worldviews of middle school students (Stevenson et al., 2014). Interestingly, the interaction of knowledge and cultural worldviews in the Stevenson et al. middle school study was opposite from those found in the Kahan et al. studies with adults. For students, increased climate change knowledge was positively related to the acceptance of anthropogenic (human induced) climate change and even had a stronger positive relationship among individualists, unlike in the adult studies. In a more recent study, Bolsen, Druckman, and Cook (2015) found that "scientists and policy advisors also appear to form beliefs about global warming that are consistent with their underlying values" (p. 286). At this time, there is no literature base comparing the worldviews, content knowledge and beliefs of both adults (parents/guardians) and teens (students) in the same household.

Cultural cognition "refers to the tendency of individuals to fit their perceptions of risk and related factual beliefs to their shared moral evaluations of putatively [assumed] dangerous activities" (Kahan et al., 2011, p. 148). Individuals are "psychologically disposed to believe that behavior they (and their peers) find honorable is socially beneficial and behavior they find base social detrimental" (Kahan et al., 2011, p. 148). Much of Kahan's work in climate change examines the cultural relationship individuals have with scientific evidence and their outlook on

the world. Similarly, in Kahan et al. (2011), individuals with worldviews differing from one another are likely to assess knowledge provided by notable experts in the field in substantially different ways. Subjects who possessed egalitarian/communitarian outlooks disagreed about the state of expert opinions on climate change, nuclear waste disposal, and handgun relations, with those subjects who possessed hierarchical/individualistic outlooks. In Chapter 28, *Cultural Cognition as a Conception of the Cultural Theory of Risk* (Kahan, 2012), Kahan provides practical advice to communicate risks to specific populations. Consistent with the cultural cognition theory of risk, it is important not to bombard individuals with information about risks, because this may cause the opposite effect; greater disbelief in the risk (e.g., climate change). He suggests that the message be framed in a way to first convince your audience there is a problem that needs solving, and then to provide solutions that are culturally affirming. Whether an audience is predominantly individualists or hierarchs, presenting threatening communication frames is less effective than proposing solutions to a concern (Kahan, 2012). For example, climate science communicators should emphasize the positive economic and environmental effects of the switch from fossil fuel or nuclear power as an energy source to alternative energy, (i.e., wind or solar), and reduce his or her focus on the negative effects of fossil fuel combustion and nuclear hazards.

Interventions—After School Club, Parental Involvement, and Behavior Change

After School Club Environments

There are a variety of after school STEM program formats throughout the nation. Some after school programs are more traditional programs that are school-site based. Others take a more mobile outlook and travel to museums, zoos, planetariums, and national parks. Still others may choose to take a more competitive approach, such as through robotics clubs, science fairs,

and Science and Math Olympiads (Sahin, Ayar, & Adiguzel, 2013; Sahin, 2013). The over-arching goal for most after school STEM clubs is not to improve grades or test scores, but to "increase involvement and exploration with STEM, decrease anxiety around STEM, and energize motivation" (Krishnamurthi, Ballard, & Noam, 2014, p. 7). Hussar, Schwartz, Boiselle, and Noam (2008) argue that in order for after school STEM clubs to be successful, they must be student centered, use cooperative learning, and conduct authentic, hands-on-activities. Additionally, many after school STEM clubs are trying to align more closely with learning standards, not only to increase students' interest in STEM content and careers, but to help transfer concepts back to the traditional classroom, as well (Carnevale, Smith, & Melton, 2011).

Interventions in after school STEM clubs should possess four attributes for success: (1) Activities should be engaging and different than those found in the traditional STEM classroom setting; (2) Activities should help students develop their STEM identities and gain membership into the STEM community; (3) Activities should allow for slight activity adaptations by STEM club leaders to meet student needs without compromising program integrity; and (4) Activities should be guided by faculty or staff who have undergone quality STEM professional development. (Barker, Nugent, & Grandgenett, 2014; Desimone, 2011; Foltz, Gannon, & Kirschmann, 2014).

After school STEM clubs need to evoke curiosity and enjoyment first, and then continue to foster interest and proficiency (Krishnamurthi et al., 2014). After school STEM clubs often are able to help students relate to difficult STEM concepts in a more authentic way by providing enriching, engaging, and interesting activities (Hoachlander & Yanofsky, 2011; McCrea, 2010). One way to provide authentic experiences is to use the resources and geography of local communities to connect students and families to the school and the community, connecting the

curriculum and teacher pedagogy to the familiar, local environment. Lessons and activities should be project-based, rather than traditional worksheets in order to challenge and stretch students (Vijil & Combs, 2015). Bevan and Michalchik (2013) acknowledge that even a singular STEM learning opportunity, no matter the setting, can be exciting and memorable. The researchers suggest, however, that opportunities should optimally be embedded in an ecology of further opportunities (e.g., including opportunities to do more advanced STEM activities and communicate with diverse role models) or the event will remain a singularity.

It is important to understand the composition of the population who will be participating in the after school STEM clubs to help build students' STEM identities and membership within the STEM community (Barton & Tan, 2010). Students are continually trying out new identities to see which ones 'fit.' One way to 'try out' new identities is through participation in novel situations and environments (Urrieta, 2007). Urrieta claims that, through participation, "people can re-conceptualize who they are, or shift who they understand themselves to be, as individuals or members of collectives" (2007, p. 120). This suggests that participation in after school STEM clubs that are designed around a supportive, community framework, will allow students to try-out their STEM identities in a safe and encouraging space. "Identity is made evident through what individuals say and do, how a student and their work is recognized and by whom, by the resources they access and activate to do so, and by how they position themselves in relation to others and to the object of the activity while taking particular roles" (Barton, Kang, Tan, O'Neill, Bautista-Guerra, & Brecklin, 2013). Barton et al. describe the development of one's identity as an on-going, multi-stage process. The formation of identity combines complex pieces of what makes the individual who they are, such as culture, gender, race, ethnicity, geography, family socioeconomic status, subjects of interest, one's place within a family, and one's place within the

school. Barton et al. assert that identity work, such as that examined for gender, must regard structures of power, privilege, and oppression within the complex pieces that form one's identity. Membership within a community is governed by specific discourses guided by the ways of knowing, doing, talking, and being (Gutiérrez, Baquedano-López, & Tejeda, 1999). When students see themselves as members of a learning community they are more motivated and invested in the activities they are asked to perform (Kier & Blanchard, 2016; Sahin, 2013).

There surely will be changes in the instruction of lessons and activities for different types of learners, taught in different informal environments, and led by different STEM club leaders, even if all of the teachers receive the exact same professional development, at the exact same time (Barker et al., 2014). Activities that are personal to students' daily lives and that integrate real world events and applications known to the population of students in an after school STEM club may help to increase interest in STEM (Lindahl, 2007). Interventions may even be strengthened if they are modified to suit the "needs, preferences, and values of specific racial and ethnic populations" (Durlak & DuPre, 2008, pp. 343–344). In particular, surface structure changes can be made that will not impact the core components of the intervention; whereas, changes in deep structure may weaken the underpinning of the intervention's core components (Resnicow, Soler, Braithwaite, Ahluwalia, & Butler, 2000). Barker et al. (2014) emphasize the importance of understanding how much and what types of changes can be made at the local level of implementation without compromising the project's original goals and objectives. For example, club leaders may provide an additional activity to help students gain further comprehension of a concept prior to the main activity and the underlying construct will be maintained. However, if club leaders decide to omit a part of an activity, such as data analysis or group wrap-up, students may not take away the main points from the activity.

Educators are more likely to adhere to the fidelity of STEM lessons and activities if they see the value for their students, they perceive it to be effective, not too difficult, not requiring too much support, and they have confidence in the included technologies (Barker et al., 2014). Desimone (2011) outlined five main features of effective professional development from the literature: it should have a content focus; it should engage teachers in active learning; it should be coherent with other professional development, knowledge and beliefs, and policies; it should have duration and spread over a semester of at least 20 hours; and it should be organized with collective participation from groups of teachers from the same grade, subject, or school in order to build an interactive learning community.

Parental Involvement

It is frequently said that parents are a child's first, and best teacher (LaRocque, Kleiman, & Darling, 2011; McKenna & Millen, 2013). However, parents today are often unsure as to the role they are expected to play in their children's education (Duma, Kapueja, & Khaylie, 2011). This role changes throughout their child's academic career and the role is often seen differently through cultural, racial, socioeconomic, and gender lenses (Berns, 2012). The definition and even the term "parental involvement" is used in a variety of ways. For instance, Avvisati, Besbas, and Guyon (2011) connect parental involvement to the direct effort by parents that has the end-goal of increasing their children's educational outcomes in formal schooling. Similarly, Bouffard and Weiss (2008) define parental involvement as any activity by parents that specifically and intentionally connects to learning.

Holloway and Kunesh (2015) note that, when using a sociocultural lens to study families, it is important to distinguish members (i.e., individuals or family units) of a seemingly similar group from one another because not all members of a group will experience "the context and

associated cultural models in an identical manner" (p. 2). Delgado-Gaitan (2012) noted that when there is a sociocultural congruency between home and school, children tend to perform better. She hypothesized that this relation may be due to language, value, or practice differences, or perhaps to the fact that parents are more knowledgeable about the ins and outs of school structure, know what to expect of their child and of the school, and know how to advocate appropriately for their child's education. Specifically, she noted that ethnically diverse families in low-SES conditions may consistently be isolated from the school culture, leading to miscommunication between the families and the school.

Parents can participate in varying forms of involvement in schools, from teaching their child about personal and family values and goals, to becoming involved in activities (e.g., projects and homework), through school communication (e.g., filling out paperwork and signing forms they have received from school), and school involvement (e.g., volunteering in the library or attending PTA meetings) (Hoover-Dempsey et al., 2005). The mechanisms, or ways, in which these forms of involvement are carried out may differ depending on the type of activity, efficacy of the parent, and personal and cultural contexts. There are inherent challenges to parental involvement due to various demographic factors such as socioeconomics, race and ethnicity, and parent's educational level. Sociocultural theorists posit that in the United States, parental involvement standards are often based on tacit or implicit standards established by "white, middle-class, non-immigrant parents" (Holloway & Kunesh, 2015, p. 3). Crosnoe (2015) asserts that "children from socioeconomically disadvantaged and/or racial/ethnic minority backgrounds tend to benefit the most from having involved parents" (p. 63).

Holloway and Kunesh (2015), in *Processes and Pathways of Family-School Partnerships across Development*, share three approaches that have proven to be successful in increasing

parental involvement: building funds of knowledge, forming partnerships with parents from underrepresented/non-dominant groups, and schools acting as brokers to form peer partnerships among parents. 'Funds of knowledge' are culturally and historically developed skills and knowledge that help families and individuals to function in society, particularly in educational settings (González, Moll, & Amanti, 2013). Relationships within these 'funds of knowledge' are described as "thick and multi-stranded." Thus, in order for teachers (or other educational personnel) to establish strong relationships with students and their families in home-based contexts of learning, such as parental roles in homework or projects, he or she must get to know "the child as the whole person, and not merely as a student" (Moll, Amanti, Neff, & Gonzalez, 2005, p. 74).

School personnel and families need to invest substantial efforts to establish mutual trust, which can help to build a foundation for long-lasting relationships (Moll et al., 2005). McKenna and Millen (2013) posit that parental engagement must include two essential components: parental voice and parental presence. Together, these comprise parental engagement. The researchers define *parent voice* as "the right and opportunity for parents and caregivers to express their thinking and understanding about their children's and families' everyday lives and educational experiences in and out of school" and *parent presence* as "a parent or caregiver's actions and involvement in their children's education" both formally and informally (p. 12). McKenna and Millen (2013) diagrammed their model of parental engagement, stressing four essential components: parental engagement needs to be active and deliberate, communal and personal, developed over time, and culturally sensitive. Parents also need to feel empowered to become involved in their children's educations (Delgado-Gaitan, 2012). Delgado-Gaitan defines empowerment as an "ongoing intentional process centered in the local community involving

mutual respect, critical reflection, caring and group participation through which people lacking an equal share of valued resources gain greater access to and control over those resources" (1991, p. 23). Delgado-Gaitan (2012) expresses that there is power in community building among parents. A group of parents within the study took it upon themselves to create a group called the "Committee for Latin Parents" (Delgado-Gaitan, 1991, p. 33). This committee became a place for parents to learn about and understand the implicit knowledge of the school system and their rights and responsibilities within the system.

Factors Affecting Behaviors

There are various drivers behind environmentally-minded behaviors of teens and adults, relative to climate change. Stern (2000) outlines the factors affecting behaviors, which includes environmental intent, personal habit or routine, and income or infrastructure. De Young (2000) also pointed out that individuals' environmentally-minded behaviors may be secondary to their non-environmental concerns. These concerns include such things as the desire to save money, motivation to enhance personal competence, and to preserve time for the development of social relationships. Indeed, various types of environmentally-minded behaviors can be compartmentalized. Gifford et al. (2011) define people's curtailment vs. efficiency behaviors. Curtailment behaviors are efforts, such as turning off a light switch, that are repetitive and work to reduce consumption. Efficiency behaviors, such as purchasing an electric vehicle, are often one-time purchases to adopt a more efficient technology. Bolderdijk, Gorsira, Keizer, and Steg (2013) studied the effects of an environmentally-focused informational intervention on research participants. These researchers found that although the content knowledge of the participants increased significantly, what people actually do with the knowledge is dependent upon whether the individuals personally care or value environmental quality. Semenza et al. (2008) found that

certain demographic groups were more likely to report environmentally-minded changes in their behaviors in response to climate change information. Those who were more concerned, more educated, and younger were more likely to change their behavior. Additionally, results from Kim, Jeong, and Hwang (2012) indicated that participants' attitudes about climate change prevention, their perception of the severity of climate change, response efficacy, and self-efficacy were major factors in their intentions to carry out pro-environmental behaviors.

Summary

This chapter highlighted the main cornerstones of research that have been conducted in the area of climate change communication with regard to rural, predominantly minority middle school students and their parents. First, this chapter identified the global importance of climate change, followed by a review of essential climate science and addressed popular misconceptions through climate literacy. Main concerns were addressed about climate change communication among all individuals, especially minorities and low SES groups. Climate change communication frames that have been applied with participants were also presented. Constructs related to knowledge, beliefs, and cultural worldviews, were examined, all of which contribute to positive environmental behaviors in Patchen's model of Determinants of Behavior (DOB) Model of Climate Change (Patchen, 2010). Finally, the literature on learning environments (after school STEM clubs) and the role of the parent in the intervention process (parental involvement) were presented.

Chapter 3 is a publication ready manuscript examining the impact of a climate change intervention on climate change beliefs and content knowledge of rural, middle school students participating in an after school STEM club, with respect to their worldviews. These students were engaged in one to three researcher-designed climate change activities. In this quantitative

study, pre- and post-intervention surveys were collected and analyzed to assess the effectiveness of the dosage, design, and content of intervention activities led by trained STEM Club teachers.

Chapter 4 is a publication ready manuscript that uses the Determinants of Behavior (DOB) Model (Patchen, 2010) of Climate Change to categorize climate change talk among families who watched climate change documentaries in their homes and families who participated in researcher interviews about climate change. Exemplars for each of the constructs in the model are provided and the level of engagement of the families during the at-home intervention was examined for trends in climate change beliefs and content knowledge shifts.

Chapter 5 synthesizes the main findings from the study, relating findings to what has previously been found in the literature. Also, recommendations emergent from the study are discussed, limitations of the study are addressed, and future research plans are suggested.

CHAPTER THREE

Investigating rural, middle school students' beliefs and knowledge about climate change and their worldviews during an after school STEM club intervention

Abstract

Although 97% of the scientific community acknowledges that the Earth's climate is changing due to human influences, the percentage of the general American public with a similar viewpoint is much lower (63%). This study examines the climate change beliefs and content knowledge of rural middle school students in the Southeastern United States. Students in after school STEM Career Clubs (N = 96) were engaged in one to four researcher-designed climate change activities. Pre- and post-intervention surveys were collected and analyzed to assess the impact of the intervention activities led by trained STEM Club teachers. Additionally, the relationships between student beliefs, content knowledge, and worldviews were explored. Initially, a surprisingly large percentage of students believed that global warming is occurring (70%) and is occurring at least in some part due to human influence (69%). Students learned significantly more total climate change knowledge post-intervention, although their climate change beliefs did not change. Males' scores improved significantly more on the climate change content knowledge test than that of females. Gains in content knowledge could be traced to engagement in specific club activities. The vast majority (over 70%) of students held egalitarian worldviews, while students were evenly split with half on the individualism and the other half on the communitarian worldview scale. Student worldviews were correlated to responses on the affective items of the survey but they did not predict students' climate change content knowledge. This study indicates that significant gains in climate change content knowledge can be attained through short-term out-of-school interventions. However, in order to change beliefs, perhaps longer and more sustained interventions are needed.

Introduction

Over the last century, the rate of the increase of annual average global temperature has continued to rise, causing an increase of surface air temperatures over land and oceans (Stocker et al., 2013). Anthropogenic global warming, caused by human activities, is now considered to be a driving force in melting polar icecaps and glaciers and causing the sea level to rise 17 cm in the last century (Anderson, Boesch, Burkett, Carter, Cohen, Grimm, Hatfield, et al., 2009; Church & White, 2006; Stocker et al., 2013). Approximately 97% of scientists believe that the Earth is warming and that the driving force is caused by humans (Cook et al., 2014; Tol, 2014). There has been a substantial upswing in the last decade in the number of Americans who

"believe" that climate change is occurring; however, the extent to which climate change is occurring, who or what the main contributors to climate change are, and the amount of content knowledge about climate change are still variable in the American population at large (Leiserowitz, Maibach, Roser-Renouf, Feinberg, & Howe, 2012). In Gallup polls of Americans from 1998-2014, between 62% and 75% of those surveyed thought that global warming was happening or would happen in their lifetime, but only 25% to 40% believed it would pose a serious threat to their way of life (Jones, 2014). In studies conducted by the Yale Project on Climate Change, Leiserowitz, Smith, and Marlon (2010; 2011) found that although about 63% of American adults believed that global warming is happening, only 54% of American teens held similar beliefs. When the authors tested climate change knowledge, 54% of American adults scored an *A*, *B*, or *C*, while only 46% of American teens received a passing score (>*F*).

Efforts to introduce scientific evidence, mitigation strategies, and adaptation strategies for climate change in the K-12 classroom are underway (Bofferding & Kloser, 2014). One goal of the Next Generation Science Standards (NGSS Lead States, 2013) is to emphasize global climate change at all secondary education levels through the Earth and Science core ideas. The NGSS standard designed for middle school states:

> 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 (NGSS Lead States, 2013, p. ESS3.D).

These progressive standards have been adopted in approximately a quarter of the states in the United States (US) (NGSS Lead States, 2013). Some states' legislators have expressed

reservations, especially states (e.g., Florida, Texas, South Carolina) with strong positions against teaching more controversial topics, including climate change (Robelen, 2013).

Bord, O'Conner, and Fisher (2000) assert that global warming beliefs and behavioral intentions are directly linked to one's knowledge—both correct and incorrect knowledge. These researchers also found that personal risk perception of a changing climate is stronger in people who may live in areas that are particularly vulnerable to those risks, such as coastal communities subject to impacts from sea level rise or areas in which drought conditions have impacted local agriculture and economies. Education efforts should be explicitly tailored to address the climate change concerns of locally impacted communities (Myers, Maibach, Roser-Renouf, Akerlof, & Leiserowitz, 2013), as regions of the nation and the world will experience direct and indirect effects differently, some more dramatically than others (Gutierrez & LePrevost, 2016). From their review of the literature, Gutierrez and LePrevost document that rural and impoverished populations in regions in the southeastern US are particularly vulnerable to climate change related impacts, such as sea level rise, hurricanes, heat waves, and drought. Taber and Taylor (2009) assert that "schools should be able to play a vital role by teaching about the environment and environmental issues but also encouraging children to be advocates for their environment and actively participate in positive action towards the environment" (p. 98). One way in which the authors found that middle schools were able to successfully teach students about global warming involved careful selection of "concrete, hands-on learning experiences" (Taber & Taylor, 2009, p. 106). Thus, it is essential for students to develop accurate content knowledge through engaging, hands-on learning experiences that are specific to his or her own geographic location in the world.

In contrast to a formal, traditional public school setting in which teachers may be predominantly concerned with conveying content in preparation for standardized tests and maintaining order, informal science settings have strong engagement components, in order to motivate students to attend and to drive student interests (Barker et al., 2014). The settings can provide an alternative means to begin introducing climate change evidence and content to American youth, and many informal education organizations (e.g., robotics clubs, Science Olympiad, STEM Clubs) have gained traction within the last decade (Robelen, 2011; Vijil & Combs, 2015). Yet, research provides scant evidence regarding the best intervention design and implementation parameters for middle school climate science education. Although climate change curricula options have been developed for the traditional classroom, this study will examine the impact of out-of-school time (OST) climate change interventions on rural, high poverty middle school students' beliefs and content knowledge.

Literature Review

The Science of Climate Change

Climate refers to the long term weather patterns occurring over a region within a 30-year window (KSC, 2015). Global climate change takes into account various parameters that fall under the umbrella of 'climate,' such as the average temperature, amount of precipitation, and occurrence of severe weather events. The trends in these environmental parameters are currently fluctuating and are predicted to continue changing, affecting regions of the world differently. Anthropogenic global warming, warming due to the activity of humans, has occurred due to the excessive use and release of greenhouse gases. These gases are primarily carbon dioxide, methane, and nitrous oxide, released through the combustion of fossil fuels in the industrial and transportation sectors (Shepardson, Niyogi, Choi, & Charusombat, 2011; Stocker, Qin, Plattner,

Tignor, Allen, Boschung, Nauels, et al., 2013). These gases trap radiation from the sun and increase the average global temperature, much as a greenhouse traps radiation from the sun to create a warm, sunlit environment for plant growth The Intergovernmental Panel on Climate Change (IPCC) (Stocker et al., 2013) documents that in the last 50 years, daily minimum temperatures have increased faster than the daily mean or maximum temperatures. Since 1970 there have been increasing numbers of days above 95°F and nights above 75°F, and decreasing numbers of extremely cold days (Kunkel, Karl, Brooks, Kossin, Lawrimore, Arndt, Bosart, et al., 2013). The average global temperature has risen (especially over the last 20 years), oceans have warmed about 0.3^{o}F since 1969, and the acidity levels in oceans has increased by 30% since the beginning of the industrial revolution (NOAA, 2015; Anderson et al., 2009; Levitus, Antonov, Boyer, Locarnini, Garcia, & Mishonov, 2009; Stocker et al., 2013).

Anthropogenic climate change will create serious problems for human health, economics, and the security of resources and safety (Melillo et al., 2014; Stocker et al., 2013). For example, temperature extremes and seasonal shifts have caused an additional strain on the energy infrastructure; farmers have had to reassess crop type and land use as droughts have caused a reduction in crop yields, lightning strikes have increased wildfire incidences, and sea level changes have caused salt water intrusion and increased storm surges (Anderson et al., 2009). Drought, seasonal changes in growing seasons, and increased temperatures are expected to affect breathing and lung function, due to an increase in air pollutants, allergens, and breathable ozone (Portier, Tart, Carter, Dilworth, Grambsch, Gohlke, Hess, et al., 2010). Portier et al. also assert that agricultural food supplies will be affected by the increasing blasts, rusts, blights, and rots that are affected by climatic conditions, which drive prices up. Anxiety and emotional stress are expected to rise in populations who are affected by extreme weather events brought on by

climate change (Berry et al., 2010). Additionally, the habitat reach of vector-borne or zoonotic diseases are expected to expand due to these changes (Portier, et al., 2010). Climate change is a global issue; yet it affects individuals and families in personal ways, at the local and regional levels. Given these impacts, it is essential to communicate scientific information in meaningful ways to students and their families.

Climate Change Beliefs and Content Knowledge of Adults and Secondary Students

Climate change content knowledge and beliefs have been active areas of research in the United States and worldwide since the end of the 20th century and throughout the 21st century. Both adults, and most recently K-16 students, throughout the United States have been surveyed and polled to gain insight into the depth of their knowledge and associated climate change beliefs. Leiserowitz and his fellow researchers on the Yale Project on Climate Change Communication surveyed adults and teenagers (ages 13-17) to access their knowledge and beliefs related to climate change (Leiserowitz et al., 2010, 2011). The survey also examined the public's desire for more information, information trust, risk perceptions, policy preferences, and behaviors. In a period of one month, the *American Teens' Knowledge of Climate Change* nationwide survey generated 2,030 responses of American teens, which will be detailed, below.

Climate Change Beliefs

The Leiserowitz et al. (2010; 2011) instruments addressed beliefs about anthropogenic climate change. These surveys indicated significant differences between adults' and teenagers' beliefs about global warming. While 63% of adults reported believing that global warming is occurring, only 54% of teens responded similarly. Neither adults (39%) nor teenagers (35%,) knew that most scientists believe global warming is occurring. In a study targeted at teens,

Stevenson, Peterson, Bondell, Moore, and Carrier (2014) found that almost 20% of teens either were not sure that global warming was occurring or believed that it was not occurring.

The factors that seem to strongly influence adult beliefs about climate change are political ideology and worldviews (Kahan, 2012; Smith & Leiserowitz, 2012). Individuals with a more democratic or libertarian political alignment, as well as those with egalitarian (believes in equity for all) and communitarian (supports a more cooperative social structure) worldviews have been more likely to report climate change beliefs. Also, egalitarian and individualism (believes the needs of one are more important than the needs of the whole) worldviews were found to be significant predictors of risk perception (Smith & Leiserowitz, 2012). People often see 'climate change' as though it is something that is distant to their lives or is portrayed by media as a dire situation without a meaningful solution (Boykoff, 2013; Smith & Leiserowitz, 2012). Affective responses to environmental issues have been found to be essential to developing pro-environmental beliefs and behaviors, as compared to other models like the 'information deficit model' (Howell, 2011). The information deficit model asserts that people who are fed knowledge will begin acting in accordance with that knowledge (Anable, Lane, & Kelay, 2006). While it is important for teens and adults to gain accurate climate science knowledge, Howell (2011) found that it is not enough to simply address knowledge to affect beliefs and behavior.

Climate Change Knowledge and Misconceptions

Results from both the adult and teen surveys of Leiserowitz et al. (2010; 2011) highlighted "important information gaps in knowledge and common misconceptions about climate change and the earth system" (2011, p. 5). Although certain disciplines have shifted to the term, "alternative conceptions," the fields of climate science and climate communication still

use the term “misconception.” Thus, “misconception” will be used throughout this text to refer to knowledge that is at odds with scientific knowledge. Interestingly, the individuals surveyed by the authors had relatively high climate change trust for scientists and scientific organizations; yet respondents self-reported a lack of understanding of climate change. There are several key concepts about which teens were more knowledgeable than adults on the Leiserowitz et al. nationwide US surveys: 57% of teens understood that global warming is anthropogenic in nature, as opposed to only 50% of adults; 52% of teens knew that carbon dioxide is the atmospheric gas that mainly contributes to human-induced global warming, as compared to 45% of adults; and 77% of teens knew what the greenhouse effect is, compared to 66% of adults (Leiserowitz et al., 2011).

Climate change literacy among middle school students can be challenging for communicators due to the misconceptions, risk perceptions, and cognitive and affective barriers of populations (Stevenson et al., 2013). Stevenson et al. identified popular misconceptions among middle school students, such as: the concentration of greenhouse gases destroys the ozone layer and weather and climate are synonymous. Lombardi, Sinatra, and Nussbaum (2013) note that many people view human-induced climate change as implausible. The authors contend that changing these conceptions as people learn about climate change will require them to make plausibility judgments that are both critical and reflective about scientifically accepted models of climate change. Only then will individuals be able to make a significant conceptual shift in their climate change understanding and beliefs. Lombardi et al. designed a study to include all 7th grade students in one middle school in the Southwestern US. In a quasi-experimental design, a sub-group with half of the students reflected on two alternative models of climate change: a human-induced model (scientifically accurate) and an increasing solar energy model (non-

anthropogenic, popular skeptic model), while other students received traditional instruction on climate change. The results indicate that when students were provided with an instructional scaffold to help them critically evaluate evidence, they had shifts in plausibility judgments (information that has the appearance of credibility and is believable) and students' misconceptions. These studies suggest that addressing misconceptions directly and modeling alternative theories in climate science curricula and interventions may help students to reconsider their thinking and be able to accept scientific explanations.

In a research study with middle and high school students in the Midwestern US, Shepardson, Niyogi, Choi, and Charusombat (2011) found that students believed that global warming is caused by air pollution and that ozone depletion is the driving factor in global warming. (Note: Pollutants may *or* may not cause warming—some pollutants even cool the atmosphere, and the hole in the ozone is not directly related to the greenhouse effect, which warms the atmosphere.) Shepardson et al. also found that students do not perceive that global warming or climate change have any real, perceived consequences in their own lives. Along the same lines, Bodzin, Anastasio, Sahagian, Peffer, Dempsey, and Steelman (2014) investigated general climate change knowledge in urban 8th grade students and found a similar lack of student understanding about weather and climate concepts, the composition of the Earth's atmosphere and greenhouse gases, and the anthropogenic sources contributing to climate change. Bodzin et al. made specific recommendations for how to implement curricula to help address climate change related misconceptions. These include: exploring temperature and precipitation trends over a 50-60 year period, integrating human's impact on the carbon cycle, and investigating the implications of human population increases and sea level rise. McCaffrey and Buhr (2009) also found climate change misconceptions problematic among students, teachers,

and public audiences, and recommended that the use of effective mental models and strategies can overcome these misconceptions and should be integrated into teacher professional development. McCaffrey and Buhr found 10 topics related to climate change (e.g., climate, atmospheric science, fossil fuel energy use) where models may be effective including: models for axial tilt as a reason for Earth's seasons, prehistoric plants as the source for fossil fuel energy, and ways to differentiate between incoming ultraviolet and outgoing infrared radiation as related to the greenhouse effect. They also described the need to equip educators with the proper resources and professional development opportunities to be better equipped to explain climate change topics.

Factors Found to Influence Climate Change Beliefs and Content Knowledge

In a recent study, Bolsen et al. (2015) found that an ideological divide over the cause of global warming "gets significantly larger dependent on the respondents' knowledge about politics, energy, and science" (p. 271). "Democrats and liberals are more likely to accept the scientific consensus regarding the reality of global warming, while conservatives and Republicans are significantly less likely to express a belief that is consistent with the scientific consensus on this issue" (Bolsen et al., 2015, p. 286). In addition to the direct influence climate change content knowledge has on climate change beliefs, demographic factors and other values have been shown to influence beliefs, as well. Whitmarsh (2011) found that environmental values and political affiliation were the most important predictors of climate change skepticism among United Kingdom survey respondents age 16 and older. Additionally, she found that the uncertainty of respondents may stem more from their perceptions of the trustworthiness and reliability of sources than with a climate change knowledge deficit.

Other demographic factors that have been shown to influence climate change beliefs and content knowledge include age, socioeconomic status, level of education, religion, and gender (Shao et al., 2014). Younger people tend to perceive that global warming is a serious problem (Shao et al., 2014), yet older individuals have a stronger feeling of personal responsibility for it (Kellstedt, Zahran, & Vedlitz, 2008). Socioeconomic status, including both educational attainment and annual income, has been found to have a direct relationship to skepticism of the media's portrayal of the seriousness of global warming (McCright & Dunlap, 2011). Individuals with a higher reported level of education are more likely to believe in anthropogenic climate change if they have a more Democratic or liberal political ideology as compared to a more Republican or conservative ideology (Shao et al., 2014). Individuals' religious ideologies may cause followers to either strongly support or construct barriers to taking steps to address climate change issues (Gifford, Kormos, & McIntyre, 2011). Gifford et al. term the "belief in a religious or secular deity," *suprahuman powers*. Beliefs in suprahuman powers have been shown to either motivate populations to take action to mitigate or adapt to a changing climate, or to strictly follow secular beliefs and take no action, arguing that "Mother Nature will take a course that mere mortals cannot influence" (p. 813). Gifford and Comeau (2011) explain the influence of gender, asserting that women often express greater concern about the changing climate and self-competence to engage in climate change mitigation efforts, as compared to males.

Individual Worldviews and their Relation to Climate Change Beliefs and Knowledge

In her study of climate change skeptics and determinants of climate change beliefs, Whitmarsh (2011) found that "beliefs about climate change are fundamentally linked to existing values and worldviews" (p. 697). This link has been extensively examined by Kahan, Jenkins-Smith, and Braman (2011) who developed a short scale to determine basic factors related to an

adult's view of the world. In their simplified version of cultural worldview, the authors focus on two dichotomies for how people may see the world they live in: egalitarian vs. hierarchical and communitarian vs. individualist, as shown in Figure 3.1. On the vertical axis, a person who is strongly egalitarian believes in equity for all, whereas someone with a more hierarchical view believes that human society should be constructed in levels, with some individuals holding higher importance than other individuals. Along the horizontal axis is the communitarian to individualist continuum. A person who has a strong communitarian view of the world would support a more cooperative societal structure, whereas an individualist believes that the needs of one are more important than the needs of the group. The responses to 12 statements are on a Likert Scale with 6 options (Strongly Disagree, Moderately Disagree, Slightly Disagree, Slightly Agree, Moderately Agree, Strongly Agree).

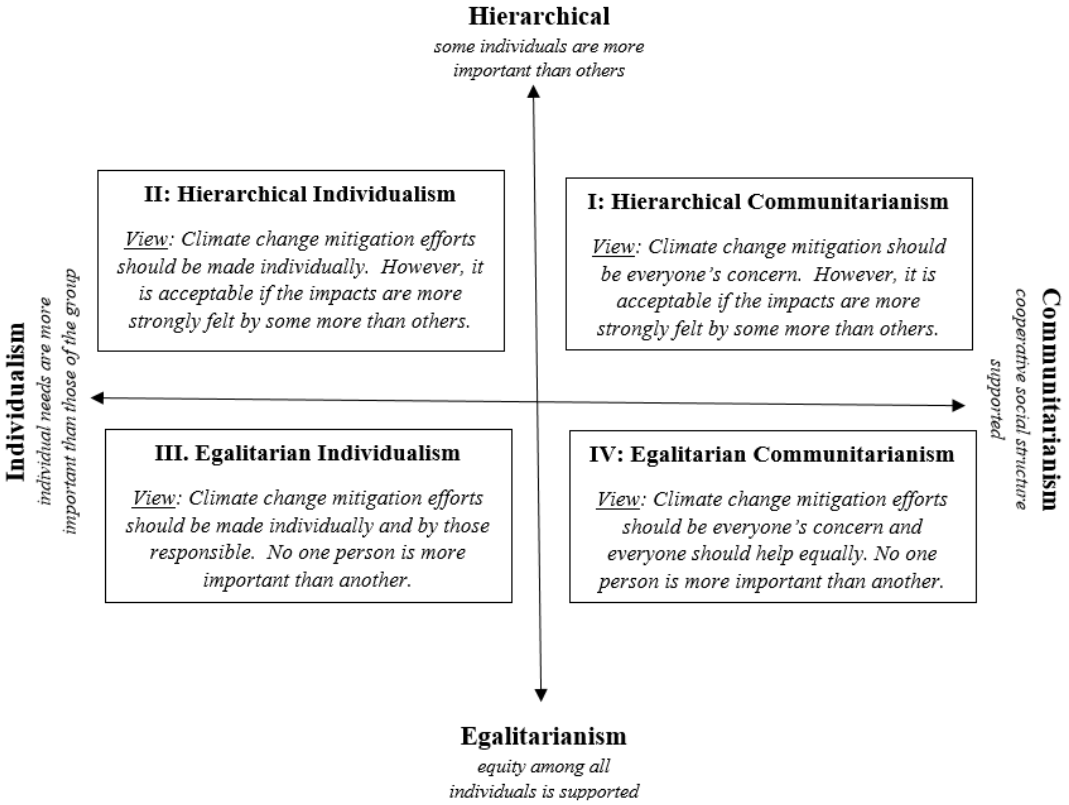

Figure 3.1. Worldview continua to include climate change views (adapted from Kahan, 2012).

Kahan et al. (2011) and Kahan et al. (2012) use these worldview continua in conjunction with other constructs, such as scientific literacy, scientific understanding, and numeracy (how well individuals can understand and use numerical information), to determine if science and mathematics content knowledge are significant contributing factors in climate change risk perceptions. Kahan et al. (2012) found that higher science literacy and numeracy scores are associated with a small decrease in the perceived seriousness of climate change risk. However, perhaps more importantly, they found that with most lay (non-scientist) individuals, the strongest factor influencing climate change beliefs is the individual's social relationship to his peers. Cultural worldviews are strongly influenced by one's social group. Individuals may consciously or subconsciously try "to avoid dissonance and their group standing" by 'fitting in' with others holding their same worldviews. For example, people who hold an individualism hierarchical position in quadrant II in Figure 3.1, will tend to align themselves with others who also believe individuals should take responsibility for their own actions and that some people may be more impacted by others.

Other researchers have examined the worldviews of middle school students (Stevenson et al., 2014). Interestingly, the interaction of knowledge and cultural worldviews in this middle school study was the opposite of those found in the Kahan et al. studies with adults. For students, increased climate change knowledge was positively related to the acceptance of anthropogenic climate change and positively related to students who identified as individualists on the worldview scale, unlike the results found in the adult studies. Vollebergh, Iedema, and Raaijmakers (2001) note that worldviews are still in a state of flux throughout the teenage years. Perhaps it is this plasticity during this crucial stage of development when an increase in knowledge may be able to overcome a traditionally more skeptical categorization on the

worldview scales (i.e., individualistic and hierarchical) (Stevenson et al., 2014). Bolsen, Druckman, and Cook (2015) found that "scientists and policy advisors also appear to form beliefs about global warming that are consistent with their underlying values" (p. 286). These findings suggest that it may be more successful to begin creating a climate literate population by starting to teach content in early grades, as beliefs may be slightly more pliable while worldviews are still morphing.

Climate Change Beliefs, Knowledge, and Worldview Summary

To date, there are no published studies that examine the worldviews of students and their climate change content knowledge and beliefs during an after school intervention. The literature indicates that middle school students, ages 11-14, have prior misconceptions regarding climate change content knowledge, but that well-designed interventions can address and remediate these misconceptions (Bodzin et al., 2014; McCaffrey & Buhr, 2009; Stevenson et al., 2014).

Development of Climate Change Interventions

Studies have shown that students are often more invested in a topic if it holds some sort of personal relevance to their lives (Palmer, 2009; Swarat, Ortony, & Revelle, 2012). Maio and Haddock (2007) found that messages that were designed to be personally relevant were more persuasive than general messages. Scannell and Gifford's (2013) findings indicate that when local examples are used for climate change impacts, it makes the message more "tangible and more comprehensible" (p. 76). Their Canadian, adult study participants who had a stronger *place attachment* ("formation of emotional and cognitive bonds with a particular place") were more engaged in issues regarding climate change (p. 66).

Swarat, Ortony, and Revelle (2012) found that student interest in instruction was centered more around the *form* of the activity over the topic of study or the learning goal. Research by

Palmer (2009) with 9th grade students highlighted several key features of instructional activities that seemed to generate the most student interest. Students reported a higher level of interest during the experimentation and demonstration phases of instruction. Additionally, students identified the novelty (coupled with suspense and surprise) of the content and activity as the greatest factor in interest generation, followed closely by choice, physical activity, and social involvement.

Researchers have determined that one of the best ways to actively involve students in authentic science is by having them take measurements and make observations (Beatty, 2012; Hestness, McDonald, Breslyn, McGinnis, & Mouza, 2014). The Next Generation of Science Standards (NGSS) (NGSS Lead States, 2013) emphasize the importance of linking student-generated data with that of climate scientists to make links between content and what is occurring in their natural surroundings. Additionally, authenticity of climate science data can be enhanced by inviting climate scientists in to speak with students to share their research and present climate science facts (Hestness et al., 2014).

Technology literacy is important in the development of climate change activities for teachers and students (Hestness et al., 2014). Technology makes learning activities more personal by providing chances to generate novel data sets, making learning more authentic (Swarat et al., 2012). Swarat et al. (2012) found that the following technologically-infused activities have been shown to increase student learning and motivation: modeling, digital probes, visualization tools, interactive games, and virtual simulations and experiments. Additionally, students reported a greater interest in hands-on, technology infused activities over those that were “purely cognitive or less physically engaging” (Swarat et al., 2012, p. 530).

Activities that are personal to students' daily lives and that integrate real world events and applications known to the population of students in an after school STEM club may help to increase interest in STEM (Lindahl, 2007). 'Real-world' scientific relevance can help to "better engage young people" (Archer et al., 2010, p. 624). Interventions may be even more impactful if they are modified to suit the "needs, preferences, and values of specific racial and ethnic populations" (Durlak & DuPre, 2008, pp. 343–344). In research by Stevenson, Peterson, Bondell, Moore, and Carrier (2014), non-White adolescents and female adolescents were more likely to accept anthropogenic global warming as true as compared to White and male adolescents. Stevenson et al. (2014) recommend that ethnicity and gender should also be considered when developing climate literacy interventions. It has been suggested that students of color should be exposed to individuals (e.g., local scientists, professionals) who look, act, and talk like they do, to help students begin developing a science (STEM) identity (Carlone & Johnson, 2007). For example, research noted in the *Training Manual on Gender and Climate Change* suggests that females may be "more responsive to technical [climate change science] information when it is presented in a social context" (Aguilar et al., 2009, p. 185).

It is also important to recognize the role of the facilitator in student learning. Shea, Mouza, and Drewes (2016) studied climate change professional development (PD) with middle and high school teachers, collecting data on changes in student attitudes and beliefs as a result of a unit-long intervention in a traditional classroom setting. Guided by the literature, these researchers included three main components in the intervention: robust science content, good pedagogy in a science context, and the use of as much of the local environment as possible to help explain content (Hestness et al., 2014; Shepardson & Niyogi, 2012; Sondergeld, Milner, & Rop, 2014). Through appropriately designed interventions, the Shea et al. study helped students

to become more aware of climate change and made positive impacts on student climate change beliefs.

Some of the complex climate science content that teachers are asked to address include the link between greenhouse gases and solar radiation, the effect of fossil fuels to the greenhouse effect, the earth's energy balance, future climate change projects, and climate modeling (Ekborg & Areskoug, 2006; Sadler, 2011). Additionally, teachers often engage in conversations about socio-scientific issues like climate change that include politics, economics, and ethics (Sadler, 2011). Quality professional development can help to equip teachers with the proper tools to have meaningful conversations with students about related "socioscientific issue[s] with scientific, political, economic, moral, and ethical overlays" that climate change discussions often incite (Hestness et al., 2014, p. 322). Addressing climate change content in teacher professional development gives teachers tools to help develop their students into life-long learners, who will ultimately need to make informed climate related decisions as adults.

These studies, taken together, suggest that in order for climate change interventions to impact middle school students' climate change beliefs and content knowledge, it must be personally interesting, engaging and active, technologically oriented, infused with real-world relevance, and led by well-trained, knowledgeable facilitators.

Theoretical Framework

Much of the work in climate change research examines the cultural relationship individuals have with scientific evidence and their outlook on the world. Kahan et al. (2011) found that individuals with differing worldviews tend to assess knowledge provided by notable experts in the field in different ways than those of the scientific consensus. Participants who possessed egalitarian/communitarian (E/C) outlooks disagreed with experts on climate change, nuclear waste disposal and handgun relations. Those with hierarchical/individualist (H/I) worldviews were more

likely to respond that experts (scientists) would *not* perceive excessive risk of climate change, nuclear waste disposal, or handgun availability, as compared to those with E/C views. In *Cultural Cognition as a Conception of the Cultural Theory of Risk*, Kahan (2012) provides practical advice to communicate risks to specific populations. Consistent with the cultural cognition theory of risk, it is important not to bombard individuals with information about risks, because this may cause the opposite effect; greater disbelief in the risk (e.g., climate change). He suggests to first frame the message in a way to convince your audience there is a problem that needs solving, such as the fact that the earth is heating up (regardless of who or what is causing this increase). Then, provide solutions that are culturally affirming, such as substitute nuclear power plants or alternative energy sources (instead of placing additional restrictions and policy control, especially for those with H/I worldviews). Whether an audience is predominantly made up of individualists or hierarchs, Kahan asserts that presenting threatening communication frames is less effective than proposing solutions to a concern. For example, communicators should emphasize the positive economic and environmental effects of the switch from fossil fuels to alternative energy, (e.g., wind or solar), rather than the negative effects of fossil fuel combustion.

Research Questions

This study investigates the climate change beliefs and knowledge, and cultural worldviews of rural students in the southeastern US who are participating in an after school climate change intervention. Given this focus, the following research questions were investigated:

1. Are there changes in students' beliefs and content knowledge about climate change?
2. What are students' worldviews and what factors (i.e., school, grade, gender. ethnicity, and religious beliefs) most strongly correspond with students' worldviews?
3. What are the relationships between students' climate change beliefs and knowledge, worldviews, and demographic factors?

Methods

The goal of this Climate Change study was to give middle school students exposure to climate change knowledge through direct, hands-on experiences in an after school STEM Career Club. Through these experiences (the intervention), it was hoped that students would gain knowledge and beliefs about climate change that were more consistent with the scientific community. Additionally, it was hoped that students would begin to identify (and perhaps take) steps to address climate change.

Participants

Students were invited to participate in an existing after school STEM Career Club project involving four middle schools in four rural school districts in the southeastern United States (Blanchard et al., 2014). The four STEM Career Clubs were in year 2 of a 3-year NSF ITEST grant cycle, and all students participating in the program were invited to participate in the climate change intervention and to complete pre- and post-intervention surveys (post-surveys immediately followed the intervention). There were 243 students who attended the STEM Career Clubs at least once during the intervention semester throughout the four districts. A subset of these students (N = 96) submitted informed consent forms and completed both pre- and post- survey data and were included in analyses for this study. All school names used in this study are pseudonyms. The intervention was conducted during the fourth, fifth, and sixth club meetings of the Fall 2015 semester.

The demographic data for students in each of the STEM Career Clubs is similar to that of each school. As Table 3.1 shows, the largest percentage of students participating in the clubs are African American (M = 53.9%), followed by Caucasian (M = 24.4%). Although there are fewer African American students in the STEM clubs than in the schools, the mean percentage of

African American students (53.9%) is higher than that of the state (22.0%). In three of the four STEM Clubs there was a greater percentage of Hispanic students represented in the club than in the overall school demographics.

Table 3.1

School District and STEM Club Demographics

District **School** **STEM Club**	**African American**	**American Indian/ Alaskan**	**Asian/ Pacific Islander**	**Caucasian**	**Hispanic**	**Two or more Races**
Taylor County						
School	49.6	0.4	0.6	45.2	4.2	1.6
[1]STEM Club	43.9	7.3	2.4	36.6	9.8	0.0
Butler County						
[2]District	70.4	0.0	0.0	24.2	3.5	2.0
[1]STEM Club	59.3	5.6	1.9	16.7	3.7	13.0
Clark County						
[2]District	56.9	0.2	0.4	38.4	6.2	1.4
[1]STEM Club	52.2	1.5	1.5	25.4	11.9	7.5
Gulf County						
School	72.1	6.3	0.2	13.2	6.3	1.9
[1]STEM Club	66.7	5.6	0.0	16.7	0.0	11.1
State Census Averages	22.0	1.6	2.7	71.7	8.9	2.0
STEM Club Averages	53.9	4.4	1.7	24.4	7.8	7.8

Note. Demographics are reported ([1]) based on student self-identification which may cause slight variation in data as compared to county statistics. Where available, percentages from individual schools were used; however, two of the schools are within 2 years of being founded and thus, do not have supporting data. In these two cases ([2]), district demographic data have been used as a proxy. (http://nces.ed.gov/ccd/schoolsearch/; http://quickfacts.census.gov)

Grade level and gender of students in individual STEM Clubs are shown in Table 3.2 for the semester of study. This demographic data was self-reported by the students. All grade levels in the school are represented in the clubs, with the greatest number of students in the lowest grade (either 5th or 6th), M = 53.9%. Although most schools have a similar number of males and females, one school (Gulf) has a higher number of females (73.7%).

Table 3.2

STEM Club School Grade Level and Gender Percentages

School	5th Grade	6th Grade	7th Grade	8th Grade	Males	Females
Taylor Middle School (TMS)	29.3	19.5	22.0	29.3	46.3	53.7
Butler Middle School (BMS)	N/A	46.3	31.5	22.2	44.4	55.6
Clark Middle School (CMS)	N/A	56.5	30.4	13.0	47.8	52.2
Gulf Middle School (GMS)	N/A	68.4	26.3	5.3	26.3	73.7
Average Percentages	N/A	47.7	27.6	17.5	41.2	58.8

Note. Only one school in the study had a 5th grade level; N/A = not applicable.

Table 3.3 displays additional school district data. In three out of the four schools served by the STEM Career Club project, more than 90% of students receive free and/or reduced price lunch (F&RL); thus the poverty level of students in these schools is significantly higher than that of the state (52.8% F&RL). These schools also experience higher teacher turnover (34.2%) than the state (16.3%). Also, the schools in the study have fewer fully licensed teachers (78.8%), as compared to the state (92.7%); 82.1% of the STEM Career Club teachers are fully licensed.

Table 3.3

School-Site Data for School Size, Percent Free and Reduced Lunch, Teacher Turnover Rate, Fully-Licensed Teachers, and Fully-Licensed STEM Career Club Teachers for the Year of Study

School	School Size	Percent Free & Reduced Lunch (%)	Teacher Turnover Rate (%)	Fully-Licensed Teachers (%)	STEM Career Club Teachers Fully-Licensed (%)
Taylor MS	384	>90	40.7	81.8	75.0
Butler MS	430	>90	36.0	76.5	87.5
Clark MS	261	70-75	N/A	84.6	85.7
Gulf MS	469	>90	25.8	72.4	80.0
State Averages	**659**	**52.8**	**16.3**	**92.7**	**--**

Note. Source: https://ncreportcards.ondemand.sas.com; http://www.ncpublicschools.org/fbs/resources/data/; N/A = not applicable due to newness of school

Students in the partnership districts consistently underperform students statewide in reading, math, and science, as shown in Table 3.4. In the state, Levels 1 and 2 indicate that the student did *not* perform at the acceptable threshold for proficiency. Levels 3-5 on standardized state assessments indicate levels of proficiency in a subject area, with Levels 4-5 indicating college and career readiness.

Table 3.4

Middle School End of Grade (EOG) Test Scores for Participant Schools, Year Prior to Study

School	**Percent Not Proficient (Levels 1-2)**		**Percent Proficient or Above (Levels 3-5)**	
	Math	**Science**	**Math**	**Science**
Taylor MS	88.3	60.9	11.7	39.1
Butler MS	85.7	50.4	14.3	49.6
Clark MS	44.6	12.7	55.4	87.3
Gulf MS	82.4	45.2	17.6	54.8
STATE AVERAGES (6-8)	53.8	27.4	46.2	72.6

Note. Mathematics (M) tests are given in grades 6-8 (averaged value for grades 6-8 shown in table; 5th grade results excluded for this table for better comparison to state averages); Science (S) tests are only given in grade 8 only; percentages are shown for the 8th graders only.

Overall, students within the participating districts significantly underperform students in the state (Table 3.4). Clark MS is the exception, a small STEM school that is demographically diverse. Most students (58.4%) in the participating middle schools scored a Level 1 or 2 on their reading end of grade test, as compared to the state average of 44.4%. Overall, most students (75.3%) in the participating middle schools scored a Level 1 or 2 on their mathematics end of grade test, as compared to the state average of 53.8%. Eighth grade students in the participating middle schools scored a Level 1 or 2 (42.3%) (failing) on their 8th grade science end of grade test, as compared to the state average of 27.4%. In order to address some of these critical content area needs, the research intervention developed for this study addressed state standards, particularly those in science and also, but to a lesser degree, in mathematics.

Project Design

Instrument Preparation

Both the adult (18+) and teen (13-17) versions of the Climate Change surveys by Leiserowitz, Smith, and Marlon (2010; 2011) have been used with adult and teen populations throughout the United States. However, for use in this study the instruments were modified according to the target constructs to be measured, length of the survey, and content level. For example, the items on the Leiserowitz et al. survey that addressed measures of trust in information sources, policy preference, and behaviors were cut, as were 15 questions that were not specifically addressed in the climate change intervention (e.g., coral bleaching, ocean acidification, whether or not schools should teach about global warming) or that were judged to be too advanced for middle school content level (e.g., amount of CO_2 in ppm in the atmosphere, the gradual/fragile/stable/threshold climate system models, specifically how much the temperature has changed and is expected to change). The climate change content knowledge, beliefs, and worldview surveys were combined into one survey in Qualtrics for students to take online at their school site (see Appendix A).

Intervention Materials

Student interventions were designed by the researcher to take place during three after school STEM Career Clubs (2 hours each) at each of the four school sites. These sessions focused on climate change content, and included exposure to related careers (e.g., state climatologist, solar panel company owner, environmental engineer). Activities included collaborative discussions with peers, laboratory activities, and interactions with climate related professionals, detailed in Table 3.5. Efforts were made to introduce activities that were related to the local community (e.g., solar farms, measuring and recording local weather conditions).

Table 3.5

Agendas for Three Climate Change Clubs and Related Survey Constructs

Agenda/Activities	Survey Constructs
Weather vs. Climate—Meeting #1	
1. Pre-intervention survey- Climate Change Content Knowledge, Beliefs, Worldview (in Qualtrics online) *(25 min)*	All constructs of CC beliefs, knowledge and worldviews
2. Card Sort- Is it climate or weather? *(10 min)*	WvC, RGW
3. Science Girl-Climate vs. Weather Video: https://youtu.be/Eij91cInLHI *(3 min)*	WvC, FF, FFE, CGW, RGW, EGW, GWMB
4. Weather Lab- Temperature, Relative Humidity, Wind Speed, and Cloud Cover/Type Lab *(60 min)*	WvC
5. Speaker: State Climatologist (videoconference) *(20 min)*	WvC, CGW, CH, EGW (same speaker all clubs)
Role of Carbon Dioxide and Carbon Footprint—Meeting #2	
1. Students set up carbon dioxide greenhouse activity…let run (set-up and discussion and then revisit at the end of meeting) *(30 min)*	CGW, EFF, FF, GG
2. WHILE EXPERIMENT IS RUNNING: National Geographic-Climate Change and Global Warming 101- http://www.hulu.com/watch/263946 *(3 min)*	CGW, EGW, FF, FFE, GWMB, RGW, WvC CGW, EFF, GWMB
3. WHILE EXPERIMENT IS RUNNING: Carbon footprinting activity to determine their personal carbon footprint with related action steps for mitigation *(20 min)*	CGW, EFF, GWMB
4. WHILE EXPERIMENT IS RUNNING: Compare students' ecological/carbon footprint with other students in the class and sample footprints from around the world and discuss differences and what can be done to mitigate carbon emissions *(20 min)*	CGW, EFF, FF, GG
5. Revisit carbon dioxide greenhouse demo, students record data and discuss results as a group/class *(10 min)*	CGW, EFF, FF, GG
6. Speaker on the influence of anthropogenic input of carbon dioxide in atmosphere (i.e., WWF representative, Fisheries and Wildlife Ph.D. student) *(20 min)*	(varied depending on focus of speaker)
Alternative Energy—Meeting #3	
1. Introduction to Alternative Energy: Video https://youtu.be/uStFvcz9Or4 *(10 min)*	CGW, EFF, FF, GG, GWMB CGW, EFF, GWMB
2. Alternative Energy Station Activity- Snap Circuits Alternative Energy Green Kits, Online energy simulations, local energy source research, energy career exploration…students have 10-15 minutes at each of the 7 stations *(90 min)*	CGW, EFF, GWMB
3. Speaker related to Energy visits club physically or via videoconference (e.g., solar panel company representative, environmental engineer) *(20 min)*	(*varied depending on focus of speaker (e.g., CGW, EGW, GWMB)*)

Note: CC = Climate Change; CGW = Contributions to Global Warming; CH = Climate History; EFF = Energy from Fossil Fuels; EGW = Evidence of Global Warming; FF = Fossil Fuels; GG = Greenhouse Gases; GWMB = Global Warming Mitigating Behaviors; RGW = Results from Global Warming; WvC = Weather vs. Climate.

Guest speakers were encouraged to share personal stories about what they liked/were like in middle school, problems they had, and how they overcame adversity. The one-day teacher

professional development, led by the researcher, engaged club teachers with the lessons and the content as if they were students, with time for questions and considering club logistics. STEM Club teachers then led their students in the club activities, which were attended by the researcher and university project team members to assist with data collection and observe.

Data Collection and Sources

Data was collected during Fall and Spring of the study year. The Internal Review Board (IRB) at the university (NCSU) approved the proposed study on September 21, 2015, Protocol #6177. STEM Career Club students received an invitation letter to be part of the climate change dissertation study. Project teachers were kept abreast of which STEM Club students had not turned in consent forms or taken post-intervention surveys, in order to extend the opportunity to all students. All data was collected online via Qualtrics survey software. Each student was invited to take the survey once prior to participating in the intervention activities and then again within a month following the third meeting. Student data was then matched with their informed consent forms. Per approved IRB protocol, if the researcher did not have a signed consent form on file, the student's data was removed from the downloaded data set. Next, student pre- and post-data were matched. Twelve students' data files were removed because they completed only post-intervention surveys. Additionally, data from 23 students who completed initial surveys but did not complete post-intervention surveys was removed. Other survey data removed included 32 students with incomplete surveys (< 50% complete) and surveys taken multiple times (6 pre, 4 post). These multiple surveys were compared against one another for completion and the less completed surveys were removed from analyses. In total, out of original surveys taken (172 pre, 198 post), 96 unique individuals' pre-post surveys were retained for analyses.

The Climate Change Content Knowledge questions were scored in Excel as either correct (1) or incorrect (0) (Leiserowitz et al., 2011). Next, sub-scale (e.g., *Weather vs. Climate*, *Energy from Fossil Fuels*) totals of correct responses were determined for each student for both pre- and post-intervention surveys. Missing data was treated the same as a "Don't Know" (0) answer response. The sub-scale totals were added together to generate a total climate change content knowledge score, referred to simply as Content Knowledge or "CK" throughout the remainder of this text. The overall CK score is an indication of overall student climate change content knowledge on both pre- and post-intervention surveys. Some of the demographic data was treated as categorical data (i.e., school, gender, ethnicity, religion, and specific meeting attendance) for analyses; whereas other data (i.e., total climate change content knowledge, all knowledge subscales, grade level, and hours of intervention) were treated as continuous data. All quantitative analyses, including descriptive data, pairwise correlations, paired t-tests, ANOVAs, multiple variable regressions, and interactions were analyzed using *Stata® 13*.

Climate Change Beliefs and Content Knowledge Survey

The *American Teens' Knowledge of Climate Change Survey* (Leiserowitz et al., 2011) measures various types of knowledge about climate change, such as how the climate change system works, causes, consequences, and solutions to global warming, anthropogenic causes of global warming in a historical/geographic perspective, and practical knowledge enabling action. Example items from the survey include:

Weather vs. Climate (WvC): *Climate and weather mean pretty much the same thing.*

0	***0***	***1***	***1***	***0***
[Definitely true,	Probably true,	Probably False,	Definitely False,	Don't Know]

Climate History (CH): *The Earth's climate is warmer now than it has been ever before.*

0	***0***	***1***	***1***	***0***
[Definitely true,	Probably true,	Probably False,	Definitely False,	Don't Know]

Contributions to Global Warming (CGW): *How much do cars and trucks contribute to global warming?*

1 1 0 0 0

[A lot, Some, A little, Not at all, Don't Know]

Global Warming Mitigating Behaviors (GWMB): *How much do you think switching from gasoline to electric cars would reduce global warming if it was done worldwide?*

1 1 0 0 0

[A lot, Some, A little, Not at all, Don't Know]

Note: Correct = 1, Incorrect and Don't Know = 0

There were a total of 79 individual questions that remained on the climate change beliefs and content knowledge survey that were given both pre- and post-intervention.

Worldview Survey

This study used two surveys based on the work of Stevenson et al. (2013). The Likert Scale response options on the worldview survey are the same as in the original adult surveys by Kahan et al. (2012) and Pratto et al. (1994), which include six-point Likert scale items ranging from strongly disagree (1) to strongly agree (6). Sample statements that correspond with each of the four views are given here:

Individualist: *I-C: #10. Individuals should take responsibility for their own lives without anyone telling them what to do.*

Communitarian: *I-C: #9. People should be able to rely on the government for help when they need it.*

Hierarchical: H-E: #5. *If certain groups stayed in their place, we would have fewer problems.*

Egalitarian: H-E: #16. *No group should dominate in society.*

There are more items (Total = 31) on the student instrument than the shortened adult version by Kahan et al. (12 items). Stevenson et al. (2014) modified the adult individualism/communitarian worldview survey (Total = 15) by Kahan et al. (2011) for age-appropriate questions and

readability based on pretesting with middle school students. The Pratto et al. (1994) survey was used to measure egalitarian/hierarchical worldviews (Total = 16).

Results

Changes in Students' Climate Change Beliefs and Content Knowledge

Beliefs

Research question one addresses changes in students' climate change beliefs and content knowledge. Basic descriptive analyses give an overview of these changes (see Table 3.6).

Table 3.6

Student Beliefs and Confidence about Global Warming Pre- and Post-Intervention

Survey Question	**Condensed Survey Response Options**	**Pre- (%)**	**Post- (%)**
Do you think global warming is happening?	Yes	69.5	71.6
	No	10.5	6.3
	Don't Know (DK)	20.0	22.1
How sure are you that global warming is happening?	Extremely/Very Sure	40.0	43.8
	Somewhat Sure	42.5	41.3
	Not at all sure/No response	17.5	15.0
Assuming global warming is happening, do you think it is… [natural/man made/not happening]	Correct	69.3	76.0
	Incorrect/DK/No Answer	30.7	24.0
Which comes closer to your own view? [of what scientists think on GW]	Correct	59.1	59.1
	Incorrect/DK/No Answer	40.9	40.1
How worried are you about global warming?	Very/Somewhat worried	60.0	66.3
	Not very/Not at all worried	40.0	33.7

Approximately 10% of the survey items targeted students' beliefs and perceptions. Initially, 69.5% of students (N = 95) believed that global warming is happening, which rose to 71.6% post-intervention. Also, the percentage of students who initially did *not* think global warming was happening dropped from 10.5% to 6.3% post-intervention. However, students were not overly confident in their beliefs, as only 40.0% of students were extremely or very sure global warming was occurring, and their confidence rose only slightly, to 43.8% post-intervention. The majority of students, 69.3%, initially acknowledged that human activities have an integral role in global warming. Following the intervention, more students (76.0%), up from

69.3%, indicated forms of anthropogenic global warming as most likely. Many students were unsure about scientists' views on global warming, which did not change pre- to post-intervention (59%). Overall, students became more worried about climate change, following the intervention (60.0% pre, 66.3% post).

Students' perceptions about the earth's climate and global warming are displayed in Table 3.7. In general, the majority of students initially felt fairly informed or well informed about sub-sets of climate change content knowledge, such as the Earth's climate system (74.2%), causes of global warming (66.3%), consequences of global warming (66.3%), and ways to help

Table 3.7

Student Perceptions of Their Knowledge about Global Warming Pre- and Post-Intervention

Survey Question	**Condensed Survey Response Options**	**Pre-Intervention (%)**	**Post-Intervention (%)**
How well informed do you feel about how the Earth's "climate system" works?	Very/Fairly well informed	74.2	67.7
	Not very well informed	19.4	21.5
	Not informed/No response	6.5	10.8
How well informed do you feel about the different causes of global warming?	Very/Fairly well informed	66.3	76.1
	Not very well informed	25.0	15.2
	Not informed/No response	8.7	8.7
How well informed do you feel about the different consequences of global warming?	Very/Fairly well informed	66.3	68.5
	Not very well informed	26.1	21.7
	Not informed/No response	7.6	9.8
How well informed do you feel about ways in which we can reduce global warming?	Very/Fairly well informed	60.0	64.8
	Not very well informed	25.6	14.4
	Not informed/No response	14.4	17.8
Have you ever heard of the 'greenhouse effect?'	Yes	84.2	93.7
	No	15.8	6.3
How much had you thought about global warming before today?	A lot/Some	29.9	37.9
	A little	33.3	29.9
	Not at all/No response(NR)	36.8	32.2
How important is the issue of global warming to you personally?	Extremely/Very Important	50.6	42.5
	Somewhat Important	29.9	34.5
	Not too/at all important/NR	19.5	23.0
For global warming, where would you place yourself?	I need a lot more info	31.0	14.9
	I need some/little more info	55.17	67.8
	I do not need more info/NR	13.8	17.2

reduce global warming (60.0%). Following the intervention, students felt more informed about each of these topics, except for how the Earth's climate system works (-6.5%). An overwhelming 84.2% of students reported having heard the term 'greenhouse effect prior to the intervention, rising to 93.7% post-intervention. More students thought a lot/some more about global warming from pre- (29.9%) to post-intervention (37.9%); although, even in the post-intervention, this represents less than half of the respondents. Interestingly, there was a decline in the degree to which students reported global warming as important, following the intervention; students (50.6%) who initially considered global warming extremely or very important, were less convinced post-intervention (42.5%). Finally, only 14.9% of students felt as if they needed much more information to make a decision about global warming post-intervention, which was down from 31.0%, pre-intervention.

Content Knowledge

The majority (60.6%) of the survey items assessed students' content knowledge about global warming and climate change. Results are displayed in Table 3.8. Prior to the intervention, 67.6% of the participants were able to accurately identify what the "greenhouse effect" is; following the intervention, this percentage rose to 78.4%. In general, students were able to correctly identify more examples and non-examples of *Greenhouse Gases* from pre- to post-intervention, with an approximately 10% increase of students answering at least 3 out of 5 responses correctly post-intervention. The results were similar for the *Weather and Climate* sub-scale, as about 8% more students answered 3 to 5 questions correctly, when they previously had only answered 0-2 correctly. Approximately 8% of students were able to answer 3-7 *Climate History* responses correctly following the intervention as compared to 0-2 correct responses pre-intervention. One of the largest shifts in pre- to post-intervention results was in the sub-scale,

Table 3.8

Student Content Knowledge on Global Warming (GW) and Climate Change Pre- and Post-Intervention

Survey Question or Sub-Scale *Category*	**Correct and Incorrect Response Frequency**	**Pre-Intervention (%)**	**Post-Intervention (%)**
The "greenhouse effect" refers to:	Correct	67.6	78.4*
	Incorrect/No response/DK	32.4	21.6*
Greenhouse Gases			
Identify which are/not greenhouse gases: carbon dioxide, methane, water vapor, hydrogen, oxygen	1-2 answers correct	53.7	44.2
	3 answers correct	34.7	45.3*
	4-5 answers correct	11.6	10.6
Weather vs. Climate	0-2 answers correct	57.9	50.5
Statements in sub-category correctly identified.	3 answers correct	20.0	28.4*
	4-5 answers correct	22.1	21.1
Climate History	0-2 answers correct	33.7	25.3*
Statements in sub-category correctly identified.	3-5 answer correct	58.9	63.2*
	6-7 answers correct	7.4	11.6*
Fossil Fuels			
Identify which are/are not greenhouse gases: coal, oil, natural gas, wood, hydrogen, solar energy	0-1 answers correct	32.6	16.8*
	2-3 answers correct	41.1	43.2*
	4-6 answers correct	26.3	40.0*
Energy from Fossil Fuels	0 answers correct	28.4	28.4
Statements in sub-category correctly identified.	1 answers correct	16.8	29.5*
	2-4 answers correct	54.7	42.1
What gas is produced by the burning of fossil fuels?	Correct	69.4	71.4*
	Incorrect/No response/DK	30.6	28.6
Which of the following countries emits the largest <u>total amount</u> of carbon dioxide?	Correct	35.0	45.0*
	Incorrect/No response/DK	65.0	55.0*
Which of the following countries emits the most carbon dioxide <u>per person</u>?	Correct	52.9	47.1
	Incorrect/No response/DK	47.1	52.9
Contributions to Global Warming	0-2 answers correct	27.4	14.7*
Contributions in sub-category correctly identified.	3-5 answers correct	46.3	50.5*
	6+ answers correct	26.3	34.7*
Which one do you think contributes <u>the most</u> to global warming?	Correct	26.1	33.0*
	Incorrect/No response/DK	73.9	67.0*
Results from Global Warming	0-2 answers correct	61.0	54.7*
Results in sub-category correctly identified.	3-4 answers correct	27.4	34.7*
	5-6 answers correct	11.6	10.5
Evidence of Global Warming	0-1 answer correct	52.6	32.6*
Statements in sub-category correctly identified.	2-3 answers correct	34.7	52.6*
	4-5 answers correct	12.6	14.7
GW Mitigating Behaviors	0-5 answers correct	51.6	43.2
Behaviors in sub-category correctly identified.	6-10 answer correct	39.0	47.4*
	11+ answers correct	9.5	9.5

Note. *Indicates changes from pre- to post- that suggest increased climate change content knowledge

Fossil Fuels. The percentage of students who were only able to identify 0-2 fossil fuel (non)examples dropped from 32.6% to 16.8% post-intervention, and there was a gain of approximately 14% of students who were able to correctly identify 4-6 fossil fuel (non)examples post-intervention. There was not a definite trend within *Energy from Fossil Fuels* nor was there a dramatic change in knowledge about which gases are produced by burning fossil fuels. Approximately 10% more students were able to identify China as emitting the most carbon dioxide (CO_2) post-intervention; however, students were slightly less able (-4.8%) to identify that the United States emits the most CO_2 per person, post-intervention. Substantially more students were able to correctly respond to statements about *Contributions to Global Warming,* as 12.6% more students scored between 3-8 correct responses, post-intervention. Although there was a positive shift of approximately 7% more students who were able to identify the burning of fossil fuels for energy or deforestation as being the highest contributing factors to global warming, this still amounted to only 33% of students who answered correctly, post-intervention. There was a positive shift (+6.2%) in students' responses for *Results of Global Warming* from pre- to post-intervention. There was a more noteworthy change in results related to *Evidences of Global Warming,* as 67.3% of students answered 2-5 choices correctly, post-intervention, compared to 47.3% pre-intervention. Finally, 8.4% of students showed a positive shift in their knowledge of *Global Warming Mitigating Behaviors* post-intervention and 56.9% were able to answer more than 6 items correct.

Student data was analyzed quantitatively using paired t-tests. T-tests were used in order to determine if there were significant changes in climate change beliefs or climate change content knowledge from pre- to post-intervention. Table 3.9 shows how students' *beliefs* changed following the climate change intervention. Based on paired t-tests, there was not a

Table 3.9

Paired t-Test Results on Students' Climate Change Beliefs and Confidence on Selected Items and Subscales

Survey Question or Sub-Scale *Category*	***df***	***t***	***p* (two-tailed)**
Do you think global warming is happening?	65	0.63	0.27
How sure are you that global warming is happening?	79	0.63	0.27
How sure are you that global warming is NOT happening?	93	0.81	0.21
Have you ever heard of the "greenhouse effect"?	94	2.38	0.01**
How well informed do you feel about how the Earth's "climate system" works?	92	2.67	0.004**
How well informed do you feel about the different causes of global warming?	91	2.11	0.02*
Personal Perception of Climate Change Knowledge	94	0.62	0.27
How important is the issue of global warming to you personally?	86	1.12	0.13
For global warming, do you feel that you need more or less information before making up your mind?	86	2.28	0.01**

Note. *$p < .05$. **$p < .01$. ***$p < .001$

significant difference in whether or not students believed global warming is happening or their level of assuredness that global warming is or is not happening. There was a significant difference in the number of students pre- and post-intervention who reported they had "heard the term 'greenhouse effect'" before, $M = 1.16$, $SD = 0.37$ for pre-, $M = 1.06$, $SD = 0.24$ post-intervention, t (94) = 2.38, $p < .01$, two-tailed. Post-intervention, students reported feeling less informed about how the earth's climate system worked, $M = 1.96$, $SD = 0.91$ pre-, and $M = 2.20$, $SD = 0.92$ post-intervention, t (92) = 2.67, $p < .01$, two-tailed. However, they felt more informed about the different causes of global warming, $M = 2.18$, $SD = 0.90$ pre-, and $M = 1.96$, $SD = 0.94$ post-intervention, t (91) = 2.11, $p < .05$, two-tailed.

Although students did not *perceive* they were more informed about climate change from pre-post intervention, it is evident through subsequent t-test comparisons (shown in Table 3.10) that students actually *were* more knowledgeable in several area of climate change content knowledge.

Following the intervention, students were more likely to feel as if they need more information on global warming before making a firm opinion on the issue, t (86) = 2.28, p = 0.01, two-tailed.

Table 3.10

Paired t-Test Results on Students' Climate Change Content Knowledge on Selected Items and Subscales

***Category* or Question/Statement**	***df***	***t***	***p* (two-tailed)**
The "greenhouse effect" refers to…[*a*.gases in the atmosphere trapping heat]	73	1.92	0.03*
Climate often changes from year to year.	72	1.84	0.04*
Weather means the average climate conditions in a region.	63	1.92	0.03*
The Earth's climate has been pretty much the same for millions of years.	53	2.21	0.02*
Evidence of Global Warming [8 statements total]	94	2.56	0.01**
Which of the following are "fossil fuels"?-Solar Energy	35	2.91	0.003**
Fossil Fuels [6 statements total]	94	2.68	0.004**
How much does each of the following contribute to global warming? —Cars and trucks	67	2.99	0.002**
How much does each of the following contribute to global warming? —Burning of fossil fuels for heat and electricity	58	3.02	0.002**
How much does each of the following contribute to global warming? —Cows	48	2.00	0.03*
Contributions to Global Warming [12 statements total]	94	3.38	0.001***
Any recent global warming is caused by the sun.	38	2.45	0.01**
Results from Global Warming [10 statements total]	94	2.17	0.02*
How much do you think the following action would reduce global warming if it was done worldwide? --Switching from fossil fuels to renewable energy (wind, solar, geothermal)	48	1.66	0.05*
How much do you think the following action would reduce global warming if it was done worldwide? --Switching from gasoline to electric cars	42	1.96	0.03*
How much do you think the following action would reduce global warming if it was done worldwide? --Placing a large tax on all fossil fuels	43	2.67	0.005**
Global Warming Mitigating Behaviors [17 statements total]	94	1.42	0.08
Before making a firm opinion on global warming, do you need more or less information?	86	2.28	0.01**
Total Climate Change Content Knowledge [77 statements total]	94	3.68	0.0002***

Note. *p < .05. **p < .01. ***p < .001

Four content knowledge sub-scales had significant changes overall and the change in total climate change content knowledge was highly significant, as well. More students were able to correctly identify what the "greenhouse effect" actually was from pre- (M = 0.68, SD = 0.47) to post-intervention (M = 0.78, SD = 0.41), t (73) = 1.92, $p < 0.05$, two-tailed. Students also better understood that climate does not change on a year to year basis. Additionally, there was a significant shift in the number of students who understood that "weather" does not indicate the average climate conditions in a region. In comparing the subscale, *Evidence of Global Warming*, from pre- (M = 1.67, SD = 1.3) to post- intervention (M = 2.09, SD = 1.36), student correct responses were significantly higher, t (94) = 2.56, $p < 0.01$, two-tailed. Students better understood that the solar energy derived from the sun that is used to generate power, such as in solar panels, is not a fossil fuel. In general, students were able to identify significantly more *Fossil Fuel* examples and non-examples on the sub-scale post-intervention (M = 3.02, SD = 1.80) than they were able to do pre-intervention (M = 2.46, SD = 1.85), t (94) = 2.68, $p < 0.01$, two-tailed. Students became significantly more aware of the influence of cars and trucks, the burning of fossil fuels for heat and electricity, and the influence of cow production on global warming as a result of the intervention. These individual item responses, as well as other responses in the *Contributions to Global Warming* sub-scale, resulted in a highly significant shift in content knowledge pre- (M = 3.72, SD = 2.38) to post-intervention (M = 4.60, SD = 2.15), t (94) = 3.38, $p < 0.001$, two-tailed. Students now realized that natural phenomena, such as the sun, are not independently responsible for global warming and they became more keenly aware of environmental impacts that result from global warming. The changes from pre to post intervention on the total subscale for *Global Warming Mitigation Behaviors* were not significant. Interestingly, students placed less significance on changes in fossil fuel use and taxes as a means

to mitigate climate change from pre- to post-intervention. Content knowledge as a whole scale was compared pre- (M = 25.91, SD = 12.47) to post-intervention (M = 29.63, SD = 11.36). The paired t-test, t (94) = 3.68, $p < 0.001$, two-tailed, indicated highly significant increases in climate change content knowledge (CK).

Students' Worldviews and Corresponding Factors

Descriptive analyses were completed to identify students' worldviews. Linear regression analyses were then conducted to determine if there were any significant relationships between the demographic data collected and students' worldviews.

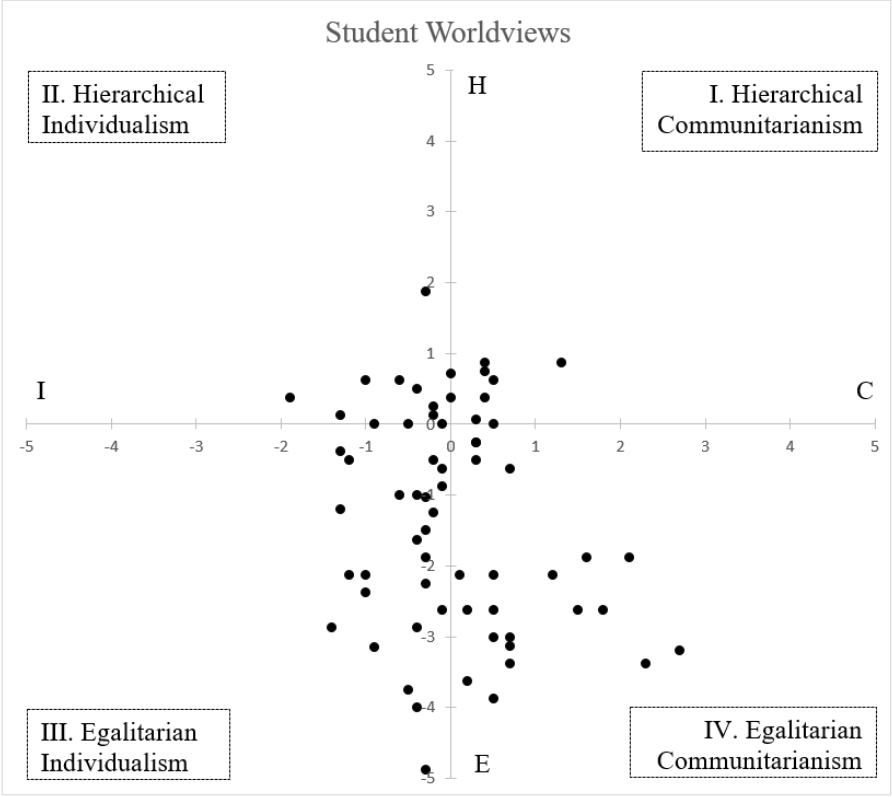

Figure 3.2. Student worldviews shown in quadrants, based on the Hierarchical(H)/Egalitarian(E) and Individualism(I)/Communitarian(C) dyad determination (n = 65)

Figure 3.2 shows the distribution of each of the four worldviews of students who completed all worldview survey data (n = 65). The closer the scatter plot point is toward +/- 5

on the *x* and *y* axes, the more strongly aligned the student is toward that worldview. The largest percentage of students (38.1%) identified as Egalitarian Individualism, followed closely behind by Egalitarian Communitarian (33.3%), shown in Figure 3.3. Approximately three quarters of the participating students reported a low to high Egalitarian worldview alignment, in which equity is valued. The proportion of students who reported either Individualism (concerned with oneself rather than the good of the whole) (48.8%) or Communitarian (concerned with the good of the whole rather than oneself) (47.7%) worldviews was approximately equal.

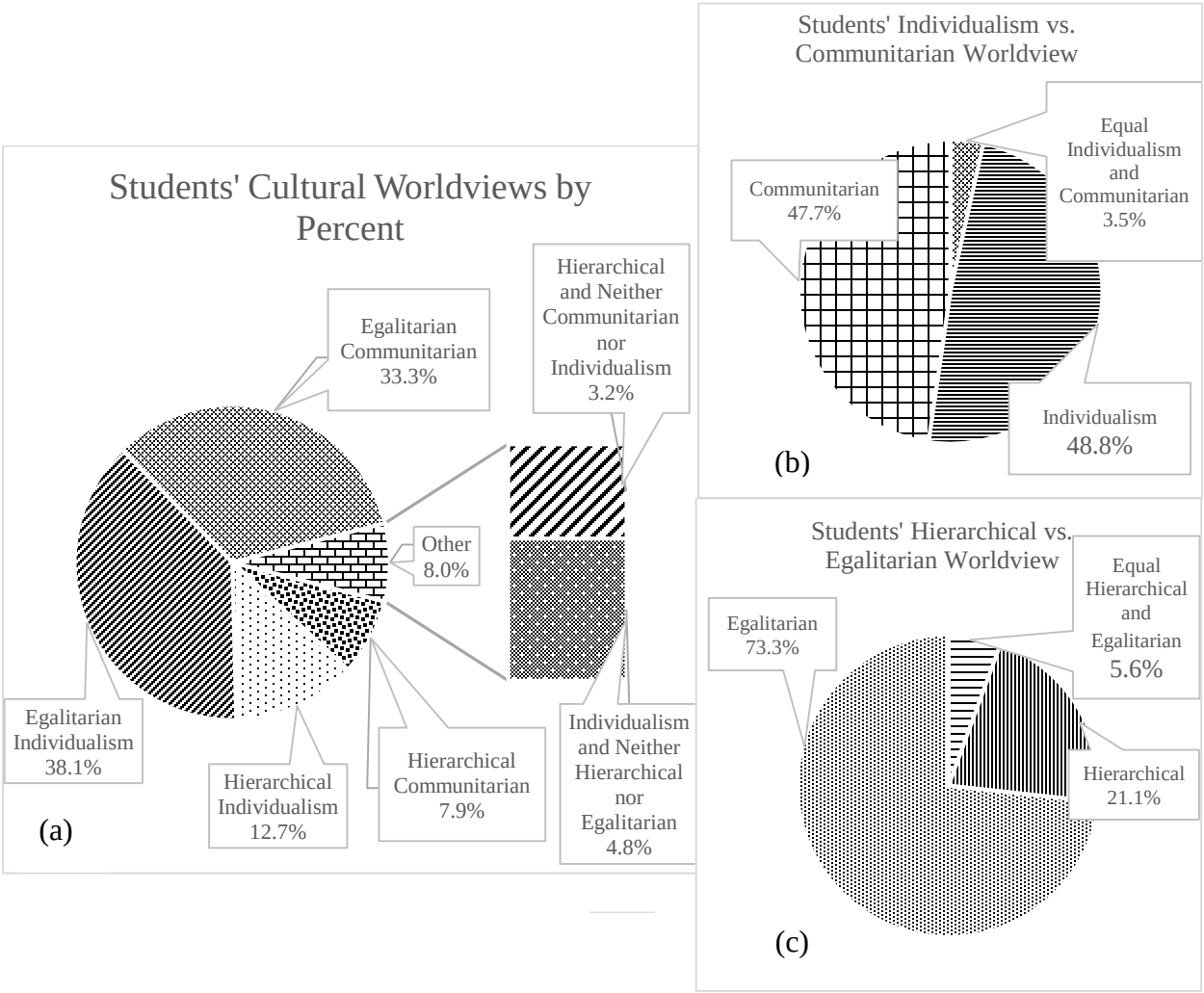

Figure 3.3. (a) Worldview responses on both worldview scales; (b) Individualism and Communitarian percentages breakdown; (c) Hierarchical and Egalitarian percentages breakdown.

School, gender, grade, ethnicity, and religion were analyzed as predictors in linear regression models, multiple regression models, and for interactions on the hierarchical/ egalitarian and individualism/ communitarian scales. No significant demographic factors were found to be predictive of worldviews in this population of middle school students.

The Relationship between Climate Change Beliefs, Knowledge, and Worldviews

Correlations, ANOVAs, and multiple regression analyses were conducted to investigate possible relationships between climate change beliefs, content knowledge, and worldviews. Pairwise correlations between various parameters of beliefs related to climate change and total climate change content knowledge are identified for pre-intervention survey results and post-intervention survey results (in Appendix B; Tables B1 & B2). Generally speaking, the direction, strength, and significance of the correlations from pre- to post-test were similar. Confidence that global warming is happening had a significant positive or negative effect. For example, the correlation between confidence that global warming is *not* happening is moderately and inversely significantly correlated to total climate change content knowledge pre-intervention, $r = -0.39$, $p < .001$, and post-intervention, $r = -.40$, $p < .001$. That is, student confidence that global warming is happening was positively associated with climate change content knowledge at a significant level. Global warming beliefs are weakly positively correlated to total climate change content knowledge for pre-intervention, $r = 0.31$, $p < .01$, and even less positively correlated post-intervention, $r = 0.22$, $p < .05$. Students' degree of worry about global warming was positively associated with the amount of time students thought about global warming for both pre-, $r = 0.27$, $p < .05$, and post-intervention, $r = 0.26$, $p < .05$, as well as the personal importance of global warming pre-, $r = 0.47$, $p < .001$, and post, $r = 0.35$, $p < .001$, both in the positive direction. There also was a moderately positive correlation between students' perceptions of

climate change knowledge and their confidence that climate change is happening both pre-, r = 0.45, $p < .001$, and post-intervention, $r = 0.46$, $p < .001$. Students who believe that global warming is happening were also confident in that belief both pre-, $r = -0.57$, $p < .001$, and post-intervention, $r = -0.55$, $p < .001$.

Additionally, the mean data of sub-groups (i.e., based on gender, ethnicity, school, grade level) of the study population were compared to one another on both the pre- and post-intervention survey data by ANOVAs to look for significant differences. Analyses of Variance (ANOVA) were run on Total Climate Change Content Knowledge based on various demographic factors included in this study for both pre- and post-intervention values. A one-way analyses of variance was conducted to see whether students' CK differed as a function of their gender. Results revealed a significant main effect for gender in the pre-intervention analysis, F (1, 93) = 5.91, $p < .05$, $\eta^2_{adj} = 0.05$ and post-intervention analysis F (1, 93) = 20.94, $p < .0001$, $\eta^2_{adj} = 0.18$. Post-hoc tests on the post-intervention data with Scheffé adjustments revealed that males (M = 35.1, SD = 7.31) scored significantly higher than female students (M = 25.3, SD = 12.17) on Total Climate Change Content Knowledge, t (93) = -4.58, $p < .0001$ than they did pre-intervention. Figure 3.4 shows mean CK scores by gender.

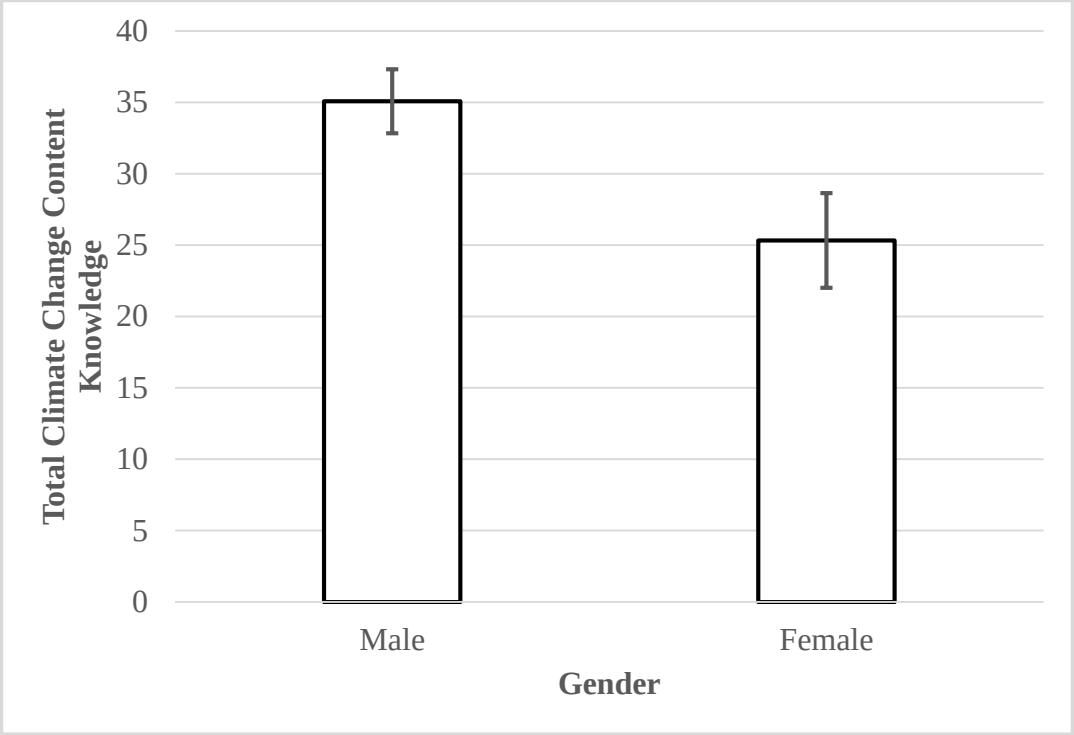

Figure 3.4. Post-intervention Total Climate Change Content Knowledge score means (*M*) as a function of gender (with confidence intervals).

The other demographic variables, such as Grade, Ethnicity, Religion, and Total Hours of intervention were analyzed using ANOVAs, as shown in Table 3.11, but none were significantly related to scores on content knowledge. It may be interesting to note, however, that the largest mean gains on the student content knowledge portion of the survey were with 5th grade students (ΔM = +8.1), African American students (ΔM = +7.0), and students participating in at least 6 hours of intervention (ΔM = +5.4).

Table 3.11

Pre- and Post-Intervention One-way ANOVA Results for Total Climate Change Content Knowledge Based on Demographic Variables

Demographic Variable	***M*** ***(df = 94)***								***F***	***p***
GENDER	Male (*N* = 42)				Female (*N* = 53)					
Pre-intervention	29.3				23.2				5.91	0.02*
Post-intervention	35.1				25.3				20.94	0.0001***
GRADE	5th (*N* = 7)		6th (*N* = 50)		7th (*N* = 24)		8th (*N* = 14)			
Pre-intervention	19.0		24.9		26.6		31.8		1.95	0.13
Post-intervention	27.1		27.2		32.3		35.1		2.53	0.06
ETHNICITY	Native American (*N* = 6)	Asian (*N* = 2)	Black/African American (*N* = 40)		Hispanic/ Latino(a) (*N* = 9)	White/ Caucasian (*N* = 20)	Other (*N* = 18)			
Pre-intervention	33.3	23.5	24.7		21.3	27.5	26.9		0.83	0.53
Post-intervention	29.8	27.0	31.7		24.0	30.2	27.6		0.83	0.53
RELIGION	Christian (*N* = 74)	Muslim (*N* = 4)	Jewish (*N* =1)	Catholic (*N* = 3)	Mormon (*N* = 1)	Atheist (*N* = 1)	None (*N* = 9)	Other (*N*=2)		
Pre-intervention	27.0	31.5	8.0	19.7	10.0	36.0	22.6	9.0	1.62	0.14
Post-intervention	29.8	29.5	21.5	32.3	39.0	45.0	26.3	26.0	0.59	0.76
TOTAL HOURS INTERVENTION	0 Hours (*N* = 4)	2 Hours (*N* = 11)	4 Hours (*N* = 32)	6 Hours (*N* = 45)	8 Hours (*N* = 3)					
Pre-intervention (baseline data)	32.8	30.3	27.2	23.1	28.3				N/A	N/A
Post-intervention	31.5	31.6	30.7	28.3	28.0				0.33	0.85

Note. *$p < .05$. **$p < .01$. ***$p < .001$

Multiple regression analyses were completed on both the pre- and post-intervention data to generate predictive values for targeted independent variables. Results of the multiple regression analysis for gender, ethnicity, grade level, and school, for both CK Pre-Intervention and CK Post-Intervention are displayed in Table 3.12. Overall, the model for the Pre-Intervention Survey explained 20% of the variance in CK scores, $R^2 = 0.196$, F (10, 84) = 2.05, $p < .04$. In contrast, the model for the Post-Intervention Survey explained 58% of the variance in CK scores, $R^2 = 0.577$, F (11, 83) = 10.29, $p < .000$. Not surprisingly, student performance on CK on the Pre-Intervention Survey was found to be a strong predictor of student success on their Post-Intervention CK. Gender is significantly associated with CK Pre-Intervention scores, $b = -5.16$, t (94) = -1.96, $p < .05$, and even more so Post-Intervention, $b = -6.48$, t (94) = -3.63, $p < .000$. Linear regression analyses found that males are predicted to score approximately 6.5 points higher than females on the CK score Post-Intervention. Ethnicity was not a significant predictive variable for CK Pre- or Post- Intervention. Several of the ethnicity sub-groups had too few participants (i.e., Native American, Asian) to make meaningful predictions about CK scores. Interestingly, grade level became less of a predictor from the Pre-, $b = 2.86$, t (94) = 1.72, $p = .09$, to Post-Intervention, $b = 1.10$, t (94) = 0.98, $p = .33$, regressions. This data aligns with the grade level data in the ANOVA Table 3.11. While the mean scores of all grade levels increased pre- to post-intervention, the shift from the 5th graders from the two survey administrations showed more significant positive gains. Thus, in the post-intervention CK data, the predictive strength of grade level in the regression was reduced. Finally, there were no significant predictors based on school.

Table 3.12

Pre- and Post-Intervention Regression Analysis Comparison of the Association between CK Scores and Demographic Variables (N = 94)

Demographic Variables	**CK Pre-Intervention**				**CK Post-Intervention**			
	β	***SE***	***t***	***p***	***β***	***SE***	***t***	***p***
CK (Pre-Intervention)[a]	--	--	--	--	0.53***	0.07	7.36	0.00
GENDER[b,c]	-5.16*	2.63	-1.96	0.05	-6.48***	1.79	-3.63	0.00
ETHNICITY[b]								
American Indian/ Native American	1.55	5.79	0.27	0.79	-6.52	3.85	-1.69	0.09
Asian	-1.49	8.87	-0.14	0.87	1.09	5.90	0.19	0.85
Black/African American	-3.86	3.30	-1.17	0.25	1.88	2.21	0.85	0.40
Hispanic/Latino	-5.95	4.81	-1.24	0.22	-1.74	3.22	-0.54	0.59
Other	0.31	4.00	0.08	0.94	-2.15	2.66	-0.81	0.42
GRADE[a]	2.86	1.66	1.72	0.09	1.10	1.12	0.98	0.33
SCHOOL[b]								
Butler MS	3.30	3.76	0.88	0.38	0.35	2.51	0.14	0.89
Clark MS	-3.65	3.78	-0.97	0.34	-1.38	2.52	-0.55	0.59
Gulf MS	2.00	4.20	0.48	0.64	-2.68	2.79	-0.96	0.64
Constant[d]	23.18***	5.42	4.28	0.00	17.60***	3.98	4.43	0.00
R^2	0.20				0.58			
Adj R^2	0.10				0.52			
F	2.05*				10.29***			
σ_{est}	11.83				7.86			

Note. *p < .05. **p < .01. ***p < .001

[a] All Pre-Intervention Total Content Knowledge Scores and Grade variables were treated as continuous variables

[b] All Gender, Ethnicity, and School variables were treated as categorical variables

[c]Gender: male = 0; female = 1

[d] Reference group = White/Caucasian Male at Taylor Middle School

The reference group for the interactions presented in Table 3.12 were males from Taylor Middle School (TMS). This is important to note because there were significant findings in the

decrease in female CK post-intervention scores at two schools. Clark Middle School (CMS), b = -12.57, $t(94)$ = -3.18, p < .000, and Gulf Middle School (GCMS), b = -12.00, $t(94)$ = -2.79, p <

Table 3.13

Pre- and Post-Intervention Regression Analysis Comparison of the Association between CK Scores and the Interaction of Demographic Variables (N = 94)

Demographic Variables	**CK Pre-Intervention**				**CK Post-Intervention**			
	β	***SE***	***t***	***p***	***β***	***SE***	***t***	***p***
Gender[a,b]/School[b] Interaction								
Male x Butler MS	6.72	4.72	1.42	0.16	1.98	4.00	0.50	0.62
Male x Clark MS	1.40	5.35	0.26	0.79	-0.04	4.53	-0.01	0.99
Male x Gulf MS	4.75	5.75	0.83	0.41	3.32	4.87	0.68	0.50
Female x Taylor MS	-0.96	5.75	-0.17	0.87	-8.68	4.87	-1.78	0.08
Female x Butler MS	1.02	4.51	0.23	0.82	-2.98	3.82	-0.78	0.44
Female x Clark MS	-9.38*	4.66	-2.01	0.05	-12.57**	3.95	-3.18	0.00
Female x Gulf MS	-0.09	5.08	-0.02	0.99	-12.00**	4.30	-2.79	0.01
Constant[d]	25.82*				33.82***			
R^2	0.16				0.27			
Adj R^2	0.09				0.21			
F	2.31*				4.61***			
σ_{est}	11.90				10.08			
School[b]/Grade[c] Interaction								
Taylor MS x Grade Level	2.85	2.01	1.42	0.16	4.18*	1.84	2.26	0.03
Butler MS x Grade Level	3.43*	1.53	2.24	0.03	3.78**	1.40	2.69	0.01
Clark MS x Grade Level	0.24	1.99	0.12	0.90	1.97	1.82	1.08	0.28
Gulf MS x Grade Level	2.84	1.71	1.66	0.10	2.58	1.57	1.64	0.10
Constant[d]	19.85***				21.83***			
R^2	0.12				0.10			
Adj R^2	0.08				0.06			
F	2.96*				2.62*			
σ_{est}	11.99				10.98			
Total Meetings Attended[b]								
0 Meetings Attended	-7.89	6.68	-1.18	0.24	-7.64	6.14	-1.25	0.22
1 Meeting Attended	-2.51	2.72	-0.92	0.36	-3.59	2.50	-1.44	0.15
2 Meetings Attended	-1.46	1.22	-1.20	0.23	-1.26	1.12	-1.12	0.26
3 Meetings Attended	-1.69	0.87	-1.95	0.05	-1.28	0.80	-1.60	0.11
Constant[d]	33.77***				36.29***			
R^2	0.06				0.04			
Adj R^2	0.02				-0.00			
F	1.36				0.92			
σ_{est}	12.37				11.38			

Note. *p < .05. **p < .01. ***p < .001

[a] Gender: male = 0; female = 1

[b] All Gender, School, and Number of Total Meetings attended variables were treated as categorical variables

[c] All Grade variables were treated as continuous variables

[d] Reference group = Male at Taylor Middle School with No Intervention Hours

.01, regression results indicate significant negative predictive values as compared to the reference group of males from TMS. Two schools were found to have significant interactions with their grade level distinctions on the Post-Intervention CK. Students at TMS (b = 4.18, $t(94)$ = 2.26, $p < .05$) and BMS (b = 3.78, $t(94)$ = 2.69, $p < .01$) were predicted to increase their CK scores by approximately 4 points per grade level. There were no significant interactions between total meetings attended and total hours of intervention on CK scores. However, this finding prompted a more in depth investigation into the impact specific meetings may have had on individual targeted questions and content subscales, as explored in Table 3.13.

While examining participation hours, the influence of individual meetings was examined through one-way ANOVAs on Total Climate Change Content Knowledge post-intervention for each of the three club meetings. The first meeting, with the *Weather and Climate* focus, had the largest number of participant participation (n = 82) out of the overall group analyzed in the ANOVA (N = 95) (see Table 3.14). The two subsequent meetings reported smaller attendance for the group being analyzed for the *Role of Carbon Dioxide* Meeting (n = 64) and the *Alternative Energy* Meeting (n = 65). The largest Total Climate Change Content Knowledge gained was most prominent in students who attended the first meeting on Weather and Climate. The post-intervention mean (M = 26.3, SD = 11.77) of students who did *not* attend the first meeting in the series was substantially lower than those who attended (M = 30.2, SD = 11.27).

There were no findings that indicated significantly more CK was learned by the students who attended more meetings or logged in more hours of intervention. Drilling down to a more granular level, there were significant differences in several of the CK sub-scales and items that were explicitly focused on during specific club meetings. Table 3.14 shows the one-way ANOVA results that specific club meeting attendance had on certain sub-scales and questions.

Students who attended the Weather and Climate Focused Club Meeting #1 were found to have significantly higher means on the *Weather vs. Climate* sub-scale, F (1, 95) = 6.77, p = .01, η^2_{adj} = 0.06, and the *Fossil Fuels* sub-scale, F (1, 95) = 7.83, p < .01, η^2_{adj} = 0.07, than those students who did not attend that meeting. Similarly, students who attended the Role of Carbon Dioxide and Carbon Footprinting Focused Club Meeting #2 were found to have significantly higher means on the *Personal Perception of Global Warming Knowledge* sub-scale, F (1, 95) = 6.77, p = .01, η^2_{adj} = 0.06. Students who attended meeting #2 were found to have significant differences in means on specific targeted questions on the survey—*Global warming will be more beneficial than harmful*, F (1, 56) = 3.86, p = .05, η^2_{adj} = 0.05; *How much had you thought about Global Warming before today*, F (1, 95) = 4.87, p < .05, η^2_{adj} = 0.04; and *How important is global warming to you personally?*, F (1, 95) = 4.23, p < .05, η^2_{adj} = 0.03. Finally, students attending the Alternative Energy Focused Club Meeting #3 were able to identify the correct response to the question, *What contributes most to Global Warming?*, significantly more than those students who did not attend, F (1, 95) = 8.06, p < .01, η^2_{adj} = 0.07.

Table 3.14

Analysis of Variance Table (ANOVA) Indicating the Significance of Specific Club Meeting Student Attendance on Specific Question and Sub-Scale Data in the Post-Intervention Climate Change Survey

Sub-Scales and Specific Questions	**Club**	***df***	***F***	***R²***	***p***
Weather vs. Climate	W&C	94	6.77	0.12	0.01**
Fossil Fuels	W&C	94	7.83	0.08	0.01**
Average Personal Perception of Global Warming Knowledge	CO_2/CF	94	7.54	0.07	0.01**
GW will be more beneficial than harmful.	CO_2/CF	55	3.86	0.07	0.05*
How much had you thought about GW?	CO_2/CF	94	4.87	0.05	0.03*
How important is GW to you personally?	CO_2/CF	94	4.23	0.04	0.04*
What contributes most to Global Warming?	AE	94	8.06	0.08	0.01**

Note. *p < .05. **p < .01. ***p < .001; W&C: Weather and Climate Focused Club Meeting; CO_2/CF: Role of Carbon Dioxide/Carbon Footprint Focused Club Meeting; AE: Alternative Energy Focused Club Meeting

Student worldviews on the individualism/communitarian scale were found to be predictive of climate change beliefs pre-intervention, F (1, 84) = 5.07, $p < .05$, $\eta^2_{adj} = 0.05$, but not post-intervention, F (1, 84) = 0.90, $p = .34$, $\eta^2_{adj} = 0.00$. The hierarchical/egalitarian student scores were not predictive of climate change beliefs pre-or post-intervention. Upon closer analyses of specific questions targeted at student beliefs, worldview was found to be significant. Post-intervention, it was found that students with varying positions on the hierarchical/egalitarian scale had significantly different levels of confidence on whether global warming is happening, F (1, 64) = 5.49, $p < .05$, $\eta^2_{adj} = 0.06$. As an individual moved more toward a more egalitarian worldview, their confidence that global warming is happening increased. Students' hierarchical/ egalitarian worldviews were predictive of what they believe causes global warming both pre- (F (1, 62) = 9.34, $p < .01$, $\eta^2_{adj} = 0.12$) and post-intervention (F (1, 65) = 8.71, $p < .01$, $\eta^2_{adj} = 0.10$). Those with a more hierarchical view were more likely to believe that global warming is caused by natural causes. Students' hierarchical/egalitarian worldview was predictive of the degree to which they worried about global warming post-intervention, F (1, 70) = 6.24, $p = .01$, $\eta^2_{adj} = 0.07$, but not pre-intervention. Those with a more hierarchical view were less likely to be worried about global warming than those with an egalitarian worldview, post-intervention. Prior to the intervention (F (1, 66) = 5.35, $p < .05$, $\eta^2_{adj} = 0.06$) and post-intervention (F (1, 70) = 5.04, $p < .05$, $\eta^2_{adj} = 0.05$), students' scores on the hierarchical/egalitarian worldview scale predicted significant differences in how much they had thought about global warming. Students with a greater hierarchical worldview were less likely to think about global warming than those with egalitarian worldviews. Students with a more individualist worldview thought more about global warming than those with a communitarian worldview, post-intervention (F (1, 84) = 6.97, $p < .01$, $\eta^2_{adj} = 0.07$). Lastly, both worldview scales were predictive of how important global

warming is to students personally, both pre- and post-intervention. Students reporting a more individualist worldview (pre: F (1, 78) = 4.74, $p < .05$, $\eta^2_{adj} = 0.05$; post: F (1, 84) = 4.80, $p < .05$, $\eta^2_{adj} = 0.04$) and a more egalitarian worldview (pre: F (1, 68) = 4.09, $p < .05$, $\eta^2_{adj} = 0.04$; post: F (1, 70) = 7.31, $p < .01$, $\eta^2_{adj} = 0.08$) were more likely to consider global warming as personally important.

Student worldviews were not found to be predictive of overall content knowledge pre- or post-intervention. However, upon further analysis, several interactions with worldview and demographic factors were found to be predictive of pre- and/or post-intervention total content knowledge, as shown in Table 3.15. The two worldview scales had strong interactions with two specific demographic factors (grade and gender), varying between pre- and post-intervention influence. The interaction with grade and the individualism/communitarian worldview scale was significant pre-intervention, yet was not significant post-intervention. Both worldview scales did not show a significant intervention with gender pre-intervention; however, each did post-intervention.

Table 3.15

Pre- and Post-Intervention Regression Analysis Comparison of the Association between CK Scores and the Interaction of Worldview Scales and Demographic Variables

Demographic Variables/Worldview	**CK Pre-Intervention**				**CK Post-Intervention**			
	B	***SE***	***t***	***p***	***β***	***SE***	***t***	***p***
Grade x I/C[a] Worldview								
Grade	3.70*	1.54	2.40	0.02	3.29*	1.35	2.44	0.02
I/C[a]	1.40	6.04	0.23	0.82	4.12	5.28	0.78	0.44
Grade x I/C[a]	-1.29	2.38	-0.54	0.59	-1.34	2.08	-0.64	0.52
Constant	17.95***				22.46***			
R^2	0.09				0.08			
Adj R^2	0.05				0.04			
F	2.62*				2.27			
σ_{est}	12.08				10.55			
Grade x E/H[a] Worldview								
Grade	2.55	2.23	1.13	0.26	3.46	1.94	1.79	0.08
E/H[a]	1.20	2.74	0.44	0.66	-0.09	2.37	-0.04	0.97
Grade x E/H[a]	-0.37	1.00	-0.37	0.71	-0.23	0.86	-0.27	0.79
Constant	20.71***				20.35***			
R^2	0.05				0.11			
Adj R^2	0.00				0.07			
F	1.11				2.78*			
σ_{est}	12.31				10.66			
Gender x I/C[a] Worldview								
Gender[b]	-5.34*	2.66	-2.01	0.05	-8.42***	2.20	-3.83	0.00
I/C[a]	-3.02	2.43	-1.24	0.22	0.50	2.01	0.25	0.80
Gender[b] x I/C[a]	2.16	3.03	0.71	0.48	1.02	2.51	0.41	0.69
Constant[e]	29.93***				35.13***			
R^2	0.07				0.16			
Adj R^2	0.04				0.12			
F	2.03				5.02**			
σ_{est}	12.20				10.09			
Gender x E/H[a] Worldview								
Gender[b]	-2.56	4.00	-0.64	0.52	-9.33**	3.19	-2.92	0.01
E/H[a]	-0.90	1.29	-0.70	0.49	-1.89	1.03	-1.84	0.07
Gender[b] x E/H[a]	1.43	1.96	0.73	0.47	0.70	1.57	0.45	0.66
Constant[e]	27.89***				32.78***			
R^2	0.04				0.24			
Adj R^2	0.00				0.20			
F	0.96				7.04***			
σ_{est}	12.35				9.87			

Note. *p < .05. **p < .01. ***p < .001

[a] I/C = Individualism (-1)/Communitarian (+1); E/H = Egalitarian (-1)/Hierarchical (+1)

[b] Gender: male = 0; female = 1

[c] Gender was treated as a categorical variable

[d] Grade and Worldview variables were treated as continuous variables

[e] Reference group = Male

Validity

Exploratory Factor Analyses (EFA) was performed on the initial climate change beliefs and content knowledge survey. Due to the expansive nature of the survey, there were 11 factors identified by the Kaiser rule as having Eigen values above 1.00. Keeping all 11 factors explains approximately 89% of the proportion of variation explained by each of the components. However, to simplify the model to only 5 factors still explains approximately 62% of the proportion of variation by each of the components. Table 3.16 shows the factor rotation matrix for the five factors in the model after it was rotated orthogonally and ranged from -0.89 – 0.80. Unrotated, twenty-seven items loaded on factor 1, twenty items loaded on factor 2, thirteen items loaded on factor 3, twelve items loaded on factor 4, and eight items loaded on factor 5 with a minimum loading factor of 0.3. All factors loaded on a three factor model with a minimum loading factor of 0.3; however, only 44.5% of the proportion of variation would be explained by such few factors for such a comprehensive survey.

Table 3.16

Factor Rotation Matrix

Factors	**Factor 1**	**Factor 2**	**Factor 3**	**Factor 4**	**Factor 5**
Factor 1	0.72	0.46	0.40	0.30	-0.11
Factor 2	0.39	-0.83	-0.01	0.38	0.12
Factor 3	-0.15	0.27	-0.18	0.49	0.80
Factor 4	0.29	0.16	-0.89	0.14	-0.29
Factor 5	-0.47	0.03	0.13	0.71	-0.51

Reliability

Reliability of the sub-scales was determined by calculating a Cronbach's alpha value to test for the internal consistency of the items within the content knowledge survey. For the applicable perception and content knowledge sub-scales, alpha values were calculated. The *Perception of Climate Change Knowledge* sub-scale consisted of 4 items (α = .42), the *Weather vs. Climate (WvC)* sub-scale consisted of 5 items (α = .58), the *Climate History (CH)* sub-scale consisted of 8 items (α = .90), the *Energy from Fossil Fuel (EFF)* sub-scale consisted of 4 items (α = .49), the *Contributions to Global Warming (CGW)* sub-scale consisted of 12 items (α = .82), the *Results of Global Warming (RGW)* sub-scale consisted of 7 items (α = .91), the *Evidence of Global Warming (EGW)* sub-scale consisted of 6 items (α = .72), and the *Global Warming Mitigating Behaviors (GWMB)* sub-scale consisted of 17 items (α = .85). Additionally, Cronbach's alpha scores on the worldview scales showed reliability: hierarchy/egalitarian (α = .78) and individualism/communitarianism (α = .83).

Discussion

Changes in Students' Climate Change Beliefs and Content Knowledge

As compared to the nationwide survey of American teens (Leiserowitz et al., 2011), 15.5% more middle school students in the current study (69.1%) initially believed global warming is occurring. After the intervention, only 6.3% of students believed that global warming is *not* happening, which was down from 10.5%, pre-intervention. There was a slight increase of 2.1% of students who were unsure as to whether global warming is happening or not. Overall, there were not significant changes in students' beliefs about climate change. The findings in this study resonate with the literature regarding the difficulty of changing one's beliefs about climate change (e.g., Hamilton & Stampone, 2013; Myers et al., 2013) . Tasquier,

Levrini, and Dillon (2016) synthesize work from many researchers into three main barriers that may "cause citizens to deny the climate change problem and…[resist becoming] involved with it" (p. 540). These barriers include the idea that climate change is not an individual but a collective problem, is either too big that people feel helpless (or too small and feel it is too trivial in their lives), and that it is too far (changes are anticipated to occur too distant in the future). A study by Lorenzoni and Hulme (2009) found that people may be willing to alter their views and attitudes through additional content knowledge; however, the greatest results will occur if the new information is consistent with their existing beliefs.

Significant shifts toward a more scientific understanding of climate change occurred. Total climate change content knowledge for students increased significantly through hands-on activities and collaboration with peers. The highest knowledge gains in survey constructs were found when students participated in hands-on data collection activities such as authentic weather parameter analyses (Club #1) and examined the role of carbon dioxide in the 2-L bottle artificial atmosphere experiment (Club #2). Students also showed significant gains on constructs when they partnered with peers to compete in a game from *Project Wild: Weather, Wildlife, Climate & Change* (Council for Environmental Education, 2015), that showed their individual knowledge of statements related to *weather* (e.g., A warm winter helps more juvenile alligators to survive) or to *climate* (e.g., Warmer winters allow alligators to expand their ranges further north and inland). Local professional speakers who focused their talks around local climate change impacts gained students' interest as evidenced through student-generated questions and discussion, providing another avenue for productive discussion related to various content knowledge constructs which showed significant gains (i.e., *Weather vs. Climate, Contributions to Global Warming, Energy & Fossil Fuels*). Thus, despite engaging in less than eight hours of

climate change activities, students showed significant gains on several CK constructs on the climate change survey.

There is scant evidence examining the impact of interventions in out-of-school time (OST) on content knowledge. In their meta-analysis of 35 OST programs from 1985-2003, Lauer, Akiba, Wilkerson, Apthorp, Snow, and Martin-Glenn (2006) found several key conclusions and implications: (1) "OST programs can have positive effects on the achievement of at risk students in reading and mathematics… [and] that program duration and student grouping influence program effectiveness;" (2) Math achievement benefits of OST programs usually occurs in secondary, rather than primary grades; and (3) OST programs do not have to solely focus on academics to have positive influences on student achievement. Lauer et al. found that duration increased program effectiveness and that programs less than 45 hours led to fewer positive findings. Social components were examined in addition to academic gains. It was determined that OST programs that stress academic and social activities have positive results on student achievement.

Demographic Factors and Worldviews

Recent literature has investigated how demographic factors influence worldviews of adults (e.g., Kahan et al., 2012, 2011) and young people (e.g., Stevenson et al., 2014). Worldviews have been shown to help predict climate change beliefs and pro-environmental climate behaviors. Thus, it was important in this study to determine if basic demographic factors influenced students' worldviews. Demographic factors were not predictive of worldviews in this population of study. Almost three-fourths of students' worldviews aligned with an egalitarian worldview. Thus, the students in this study value equity for all and do not value holding some individuals in higher regards than others. Of this majority of students with egalitarian

worldviews, about half reported more of an individualist view, while the remaining half reported a more communitarian view. Students were split between the idea that government (national, state, and local) should work with citizens to address issues and the idea that individual citizens should take a more personal role in addressing pertinent issues. There was no clear relation found between the demographic variables collected (i.e., school, grade, gender, ethnicity, religion) and worldviews. This may be due, in part, to the fact that worldviews are still in a fluctuating state during adolescence (Vollebergh et al., 2001). Unlike adults, children may continue to develop their worldviews. Another reason demographic variables were found not to be related to worldview in this population may be because this population of students was so similar (e.g., rural, Christian, African American, low income). Student worldviews may ultimately be impacted by demographic factors, but for this population of 11-14-year-old students in rural areas of the Southeastern US, the demographic factors collected did not relate to their current worldviews.

Relationships Between Climate Change Beliefs and Knowledge, Worldviews, and Demographic Factors

Climate Change Beliefs and Total Content Knowledge

Climate change beliefs were only slightly positively correlated with content knowledge pre-intervention, becoming less so post-intervention. Similarly, climate change beliefs were not predictive of total climate change knowledge. There is still uncertainty to the degree to which an increase in climate change knowledge affects climate change beliefs (Whitmarsh, 2011). Whitmarsh found that "beliefs about climate change are fundamentally linked to existing values and worldviews" and less likely a function of "educational or knowledge deficit" (p. 697) The current study suggests that an increase in overall climate change content knowledge did not cause a significant increase in beliefs about global warming. Yet, there was positive movement

from students who initially did *not* believe global warming was occurring (10.5%) to those who either thought it was occurring (+2.1%) or who became unsure (+2.1%) post-intervention. Stevenson et al. (2014) found in work with middle school students that non-White students reported greater acceptance levels of anthropogenic global warming than did their White peers. However, in the current study there were no significant differences found in the in global warming beliefs pre- or post-intervention with regard to ethnicity.

There is recent evidence to suggest that the introduction of specific climate change knowledge may have a positive effect on beliefs (Guy, Kashima, Walker, & Neill, 2014). Studies within Sweden, Switzerland, and the United States, all found that "compared with people who are ill-informed, those who possess accurate information are more accepting of the reality of climate change" (Guy et al., 2014, p. 423). Yet, in the current study, there were even fewer correlations between beliefs and content knowledge post-intervention. Overall, students increased their content knowledge of climate change to a much greater extent than their beliefs on global warming.

Gender effect on total content knowledge

Gender differences on climate change knowledge were significant, pre-intervention and became even more highly significant, post-intervention. While both males and females demonstrated significant growth in content knowledge, males showed more dramatic growth. This may be due, in part, to the topic of study and to the design of the intervention activities. Research has suggested that girls often are more receptive to biological topics (e.g., ecological health, the human body), while boys are more interested in physical sciences (e.g., chemistry, earth science) (Scantlebury, 2012). While the larger picture of climate change borders on the intersection of biological and physical sciences, the activities planned for the club interventions

were more aligned with physical science (i.e., taking weather parameters, assessing the role of carbon dioxide's interaction with light in the greenhouse effect, investigating alternative energy through snap kits), rather than biological science (i.e., determining one's own carbon footprint and comparing it to those of global citizens) and health.

In the United States, national education standards encourage collaborative group work and hands-on activities to assist in the learning process (NGSS Lead States, 2013; NRC, 2012). In light of these standards, intervention activities were designed to be action-based and include elements of cooperative work, competition, and technology. Cooperative learning has been shown to enhance learning; "team behavior is positively associated with the learning outcomes" (Virtanen, Räikkönen, & Ikonen, 2015, p. 208). During inquiry-based activities, Wolf and Fraser (2008) found that males benefited more from inquiry methods, whereas females found non-inquiry activities focused on cooperation and equity to be most beneficial. The activities in the current study were designed in a guided inquiry format and performed in self-selected groups. The design of the activities was intended to appeal to elements that have been shown to be successful across genders. Females have consistently been shown to shy away from competition-based activities as compared to their male peers (Booth & Nolen, 2012). Booth and Nolen found that this *competition-gap* in schools may be because females feel strongly about maintaining their gender identity of non-competitiveness; this may be especially important for adolescent females in coeducational environments. Students were allowed to choose their own groups for the *Weather vs. Climate* competitive activity but no grouping data was collected; thus, it is uncertain the extent to which gender differences in this activity may have had in improving content knowledge.

Students also were asked to utilize technology to observe and measure scientific data during each of the three climate change intervention club meetings through either Vernier probeware or Elenco® Alternative Energy Snap Circuits. Some feminists assert that *digital technology* has been "organized fundamentally along the lines of gender and dominated by male participants" (Selwyn, 2012, pp. 89–90). Endepohls-Ulpe, Ebach, Seiter, and Kaul (2012) found that there was a connection between environmental science topics and technology education in relation to girls' motivation. Utilizing technology in context with an environmental topic, such as climate change, may be a way to create a more 'gender-sensitive' approach to technology utilization with females. While climate change knowledge increased significantly among both genders, it is unclear the extent to which technology integration in this study served as a motivational tool by gender or as a tool to help students, particularly males, gain climate change content knowledge. However, there was significant growth for all students in the paired t-test results for specific questions regarding *Weather vs. Climate*, the *Contributions to Global Warming* construct, and the *Results from Global Warming* construct; each of which were introduced through technology-centered activities in meetings #1 and #2.

Grade Level, Ethnicity, and Intervention Hours' Effect on Total Content Knowledge

Apart from gender, the largest mean gains on the student content knowledge portion of the survey from pre- to post-intervention were with 5th grade students, African American students, and students participating in at least 6 hours of intervention. The content knowledge shifts in 5th graders between the two survey administrations showed more significant positive gains, followed by positive shifts in 6th graders. In the state standards, the word *climate* does not appear until grade 7 and *climate change* is not specifically addressed in the standards until high school science courses. Students revisit weather parameters in grade 7 and science teachers may

choose to integrate climate change curricula at this time; however, it is not addressed in specific standards until high school. Additionally, in preparation for middle school, many elementary teachers have reported that they have had to decrease time "spent on science to help children (often low performing children) on reading and mathematics" (Milner, Sondergeld, Demir, Johnson, & Czerniak, 2012, p. 128). Reducing time for science content has not only been a classroom based decision; teachers have also said they have been told by administrators to reduced time on science in lieu of time on reading and mathematics (Griffith & Scharmann, 2008; Milner et al., 2012). A study of science content knowledge in elementary students (K-2 and 3-5) found that science content accuracy increased in higher grades (Nowicki, Sullivan-Watts, Shim, Young, & Pockalny, 2013). The authors suggest that teachers often place less importance on the subject of science, as compared to others, especially in lower grades. For this reason, it is conceivable that students in the lower grades (5th and 6th) with the current study showed such dramatic growth because they previously may not have been provided opportunities to participate in substantial quantities of scientific activities, or may not have been exposed to the concepts of 'climate' or 'climate change' prior to the intervention. For these students, especially those in the early middle school grades, even limited exposure to science content knowledge and activities can make a significant positive difference in their content knowledge, as found in this study.

African American students had the largest knowledge gains in total climate change knowledge from pre- to post-intervention (Avg. +7.0 points) of all ethnicity subgroups. There have been few studies done regarding the influence that ethnicity has on climate change knowledge in students. McCright (2010) used data from a Gallup poll of US adults to find that "younger adults and whites are more knowledgeable about climate change than are their older

and non-white counterparts" (p. 77). In the initial student survey, this study found that there were no significant differences between Whites and non-Whites with regard to climate change knowledge; however, older students in the 8th grade were found to have significantly greater initial climate change content knowledge. Following the intervention, there were still not a significant between White and non-White students, but, while still significant, the difference in the means for total climate change content knowledge between 5th and 8th grades students decreased. In the design of the club activities, elements of place were woven into the construction of the intervention including the elements of social group identity, race, ethnicity, and cultural identity. Throughout the three club activities students were able to choose their own groups, identify their school site weather parameters, and determine personal positive and negative climate behaviors in their home/school/community. This allowed students to personalize activities into their self-selected social groups, increase motivation to engage, and interact with their everyday school ground environment in a novel way. Through this design, students increased overall climate change content knowledge. No qualitative data was collected from students during the club meetings; however, eliciting information regarding social groups, motivation, and the interactive nature of the activities could help better understand the importance of these elements in the intervention.

Students who completed six or more hours of climate change intervention had the highest growth in content knowledge. Also, students who attended meetings where specific constructs were addressed, did perform better (often significantly better) on related constructs on post-intervention measures. The design of the activities had a positive impact on climate change content knowledge gains by student of all ethnicities, including African American students post-intervention; this was evident particularly in students who participated in at least 6 out of the 8

possible intervention hours. These climate change content knowledge gains were large in relation to the amount of time students participated in the intervention. Additionally, students made these substantial gains through an intervention design that was completely interactive, a design approach that is often discouraged in the traditional classroom, claiming that it will take up too much time (Bunterm et al., 2014).

Worldview and Climate Change Beliefs and Content Knowledge

Worldview has recently begun to be examined extensively in adults as they relate to climate change beliefs and to inform the development of effective climate change communication strategies. Within the population of middle school students in the current study, the point where a student fell on the individualism/communitarian scale was found to be predictive of climate change beliefs pre-intervention, but not post-intervention. Individualists reported that they were more likely to think about global warming than their communitarian peers. The more egalitarian students scored on the egalitarian/hierarchical continuum, the more confident they felt that global warming is happening. Because there are no known studies that focus on the worldviews of rural, underrepresented, high-poverty students, the findings with adults will be presented.

Egalitarian adults traditionally have been more predisposed to the perception that climate change is a serious risk; whereas, individualists adults often perceive climate change as a low-risk threat (Leiserowitz, Maibach, Roser-Renouf, Smith, & Dawson, 2012; Leiserowitz, 2006). Typically, adults who hold more hierarchical and individualistic worldviews are more likely to downplay environmental risks (Kahan et al., 2012, 2011). Similarly, those students with more hierarchical worldviews were more likely to believe that the increase in global warming is more natural than man-made, were less likely to be worried about global warming, and thought about

global warming less, as compared to those with more egalitarian worldviews. Students with individualistic/egalitarian worldviews were more likely to think global warming was personally more important to them than peers with differing worldviews. Whereas student worldviews did seem to speak to certain areas of students' climate change beliefs, student worldviews were not found to be predictive of overall content knowledge pre- or post-intervention.

Total climate change knowledge was significantly improved from pre- to post-intervention, despite the lack of shifts in climate change beliefs. Worldviews were found to impact beliefs, demonstrating that the link between worldviews and beliefs is strong. Simply increasing climate change content knowledge may not cause positive changes in climate change beliefs.

Conclusions and Recommendations

Overall, the middle school students participating in this study believed that global warming is occurring. This is surprising and is higher than what has been found nationally with teens (Leiserowitz et al., 2011). The literature suggests that given the population (majority rural, African American, and impoverished) would have less belief in anthropogenic climate change. However, the students in this study were not very confident in their beliefs (40.0% of students were extremely or very sure pre-intervention; 43.8% were post-intervention), as compared to students nationally (51% of teens (these teens did not receive an intervention)). While significant knowledge gains were made overall, perhaps the most interesting finding was the dramatic positive knowledge shift by males. The intervention design structure of the activities in these out-of-school time (OST) STEM clubs had positive impacts on the content knowledge for both genders, but this was especially true for males. Students in younger grades showed the most growth in climate change content knowledge (e.g., 5th and 6th grades students began with

the least amount of climate change content knowledge and showed the greatest growth), decreasing the knowledge-gap among the grades in middle school. Other demographic variables, such as ethnicity, religion, and school, did not seem to have much impact on student beliefs or content knowledge acquisition. Engagement in a short-term, interactive climate change intervention activities led to significant gains in overall content knowledge as well as specific knowledge of constructs targeted in each club meeting. For future studies on after school climate change intervention design, it is recommended that aspects such as student motivation and interest be examined to determine the extent to which they may play in generating and maintaining students' interest and, in turn, lead to changes in beliefs and content knowledge.

Worldviews did seem to affect some parameters related to beliefs about climate change (e.g., views about the anthropogenic nature of climate change, degree of worry, amount of time spent thinking about global warming, and personal importance). Worldviews were not a significant predictor of climate change content knowledge pre- or post-intervention in this population. Assessing worldviews and gathering demographic data on students prior to intervention design or climate change communication efforts could assist educators and communicators to frame materials in the most agreeable formats for student digestion. Although it is uncertain whether or how much climate change beliefs will be changed through short-term exposure, even if scientifically accurate knowledge is successfully communicated through climate change activities. Corner, Markowitz, and Pidgeon (2014) remarked on the influence of worldview on climate change communication efforts: "one way values and worldviews shape climate engagement […] is by acting as filters on the interpretation of the information to which individuals are exposed about climate change" (p. 415). Even though the worldviews of middle

school students are in a state of flux, students will still filter new information through their values/worldviews and prior conceptions.

Recommendations

This study found that there were differences in the content knowledge gains 5th and 6th graders, African American students, and males made on the pre- and post-intervention surveys. These sub-groups of students should be examined further to help determine reasons behind these differences. Qualitative data, including researcher observations of student interactions, interviews, or short questionnaires about motivation and engagement could provide more clarity. In order assess a wider range of beliefs, content knowledge, and worldviews, more middle school students should be invited from the current population of study as well as from other populations in the region with differing demographics.

There could be a number of reasons that climate change content knowledge was altered. Climate change communication should focus on students' prior conceptions and the means and degrees to which any misconceptions may be adequately addressed and replaced (Lombardi et al., 2013). Shifts in prior non-scientifically accurate knowledge to more scientific views may prove to be essential in helping individuals make the shift from climate change skeptics to believers (Stevenson et al., 2014).

In regards to the development of climate change interventions, both demographic variables and worldviews should be examined prior to climate communication efforts when working with middle school students. Since a high percentage of students reported an egalitarian worldview, it may be appropriate to discuss climate justice (impact of climate change on vulnerable communities), on both a local and global scale. This topic may even be more salient

for students who fall into these vulnerable populations such as those living in rural regions, people of color, or the impoverished.

Climate communicators need to address ways to impact an even harder target, personal worldviews, in order to shift beliefs. This may be done through longer interventions, interventions with students earlier in life (i.e., early childhood or elementary school), or family-based interventions. For future studies on after school climate change intervention design, aspects such as student motivation and interest should be examined to determine the extent to which they may play in grabbing and maintaining students' interest and, in turn, lead to changes in beliefs and content knowledge.

CHAPTER FOUR

Investigating factors related to the intended climate change behaviors of rural middle school students and their families

Abstract

Attitudes about the environment are formed early and can be difficult to change. Therefore, it is recommended to intervene with primary and early secondary youth on important sociocultural issues such as global climate change. Not only do adults influence children's values and conceptions about environmental issues, but they are often a necessary element to take actions locally or beyond. This study examines factors related to the intended climate change behaviors in rural, middle school students and their families in the southeastern United States.

Participants in an after school STEM club and their parents were recruited to do an at-home intervention. In their homes, parents and students participated in discussions surrounding global and local climate change issues when viewing video documentaries and during interviews at their school sites. Using the Determinants of Behavior model of climate change, audio data was coded to examine trends in climate change beliefs and content knowledge shifts. For this population, they most often talked about climate change knowledge, followed by behaviors and the seriousness of the problem. Seventy-two percent of the participants were coded as having individualistic egalitarian worldviews. Families had low or high engagement with the intervention materials, and changes in climate change content knowledge from pre- to post-intervention were highest in the groups of students and parents who were highly engaged in the at-home family intervention. These findings indicate that parents and students can benefit from short-term interventions in their own homes. Also, the interventions must be explicitly chosen to fit climate communication frames that align with worldviews/values and various other factors found in the DOB framework (e.g., demographic traits, social norms, media, and knowledge) in order to make the greatest impact in participating families. With the families in this study, news outlets were considered trusted sources of scientific information and popular media icons, turned climate activists, were found to capture the participants' attention.

Introduction

Parental involvement is an important influence on children as they begin to form beliefs and understanding about the natural world. The most common type of parental involvement is homework assistance (Wilder, 2013). While simply assisting students with homework did not seem to have a significant effect on students' academic success, Wilder found that other opportunities for parental involvement within the home did show positive effects such as provision of the proper environment and materials for learning. Barbarin, McCandies, Coleman, and Hill

(2005) found African American families traditionally spend more time in home-based activities as compared to White families. It is recommended that race and ethnicity be considered when studying parental involvement (Bower & Griffin, 2011).

Family oriented at-home educational strategies are important to consider because there is recent evidence to support a more bi-directional exchange of knowledge, values, and beliefs between parent and child (Damerell, Howe, & Milner-Gulland, 2013). This is in contrast to the more commonly held view of uni-directional flow from parent to child (Damerell et al., 2013; Knafo & Galansky, 2008). While the intent of this study is not to determine the degree to which parents and their children influence one another's knowledge, beliefs, and related behaviors, it is essential to note the influence that family members may have on one another, especially in sociocultural environmental issues. Climate change is one such issue where adults and students frequently hold differing beliefs and content knowledge (Leiserowitz et al., 2011)

In their study of 6th graders, Visintainer and Linn (2015) found that one of the top places students claimed to find evidence about climate change included parents/relatives, along with science class and the media. Parents may directly express climate change knowledge (both accurate scientific information and misconceptions) or indirectly transmit other values such as worldviews and risk perceptions to their children. Using a risk perception attitude framework, Mead, Roser-Renouf, Rimal, Flora, Maibach, and Leiserowitz (2012) found that parents' membership in risk categories (indifference, proactive, avoidance, and responsive) was strongly associated with their children's' membership in the same category. Children who were categorized into either the responsive or avoidance groups sought out a greater amount of information about climate change than those who were found to be indifferent or proactive. Mead et al. found that communication about global warming increased teens' "information seeking" (p. 32). When

global warming communication among families was more frequent, Mead et al. found that adolescents were more likely to "seek out information about climate change," than in families where the communication is infrequent (p. 44).

Climate change is occurring worldwide (IPCC, 2007). People must begin positioning themselves to "target mitigation strategies to reduce the anthropogenic impact of climate change through technological developments, workplace (i.e., agricultural and industrial) practices, personal and community behavior changes" (Gutierrez & LePrevost, 2016, p. 14). While most scientists agree that mitigation behaviors need to begin immediately throughout the world to reduce greenhouse gas emissions, much of the public still sees climate change as a non-urgent threat (Anable et al., 2006; Lorenzoni & Hulme, 2009; Moser, 2010). Furthermore, mitigation efforts may not even be enough; the Intergovernmental Panel on Climate Change (IPCC) warns that individuals and communities should already begin making plans to respond to negative climate change impact, as regions are already being negatively affected (Bofferding & Kloser, 2014; IPCC, 2007).

This study examines how constructs that influence environmental behaviors (e.g., social factors, individuals' characteristics, perceived importance of the problem, individuals responsible for change) are discussed in participant family homes and in interviews with rural middle school students and their parents or guardians during a climate change intervention. Using the Determinants of Behavior framework (Patchen, 2010), underlying factors are investigated, as well as changes in their knowledge and beliefs about climate change. This climate communication study had two key objectives: 1) To engage parents and students in climate change activities in order to increase their content knowledge and promote more scientific beliefs

and behaviors, and 2) To enhance the relevance of climate change issues by promoting family-centered discussions in their homes.

Literature Review

Climate Communication

Individuals perceive climate change risks differently (Leiserowitz, 2005). Leiserowitz (2006) found that the American public has a moderate risk perception of climate change. This is due, for the most part, to perceptions of climate change danger to geographically distant people, places, and non-human life. However, a more recent study by Shao, Keim, Garand, and Hamilton (2014) found that Americans who have experienced negative impacts related to changing climate, such as increased summer heat or drought, are more likely to perceive the risk and severity of global warming. Their study also indicates that demographic factors such as age, gender, and race influence risk perception; youth, women, and racial minorities were more likely to indicate higher concern about global warming.

Gifford, Kormos, & McIntyre (2011) identify structural (e.g., poverty, poor infrastructure) and psychological (e.g., limited cognition, perceived risks, ideologies) barriers for pro-environmental behaviors related to climate change. Semenza, Hall, Wilson, Bontempo, Sailor, and George (2008) describe a number of perceptions that are barriers to individuals making behavior changes: not knowing how to change behaviors, not believing that one person's change would make a difference anyway, and not having enough money and time to make changes. Steg, Bolderdijk, Keizer, and Perlaviciute (2014) stress that pro-environmental actions need to be made more "convenient, fun, cheaper, or less effortful as to make such actions more attractive" (p. 105). Examples of these types of behaviors meeting these suggested criteria may include reducing carbon footprints by minimizing bottled water and plastic bag usage,

carpooling, or increasing carbon sinks by planting trees (Bofferding & Kloser, 2014; Bolderdijk et al., 2013).

Just as there are ways to overcome barriers for behavior change, there are ways to overcome information barriers (e.g., fragmented media system, media filtering information, sources of information) for climate change communicators (Nisbet, 2009). Nesbit that insists "messages need to be tailored to a specific medium and audience, using carefully researched metaphors, allusions, and examples that trigger a new way of thinking about the personal relevance of climate change" (p. 15). For example, someone who is highly interested in economic development and competitiveness would be positively affected by a frame centered around creating 'green' jobs to increase revenue (Nisbet, 2009). Nisbet acknowledges that in many cases, frames are not effective unless they align with their audience's preexisting interpretation of climate change. In his text, Nisbet provides an example of how author E.O. Wilson emphasized the moral and religious responsibility people have to respond to climate change through his writing and found that he was able to convince religious leaders about the importance of climate change in their mission. As the world becomes increasingly connected, news sources (e.g., cable television, internet news, social media), both reliable and unreliable, are abundant. Popular news sources have begun to cover climate change stories more frequently; however, public readership has shifted from news outlets (e.g., *New York Times*, *Washington Post*) to more social forms of communication such as Facebook and Twitter (Nisbet, 2009).

Climate Change Communication Frames

A message frame is defined by Chong and Druckman (2007) as a type of communication (e.g., words, images, or phrases) whose main purpose is to relay information about a topic or an event to its targeted audience. It has been argued that it is impossible to address the issue of

climate change with complete neutrality or without some personal context (Hulme, 2009). Nisbet asserts that it is necessary to present one's audience with the proper conversational frame based on what is known about their overall demographics (i.e., gender, age, political affiliation, religious beliefs, highest educational level), worldview (i.e. hierarchical/egalitarian and individualist/communitarian), and cultural influences. For example, when addressing populations with a highly conservative political ideology, climate communicators would not want to suggest increasing taxes to pay for new environmental initiatives unless the focus of the initiatives was based on financial gains (e.g., developing industries for green energy, providing jobs for the local workforce) rather than a singular goal of reducing greenhouse gas emissions to help the planet.

Gifford and Comeau (2011) found that women were more likely to support climate change mitigation efforts and feel greater environmental concern, despite scoring lower on related content knowledge questions. In contrast, older participants responded with a greater intent to act in pro-environmental ways but did not feel as if they were equipped or competent enough to do so. Men were found to be more responsive to framing than women overall; thus, on television stations or programs with predominantly male audiences, motivational messages, rather than sacrifice messages should be played. Motivational messages involve solutions and visions to solve problems rather than highlighting things that must be given up or sacrificed for climate change mitigation. Similarly, for a mixed audience, motivational messages should be used over sacrifice messages in order to reach the broadest portion of the overall audience. Additionally, messages intended for older audiences should strive to build confidence in their capacity to induce climate change mitigating behaviors (i.e., showing how to go about buying new energy efficient appliances, adjusting the thermostat a few degrees up in the summer and

down in the winter, and buying local foods which can help mitigate climate change), whereas messages for younger audiences should focus on ways to enhance positive mitigation behaviors (i.e., explaining potential efficient car options and green home options as they begin to earn capital and can financially afford to act in a more pro-environmental manner) because "perceived competence steadily declines with age" (Gifford & Comeau, 2011, p. 1306).

Age appropriate effective teaching and learning strategies are essential in order to stimulate changes in students' knowledge, beliefs, and behaviors (Shepardson et al., 2011). Teaching students to develop their own scientific understanding from materials is an important learning strategy for climate change education (Hestness et al., 2014). For example, students can put together presentations on various forms of traditional and alternative energies and then participate in a mock energy summit to share pros and cons of future energy options. In addition to developing argumentation skills in students, Stevenson et al. (2013) found that the development of participants' pro-environmental attitudes and behaviors can be strengthened with time spent outdoors. In adults, it is important to make information easily understandable and digestible, as most cannot invest substantial time and effort into traditional learning opportunities as their children do in classrooms on a daily basis (Myers et al., 2013). Additionally, Myers et al. recommend that the information provided to adults must be personally applicable in order to gain the most interest and buy-in. This is especially important when addressing controversial issues such as climate change. One needs to examine demographic factors and the relationship between school and home cultures specific to the population of study (Adger, Barnett, Brown, Marshall, & O'Brien, 2012; Leiserowitz, Maibach, Roser-Renouf, Smith, & Dawson, 2012). Specific examples of local mitigation strategies that could minimize costs (e.g., regulate thermostats slightly during seasons with temperature extremes, increase insulation in homes,

reduce instances of car idling) would be important to families in school districts who are living with low to moderate incomes. With the literature in mind, students and parents were invited to participate in climate change centered meetings and activities in an out-of-school setting and in their homes. The goals of this climate change study were to engage students and their family members with a climate change intervention intended to help them learn more scientifically-accurate knowledge about climate change, to identify climate change impacts and mitigation strategies in their communities, to develop more scientific beliefs, and to study the outcomes and underlying factors.

Theoretical Framework

The theoretical framework for this study, the Determinants of Behavior (DOB) Model, was created by Patchen (2010). Patchen's model (Figure 4.1) was informed by other environmental behavior models, including the Theory of Planned Behavior (TPB) (Ajzen, 1991), Value-Belief-Norm (VBN) Theory (Stern, 2000), Structural Model (Grob, 1995), Appraisal Theory (Scherer, 1999), and others related to habit, identity, knowledge, influences, and behaviors of others. Patchen found that these different theoretical frameworks addressed many similar components of environmental behavior. However, he found that "none of them alone is adequate to encompass the wide range of research findings concerning such behavior and specifically behavior at countering climate change" (p. 49). Patchen's newly generated framework relies heavily on the TPB and Appraisal Theories (Patchen, 2010).

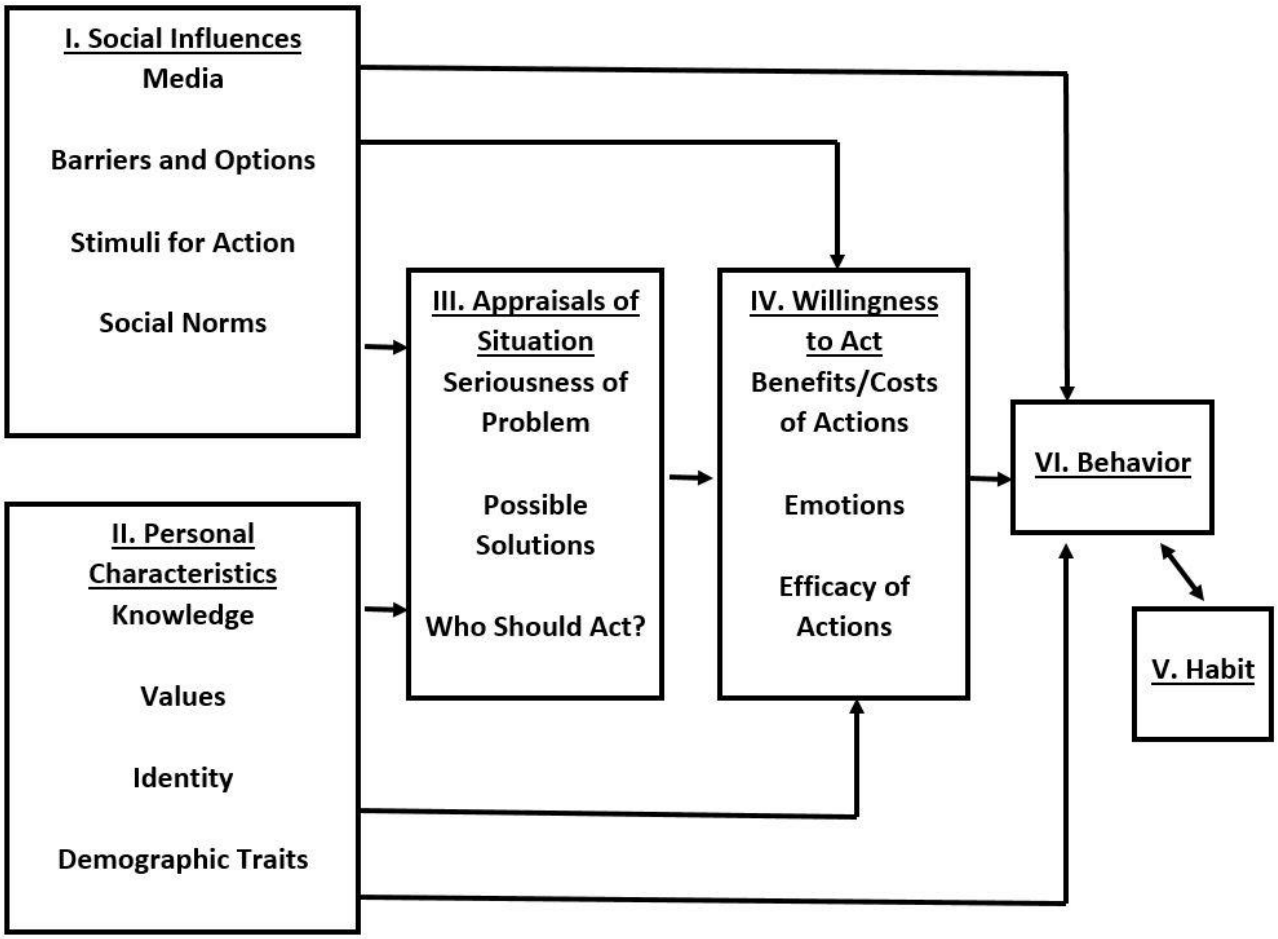

Figure 4.1. Adapted from the Determinants of behavior model of climate change (Patchen, 2010), Roman Numerals Added.

The DOB shows the unidirectional influential relationship between the majority of the constructs within the model; however, there is a bidirectional relationship between behavior and habits (Patchen, 2010). Patchen explains that the habits (the repetition of the same behaviors) will also be affected by the same factors that lead to behavioral changes. Thus, in the long-term, both behaviors and habits related to climate change will be affected by similar factors.

Research Questions

For rural middle school students and their parents/guardians in the southeastern US:

1. What underlying factors from the Determinants of Behavior (DOB) model of climate change are most often addressed by families while watching at-home climate change documentaries and taking part in interviews?

2. How do parents and their children talk about climate change during the at-home intervention and during interviews?

3. How does the level of family engagement during the at-home intervention relate to family changes in climate change beliefs and content knowledge?

Methods

Middle school students in STEM after school clubs in four rural, high poverty school districts in the southeastern United States engaged in three, two-hour climate change activities linked to their local communities (e.g., local solar farms, agriculture, health) and related careers. Additionally, all parents were invited to participate in a school-site meeting led by the researcher, to help parents learn more about climate change and to engage in a climate related carbon footprint intervention activity. A randomly selected subset of families were invited to participate in home-based activities and discussions. Finally, a randomly selected subset of families, including families who did and who did not participate in the at-home intervention, were invited to interview with a researcher concerning climate change topics.

Context

The average percentage of free and reduced student lunches in the four participating school districts was 84.8%, indicating that the poverty level of students in these schools was substantially higher than the state average (56%). These districts experienced slightly higher

teacher turnover (17.8%) than the state (16%). Additionally, the school districts in the study had fewer fully licensed teachers (83.6%), as compared to the state (94.4%).

Students within the participating schools significantly underperformed other students in the state. Students (75.3%) in the participating middle schools scored a Level 1 or 2 (failing) on their mathematics end-of-grade test, compared to the state average (53.8%). Eighth grade students (42.3%) in the participating middle schools scored a Level 1 or 2 (failing) on their 8th grade science end-of-grade test, compared to the state average (27.4%). The climate change research interventions developed for this study addressed state standards for these subject areas to help enhance student content knowledge.

Sample/Participants

Families of students participating in an after school STEM Career Club at four rural middle schools were invited to be a part of this study. The STEM Career Clubs project was in year 2 of a 3-year NSF ITEST grant cycle, and all students (N = 243) attending the clubs were invited to participate. The Internal Review Board (IRB) at the university (NCSU) approved the proposed study on September 21, 2015, Protocol #6177. Only the data from students and parents who agreed to participate in the study were analyzed. Students were provided with two consent forms to complete, one for parent involvement and one for student involvement. A total of 136 parents returned Informed Consent forms to participate in the study. On the Informed Consent forms, parents were asked for contact information (i.e., phone number, email), their preferred method of contact (i.e., phone call, email, or text), whether they would like a paper survey or a survey link to be sent via email, and whether or not they would like to participate in at-home activities with their students and/or an interview with a researcher.

At-home interventions were developed to promote meaningful family conversations

about climate change during a family video activity that provided accurate climate change information in a compelling manner. A randomly selected subset of parents and students who returned their Informed Consent forms were asked to watch two documentaries together about climate change. The participants read and responded to the researcher-provided questions aloud while audio recording their conversations that occurred prior to, during, and following the documentary videos. Additionally, a subset of the families who agreed to participate in an interview with a researcher were randomly selected and contacted by the researcher. Table 4.1 shows the breakdown of initial surveys, at-home interventions, and interviews, as well as their completion rates for each school.

Table 4.1

Initial and Actual Counts and Completion Percentage Rates for Initial Parent Surveys, At-Home Interventions Completed, and Family Interviews Completed

Schools	**Parent Surveys**		**At-Home Materials**		**Interviews**	
	Requests Sent	**Completed**	**Sent Out**	**Audio/ Text Collected**	**Parents Contacted**	**Interviews Conducted**
Taylor MS	28	9	7	4	5	3
Butler MS	27	8	6	4	5	3
Clark MS	49	8	10	5	8	2
Gulf MS	19	4	9	2	5	4
Totals	**123**	**29**	**32**	**15**	**23**	**12**
Percentage completed		**23.6%**		**46.9%**		**52.2%**

Note. All school names provided are pseudonyms and are used throughout the text. Two additional parents had agreed to interview at Clark Middle School, but did not show up for the interview time. One of the interviews at Gulf Middle School could not be transcribed or analyzed due to an audio technical issue.

Initially 71.2% of parents of students in the club agreed to participate in at-home intervention and 66.4% agreed to participate in the interview with a researcher at their school

site. All parents who provided informed consent were sent the pre-intervention Qualtrics survey link to complete the climate change beliefs, content knowledge, and worldview via their provided email. Additionally, paper copies of the same survey were sent home to parents who requested this format via their students at the STEM Career Clubs and with parents who attended the evening parent meetings (*n* = 48, in total at from each of the four schools) when the researcher spoke with and conducted an activity with parents. Parents who did not complete the survey within 2 weeks of receiving the initial link/paper copy were sent one reminder email. All parents/guardians who completed the initial survey prior to the family at-home interventions and interviews were asked to complete a post-intervention survey. Surveys were distributed to parents by email link and by paper through their students at each school site. Parents completing this post-survey online or who mailed in their responses via pre-addressed/pre-stamped envelope received a $10 gift card for their participation.

The ethnicity of parents and students who participated in the at-home intervention or researcher interviews included 55.9% African American, 29.4% Caucasian, 5.8% Native American, and 8.8% two or more races. These percentages are similar to the ethnicity averages in the four schools: 53.9% African American, 24.4% Caucasian, 4.4% Native American, and 7.8% two or more races.

The gender distribution of students participating in the at-home interventions and interviews was 43.5% male and 56.5% female and for parents it was 18.2% male and 81.8% female. The average percentage of females in the STEM Career Clubs at the time of study was 58.8%. Of the participating students in at-home interventions or interviews, the majority, 56.5%, were in 6th grade, followed by 30.4% in 7th grade, 8.7% in 8th grade, and 4.3% in 5th grade. Only

one of the four participating schools had a 5th grade class. Similarly, the 6th grade whole club representation was also high at 47.7%, followed by 7th (27.6%), and 8th (17.5%).

Materials

Fifteen at-home intervention kits, including two DVD documentaries, Season 1/Episode 1 of Showtime's *Years of Living Dangerously: The Dry Season* and local news documentary, *Exploring Climate Change*, a digital audio recorder, instructions and questions printouts, and microwave popcorn and individual sodas, were packaged. These materials were rotated through randomly chosen families who had agreed to participate in their homes at each of the four schools. As the materials were collected and audio downloaded from one family, the non-consumable items were repackaged, consumable items were replaced, and the kits were then sent home with another family. This process spanned a 3-month time frame in order to engage as many families as possible in the study. The researcher personalized efforts (i.e., texts, emails, and phone calls) to retrieve materials from families who had not returned materials to the school site. Additionally, interviews were arranged with randomly selected families who had not done the intervention and those who had, and those families who agreed to participate in the interview received a $10 gift card.

STEM Club Intervention

Student interventions were designed by the researcher. There were three intervention sessions designed for the three, two-hour after school STEM Career Clubs. These sessions included components of Science, Technology, Engineering, and Math (STEM) content related to climate science and included exposure to careers/career professionals associated with the interventions. The intervention activities included collaborative discussion with peers, laboratory activities, and interactions with climate related professionals. Students distinguished

between weather and climate through a competitive game and measured weather parameters with Vernier probeware in meeting #1. Students determined the role of carbon dioxide as a greenhouse gas by making their own greenhouse in a bottle and recording temperature increases with probeware, and calculated their individual carbon footprints and compared their footprints to students around the world in meeting #2. In meeting #3 students circulated through seven stations at which they looked at current local alternative energy use, investigated solar and wind energy by building Elenco® Alternative Energy Snap Circuits, and ran online electricity simulations. Efforts were made to introduce activities that were related to the local community (e.g., solar farms) and to give students exposure to STEM professionals as guests at the STEM Club meetings (e.g., climatologist, environmental engineer, solar energy company representative) to help personally connect students to STEM professionals. The researcher instructed and trained the club teachers during a 1-day professional development session prior to the student club meetings. Then, the STEM Career Club teachers led their students in the club interventions, which were attended by the researcher and university project team members to ensure the climate change beliefs, content knowledge, and cultural worldviews surveys were completed and teachers were supported.

Parents who attended the climate change focused STEM Club Parent Meeting received an intervention. The researcher gave a 20-30-minute presentation about climate change basics, including current and future health and economic implications of climate change in their local environments. Following the presentation, parents were asked to complete their own carbon footprint for approximately 20 minutes, and then share their results with the group. Ideas for personal mitigation behavior changes (e.g., turning off lights, installing energy efficient LED light bulbs, carpooling/reducing transportation needs) were shared. Some students attended the

parent meeting as well, helping their parents complete the carbon footprint activity together. Parents received a researcher-generated brochure outlining much of this information and a parent survey for parents to complete at their own pace and return to school via their students.

Care was taken to ensure that the at-home intervention documentaries used in this study, along with the parent (and student) meeting activities, were designed to ensure that climate change was framed appropriately for participant families based on age structure, geographic location, ethnicity, socioeconomic status, and religious beliefs. Videos were selected to include people of similar backgrounds as many of the study participants: rural, Christian, people of color, American, local, and impoverished.

Instruments Used/Data Sources

Two individual surveys were combined for both students and parents, along with basic demographic information, to measure climate change knowledge, beliefs, and worldviews. Both the adult (18+) and teen (13-17) versions of the Climate Change surveys by Leiserowitz et al. (Leiserowitz, Smith, & Marlon, 2010; Leiserowitz, Smith, & Marlon, 2011) have been used with adult and teen populations throughout the United States. However, for use in this study both the student and parent instruments used to assess climate change beliefs and content knowledge were modified according to the target constructs to be measured, the length of survey, and content level. For example, the Leiserowitz et al. survey addressed measures of trust in information sources, policy preferences, and behaviors that were cut, as were 15 questions that were not specifically addressed in the climate change interventions (e.g., coral bleaching, ocean acidification, whether or not schools should teach about global warming) or that were judged to be too advanced for the populations surveyed (e.g., amount of CO_2 in ppm in the atmosphere, the

gradual/fragile/stable/threshold climate system models, specifically how much the temperature has changed and is expected to change).

This study also used two surveys based on the work of Stevenson et al. (2013) to measure the worldviews of students. The Likert Scale response options on the worldview survey are the same as in the original adult surveys by Kahan et al. (2012b) and Pratto et al. (1994), which include six-point Likert scale items ranging from strongly disagree (1) to strongly agree (6). There are more items on the student instrument (31 items) than the shortened adult version by Kahan et al. (12 items) in part because some of the items were broken into shorter statements for age-appropriate readability and understanding. Parents were given the shortened adult version of the worldview survey by Kahan et al. (2012). The content knowledge and beliefs and worldview surveys were combined into one complete survey in Qualtrics for students to take online at their school site and for parents to take either online or on paper (see Appendix C).

Families were instructed to watch two documentaries, *Years of Living Dangerously: The Dry Season* (Season 1: Episode 1) and a local news documentary, *Exploring Climate Change*. Prior to and after watching these documentaries, families were asked to answer researcher designed questions related to climate change (Appendix D) and linked to constructs in the Determinants of Behavior (DOB) Model of Climate Change (Patchen, 2010). Families turned on a digital audio recorder prior to beginning and were asked to keep the audio recorder on throughout the videos and post-video questions to capture any conversations. Finally, interview questions were designed with the DOB model in mind, based on work by Ebi and Semenza (2008) and Semenza, Ploubidis, and George (2011). Questions addressed climate change beliefs, climate change concerns, levels of participation in the interventions, perceived changes in content knowledge and/or behaviors, and barriers to change. The audio responses from the at-

home intervention and semi-structured family interviews were coded into a priori categories outlined by the constructs and sub-constructs within the DOB framework using ATLAS.ti 6.

Reliability

All audio recordings were transcribed, verbatim. In in order to ensure reliability of the open-coded, at-home intervention and interview data, the primary researcher and a second researcher coded approximately 10% of transcripts for calibration of codes, then the researcher finished coding the remaining 90% of the audio data. The qualitative data attained from the parent/student dyad interviews was used to help triangulate and confirm results from the participants' pre- and post-quantitative surveys.

Validity

In order to address external validity, random, purposeful sampling was used to determine which families would be asked to participate in the at-home interventions and interviews that would reflect the STEM Club make-up and the make-up of each of the school sites. Approximately equivalent at-home interventions and interviews were completed at each of the four schools. Thus, those families invited to interview were not significantly different from the sample frame population at large. The audio data from interviews helped to triangulate the quantitative data and to investigate any evident changes in intended environmentally positive behaviors post-intervention. The climate change conceptual knowledge and belief instrument had been used previously, assessed for internal construct validity, and had been thoroughly tested with over 1,000 adults (Leiserowitz et al., 2010) and over 1,000 students (Leiserowitz et al., 2011) nationwide. Similarly, Kahan's worldview statements also had been thoroughly vetted in in many studies (Kahan et al., 2011; Kahan, 2012), with more than a thousand participants. The semi-structured interview questions were informed by Semenza et al. (2008) and the open-ended

questions accompanying the at-home interventions were assessed by a climate change content expert and qualitative researcher to test the content value prior to deployment.

Findings

Underlying Factors Addressed by Families

The Determinants of Behavior (DOB) (Patchen, 2010) framework was used to analyze qualitative data for factors (e.g., social influences, personal characteristics, appraisals of situation, willingness to act, habit) that may contribute to families' climate change behaviors, as shown in Figure 4.2.

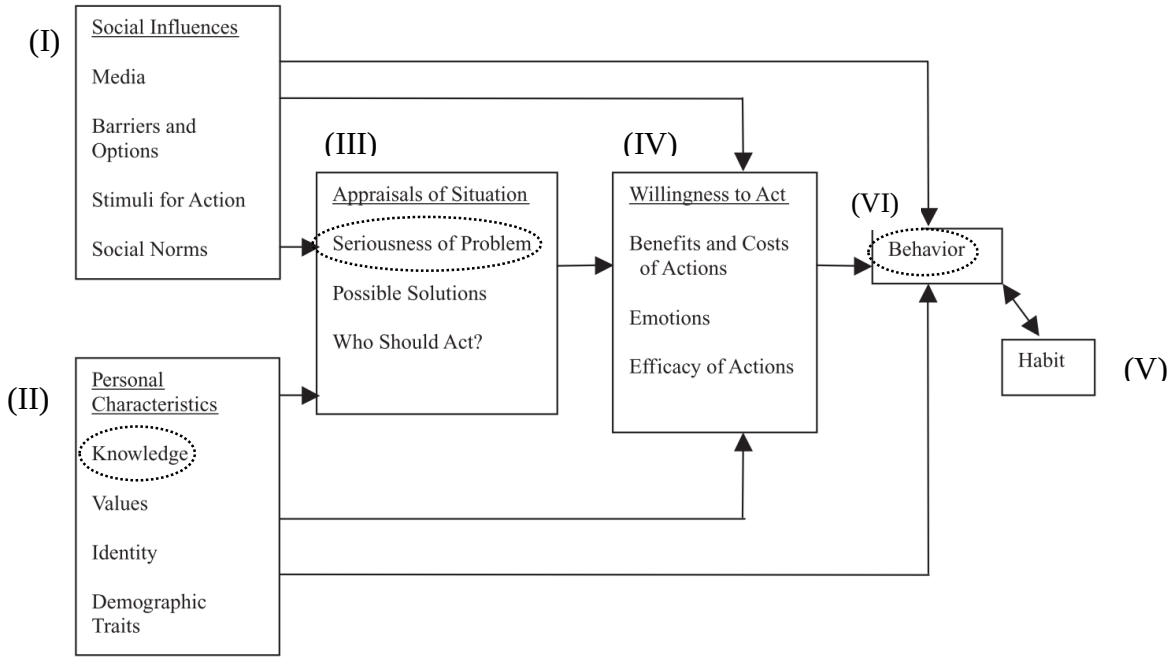

Figure 4.2. Determinants of Behavior (DOB) model of climate change adapted from Patchen (2010), labeled with Roman numerals.

Using Patchen's (2010) detailed explanations within his manuscript, the audio for both the at-home interventions and researcher interviews were coded into the components in each of the main constructs of the DOB model. (Example statements for each of the specific components are provided later in the findings.) Participants most often talked about climate

change *Knowledge* (Construct II, 26.1%), followed by *Behaviors* (Construct VI, 11.5%), the *Seriousness of the Problem* (Construct III, 10.6%) and *Media* (Construct I, 9.0%). Frequency counts for all factors that were expressed by participants are displayed in Figure 4.3.

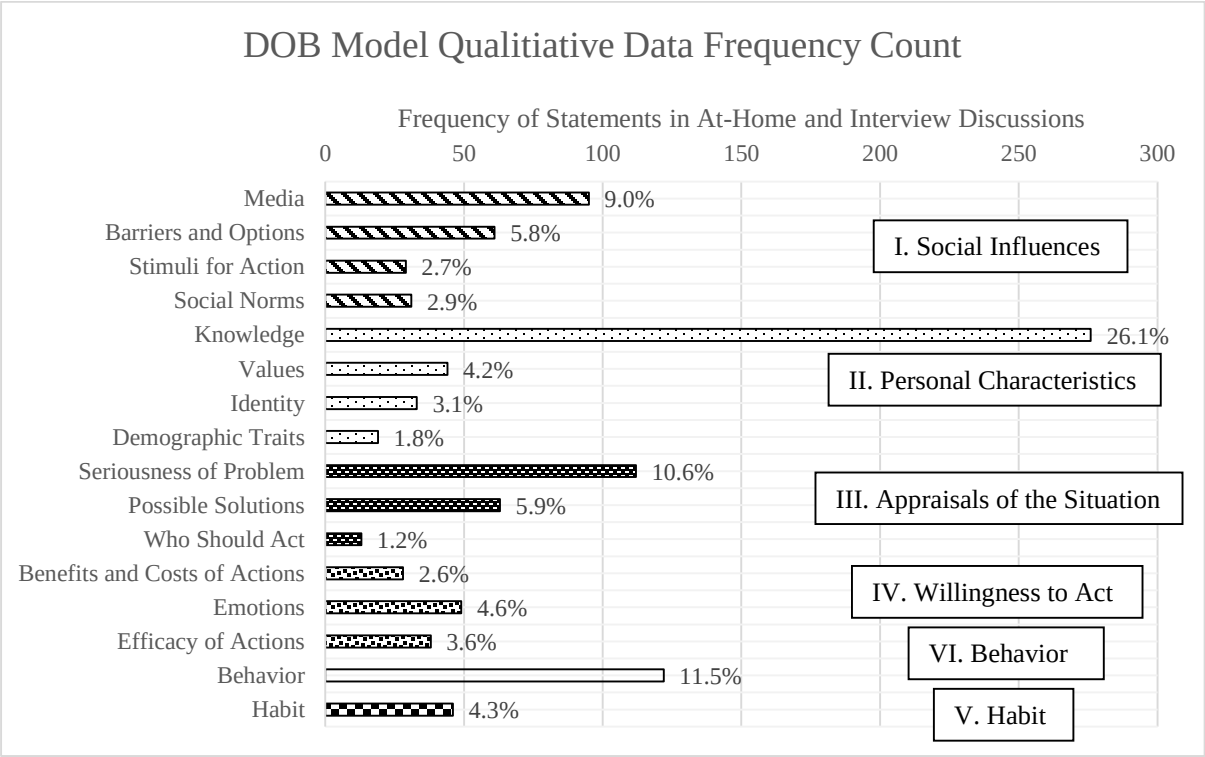

Figure 4.3. Frequency counts for at-home and interview data using Determinants of Behavior for climate change framework.

Additionally, based on the families' responses during the at-home intervention and interview data, *Personal Characteristics* (Construct II, 39.7%) and *Social Influences* (Construct I, 23.1%) were the most common constructs expressed by participants (as shown in Figure 4.4). Scant conversation focused on the personal *Habits* construct (4.9%) or *Willingness to Act* (12.3%) aspects of the DOB.

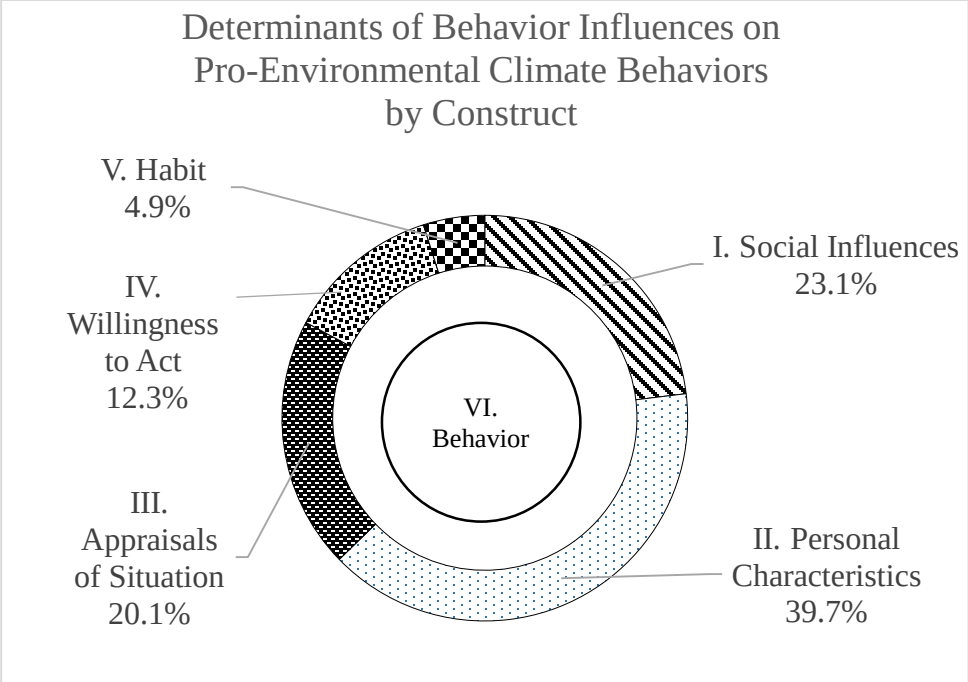

Figure 4.4. Determinants of Behavior construct percentages for at-home and interview data influencing pro-environmental climate change behaviors.

Levels of engagement during the at-home documentary intervention were established by the researcher after listening to the audio data and reviewing transcripts. Some families were invested in gaining the full-experience of the documentary and family discussion (high engagement), while some families completed the minimal requirements (low engagement). For example, low engagement families watched the videos and did not answer questions fully or at all, families did not talk during the documentaries and gave minimal responses pre- and post-intervention, parents only minimally participated and discussion was concentrated among siblings in the home, and families chose to write minimal responses on the question sheet provided instead of audio recording discussions (see Appendix D). Figure 4.5 shows the average differences of the at-home audio data coded for each of the six constructs in the DOB framework comparing low and high intervention levels. The largest differences between the low and high

levels of engagement by percentage were found in the discussion of *Social Influences* (45.1%), *Willingness to Act* (42.1%), *Behavior* (42.6%), and *Habit* (55.0%).

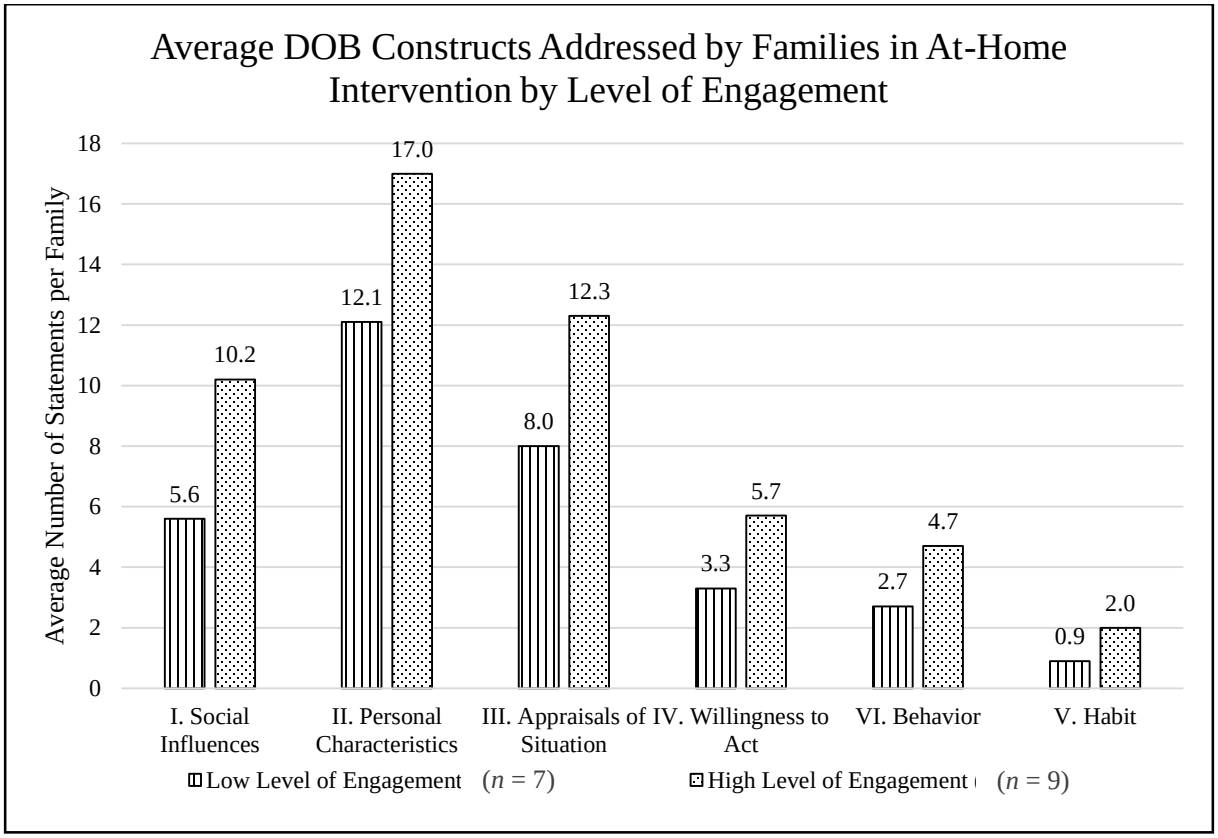

Figure 4.5. Average number of statements coded into the constructs of the DOB framework during the at-home intervention based on level of familial engagement (low and high).

Families who participated at a high level of engagement during the at-home intervention discussed types of knowledge differently. In order to further analyze the types of knowledge families spoke about, the types of knowledge observed were broken down into Johannsson and Perjons' (2014) types of knowledge categorization: definitional, descriptive, explanatory, predictive, explanatory and predictive, and prescriptive. According to Johannesson & Perjons *definitional knowledge* includes "concepts, constructs, terminologies, definitions, vocabularies, classifications, taxonomies" (p. 22). *Descriptive knowledge* provides a summary or generalization of occurrences and experiences. *Explanatory knowledge* offers further

understanding such as how and why. On its own, *predictive knowledge* proposes a prediction without explaining the foundational basis for making the prediction. In this study, predictive knowledge was often paired with explanatory knowledge during talk as a hybrid, *explanatory and predictive knowledge*, "offer[ing] both explanations and predictions" (p. 24). Finally, *prescriptive knowledge* includes models and methods to solve constructive problems.

Highly engaged participants discussed definitions more (21.3%), described content more (45.5%), and discussed prescriptive knowledge more (67.6%) than low-engagement families, as shown in Figure 4.6. However, the families who were minimally engaged averaged greater percentages more of explanatory (18.9%) and predictive (21.2%) knowledge during conversation. Overall, definitional knowledge was most talked about by both low and highly engaged families. On average, highly engaged families talked about prescriptive type knowledge twice as much as lesser engaged families.

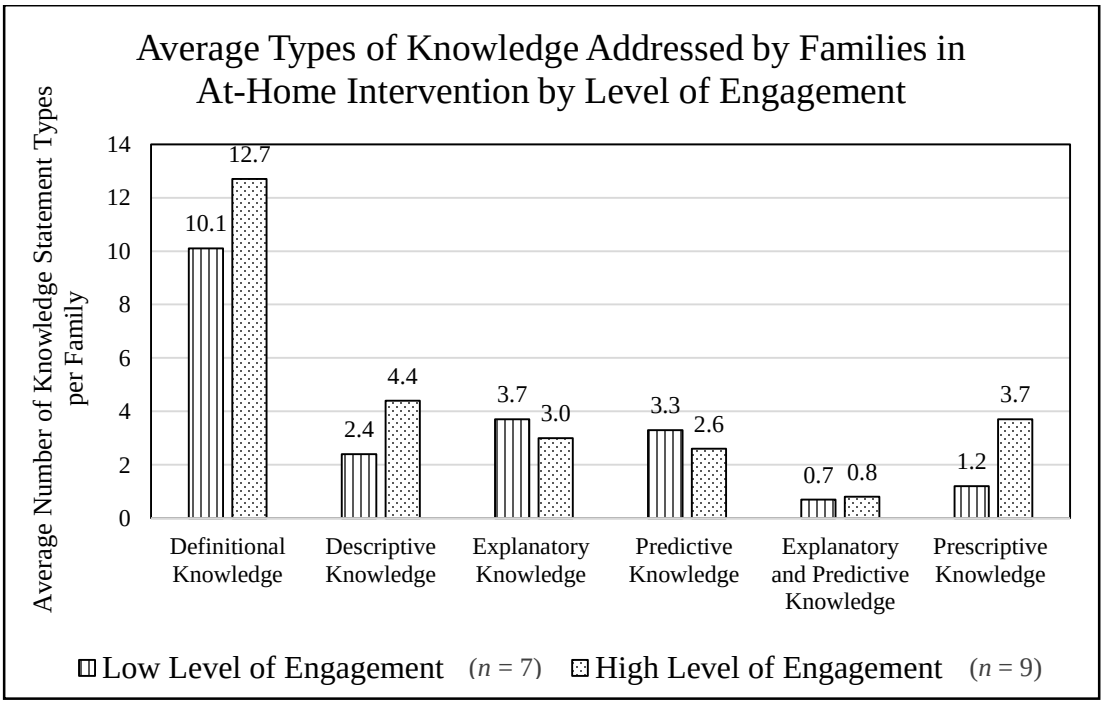

Figure 4.6. Average number of knowledge statements coded into the type of knowledge addressed during the at-home intervention based on level of familial engagement (low and high).

How Parents and Their Children Talk about Climate Change

Analyses of audio data from the at-home intervention and interviews (questions in Appendix E) was completed using constructs in the Determinants of Behavior (DOB) framework by Patchen (2010) . Both types of audio data were analyzed together because the instruments used to collect data were explicitly constructed to target constructs in the DOB framework. Throughout this section, findings refer back to the DOB framework (see Figure 4.2). Reported percentages are based on frequency counts of number of times statements are coded into the a priori categories in the DOB framework.

I. Social Influences

Social influences, such as media, barriers and options, stimuli for action, and social norms were talked about almost a fourth of the time (23.1%). Social influences seem to be a frequently addressed component affecting climate behaviors with this intervention design with this population of participants.

Ia. Media

Families described the power of local news reports and documentaries about climate change such as Deborah, an African American mother, during her at-home discussion with her daughter and husband.

> *Deborah (mother)*: WKYZ. It's different when you see it, like at home. When you hear what they're saying about things that's affecting us here. Right here versus the other movie, showing stuff around different countries. So yea, it does - it really, really opened your eyes to just why the weather is how it is here.

Also, the presence of international movie screen personalities or politicians were noted by several of the families (n = 6), including Deborah:

> *Deborah (mother):* We watched Harrison Ford in a lot of movies. I can't think of the other guy's name, but I've seen him before.
> *Interviewer:* Cheadle.

> *Deborah (mother):* Right, I've seen him in movies before.
> *Interviewer:* Iron Man?
> *Deborah (mother):* Yea. Mmm. It opens your - when you see them, it almost kind of makes you – [Think…] OK, wait a minute, let me listen. …And what make[s] it-when you see a familiar face, you know?

Prior to watching the at-home family documentaries, families were asked to comment about the credibility of the sources of information. Approximately (32%) of families noted that local and national news sources (e.g., newspapers, local television news stations) were trustworthy. Kira, an aunt of an African American STEM Club student, remarked: "Well, I usually listen to the WKYZ news which is very credible, is always right. Or Channel 2 and they're pretty good….or even *The Weather Channel*."

Ib. Barriers and Options

Patchen's (2010) model includes social barriers (e.g., lack of access to materials or technology) that may or may not prevent individuals or families from carrying out pro-environmental climate behaviors. Many families (77.3%) discussed the perceived or actual barriers associated with personal pro-environmental behavior (i.e., financial costs, lack of communication), although much more frequently by parents than by students. When asked in an interview about things that might get in the way of a more environmentally-friendly lifestyle, Crystal, a Caucasian mother, remarked:

> *Crystal (mother):* [About electric cars] They're so expensive. … I mean - I'm trying to think. I would like to convert to a different heating source. But money is a hindrance.

Similarly, for Rita, an African American mother, reducing transportation for work is a barrier:

> *Rita (mother)*: Me, on the other hand, if I could change anything and if I was able to, it's how we've got to have cars that use gas and stuff for transportation, try to do less transportation but right now we can't because we're working.

Study participants also noted that individuals within the climate change conversation need to make more attempts to understand the perspectives of all individuals involved, including

politicians, religious leaders, people across state and international borders, and citizens within one's own country who are on opposite sides of the political spectrum. They noted the inability of key decision-makers involved in the climate change conversation to work together. Audrey, an African American mother, expressed the following to her son during the at-home documentary discussion:

> *Audrey (mother):* I think one of the ways to start changing the conversation is to first understand the opposition. So I have to understand what you think before I can explain anything to you. If not, we're just talking back and forth through a wall. … I have to understand where you're coming from. You have to understand where I'm coming from in order for us to find a bridge that we can have common ground on.

During the at-home discussion with the extended family present (grandfather, grandmother, mother, father, son, and daughter), Elsie, a Caucasian grandmother, shared her thoughts about multiple perspectives with her daughter, Candice:

> *[responding to a community in the video where many families lost their jobs due to drought]*
> *Elsie (grandmother):* And then they [the community] could get them to maybe do more. Like the girl who goes to church and had lost her job and stuff and was -
> *Candice (mother):* Yea, they going to listen to the common people.
> *Elsie (grandmother):* Right, they were - then when she went to listen to the scientists and they related it more to the religious terms, then she understood more. So you see what I'm saying, that's how I feel it would help people more if they would all work together.

Ic. Social Stimuli for Action

Patchen (2010) identifies five distinct areas that are included in the Stimuli for Action construct: prompts, eliciting commitments, goal setting, feedback, and rewards and penalties. Prompts are defined as either verbal or written communications that are designed to make individuals take action. This can be done through flyers, brochures, or in-person communications. Following the documentary, Joseph's mother Audrey asked him if his actions could have an impact on climate, Joseph, an African American 6th grader at Gulf Middle School suggested, "Mmm. Like if I can try and start something, like a little website or something. A

website to show something—things we can fix about climate change and things that we can stop doing, what's wrong with it."

During the family discussion and immediately following a portion in *Years of Living Dangerously* in which Syria was brought to war due to drought and resource depletion, Joseph expressed his commitment.

> [I] really want to do something about it [climate change]. [It is] getting to the point around the world that I don't even know, carrying guns in order to go—have to be scared for their life because people want to burn trees in order to make money.

Goal setting (having clear objectives for positive climate behavior changes within an organization), feedback (reports are made to assess what has been done and still needs to be done to reach a goal), and rewards and penalties for climate change-related behaviors were not addressed during the at-home conversations or interviews.

Parents often talked about the importance of being aware of what is going on in the world through news outlets, social media, and other prompts so that they can best guide their children. Deborah, African American mother of a 6th grade daughter, said:

> *Deborah (mother)*: Especially me as a parent, I don't want her [my daughter] to come and say, well how about what's going on in Texas? And I'm looking at her like…She's coming here learning stuff and I'm not learning anything. You know, I can't tell her what's right or wrong. So I want to be up on things.

Id. Social Norms

Audrey specifically addressed the social norms in her office:

> *Audrey (mother):* I think we could probably be more energy efficient as an office. But…social norms are that you have to have that fax, and copier, and printer as opposed to having a one unit. You know, so, I think sometimes you have that mindset, and then you go into a place, an established place, and they're not in agreeance with what you want and what your ideals are. So, you have to kind of make concessions and say, "Oh, well, I still need my job, so I have to deal with all of this."

Audrey also addressed social norms regarding her family's current use of energy in her home:

Audrey (mother): I'm so dependent on technology in our home. That's one of the biggest things—everything is wired. And so, I didn't realize, looking at that packet [personal carbon footprint intervention activity], seeing that big number in that [technology] section was kind of, like, you know, an eye opener. It's like, oh, we are really dependent on, like, so many things in the house.

II. Personal Characteristics

As the DOB framework shows, the *Personal Characteristics* of individuals play a direct role in affecting the way individuals appraise a situation and whether they are willing to act on situations. Patchen's (2010) four categories of *Personal Characteristics* include: knowledge, values, identity, and demographic traits.

IIa. Knowledge

In this study, almost a quarter of the statements within the home and during interviews involved knowledge as evidenced through frequency counts. Participants most often expressed descriptive knowledge (30.3%), followed closely by definitional knowledge (28.5%), and explanatory knowledge (20.4%), as shown in Figure 4.7.

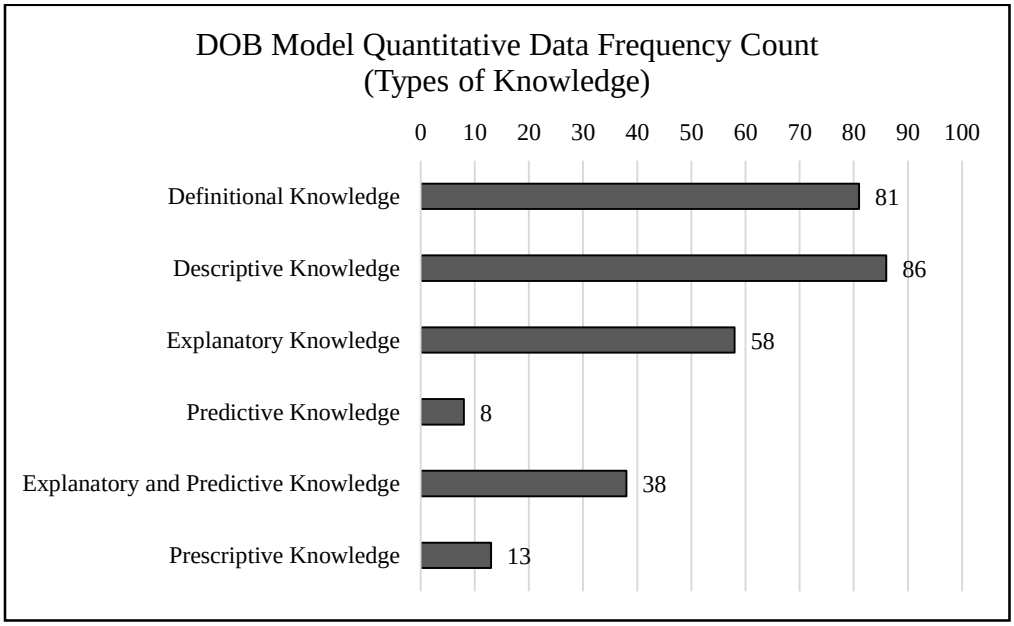

Figure 4.7. Frequency counts for at-home and interview data of Types of Knowledge (Johannesson, 2014).

An exemplar exchange is given in Table 4.2 for each of the six types of knowledge. Additionally, the percentages of each of the types of knowledge coded are shown in the left column. A brief statement is provided in parenthesis prior to the exemplar to set the scene for the dialogue if the context of the exchange was unclear. Relationships are given, but each of the examples should be taken as separate, unique statements and assumed from different families.

Table 4.2

Types of Knowledge Exemplars from Audio Data during At-Home Intervention and Interviews

Types of Knowledge (Percent Identified)	**Knowledge Exemplar**
Definitional (28.5%)	*Mother:* Do you know what climate change is? I mean, do you know anything about climate change? It's like due to the use of human - human use of fossil fuels. It releases carbon dioxide and gases into the air. I think it affects the sea levels, the eco-systems. Causes severe weather and droughts.
Descriptive (30.3%)	*Mother:* I know that there was a recent summit. I believe it was in France. [I'm] almost positive it was in France where countries committed to climate change. And I do know that the news is now reporting that the United States, that the Supreme Court is going to bar any promise that we made in that summit. So I think that's interesting.
Explanatory (20.4%)	*Mother:* …thinking back to younger days. I remember hearing - well I remember hearing my mom and my aunts talking about how children didn't get as sick as much as they do now…because she's out of the hospital [motioning to her daughter] and has asthma and you know, I know I believe that the deforestation and all the more driving - because people used to walk everywhere at one time, mostly everywhere.
Predictive (2.8%)	*(sibling children talking about how many foods have palm oil in them and that planting palm usually necessitates deforestation)* *Daughter:* I didn't know that. We're eating palm trees. Out of cereal. And ice-cream and soap. Really? *Son:* And candy. *Daughter:* So what's going to happen if we don't have more trees. *Son:* Have no more food. *Daughter:* Or soap. What would happen if we had to close all the stores and everything around? *Son:* We wouldn't have food or anything…or soap or anything or drinks…or products.

Table 4.2 Continued

Types of Knowledge (Percent Identified)	Knowledge Exemplar
Explanatory & Predictive (13.4%)	*Mother:* Look, it can cause fires too when it's real dry. That's what it's showing right now. Looks like mud. It's not, it's where plants and stuff have died. Look. Doesn't that look like mud [peat]? So it's carbon in the ground. And if it were to catch on fire it would release the carbon in the air. And it burns for so long, it just keeps on putting carbon in the air. We're doing it to ourselves.
Prescriptive (4.6%)	*Mother:* So I think what we do now, all the electronics we use, the cars we drive, I think all that affects climate on some level. And we can reduce our carbon footprint, which would kind of have an impact and if everybody did that then we would have a global impact.

Knowledge (Misconceptions)

Given that the information contained in the materials was new to most of the participants, it's not surprising that there were many ideas expressed that were not scientifically accurate. There were 66 instances of misconceptions noted, out of 284 knowledge statements coded. The majority of the climate science misconceptions were coded into one of these eight categories: Ozone/CFC's Relationship to Carbon Dioxide (19.0%), Effects of Energy Production (6.3%), Greenhouse Effect (4.8%), Acid Rain (3.2%), Volcanic Eruptions = Warming Earth (3.2%), Carbon Dioxide vs. Oxygen (9.8%), Weather = Climate (19.0%), and Climate Change = Global Warming (6.3%). Exemplar statements are linked to each of these misconception categories and each of the eight misconceptions are explained in more detail in Table 4.3. Each example should be taken as a separate, unique misconception that came from different families participating in the study.

Table 4.3

Climate Science Misconceptions Found in Audio Data, with Exemplar Statements Included

Misconception Category	**Exemplar Statement** *[with misconception further explained]*
Ozone/CFC's Relationship to Carbon Dioxide	*Mother:* All these extra vehicles. *Grandfather:* Huh? *Mother:* The vehicles. All this gas and stuff that they're putting out. *Grandfather:* Yea, more roads. More vehicles on the road. *Mother:* It's doing away with the ozone layer. *[Misconception explained: Car emissions contain little to no ozone depleting compounds like chlorine-/bromine-heavy substances (e.g., chlorofluorocarbons, methyl bromide) and holes in the ozone are not predominantly responsible for global warming, unlike greenhouse gases]*
Effects of Energy Production	*Mother:* [reading the question] Of the following, which one do you think contributes most to global warming? [answering] Burning the fossil fuels for heating, electricity, cars and trucks, hole in the ozone layer, toxic waste, the sun, nuclear - the most - *Son:* I say power plants. The nuclear power plants? *Mother:* Yeah. *Son:* The one is - first of all, it's already toxic. Second of all, it's producing carbon dioxide, so it's hurting our ozone layer and hurting our water when they're polluting our water and air. And then the gases from - hurt us, ourselves, if it [doesn't] go to the ozone layer, it hurts us. But once we breathe in it hurts our lungs and everything and mess up our body systems. *[Misconception explained: Nuclear power plants have relatively low emission levels of CO_2, the main source of anthropogenic global warming.]*
Greenhouse Effect Process	*Mother:* I can't remember exactly, but it was something about a wall. Like in the atmosphere. In - they had H-2-4, something, all these gases, where those gases formed a barrier and whatever it is has to go out of it can't, and that's why the climate is off the way that it is in the atmosphere. And that comes from us. *[Misconception explained: While hinting at the science behind the effect of greenhouse gases, this mother is unsure of what specific gases contribute the most to the greenhouse effect and how the effect works.]*
Acid Rain and Global Warming	*Mother:* Well it says how much does each of the following contribute to global warming? Well we don't get acid rain. *Son:* What is acid rain? When would it ever rain acid? *Mother:* Never. *[Misconception explained: While acid rain and global warming can be the result of burning fossil fuels, especially coal, this mother and son did not know how acid rain and global warming are related and did not understand what 'acid rain' actually is.]*

Table 4.3 Continued

Misconception Category	**Exemplar Statement** *[with misconception further explained]*
Volcanic Eruptions = Warming Earth	*Son:* No, it [volcano] lets off the heat when they erupt. It lets off heat on the earth and since the ozone is trapped, it traps the heat, so it's making the earth heat up more so do you think we're going to have more volcanoes to cool down the earth? *[Misconception explained: While it is true that the net effect on the earth from a volcanic eruption is cooling, this student does not seem to be clear on whether or not a volcanic eruption cools or heats the atmosphere.]*
Carbon Dioxide vs. Oxygen	*Daughter 1:* Oh, I know how. The trees are important because they trap in bad gases for the - bad gasses for us to breath in and breath out. *[Misconception explained: While this student does understand that trees are a sink for CO_2, she doesn't appear to understand that humans use respiration to rid the body of CO_2 and take in O_2. She believes that all CO_2 is bad and unnatural for humans.]*
Weather = Climate	*Aunt:* Have you heard the term climate change? *Niece:* Yes, I learned about it in school. Climate change is when you feel different, like let's say it's raining or it's snowing or it's storming. Different climate changes than regular place. Like one place could have snow, one place could have rain. *[Misconception explained: This student realizes that climate does have something to do with weather, but does not indicate that she understands climate to be a long-term (approximately 30 year) weather trend.]*
Climate Change = Global Warming	*Grandfather:* I'd tell them to look at the film and understand that we need to do something about climate control and we need to do it now before it's too late and we all - the whole world be living in a desert. *[Misconception explained: Not all areas around the world will experience equal effects of climate change; some areas may be dry, some may be wet, others may not warm as quickly as others. Not all regions are expected to become dry and hot.]*

IIb. Values

Patchen (2010) describes values in terms of featuring societal welfare over personal welfare (i.e., communitarian over individualist worldview), prioritizing more utilitarian outcomes, focusing on non-material over material goals, concentrating on long-term rather than only short term outcomes, and having more of an egalitarian rather than hierarchical worldviews. Depending on the main focus of an individual's values, behaviors may seem to be "green" on the surface; yet have underlying motivations other than pro-environmental gains (e.g., someone buys

an electric vehicle to save money on gas rather than help mitigate climate change). In this study, parents like Audrey spoke about an obligation to help protect the environment for her children and grandchildren, suggesting an underlying value for family and future generations:

> *Audrey (mother):* As a parent, I guess I am for the future, for my children and grandchildren. The long term effects from what I'm reading and hearing, right, could be devastating, the stronger storms and all of that could have a far greater impact than anything that we're used to.

Sarah, a Caucasian mother who participated in the interview but not the at-home intervention, valued personal responsibility:

> *Sarah (mother):* …You know, it's their [kids'] future. So, I think getting them involved, even at their age now, would help teach them a responsibility and also, you know, of cleaning up our environment. And if they actually see what comes out of it, they might be more proud and more apt to start doing things themselves to help.

IIc. Identity

Individuals often purposefully or even unintentionally act in ways that align to their actual or self-perceived identity (Patchen, 2010). Patchen focuses more on one's environmental identity while acknowledging that many identities are unrelated to the environment "(e.g., veteran, father, writer)" yet are influential on behaviors, as well (p. 59). Within this study, more than 70% of students self-identified as Christian; the audio data from the families supported this, as many families identified themselves as Christians in the dialogue. While watching the at-home documentary, *Years of Living Dangerously*, Melissa, a Caucasian mother to her 6th grade daughter, Shannon, spoke about personal faith in regard to the droughts in Texas:

> *Melissa (mother):* But what's one way that we know that talks about the weather patterns changing and stuff?
> *Shannon (daughter):* The Bible.
> *Melissa (mother):* That's right. And as a Christian, we trust the Bible, right?... I think we do need to pray for rain and change.

Additionally, students and adults often shared their familial relationships during interviews, such as "We are mom and dad to Jessica, and husband and wife." Families also shared physical and/or geographical information about their past and present homes. During a portion of the video documentary, the camera showed video of livestock and LaToya, an African American mother, related the harsh impact of climate change on the livestock and farmers, who had to sell their livestock, to her own life:

> *Video:* But it is more than a dry spell - Monty tells me he's had to sell two-thirds of his stock just to stay in business. He's not alone.
> *LaToya (mother):* They look like our cows, don't they?...Well we live out here in the country so they do a lot of farming. So the tractors and all that stuff is polluting the air.

Also, Audrey, an African American female, drew on her past childhood identity growing up in urban New Jersey to explain her identity as a steward of the environment today:

> *Audrey (mother):* Right. Well, I'm from Staten Island, originally, which probably had the the biggest landfill and you can see it [from space]. We have a museum on Staten Island that shows where you could see the trash from…. And I remember being a kid going to the museum and seeing the satellite image of our trash and thinking this is serious that we have that much trash!

IId. Demographic Traits

Neither casual conversations in the home nor in interviews provided much demographic data from which to draw. The only demographic data that was spoken included a student's grade level or school or the region of the country where a parent was reared. For example, a mother remarked: "Well, I definitely believe that there is a change. I might be wrong. But I just can recall when I was younger, living here as opposed to now, it didn't get as cold then as it does now. And in the summer it didn't seem as hot as it does now."

The basic demographic data for the study participants is shown in Table 4.4, for all who provided this self-reported information. The parents and students were 55.9% African American, 29.4% Caucasian, 5.8% Native American, and 8.8% two or more races. The gender

distribution of participating students was 43.5% male and 56.5% female, and for parents it was 18.2% male and 81.8% female. Of the participating students, the majority, 56.5%, were in 6th grade, followed by 30.4% in 7th grade, 8.7% in 8th grade, and 4.3% in 5th grade (one middle school had 5th graders). Approximately 80% of students and parents who completed the survey identified themselves as either Christian or Roman Catholic. Of the 10 parents who identified their family's socioeconomic status (SES), 3 fell within the < $25,000 bracket, 4 fell within the $25,000-$50,000 bracket, 2 within the $51,000-$75,000 bracket, and 2 within the $76,000-$100,000 bracket. Finally, most parents (*n* = 10) reported some college experience (50%), followed by college graduate (30%), and then high school graduate (20%). For further demographic information on specific study participants, see Appendix F.

III. Appraisals of Situation

People assess situations through both *Social* and *Personal* lenses, as previously examined in the DOB framework (Patchen, 2010). The general public often filters and appraises a situation based on their perceptions of how weighty a problem is, the solutions that may be able to address the situation, and a responsibility check of who should take action.

IIIa. Seriousness of Problem

Through watching climate change documentaries that presented information from both global and local perspectives, participants were able to see both global and more familiar effects that climate change is having and will continue to have. Marcus, African American brother of a 6th grade student, acknowledged the regional impact of sea level rise and increasing hurricane intensity caused by a changing climate, after watching the locally-produced documentary at home:

> *Marcus (brother):* Yes, because with the house—where the houses are in front of the beaches, sometimes when it gets so hot and when it rains it might become flood[ed] and

> there could be hurricanes and it might be too close to the beach and the houses might get destroyed.

After watching the locally produced news documentary in her home, Deborah expressed the more targeted impact the locally made film had on her perceptions, in contrast to the documentary with a more global perspective:

> *Deborah (mother):* WKYZ…It's different when you see it, like at home. When you hear what they're saying about things that's affecting us here. Right here versus the other movie, showing stuff around different countries. So yeah, it does - it really, really opened your eyes to just why the weather is how it is here.

The "seriousness of the problem" was the third most often coded factor in the audio data, at 10.6%. Both students and parents, like Caucasian mother, Susan, and her son, Jeremy, frequently remarked about the deaths of elephants featured in the film, *Years of Living Dangerously*:

> *Susan (mother):* Oh, those elephants.
> *Video:* That I found in nature. A kind of god. An organization of beauty that for me -
> *Susan (mother):* That's so sad.
> *Jeremy (son):* I don't get it. What happened?
> *Susan (mother):* They killed the animals.

Many families, like Audrey's family, also expressed concerns that the conflicts in Syria that were caused by limited resources may soon spill over into issues for the United States:

> *Audrey (mother):* Well I think that - look at what's going on California [the drought] - that it's not going to be- we're not too far off, here in America. So understanding what's happening there [in Syria] is not something that's just going to stay there. I think that if we don't do something then it could translate to here, where we're fighting for resources as well. Right? […] And I think that ultimately if we don't do something then that could be us. We could be engaged in a long war over a natural resource [water] that we helped diminish.

IIIb. Possible Solutions

Patchen (2010) outlines three specific types of solutions to climate change—technological solutions, changing lifestyles, and support for public policies. Most often in this

study, families talked about changes in their own personal or family lifestyles as potential solutions, such as reducing their carbon footprints [one of the intervention activities] by minimizing transportation, filling their electricity needs with solar energy, and by communicating climate change information and potential solutions to others. Often audio data related to both behaviors (being done now) and possible solutions (possible personal behavior change), and were coded twice. Examples from the data of each of the three identified possible solutions categories are:

Technological Solutions

[interview response about individual ways to mitigate climate change]
Melissa (mother): Yeah. Not waste it [electricity] maybe. What about solar electricity. I know it [the film] didn't talk about it in this one, but I think electricity, like maybe if we used some solar and buy efficient bulbs and different things, maybe that would help out too.

Changing Lifestyles

[interview response from a 6th grade, female, African American student about ways she can help mitigate climate change in the future]
Shana (female student): Well when I grow up, I'm going to try to move and get kind of - get a house close to Wal-Mart© so then we can walk across the street and buy food so we won't have to waste any gas or anything. So we won't pollute the air as much.

Support for Public Policies

[family discussion following the at-home documentaries in a Caucasian household about what should be done to help mitigate climate change]
Elsie [grandmother]: Smoking.
Herman [grandfather]: Yes, have more regulations set out to stop people from burning coal. People [need to reduce] emissions from cars and stuff and stop cutting down all the trees.

IIIc. Who Should Act?

Over 95% of data about who should act was coded at the individual action level. People frequently noted their personal role or their family's role in climate change mitigation behavior efforts in their communications, but there were few exchanges regarding actions that should be taken at a state or national level. Some participants in different households, such as Elsie (a Caucasian grandmother) and Vanessa (an African American mother), were knowledgeable and concerned about international action, even prior to the intervention activities.

International/Nationally Minded

> *Elsie (grandmother):* It's global. - the whole world's got to listen and just pay [attention]. Like everybody could use their contribution. Like the politicians, if they would listen more to the religious leaders and especially the scientists, if the scientists would listen to the religious leaders, they could then touch the people because the people want to follow the religious leaders more.
>
> *Vanessa (mother): [acknowledging the importance of international/national cooperation, but not optimistic]* When you look at it on an individual level, it's kind of hard to say this is something that I'm doing personally. …releasing all this pollution, you don't think, individually, you can do anything about that. You have to have the corporations or whatever - or the plants or whatever, you've got to have that stuff in order to provide the things that we use individually. So it's like what do you do? Stop - everybody has to agree to come on the court to stop using that stuff. Is that realistic?

Yet, most study participants, like Deborah and Herman, were more focused on actions they had control over—themselves and their immediate, individual families.

Community/Familial Minded

> *Deborah (African American mother):* …So you know, tell me [speaking generally to the group] what I need to do and maybe I will to help more. Oh, maybe we could plant a garden. I don't know. I guess we could do something like that.
>
> *Herman (Caucasian grandfather):* [Responding to a question about what he'd tell a friend about the main point of the film; respondent repeatedly indicated the need to have a personal hand in mitigation efforts] I'd tell them to look at the film and understand that we need to do something about climate control and we need to do it now before it's too late and we all- the whole world be living in a desert.

IV. Willingness to Act

To this point, the DOB model has outlined how the constructs of *Social Influence*, *Personal Characteristics*, and *Appraisals of the Situation*, can help influence climate change behaviors. Once an individual is able to appraise climate change—the seriousness, potential solutions, and whose responsibility it is to begin action—he or she may internally decide their own *Willingness to Act* and make behavior changes based on several factors within this construct (e.g., *Benefits and Costs of Actions*, *Emotions*, and *Efficacy of Actions*).

IVa. Benefits and Costs of Actions

The first aspect in the *Willingness to Act* construct takes into account one's judgment of the benefits and/or costs of (in)actions. Becky, who is Caucasian and in the STEM club, questioned her brother Chad during the at-home intervention documentary, after learning about a war in Syria that was initiated by drought conditions:

> *Becky (sister):* So would you go with them to fight a war if you were in their shoes? On the revolution side?
> *Chad (brother):* Yes.
> *Becky (sister):* Would you?

Chad seems to realize the effect that climate change mitigation inaction may have for families experiencing drought conditions with little or no food or water for their families in Syria. In an interview, Shana, an African American 6th grade student, mentioned walking to destinations, rather than driving, as a means to mitigate emissions and to receive the health benefits from doing so:

> *Shana (female student):* In the summer we sometimes walk to the store because it's right across from us. And if we think about just riding around, we don't use the car - the van. We just ride our bikes. And that gives us energy - I mean - and we start out with energy, I mean that gives us less energy.

Audrey, whose husband works for a solar farm, mentioned in her interview that her family is considering installing solar panels on their home to help mitigate greenhouse gas emissions and to save money on electricity services:

> *Audrey (mother):* I think one of the things that I've talked with my husband about is solar power for our home. We've talked about that, and we've talked about more energy efficient vehicles, as opposed to the gas guzzlers, the emissions, the cars that we have now. So, we have talked about that and not just about saving money, but I remember coming home after the last meeting and saying, "Hey, we kind of burn a lot more than I thought we did. I thought we were doing really good, and we're not doing as good as I thought we were."

IVb. Emotions

Parents and students expressed emotions in their own homes often through sounds or utterances such as 'mmhmm,' 'yeah,' or 'awww,' while responding to occurrences during the documentaries.

> *[LaToya, an African American mother, in response to a part in the video where families in Syria were forced to go without basic necessities due to drought and subsequent war over resources:]*
> *Video:* More than two million were forced into extreme poverty.
> *LaToya (mother):* All of them babies.

> *[Janelle, an African American mother's reaction following the* Years of Living Dangerously *documentary:]*
> *Janelle (mother):* Well, what I thought was very interesting was that climate change was affecting people and they were losing their jobs. I think that was very interesting and sad. And that the climate change is that deep … once they lose their jobs, it's a domino effect. They lose the house and everything else. So that was a very sad situation.

> *[Melissa's saddened response to a part in the video where people had to leave their homes in a Texas town due to drought and a factory closing its doors was:]*
> *Melissa (mother):* [It's the] only place you've ever known because there's no jobs. Got to start over.

> *[In response to the interview question, are you worried about climate change, Crystal responded:]*
> *Crystal [mother]:* Yeah, my fear is that it's going to only get worse from here.

IVc. Efficacy of Actions

While students felt as if their actions would be efficacious, parents were more skeptical about the effectiveness of any individual actions. The degree to which individuals felt their individual actions could help mitigate climate change varied from high- to low-efficacy.

High Self-Efficacy Individual Climate Mitigation Behaviors

> *Rita (mother):* [in response to at-home questions following the documentary] OK, so can you or your family do things that impact climate?... Yes, we can.
> *T.J.(son):* Yeah. The carbon dioxide from the cars, when we're burning gas.

Moderate Self-Efficacy Individual Climate Mitigation Behaviors

> *Audrey (mother):* [in response to at-home questions following the documentary] I would kind of - like I said in the beginning, cut back on what I use, talk about it [climate change mitigation and behaviors] more with other people, spread the word, maybe bring it to other people more often so that they can think about what they're doing and I think ultimately if everyone is doing a little bit, it will have a big impact because everyone is doing it. So I mean, everyone has their part. The animals in the ecosystem. Everyone has their part, so everyone has to be willing to do something.

Low Self-Efficacy Individual Climate Mitigation Behaviors

> *Deborah (mother):* [in response to an interview question] Yeah. So I mean, you know, me as one person there is really nothing that I can - I mean, unless we start making it [climate change] aware to some people. You know? I might be here in a room with fifteen people and somebody might be on a committee that could do something that I may not know about and I'm bringing it to their attention. I mean, maybe that's how - but other than that, I don't know.

V. *Habit*

Families in the study mentioned many modern technological conveniences of living in the developed world that they have become accustomed to using in their day-to-day lives. Rhonda, an African American mother to Shana, talked in the interview about the thoughtless convenience of owning a personal car:

> *Rhonda (mother):* I mean if you stop and think, there are numerous ways that we could conserve. But we're so used to - let's just hop in the car, I'm only going across the street,

> so - you know, I'll just drive over. I don't have that far to drive and you don't always think about it.

African American mother, Sharron, explained in the interview the advent of modern appliances in her home that were not as consistently utilized in homes in prior generations:

> *Sharron (mother):* Well this is one thing. I use my dryer a lot and I know that emits something through that pipe that goes outside. My mother, she's not using her dryer as much. She hangs her clothes the old-fashioned way on the wire. But I use my dryer all the time.

In the interview, Deborah noted that many people are unaware of what ingredients comprise their foods and where ingredients come from in foods and other commodities:

> *Deborah (mother):* [After learning that there is major deforestation happening in Indonesia due to the palm oil industry] And we have an impact on that because I mean, we're eating cookies.
> And we're eating all the stuff that they're using this palm oil for. It's in everything. Soap. So I mean it's got to be a change. All across the board. We all have to say OK, well I'm not buying that.

While many habits mentioned by families may contribute negatively toward climate change (more than 70%), occasionally families mentioned positive environmental actions that are second nature to them, such as when T.J. and his mom, Rita, discussed how they recycle organic materials during their at-home discussion.

> *T.J. (son):* [Reading the question out loud] Is there anything that you currently do that positively impacts our environment. If so, what?
> *Rita (mother):* Recycle.
> *T.J. (son):* I bury all biodegradable stuff for fertile soil. For when I do my plants and stuff.
> *Rita (mother):* Yea, like when our dogs passed away, we buried them. Put them back in the earth and you know, that helps the plants and stuff grow.

VI. Behavior

The goal of the Determinants of Behavior (DOB) theoretical model is to "organize the broad range of research findings" relative to climate change pro-environmental behavior development (Patchen, 2010, p. 47). The final construct in the DOB model is *Behavior*. This

construct addresses factors and motivation to behave in certain ways regarding climate change pro-environmental behavior. When asked about their environmental behaviors related to climate change, students and parents often gave generic responses (e.g., acknowledging that they recycle to reduce pollution or reduce their water usage), and they would rarely make any indication that they understood the link between behaviors and climate change mitigation. Their responses were coded as behaviors that families can do, already do, and intend to do in the future.

Can Do Behaviors

[Mother, Rita, and son, T.J., discuss some things they can-do around the house to make positive environmental changes after the at-home documentary:]
T.J. (son): I would change - if we could, I would change the amount of wood we burn because you know, we got the wood heater and once the smoke goes through the chimney, it gets in the ozone layer as it goes up.
Rita (mother): Yeah, in the air and it pollutes.

[In response to the interviewer's question about personal behaviors Joseph, a 6th grade African American student believes that communication is an important pro-environmental behavior:]
Interviewer: How about you? Have you thought about things you can change within the local environment?
Joseph (male student): I thought of, like, I can tell people, like, ways to change - different ways so that you can, like, try to prevent it as much as you can.

Currently Do Behaviors

[Audrey mentions in the interview that she has recently changed her habits related to her treatment of technology and energy that she had not addressed previously:]
Audrey (mother): I power off everything at work now, which is something I didn't do before. I kind of just left. And I have three computers at work that I use, and so I power all of them down before I leave. Put my printer and fax on standby and - because I don't need to get a fax overnight. […] I don't keep them plugged in. A lot of times, like, my iPad and everything, when I'm not using it, it would stay plugged in, which is burning power... Leave a room, turn everything off, whereas before, because I felt my house was energy efficient, I wouldn't even think about it.

[Jackie, a Caucasian mother of 8, shares what she learned from doing the carbon footprinting activity in the STEM Club parent meeting where she learned how many Earths it would take to support human life if everyone on Earth lived like her:]
Jackie (mother): I can say, for me, since we've been in the STEM program, I turn the water off when I brush my teeth. I try to take smaller showers. You're just more aware of

everything because our last [parent] meeting we had to write down how many Earths it would take for one person, and it was pretty high. I think that if one person can make a change, then everybody will follow eventually, hopefully.

Intend to Do Behaviors

[In the interview, Joseph was asked about any pro-environmental behaviors he has thought about making in the future. His response was:]
Joseph (son): Sometimes, I think about stuff like when I grow up and have a family and stuff, we might have, like, an electric car and stuff like that. You know, have cars that don't really use gas a lot and stuff like that.

[Natalie, an African American mother, did not participate in the at-home intervention; however, when asked about things she would like do in the future to behave in a more pro-environmental way, she responded:]
Natalie (mother): I'm thinking about that one too, because I was like - they always say a Honda is always good on gas on highways. Just got to try to get me a Honda.

[Women from three generations discussed what they or their family would do differently after watching the at-home documentaries:]
Kylie (daughter): Describe anything you or your family would change or do differently after watching this film.
Elsie (grandmother): Support - like when you hear it or you take [things] serious[ly] and support other causes that maybe you don't take seriously.
Candice (mother): Don't ignore it.

Relationship between the Level of Family Engagement and Family Changes in Climate Change Beliefs and Content Knowledge

The level of family engagement during the at-home video intervention activities was examined in relation to any observed changes in climate change beliefs and content knowledge from pre- to post-intervention surveys. While families within this study reported in the climate change beliefs, content knowledge, and worldviews survey having heard the term climate change prior to viewing the at-home documentaries or participating in interviews more than 95% of the time, their prior engagement in the topic had been minimal. Most parents reported hearing about the term climate change in school or occasionally on television news broadcasts and had not had the opportunity to become educated further on the topic. The majority of the parents reported

low engagement of the topic of climate change; thus, it was important to relate climate change impacts and mitigation strategies to their local communities.

Additionally, the level of engagement with the intervention activities were different in the homes. Through the audio data, the researcher placed each family into one of three categories of intervention: None (i.e., family may or may not have been invited to watch the documentaries at home; either way, these families did not watch the documentaries but did complete the interview), low (i.e., families participated in the at-home intervention minimally with little to no discussion noted before, during, and after the documentaries), and high (i.e., families actively engaged in the at-home intervention; this was especially evident in high parental participation through audio discussion).

There were no changes in student or parent beliefs about global warming in those who did not engage in the intervention. Two students changed their global warming beliefs from "yes" to either "don't know" or "no" in the low engagement group; however, in this same group, one parent changed beliefs from "don't know" to "yes" and another from "no" to "yes." In the highly engaged group, one student changed their climate change belief from "no" to "yes" from pre- to post-intervention and one parent became unsure about her belief, post-intervention. Therefore, no clear trend was observed between level of engagement in the at-home intervention and changes in climate change beliefs. However, while there were no changes noted in the group who did not participate in the at-home intervention, it seems as if the exposure to the intervention at-home caused some participants to re-assess their climate change beliefs from pre- to post-intervention. It is important to note that all but one student attended at least one of the in-club intervention activities and two parents included in Table 4.4 attended a parent meeting during which climate change materials were actively examined.

Table 4.4

Climate Change Beliefs from Pre- to Post- Intervention for Students and Parents Who Participated at Various Levels of Engagement in the At-Home Activity

Level of Engage-ment	**Student CC Beliefs**				**Parent CC Beliefs**			
	Relationship[1]	**Hours**	**Pre-**	**Post-**	**Relationship[1]**	**Hours**	**Pre-**	**Post-**
None								
	Daughter	6	DK	B	Mother[2]	1	B	B
	Daughter	6	DK	B			--	--
	--	--	--	--	Mother	0	B	B
Low								
	Daughter	8	B	B	--	--	--	--
	Brother[3]	6	B	B	--	--	--	--
	Brother[3,4]	2	DB	B	--	--	--	--
	Daughter	8	B	DK	--	--	--	--
	Son	8	B	B	--	--	--	--
	Daughter	4	DK	DK	Mother	2	DK	B
	Son	6	B	B	--	--	--	--
	Son	6	B	DB	Father	2	DB	B
High								
	--	--	--	--	Mother[2]	3	B	DK
	Daughter	6	DK	DK	--	--	--	--
	Son	6	DK	B	--	--	--	--
	Son	6	B	B	--	--	--	--
	--	--	--	--	Mother[2]	3	B	B
	Daughter	6	B	B	--	--	--	--

Note. B = Believes; DB = Doesn't Believe; DK = Doesn't Know/Unsure; In this table students are matched with their parent, if data was available, as indicated in the identity/relationship columns. [1] Parent attended the parent meeting when the climate change intervention[2]. Two students in the at-home study for whom survey data was collected were brothers.[3] Student did not attend any intervention club meetings and only watched the documentaries at-home[4]; individuals in the same families appear in rows divided by solid black lines.

As a group, parents gained the most climate change content knowledge in the study (+65 points total growth), as shown in Table 4.5. Additionally, the level of engagement seemed to matter. In total, parents with no at-home engagement increased their content knowledge by 3.5 points on average, low engagement parents increased by 6.5 points on average, and high engagement parents increased by 22.5 points on average. Based on this sample, students having the highest levels of engagement in the at-home intervention also had the most growth post-intervention. It is unlikely, however, that the at-home intervention was the only exposure

students received between pre- and post-test, as all students providing content knowledge data attended at least one STEM Career Club targeted on climate change related content, with most attending either 2 or 3 meetings.

Table 4.5

Total Net Change in Pre-Post Climate Change Content Knowledge(CK) Scores of Families with No, Low, and High Levels of Engagement during At-Home Intervention

	No At-Home Intervention	Low Level of Engagement	High Level of Engagement	Total Net Content Knowledge
Net Student CK	**0** (*n* = 2) *Student 1:* 6 hrs *Student 2:* 6 hrs	**-10** (*n* = 3) *Student 1:* 8 hrs *Student 2:* 4 hrs *Student 3:* 6 hrs	**+23** (*n* = 4) *Student 1:* 6 hrs *Student 2:* 6 hrs *Student 3:* 6 hrs *Student 4:* 6 hrs	**+13** (*n* = 10)
Net Parent CK	**+7** (*n* = 2) *Parent 1:* 0 hrs *Parent 2:* 1 hr	**+13** (*n* = 2) *Parent 1:* 2 hrs *Parent 2:* 2 hrs	**+45** (*n* = 2) *Parent 1:* 3 hrs *Parent 2:* 3 hrs	**+65** (*n* = 6)
Net Student and Parent CK	**+7** (*n* = 4)	**+3** (*n* = 6)	**+68** (*n* = 6)	**+78** (*n* = 16)

Discussion

DOB Framework Examined

The Determinants of Behavior model provides a general framework for organizing factors that may contribute to pro-environmental climate change behaviors. By using the DOB framework to analyze family discussion in homes, it was clear that varying levels of family engagement were important. The at-home audio data, in conjunction with survey data, provided evidence of shifts in climate change beliefs and content knowledge relative to the families' level of engagement in the at-home activity. A recent study by Myers, Malibach, Roser-Renouf, Akerlof, and Leiserowitz (2013) found that adults who have low engagement or exposure in the area of global warming are influenced more by personal experience than by their own global

warming beliefs. In contrast, adults who are already highly engaged and knowledgeable about global warming will most often use personal interactions with a changing climate to further solidify their pre-conceived beliefs. The level of engagement did not affect the relative percentages of conversation in each of the DOB sub-constructs. Families who were less engaged were consistently found to have lower frequency counts. Parents and students most frequently discussed descriptive or definitional information related to climate change, followed by the seriousness of the problem. The six constructs of the model will now be examined in light of the findings generated from the study, as well as identification of areas of the model that may need further examination.

Social Influences

While changing climate change beliefs through media exposure is highly unlikely since changes in beliefs often require extended temporal influence, media exposure often does increase understanding and content knowledge regarding climate change (Krosnick, Holbrook, & Visser, 2000). The way climate change is framed has been shown to have varying levels of positive or negative effects on populations' intentions to behave environmentally (Morton et al., 2011). However, mass media outlets can misrepresent or over-represent outlier/skeptic views and mislead and/or inappropriately serve the "collective public" (Boykoff, 2013, p. 796). This is important to note because multiple study participants mentioned the extent to which they trust news outlets to report accurate information. Indeed, famous popular culture icons (e.g., Harrison Ford, Leonardo DiCaprio, Arnold Schwarzenegger, Mark Ruffalo) who have taken up the mantle as climate change activists, may make more of an impact on the public's perception of climate change than scientists who are working in the field. Their fame can help to grab the attention of the public who had previously been disengaged and potentially act to distribute accurate

scientific information about climate change. Certainly this seemed to be the case, in this study. However, news media, as well as television and movie personalities, may be equally misleading of accurate climate science information.

Parents mentioned their inability to be effective in climate change mitigation on a personal level and the potential economic costs associated with mitigation options as barriers to compliance. Many studies have indicated that the easier and cheaper the pro-environmental behavior, the more likely individuals are to enact the behaviors in their everyday lives (Haustein & Hunecke, 2007; Watrous & Fraley, 2007). Efforts were made to remove barriers for personal climate change mitigation in the parent meeting intervention by sharing economical, easy fixes to reduce costs and help mitigate their family's personal carbon footprints. However, in the study population, in both at-home video discussion and interviews, the top barrier to personal behavior changes was cost (e.g., financial, time, effort). One parent, who was unable to attend the parent meeting to learn options to begin helping mitigate climate change at the individual level, remarked that she just needed someone to tell her what she needs to do so that she can do it. Other parents discussed financial costs as a major hindrance for personal mitigation efforts.

Energy usage by participants' families and in work environments were consistently mentioned throughout the audio data. In relation to energy usage trends through transportation, parents often noted the feeling the normality of utilizing personal cars for short commutes and acknowledged their addiction to technology as a social norm in the US. Several family members even vowed to decrease their personal use of non-essential energy. Social norms and social networks can be powerful tools to help create and maintain pro-environmental climate behaviors (Gifford et al., 2011; Patchen, 2010; Peeters, 2014). Early work by Fishbein and Ajzen (1977) examined the influence of social norms in developing intentions and behaviors. Patchen's DOB

framework is based, in part, on Ajzen's (1991, 2006) Theory of Planned Behavior which asserts that in order for individuals to have an intention to make pro-environmental changes, individuals must believe that social norms are supportive of the behavior and the behavior is congruent with the group values that the individual believes to be most important (Gifford et al., 2011). One of the common social trends in developed nations, which has ironically helped accelerate global warming from excessive emissions, is the generation and use of energy from 'dirty' sources for industry and technology. The upward trend of energy usage is consistent throughout the southeastern US region and the nation; in 2011, the US (5483 MMT) was only surpassed by China (8127 MMT) in total carbon dioxide emissions from the consumption of energy (U.S. Energy Information Administration, 2015). Thus, social norms regarding energy usage within the culture throughout the US is a substantial factor in the development of pro-environmental climate behaviors in the population.

Personal Characteristics

Pro-environmental climate behaviors may be a result of an increase in content knowledge on the subject (Guy et al., 2014). While an increase in knowledge has not consistently been found to cause a change in climate change beliefs, it has caused an increase in behavioral intentions and support of pro-environmental political agendas regarding climate change policies (Moser & Dilling, 2007). The findings in this study support prior research regarding climate change beliefs and content knowledge. Although there was some positive movement from don't know or non-believers to believers of students (n = 4) and parents (n = 2) from pre- to post-intervention, there were also a few students (n = 2) and parents (n = 1) who changed their view from believer to either don't know or don't believe post-intervention. Overall, the total content knowledge change of both students and parents was positive from pre- to post-intervention. The

parent group showed the greatest growth, even though they had lesser intervention time. One should keep in mind that all students who provided content knowledge data attended at least one, or more, 2-hour STEM club meetings. Findings seem to indicate that in order to change climate change beliefs, one must target more than simply content knowledge; yet, minimal interventions can generate positive gains in related content knowledge.

The DOB framework did not provide suggestions as to how knowledge should be explored or examined. It was clear in the findings that students and parents alike had varying degrees of accurate scientific understanding about climate change as well as many misconceptions. In the Leiserowitz et al. (2011) study of American teens, 35% believed that the hole in the ozone is a main cause of global warming and 21% thought that aerosol cans usage currently contributes to global warming. Further, studies indicate that the general public's perception of their own personal climate science knowledge is much greater than it actually is (McCaffrey & Buhr, 2009). Popular misconceptions unearthed in this study, such as the relationship of carbon dioxide to the destruction of the ozone layer and the concept that 'weather' and 'climate' are synonymous terms, aligned with findings in the literature (e.g., Leiserowitz et al., 2011; McCaffrey & Buhr, 2009; McNeill & Vaughn, 2012). Families consistently linked general environmental behaviors such as recycling, household water conservation, or not littering to mitigation strategies to combat climate change. While these behaviors may have an indirect positive effect reducing climate change, they often conflated all anti-pollution, pro-environmental behaviors as being directly related to climate change.

Worldview scales can also be examined to paint a picture of individuals' values. Kahan, Jenkins-Smith, and Braman (2011) examined two dichotomies of worldview, communitarian vs. individualism and egalitarian vs. hierarchical. Of the students and parents who participated in

either at-home intervention activities or interviews and who also completed the worldview survey, 72% reported individualistic and egalitarian worldviews. Individualistic (i.e., more concerned with oneself rather than the success of the whole) worldview values are usually not aligned with the pro-environmental behavior actions Patchen identified. However, a majority of study participants did respond with a more egalitarian (i.e., equity is valued) worldview which is normally aligned with pro-environmental behavior tendencies. Three-fourths of the study participants aligned with a worldview (individualistic) that may be direct conflict in relation to environmental behavior motivation. In designing climate interventions and informational media for this population, it is advisable to highlight the personal benefits of mitigation behaviors for many areas including health and economics as well as the environment. Climate justice issues could also be addressed to speak to the egalitarian side because in the Southeastern US, climate change impacts will affect populations differently, especially the vulnerable (i.e., impoverished, elderly, traditionally underrepresented) (Gutierrez & LePrevost, 2016).

Patchen's (2010) view on identity was used in this study. Patchen acknowledges that "a person's values may be shaped in part by his or her *self-image*" (p. 59), a term to describe one's identity. Most often in this study, dialogue focused on general identities such as mother, father, son, 6th grader, or farmer and less frequently on identities related to environmental action (e.g., environmentalist, nature-lover, conservationist).

Due to the small sample size for this study and low parental survey response rates, it is unclear if demographic variables (i.e., gender, level of education, socioeconomic status, ethnicity, religion) affected worldviews, content knowledge, or beliefs. Distinguishing the influence demographic variables within this particular sample proved challenging due to the homogeneity of several variables including religion (74.1% Christian/Roman Catholic) and

worldview (72.0% Individualism Egalitarian). There were no trends noted in relation to demographic variables and climate change beliefs or content knowledge for this population. Demographic groups have been shown to have values, concerns, and content knowledge that may affect their pro-environmental climate behaviors. Whereas more scientifically accurate climate science knowledge has not necessarily been found to increase the belief that climate is changing, those with more content knowledge and often those with higher levels of education are usually more concerned (Xiao & Dunlap, 2007). Kahan et al. (2012) however, determined a polarization of climate change perceptions as a result of an increase in science literacy based on worldview. Additionally, the values demonstrated by worldviews have been shown to have foundations in demographic differences. Combinations of demographic characteristics have been shown in previous studies to be more or less likely to act in pro-environmental ways and either support or oppose environmental policy efforts. For example, well-educated females from the Northeastern United States are more likely to support environmentally supportive efforts (Leiserowitz, 2006).

Appraisals of the Situation

The DOB framework outlined that social and personal factors influence one's perception of the seriousness of climate change. Families mentioned global problems related to climate change more infrequently than they did ways that these problems could filter in to the US and into their own lives. Patchen (2010) acknowledged that, for many, climate change is still "a rather abstract and remote problem" (p. 54). The more proximal the problem, the more likely participants were to express their concern. Most climate change studies examining risk perceptions and the seriousness of the issue use adults as their population of reference. In a study of global warming risk perceptions of adults from 2001-2010, Shao, Keim, Garand, and

Hamilton (2014) examined demographic characteristics and political orientations in national surveys to explore the severity of global warming and climate change to certain groups of people. This study found that "women, blacks, and Hispanics are more likely to view global warming as a very serious problem" (Shao et al., 2014). Additionally, the young, the more educated, and low to middle-class were more likely than their counterparts to find global warming as serious. The researchers also found that individuals who did not attend religious services and Democrats and liberals were more likely to see the severity of global warming. Based on the low numbers of male adult participants in the at-home intervention and interviews, it is difficult to assess whether there were differences in how they appraise climate change risks.

Talk within the study mostly fell at the individual action level, which may correspond to the overwhelming percentage (75%) of responding family members in this study who were found to be individualistic rather than communitarian. Only two families mentioned mitigation strategies involving governmental action or the need for related policy changes. This is most likely due to the fact that, in general, families had little background knowledge about climate change and perhaps even less knowledge about current movement on the national and international policy front. Even if individuals believe that climate change is a serious problem and there is something that can be done to mitigate it, a most important questions that remains is, *Who Should Act?* Along this same regard, whose responsibility is it to act? There is a hierarchy to climate change action beginning at the large scale international level and working down through national, state, local, and even community and personal levels (Kythreotis, 2012; Patchen, 2010).

Willingness to Act

When study participants began to appraise climate change impacts and link their own (in)actions to serious situations that could impact their own lives like a job loss due to drought, family food insecurities, and war over resources, they were much more willing to take action. Additionally, if the behavior change was easily made with only minimal "cost" (i.e., switching to LED light bulbs, minimizing electricity use when unnecessary, adjusting the thermostat a few degrees to minimize heating/cooling demands), it was more likely to become an intended behavior, and eventually a habit. These findings resonate with the literature. Individuals often weigh the costs and benefits of their actions or inactions in response to a problem (Steg et al., 2014). The seriousness of the problem may dictate the extent to which individuals are willing to act (Viscusi & Zeckhauser, 2006). The benefits and costs related to climate change mitigation behaviors is not exclusive to mitigating climate change. Actions may have far reaching effects into other areas such as health and economics (Thomas, Sabel, Morton, Hiscock, & Depledge, 2014; Toi, 2014). In regards to economics and climate change policy, the emissions of greenhouse gases are "predominantly from high-income countries while the negative effects of climate change are predominantly in low-income countries" (Toi, 2014). Even in developed countries, climate change will have impacts on health by factors such as food safety and nutrition (Lake et al., 2012). The extent of the benefit or cost for action or inaction may be proportional to the degree to which the action may have an effect on climate change mitigation.

This study was done in an area of the Southeastern US with high percentages of families in poverty, people of color, and Christians. Both at-home intervention documentaries addressed the "conflict" between religion and climate change in a thoughtful and respectful manner. The video documentaries also were purposefully chosen to attempt to mirror the participant

population (e.g., based on ethnicity, rurality, SES, religion) by showing impacts observed from changing climate conditions around the world in order to induce empathy and incite behavior changes. This strategy for intervention framing seemed to be impactful, as evidenced through conversation among families in the study. Myers, Nisbet, Maibach, and Leiserowitz (2012) examined individuals' emotional reactions to climate change as an essential component in climate change communication efforts. Tasquier, Levrini, and Dillon (2016) also found a strong link between reactions in their work with epistemological climate change knowledge using modelling activities and "students' emotional and social attitude towards climate change" (p. 559). Positive emotional appeals have been shown to have hopeful results in US adults (Markowitz & Shariff, 2012). However, eliciting more negative emotions, such as anger or fear, can also elicit more support of policy or spur individuals to believe climate science is more important than they did previously (Leiserowitz, 2006). The use of negative emotions could have an opposite response in those that are already dismissive or angered and cause a backlash in concern for climate change (Myers et al., 2012). The use of emotions as a means of behavior change should be purposefully utilized based on the population of interest.

When families were asked if they thought that their individual actions could make a difference in climate change, it was clear that middle school students in this study still believe they can change the world. Yet, parents were more skeptical about their ability to be impactful and frequently noted that they would need to amass a collective effort to begin making a dent in climate change. While individual efforts may not slow down climate change, a joint effort in motivation and drive by children, and the organizational abilities and political influence of parents, could collectively begin to make a dent. Several students and parents within the study spoke to the empowerment of group mobilization and development of means of communication

(e.g., websites development, talking with friends). In a study by Meinhold and Malkus (2005), high school students were found to be more likely to engage in pro-environmental behaviors the more efficacious they perceived their actions to be. In issues such as climate change where uncertainty of future impacts is prevalent, it is important that people are empowered to take effective action (Lam, 2014). Otherwise, as Grothmann and Patt (2005) discovered, uncertainty in the absence of efficacy may often bolster individuals' denial and defensiveness to cope, rather than to respond (Morton et al., 2011). Motanda, Kals, and Becker (2007) found that one's self-efficacy to make change to be the strongest predictor of pro-environmental behaviors.

Habit

Habit, while not directly linked to the other four constructs already examined, does appear in the DOB framework as a separate construct. Habit refers to "an individual psychological construct, conceptually different from behavior, that generates impulses to repeat familiar behaviors in particular settings" (Kurz, Gardner, Verplanken, & Abraham, 2015). It was difficult to distinguish behavior from habit in this study. If participants suggested a consistent behavior pattern, the behavior was coded as habit. Observations, rather than self-report, would draw a more accurate picture of an individual's behaviors and habits. Patchen (2010) explains that since habits are formed by repetition of the same behaviors over and over again, many of the same constructs from the model that affect behaviors will also, in turn, affect habits. Given that parents were mostly being introduced to climate change information, they had not developed many pro-environmental climate habits. Habit, or past performance frequency, may be the strongest predictor of persistent behavior trends (Carrus, Passafaro, & Bonnes, 2008; Terry, Hogg, & White, 1999).

Conclusions and Recommendations

This study found that students and parents who were highly engaged in a short-term climate change intervention in their homes were able to greatly increase their content knowledge post-intervention. Additionally:

- Families who were less engaged were consistently found to have lower frequency counts throughout the sub-constructs. Definitional knowledge was most talked about by both low and highly engaged families, and on average, highly engaged families talked about prescriptive type knowledge twice as much as lesser engaged families.
- As a result of coding qualitative audio data into the Determinants of Behavior (DOB) framework, parents and students were found to most frequently discuss information related to climate change, followed by the seriousness of the problem.
- Of the students and parents who participated in either at-home intervention activities or interviews *and* who also completed the worldview survey, 72% reported individualistic/egalitarian worldviews. Three-fourth of the study participants aligned with a worldview (individualistic). An individualistic worldview has been found to be direct conflict to pro-environmental behavior motivation. Talk within the study mostly fell at the individual action level, which may correspond to the overwhelming percentage (75%) of responding family members in this study who were found to be individualistic rather than communitarian.
- When study participants began to appraise climate change impacts and link their own (in)actions to serious situations that could impact their own lives, such as losing a job because of drought, family food insecurities, or war over resources, they talked as if they would be much more willing to take action.

- When families were asked if they thought that their individual actions could make a difference in climate change, it was clear that middle school students in this study believed they could make a difference even at an individual level. Yet, parents were more skeptical about their ability to be impactful and frequently noted that they would need to amass a collective effort to begin making a dent in climate change.

Recommendations

In designing climate interventions and informational media for this population, it is advisable to highlight the personal benefits of mitigation behaviors for many areas, including health and economics as well as the environment. Climate justice issues could also be addressed to speak to the egalitarian worldview expressed by participants because in the Southeastern US, climate change impacts will affect populations differently, especially the vulnerable (i.e., impoverished, elderly, traditionally underrepresented) (Gutierrez & LePrevost, 2016).

Greater effort should be made with participating families to help develop their environmental identities, because "people tend to act in ways that they believe are appropriate for those identities" (Patchen, 2010, p. 59). Development of participants' environmental identities may be enhanced through exposure to national parks or by the creation of social interactions through eco-communities (Georg, 1999; Ramkissoon, Weiler, & Smith, 2012).

Relatedly, in the area of climate science communication and framing, it has been determined that communications should not paint a hopeless picture of helplessness for climate change without presenting possible solutions to begin counteraction. A frame should not only address the problem, but also what can be done about it (Nisbet, 2009). Families should be given simple checklist solutions that identify ways in which they can make positive behavior changes.

This could include a tiered list of individual, family, community, and regional/national level intervention strategies that can be selected depending on personal interests.

Based on the low return of rate of parent surveys, the quantitative data for parents was not able to be generalized for similar populations of rural middle school students' parents in the southeastern United States. More work needs to be done to increase familial involvement. Families who are highly engaged could begin developing individual and community action plans that focus on the health of their local environment. This can be done through work at schools, community centers, and even religious centers by connecting with local and regional organizations who may already have an invested interest. This will allow individuals to feel empowered to make changes and give their efforts the agency of change that is needed.

Additionally, it was unclear in the DOB model whether behaviors that families suggested that they should do, or be willing to do, fit better in the possible solutions sub-construct or the behaviors construct. Thus, possible solutions (e.g., buy more fuel efficient cars, use less residential electricity, pay more taxes to help mitigate climate change) were often double coded in the behaviors construct and under possible solutions if the activity was being done or was otherwise noted as a possible personal behavior change. This could be made explicit in the model design for future studies.

CHAPTER FIVE

Conclusion

"I think this program is very important for our children to start thinking…. for these children in this area, where everything is so spread out and everything is so relaxed, to be able to see the effect that they're having on the world…it's detached here. So, I think that it's important for the children to be able to see what you do here in little Gulf County does have an impact on the world." (Audrey, mother)

Students, and particularly parents, remarked about the importance of introducing accurate climate science information through the intervention experiences at their rural schools. Generally speaking, scientists and a substantial portion of the American public do not hold similar "beliefs" about climate change. Ninety-seven percent of the scientific community asserts that the Earth's climate is changing due to human influences, whereas the percentage of the general American adult with a similar viewpoint is significantly lower, at approximately 63% or less (Leiserowitz et al., 2010). According to the *National Research Council,* this warming trend is expected to increase in its speed and intensity over the next 30 to 80 years (Committee on Understanding and Monitoring Abrupt Climate Change and its Impacts, 2013). The southeast region of the United States is exceptionally vulnerable to climate change-related events, such as sea level rise, heat waves, hurricanes, and drought, due to latitude, topography, and proximity to the Atlantic Ocean and Gulf of Mexico (Carter et al., 2014; Gutierrez & LePrevost, 2016). Based on the imminent global and regional impacts that are affecting and will continue to affect families in this study region, interventions were designed and implemented. This study investigated the factors underlying changes in the climate change beliefs and content knowledge of rural, high poverty middle school students and their families who were engaged in a climate change intervention, in the southeastern US.

Factors Influencing Climate Change Behaviors in Students and their Parents

Individuals' behaviors and intentions to act are influenced by many factors, both internal and external. For many of the study participants, climate change was a novel topic of study. Generally, students and parents perceived their knowledge of climate change to be more extensive than it was, based on survey responses. Yet, even with a climate change knowledge deficit, the majority (>70%) of students and parents believed that the climate was changing. This study examined various factors related to climate change behavior including: climate change knowledge, beliefs, and worldviews.

Determinants of Behavior Model: Inclusions and Suggested Alterations

Patchen's (2010) Determinants of Behavior (DOB) Model was used in a novel way in this study. The design of the DOB model was *not* originally intended to be used as a way to organize and code qualitative data based on family discussions while watching climate change documentaries or during interviews with researchers. Informed by several established models of environmental behavior (e.g., the Theory of Planned Behavior (TPB) (Ajzen, 1991), Value-Belief-Norm (VBN) Theory (Stern, 2000), Structural Model (Grob, 1995), Appraisal Theory (Scherer, 1999)), the framework provided solid pathways to investigate individuals' climate related beliefs and behaviors.

The use of the DOB model in this study has helped to identify areas in which the model could be made more explicit for use with various data sources. The DOB model was not comprehensive enough to address the expansive range of various types of knowledge, thus the 6 Types of Knowledge by Johannesson and Perjons (2014) was necessary to use. While 'Knowledge' appeared as a sub-construct in the *Personal Characteristics* category in the DOB model, it was unclear the role that nonscientific understanding and misconceptions played in this

and the other constructs in the model, including behaviors. This was found to be an important consideration due to the novelty of climate change information to many of the study participants. The development of basic *definitional* and *descriptive* knowledge was a pervasive part of the family talk (conversations during home interventions). This suggests that many families were not aware enough of climate change issues to even begin making climate friendly behavior changes. Knowledge was found to be such a critical component of this study, that it has been represented as its own separate construct in a modified model, with a more bi-directional (↔) influence to the other constructs in the DOB model (see Figure 5.1). Additionally, based on family dialogue, it was often difficult when coding to distinguish actual behaviors from possible solutions. Families often talked about behavior changes or actions they could take to help improve climate; however, it was often unclear if these should be considered 'Possible Solutions' in the *Appraisals of the Situation* construct or as a behavior (because it has yet to become a *Habit*). Perhaps this is a limitation of the data sources used in this study, as behaviors and habits were only self-reported and not observed.

Most Commonly Discussed Factors Leading to Climate Change Behaviors

The most commonly discussed factors from the DOB model were various forms of knowledge, followed by the seriousness of the problem, and specific behaviors family members do or could do to positively reduce their impacts on climate. It became increasingly evident through the analyses of family audio data that people at different life stages (e.g., teen, young adult, middle age) and people with differing demographic backgrounds (e.g., rurality, ethnicity, religion, gender) place more importance on some constructs over others. For example, parents were highly concerned with the costs related to making changes in climate related behaviors. Parents also were more concerned about the efficacy of their actions as compared to their

children. Many families expressed how their strong Christian religious beliefs affected their assessment of climate change, particularly throughout the at-home intervention documentaries. Mothers often addressed the seriousness of the climate change problem in relation to their emotional reactions to climate change impacts. Through more in- depth analyses of individuals, rather than a general overview at the family level, certain constructs of the DOB would hold greater weight than others. The findings in this study indicated that *Personal Characteristics* (including knowledge, values, identity, and demographic traits) may also impact the *Social Influences* construct and may be more fittingly represented in the arrangement shown in Figure 5.1 for the individuals in this study. For example, parents in the study noted different media outlets, barriers for behavior change, and different stimuli for action, based on their age, well developed worldviews, and other established demographic traits and identities.

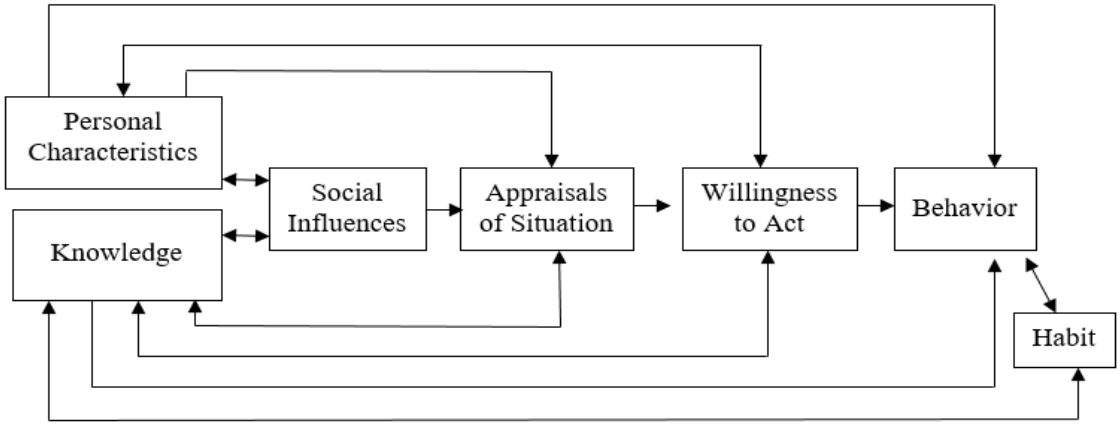

Figure 5.1. Revisions to the Determinants of Behavior (DOB) model of climate change (Patchen, 2010), based on study findings.

Students' Climate Change Beliefs, Content Knowledge, and Worldviews

A higher percentage of middle school students in the study believed global warming is occurring as compared to teens (15-17) in the nationwide survey by Leiserowitz et al. (2011).

While only 2.1% *more* students believed that global warming is occurring post-intervention compared to pre-intervention (69.5 %; 71.6%), 4.2% of students shifted from not believing global warming is happening to either a more unsure or affirmative response that global warming is happening. Shao, Keim, Garand, and Hamilton (2014) found that demographic factors such as age, gender, and race influence risk perception; youth, women, and racial minorities were more likely to indicate higher concern about global warming. In the current study, increased risk perception was more strongly related to more egalitarian worldviews than any demographic factors, including age, gender, or ethnicity.

Students scored significantly better on total content knowledge, with the most significant changes occurring in male students, post-intervention. Additionally, the highest growth was found in students in the 5th and 6th grades and African American students. While there was not a significant relationship between the total intervention hours students participated in and their total content knowledge, students who attended club meetings where specific content (e.g., weather vs. climate, climate change mitigation strategies, greenhouse gases) were addressed performed significantly better on those targeted constructs on the survey post-intervention. Gains were found on content about which students had explicitly participated in collaborative hands-on data collection, competitive games, discussions with peers, and interactions with environmental science professionals. Students in families who were highly engaged in the at-home intervention activity benefitted more than those with no or low engagement, scoring an average of 5.75 points higher on the content tests. It was not necessary to believe in climate change in order to learn about climate change, as climate change beliefs were not predictive of total climate change knowledge.

Pre-intervention, the more strongly individualistic a person was on the individualism/ communitarian worldview scale, the more likely he or she was to believe in global warming. Individualists were also found to be more likely to think about global warming than their communitarian peers. The highest percentage of students (38.1%) reported worldviews that were individualistic/egalitarian and global warming was personally more important to them than their peers who held differing worldviews. Demographic factors were not predictive of students' worldviews in this population. Worldviews were related to climate change beliefs (particularly on specific items concerning beliefs and perceptions), but did not impact content knowledge.

Parents' Climate Change Beliefs, Content Knowledge, and Worldviews

Due to the low number of parents who chose to participate in the at-home intervention and/or the interview *and* who completed the pre- and post-intervention surveys, it is difficult to make predictions for the entire parent population within this study. There were positive shifts in the beliefs of several parents who participated in the study. The level of participation matters. Also, parents who were highly engaged during the at-home intervention (n = 2) with their child(ren) learned more climate change content knowledge (+45) than those who were engaged to a lesser degree (+13, n = 2) or did not participate in the at-home intervention (+7, n = 2). Similar to the students, parents most often reported an individualistic/ egalitarian worldview.

Climate Change Intervention Design

Worldviews as a Way to Frame Interventions

Corner, Markowitz, and Pridgeon (2014) assert that worldviews act like a filter "on the interpretation of information to which individuals are exposed about climate change" (p. 415). Within this study, the majority of parents and students held more individualistic/egalitarian worldviews, followed by those with communitarian/egalitarian worldviews. Generally speaking,

the more hierarchical and individualistic people's worldviews are, the more likely they are to devalue environmental risks (Kahan et al., 2012). There are no known published studies that have conducted a climate change intervention with parents and students. Post-intervention, 66.3% students in the current study responded they were very or somewhat worried about climate change (which was up from 60.0% pre-intervention), compared to 43% of teens surveyed by Leiserowitz et al. (2011).

Influence of Demographic Variables in Intervention Design

STEM club activities were designed to be different than activities that students do daily in their regular classrooms. The hybrid nature of space that meshes elements of both formal and informal educational settings, called out-of-school (OST) time, allows room for extension activities related to classroom content or exploration of topics that are not addressed in the course standards. Through this type of informal club structure, activities can be created to specifically engage the participants involved.

African American students made the greatest gains in content knowledge following the climate change intervention of all ethnicity sub-groups identified in this study. African American students comprised 53.9% of the STEM Club students. Most students have perceived ideas of what STEM professionals look like. They are often described as Caucasian males, who work, and have no personal life or family, and lack creativity (Capabianco, Diefes-Dux, Mena, Weller, & Capobianco, 2011; Fralick, Kearn, Thompson, & Lyons, 2009). Thus, efforts were made to include people of color in videos presented in these activities and in interactions with professional STEM speakers, when available. This allowed students of color to more easily identify with these climate change experts. Also, profiles of people from around the world with diverse ethnicities and cultures were used as comparison profiles during the carbon footprinting

activity. Students compared how many Earths it would take to support an individual's lifestyle choices if everyone on Earth used resources and energy like they did. Students were able to gain a global perspective regarding their carbon footprints and individuals' footprints worldwide through a multicultural lens. All students, including students of color, made substantial gains on the *Global Warming Mitigating Behaviors* construct.

Fifth and sixth grade students made the highest gains on total content knowledge of students in grades 5-8. Activities were designed to present students with basic knowledge of climate change, under the assumption that students had not previously been exposed to the topic. Clearly, addressing climate change at the most basic levels through the intervention design was essential when working with high percentages of 5th and 6th grade students (>50%) for whom the term 'climate' had not yet been introduced in the school curriculum. Selected content videos were chosen to be age appropriate—one video even included an African American, female student who was competing with her project on climate change in a middle school science fair.

Male students, comprising approximately 42% of total STEM Club students, had significantly higher gains in climate change content knowledge, as compared to females. Although the use of technology has been shown to enhance male students' content knowledge and motivation, studies have shown that technology usage in today's classrooms can be a motivating factor for all students (Vekiri, 2013). Each of the three club meetings involved some type of technology use (Vernier probeware with TI-Nspire™ graphing calculators for Meetings #1 & #2, Elenco® Alternative Energy Snap Circuits for Meeting #3). These were novel uses of technology for the students; thus, there was a slight technology learning curve to ensure proper use of the equipment. In a study by Virtanen et al. (2015), girls in elementary school were found to be more fearful of doing something wrong when using technology; whereas boys liked

building electronic devices and using a ‘test and try’ method to solve problems. Although the researcher did not observe differences in engagement, it is possible that males felt more comfortable using new technologies, felt more free to test and try, and even to fail. If this were the case, male students could have become better acclimated to the new technology at a faster rate, which could have enabled them to learn more content knowledge. It is recommended that further studies of after school clubs try to collect data on student engagement and perhaps student motivation.

Family Engagement

Families who were highly engaged in the at home climate intervention had greater gains in content knowledge and talked more positively about the experience of participating in family learning experiences in their homes. Parental involvement in children’s education is beneficial for all children, but especially for children of racial/ethnic minorities or those socioeconomically disadvantaged (Crosnoe, 2015). Through interviews, it was revealed that several parents were concerned about being uninformed about topics their students were learning about at school. For example, Deborah, an African American mom, spoke about her desire to be informed:

> I mean, you don't want to…especially me as a parent, I don’t want her to come and say, well how about what’s going on in Texas? And I’m looking at her like [*blank stare*]. She’s coming here learning stuff and I’m not learning anything. You know, I can’t tell her what’s right or wrong. So I want to be up on things.

If the primary goal of public schools is to educate students, then parent involvement is a means to accomplishing this goal. However, this is often difficult to bring to fruition. Approximately 70% of parents who completed the Informed Consent form for the study noted that they would be willing to participate in the at-home activities with their child(ren). Yet, out of the 32 families who were provided materials to complete the at-home intervention, only 15 (46.9%) followed through the task completely by watching the documentaries and responding to

the provided questions. The literature documents that parents are often unsure of the role they are expected to take in their child(ren)'s education (Berns, 2012; Duma et al., 2011). Many parents need to feel that their children and/or their children's school want them to be involved in their children's education. Initially, parents seemed highly interested in participating in an at-home learning activity with their child(ren). The most common reasons for not following through with the at-home intervention that were shared in the follow-up interviews was either a lack of time or the busyness of everyday life. Parents make statements like "Well, I've had it [the at-home intervention materials]. I haven't had a chance to do it" or "I actually was about to start to [watch the documentaries] and then the TV had actually been occupied at the moment."

It seemed as if parents had a desire to become more involved with their child(ren)'s school experience through this opportunity for after school, at-home enrichment. Stacer and Perrucci (2013) found that when parents felt more positively connected to their child's school and felt a desire by the school for their involvement, they were actually more involved in the school. Schools that provide a welcoming and proactive request for parent involvement and that identify clear parental involvement roles are likely to get the best buy-in from parents (Stacer & Perrucci, 2013). This study showed that parents are highly interested in becoming involved in educational activities with their child(ren). The reality, however, is that conflicts arise and priorities are shifted when it comes down to actually completing the task (< 50% of families who received the at-home materials completed the intervention). Based on parents' responsiveness, they seemed glad to have been invited.

Recommendations

In order to fully explore the DOB model of climate change, a comprehensive tool should be designed to complete case study level analyses with various types of data sources. Many of

the constructs and sub-constructs can be measured with interview questions. However, through this study it became evident that in order to get a clearer picture of an individual or family's determinants of behaviors related to climate change, climate change content tests, demographic surveys, worldview or value assessments, and behavior/habit observations would be necessary.

Though student surveys were completed during scheduled club time or the regular school day, parent surveys were completed at home, making it advisable in the future to shorten parent surveys to address only essential components needed for basic analyses. It seems that parents would be more likely to complete surveys during their free time if the survey takes less time to complete.

Climate change beliefs are filtered through individuals' values and worldviews (Corner et al., 2014). This suggests the need to design intervention activities and content to appropriately frame climate change for the population of interest. Based on previous work with students and parents in the study, the researcher had a general idea of the demographics of the students and parents in the population of study. Given the important role of worldviews in this study, it is recommended that an assessment of worldviews be taken prior to engaging in climate change communication efforts. Perhaps an abbreviated survey could be administered.

It may have been even more beneficial if efforts to highlight climate justice issues had been interwoven into the intervention activities, since approximately 75% of students and the majority of parents held egalitarian worldviews. *Climate justice* highlights those who are responsible for the changing climate and assures the equitable inclusion and participation of all affected parties (Bulkeley, Carmin, Castán Broto, Edwards, & Fuller, 2013). Those with egalitarian worldviews are concerned with equity and equality for all and might be especially concerned with the impacts of climate change on vulnerable (e.g. "communities of color,

indigenous people, the geographically isolated, and those who are socioeconomically disadvantaged and already experiencing poor environmental quality" (Gutierrez & LePrevost, 2016, p. 1)) communities. Clearly many of the study participants were responsive to the difficult situations faced by individuals featured in the at-home documentaries they watched. It is also recommended that families with egalitarian worldviews be introduced to ways that they could learn more and get involved in community organizations or through the school to begin outreach and help to mitigate climate change in addition to personal behavior changes. Organizing community mitigation teams would be especially useful for students and parents reporting a more communitarian cultural worldview.

The at-home intervention activity for this study required a time commitment of almost 2 hours. While two hours may not seem like an excessive amount of time, it is important to note that this at-home intervention request may have been the first of its kind for participating families. In future invitations sent to families regarding at-home activities requiring family engagement, time requirements and necessary materials need to be examined. At-home activities could be designed in tiers. Activities should take no more than two hours to complete in their entirety; however, there could be break-away points where families can either do just one or two activities that require less time or they can finish one smaller activity and resume at a later time. Additionally, all of the first or second tier activities should only require materials that are readily available to the families (e.g., a printed copy of a science-based article, an activity sheet, a case study) because even if DVDs or other media are provided, it is not guaranteed that families will have the equipment or internet access to participate in their homes.

Limitations of this Study

There were several limitations for the study. Overall, the sample size for this study was small. Specifically, there were low numbers of some demographic sub-groups (e.g., religion, ethnicity, grade levels) for robust analyses of these smaller groups. The overall population was drawn from rural, high poverty schools, thus results may not translate to other populations of students nationally or even in the southeastern US region. While the researcher did not directly facilitate the club activities, the researcher did lead the professional development when teachers were trained, observed many of the 12 club meetings throughout the four schools when the interventions were carried out, and interviewed students regarding their intervention experiences. Thus, the researcher was not primarily responsible for facilitating the activities with the students and variations among the instruction in the four schools may have impacted the fidelity of the intervention design. However, since the researcher or at least one other member of the STEM Career Club university team were always present at club meetings, teachers were able to get support as needed. It is unclear if this support affected the study in any way. Finally, the interventions were short-term; each of the three club meetings were two hours. If students participated in the at-home (2 hour) intervention, the maximum number of hours students could have had contact with the intervention materials was 8 hours (plus an additional 1 hour if the student participated in the parent meeting as well). If parents came to the parent meeting (1 hour) and participated in the at-home activity with their child(ren), they would have participated in a maximum of 3 hours of intervention.

Implications for Future Research

Interview data, not shared in this dissertation, indicated that many parents who participated in the at-home intervention and/or the interview were enthused about the opportunity

to learn alongside their students. Some parents indicated that they want to be able to stay abreast of what their student is learning in school so that they can be more involved in their child(ren)'s education. Other parents expressed their desire to learn more about climate change and become better informed through the news and other related documentaries. Thus, in future work with K-12 students, through both traditional classroom and informal out-of-school-time (OST) organizations, it is important to provide frequent opportunities for parents to learn along with their child(ren) and to study this learning. This may be particularly important when sociocultural issues are involved but may be beneficial for a variety of topics to help strengthen relationships between the family and schools, strengthen relationships within families, and continue developing a more informed population.

Data that more closely examines students working in groups would be useful to follow up on the gender differences observed in this study and to look at students' motivations in other hands-on, technologically oriented activities. Expanding the length of the study could provide richer, more expansive data to further draw conclusions.

In future work with the STEM Career Club, an at-home intervention can be designed to further involve parents once during each of the four, 3-club meeting themes throughout the upcoming school year. Further efforts will be made to seek participation from a larger group of parents. However, those families who participated in the at-home climate change interventions in this study and who are still participating with the STEM Career Clubs next year at their school sites, will be invited to participate in additional data collection, reassessed for any behavior changes post-intervention, and provided an opportunity to further explore climate change mitigation strategies involving their local communities. The design of the intervention will be

based on what has been found in this study related to the demographics, worldviews, general knowledge, and general misconceptions of the populations within these schools.

From a more global perspective, the students in this study were more likely to believe climate change is occurring and that it is happening as a result of anthropogenic global warming than has been previously found (Leiserowitz et al., 2011). However, middle school students were not confident in this belief, most likely due to their lack of accurate climate change scientific knowledge and developing worldviews. More work needs to be done to develop interventions focusing on dispelling climate science misconceptions within climate messaging frames appropriate for specific cultural worldviews and demographic variables (e.g., gender, ethnicity, regional geography, age, religion). This can be done in conjunction with schools, informal science education centers, families, and local and regional environmental organizations (e.g., Nature Conservancy, conservation networks, Sierra Club, 4-H). By engaging students and parents in climate change education, we can meet the call for climate literacy as we empower *all* to act.

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APPENDICES

Appendix A

Students-Climate Change Knowledge, Beliefs, and Worldview Survey

My FIRST Name is:

My LAST Name is:

Today's DATE is: (MM/DD/YYYY)

My school is:

- ❍ Taylor Middle School
- ❍ Butler Middle School
- ❍ Clark Middle School
- ❍ Gulf Middle School

In 5 words or less, what words/terms first come to your mind when you hear the term "Climate Change?"

1. Recently, you may have noticed that global warming has been getting some attention in the news. Global warming refers to the idea that the world's average temperature has been increasing over the past 150 years, may be increasing more in the future, and that the world's climate may change as a result. What do you think? Do you think that global warming is happening?

- ❍ Yes
- ❍ No
- ❍ Don't Know

1a. How sure are you that global warming is happening?

- ❍ Extremely Sure
- ❍ Very Sure
- ❍ Somewhat sure
- ❍ Not at all sure

1b. How sure are you that global warming is not happening?

- ❍ Extremely sure
- ❍ Very sure
- ❍ Somewhat sure
- ❍ Not at all sure

2. Assuming global warming is happening, do you think it is...

- ❍ Caused mostly by human activities
- ❍ Caused by both human activities and natural changes
- ❍ Caused mostly by natural changes in the environment
- ❍ None of the above because global warming isn't happening
- ❍ Other
- ❍ Don't know

3. Which comes closer to your own view?

- ❍ Most scientists think global warming is happening
- ❍ Most scientists think global warming is not happening
- ❍ There is a lot of disagreement among scientists about whether or not global warming is happening
- ❍ Don't know enough to say

4. How worried are you about global warming?

- ❍ Very worried
- ❍ Somewhat worried
- ❍ Not very worried
- ❍ Not at all worried

5. Personally, how well informed do you feel about...

	Very well informed	Fairly well informed	Not very well informed	Not at all informed
How the Earth's "climate system" works	❍	❍	❍	❍
The different causes of global warming	❍	❍	❍	❍
The different consequences of global warming	❍	❍	❍	❍
Ways in which we can reduce global warming	❍	❍	❍	❍

6. Have you ever heard of the "greenhouse effect"?

- ❍ Yes
- ❍ No

6a. The “greenhouse effect” refers to:

- ❍ Gases in the atmosphere that trap heat
- ❍ The Earth's protective ozone layer
- ❍ Pollution that causes acid rain
- ❍ How plants grow
- ❍ Don't know

7. Which of the following gases in the atmosphere are good at trapping heat from the Earth's surface? (Mark all that apply.)

- ❑ Carbon dioxide
- ❑ Methane
- ❑ Water vapor
- ❑ Hydrogen
- ❑ Oxygen
- ❑ Don't know

8. Are each of the following statements definitely true, probably true, probably false, definitely false, or you do not know?

	Definitely true	Probably true	Probably false	Definitely false	Don't know
Weather often changes from year to year.	❍	❍	❍	❍	❍
Climate means the average weather conditions in a region.	❍	❍	❍	❍	❍
Climate often changes from year to year.	❍	❍	❍	❍	❍
Weather means the average climate conditions in a region.	❍	❍	❍	❍	❍
Climate and weather mean pretty much the same thing.	❍	❍	❍	❍	❍

9. Are each of the following statements definitely true, probably true, probably false, definitely false, or you do not know?

	Definitely true	Probably True	Probably false	Definitely false	Don't know
In the past, the Earth's climate always shifted gradually between warm and cold periods.	❍	❍	❍	❍	❍
Climate changes have played an important role in the advance or collapse of some past human civilizations.	❍	❍	❍	❍	❍
The Earth's climate is warmer now than it has ever been before.	❍	❍	❍	❍	❍
In the past, rising levels of carbon dioxide in the atmosphere have caused global temperatures to increase.	❍	❍	❍	❍	❍
In the past, rising global temperatures have caused carbon dioxide levels in the atmosphere to increase.	❍	❍	❍	❍	❍
Compared to the climate of the past million years, the last 10,000 have been unusually warm and stable.	❍	❍	❍	❍	❍
The Earth's climate has been pretty much the same for millions of years.	❍	❍	❍	❍	❍
The Earth's climate is colder now than it has ever been before.	❍	❍	❍	❍	❍

10. The average temperature of the Earth's surface is currently about 58 degrees Fahrenheit (^{o}F). What do you think the average temperature of the Earth's surface was during the last ice age?

11. Which of the following are "fossil fuels"?

	Yes	No	Don't know
Coal	❍	❍	❍
Oil	❍	❍	❍
Natural gas	❍	❍	❍
Wood	❍	❍	❍
Hydrogen	❍	❍	❍
Solar energy	❍	❍	❍

12. The energy in fossil fuels originally came from:

	Definitely true	Probably True	Probably false	Definitely false	Don't know
The fossilized remains of dinosaurs	❍	❍	❍	❍	❍
Photosynthesis by plants over millions of years	❍	❍	❍	❍	❍
The sun	❍	❍	❍	❍	❍
Uranium in the Earth	❍	❍	❍	❍	❍

13. What gas is produced by the burning of fossil fuels?

❍ Oxygen
❍ Hydrogen
❍ Helium
❍ Carbon dioxide
❍ Don't know

14. Which of the following countries emits the largest total amount of carbon dioxide?

- ❍ United States
- ❍ China
- ❍ India
- ❍ Germany
- ❍ Japan
- ❍ Don't know

15. Which of the following countries emits the most carbon dioxide per person?

- ❍ United States
- ❍ China
- ❍ India
- ❍ Germany
- ❍ Japan
- ❍ Don't know

16. How much does each of the following contribute to global warming?

	A lot	Some	A little	Not at all	Don't know
Cars and trucks	❍	❍	❍	❍	❍
Burning of fossil fuels for heat and electricity	❍	❍	❍	❍	❍
Deforestation	❍	❍	❍	❍	❍
The hole in the ozone layer	❍	❍	❍	❍	❍
Toxic wastes	❍	❍	❍	❍	❍
Aerosol spray cans	❍	❍	❍	❍	❍
Nuclear power plants	❍	❍	❍	❍	❍
Volcanic eruptions	❍	❍	❍	❍	❍
The sun	❍	❍	❍	❍	❍
Acid rain	❍	❍	❍	❍	❍
The space program	❍	❍	❍	❍	❍
Cows	❍	❍	❍	❍	❍

16a. Of the following, which one do you think contributes most to global warming?

- ❍ Burning of fossil fuels for heat and electricity
- ❍ Cars and trucks
- ❍ The hole in the ozone layer
- ❍ Deforestation
- ❍ Toxic wastes
- ❍ The sun
- ❍ Nuclear power plants
- ❍ Volcanic eruptions
- ❍ Cows
- ❍ Aerosol spray cans
- ❍ The space program
- ❍ Acid rain

17. Are each of the following statements definitely true, probably true, probably false, definitely false, or do you not know?

	Definitely true	Probably True	Probably false	Definitely false	Don't know
Global warming will cause some places to get wetter, while others will get drier.	❍	❍	❍	❍	❍
The decade from 2000-2009 was warmer than any other decade since 1850.	❍	❍	❍	❍	❍
Scientists can't predict the weather more than a few days in advance – they can't possibly predict the climate of the future.	❍	❍	❍	❍	❍
Scientists' computer models are too unreliable to predict the climate of the future.	❍	❍	❍	❍	❍
The Earth's climate has changed naturally in the past, therefore humans are not the cause of global warming.	❍	❍	❍	❍	❍
Global warming will cause temperatures to increase by roughly the same amount in all countries.	❍	❍	❍	❍	❍
Any recent global warming is caused by the sun.	❍	❍	❍	❍	❍
The record snowstorms this winter in the eastern United States prove that global warming is not happening.	❍	❍	❍	❍	❍
The Earth is actually cooling, not warming.	❍	❍	❍	❍	❍
Global warming is happening, but will be more beneficial than harmful.	❍	❍	❍	❍	❍

18. Which of the following statements is correct?

- ❍ All of the glaciers on Earth are melting away
- ❍ Most of the glaciers on Earth are melting away
- ❍ Some of the glaciers on Earth are melting away
- ❍ None of the glaciers on Earth are melting away
- ❍ Don't know

18a. Over the past 100 years, has the speed of glacier melting increased, decreased or stayed the same?

- ❍ Increased
- ❍ Stayed the same
- ❍ Decreased

19. If no additional actions are taken to reduce global warming, how much do you think global sea levels will rise by the year 2100?

- ❍ 10-12 feet
- ❍ 3-4 feet
- ❍ 6-9 inches
- ❍ Zero
- ❍ Don't know

20. How much do you think each of the following actions would reduce global warming if they were done worldwide?

	A lot	Some	A little	Not at all	Don't know
Switching from fossil fuels to renewable energy (wind, solar, geothermal)	❍	❍	❍	❍	❍
Planting trees	❍	❍	❍	❍	❍
Reducing tropical deforestation	❍	❍	❍	❍	❍
Reducing toxic waste (nuclear, chemical)	❍	❍	❍	❍	❍
Switching from gasoline to electric cars	❍	❍	❍	❍	❍
Driving less	❍	❍	❍	❍	❍
Increasing public transportation	❍	❍	❍	❍	❍
Switching from regular (incandescent) to compact fluorescent light bulbs	❍	❍	❍	❍	❍
Insulating buildings	❍	❍	❍	❍	❍
Switching from fossil fuels to nuclear power	❍	❍	❍	❍	❍
Banning aerosol spray cans	❍	❍	❍	❍	❍

Stop punching holes in the ozone layer with rockets	❍	❍	❍	❍	❍
Placing a large tax on all fossil fuels	❍	❍	❍	❍	❍
Having at most 2 children per family	❍	❍	❍	❍	❍
Fertilizing the ocean to make algae grow faster	❍	❍	❍	❍	❍
Stop eating beef	❍	❍	❍	❍	❍
Using airplanes to scatter dusts high in the atmosphere	❍	❍	❍	❍	❍

20a. Of the following actions, which one do you think would reduce global warming the most?

- ❍ Switching from fossil fuels to renewable energy (wind, solar, geothermal)
- ❍ Planting trees
- ❍ Reducing tropical deforestation
- ❍ Reducing toxic waste (nuclear, chemical)
- ❍ Switching from gasoline to electric cars
- ❍ Driving less
- ❍ Increasing public transportation
- ❍ Switching from regular (incandescent) to compact fluorescent light bulbs
- ❍ Insulating buildings
- ❍ Switching from fossil fuels to nuclear power
- ❍ Banning aerosol spray cans
- ❍ Stop punching holes in the ozone layer with rockets
- ❍ Placing a large tax on all fossil fuels
- ❍ Having at most 2 children per family
- ❍ Fertilizing the ocean to make algae grow faster
- ❍ Stop eating beef
- ❍ Using airplanes to scatter dusts high in the atmosphere

21. How much had you thought about global warming before today?

- ❍ A lot
- ❍ Some
- ❍ A little
- ❍ Not at all

22. How important is the issue of global warming to you personally?

- ❍ Extremely important
- ❍ Very important
- ❍ Somewhat important
- ❍ Not too important
- ❍ Not at all important

23. On some issues people feel that they have all the information they need in order to form a firm opinion, while on other issues they would like more information before making up their mind. For global warming, where would you place yourself?

- ❍ I need a lot more information
- ❍ I need some more information
- ❍ I need a little more information
- ❍ I do not need any more information

People in our society often disagree about how far to let individuals go in making decisions for themselves and issues of equality and discrimination. How strongly do you agree or disagree with each of these statements?

	Strongly Disagree	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree
The government (at any level) interferes far too much in our everyday lives.	❍	❍	❍	❍	❍	❍
Sometimes the government needs to make laws that keep people from hurting themselves.	❍	❍	❍	❍	❍	❍
It's not the government's business to try to protect people from themselves.	❍	❍	❍	❍	❍	❍
The government should stop telling people how to live their lives.	❍	❍	❍	❍	❍	❍
The government should do more to advance society's goals, even if that means limiting the freedom and choices of individuals.	❍	❍	❍	❍	❍	❍
Government should put limits on the choices individuals can make so they don't get in the way of what's good for society.	❍	❍	❍	❍	❍	❍

It's society's responsibility to make sure everyone's basic needs such as food, housing, and healthcare are met.	❍	❍	❍	❍	❍	❍
It's a mistake to ask society to help every person in need.	❍	❍	❍	❍	❍	❍
People should be able to rely on the government for help when they need it.	❍	❍	❍	❍	❍	❍
Individuals should take responsibility for their own lives with out anyone telling them what to do.	❍	❍	❍	❍	❍	❍
Our government tries to do too many things for too many people. We should just let people take care of themselves.	❍	❍	❍	❍	❍	❍
If the government spent less time trying to fix everyone's problems, we'd all be a lot better off.	❍	❍	❍	❍	❍	❍
People who make money in business have a right to enjoy their money however they want.	❍	❍	❍	❍	❍	❍

Hard work and competition-not governmental programs-are the best way to supply people with the things they need.	❍	❍	❍	❍	❍	❍
Making money is why people work hard.	❍	❍	❍	❍	❍	❍

	Strongly Disagree	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree
Some groups of people are simply inferior to other groups.	❍	❍	❍	❍	❍	❍
In getting what you want, it is sometimes necessary to use force against other groups.	❍	❍	❍	❍	❍	❍
It is OK if some groups have more of a chance in life than others.	❍	❍	❍	❍	❍	❍
To get ahead in life, it is sometimes necessary to step on others.	❍	❍	❍	❍	❍	❍
If certain groups stayed in their place, we would have fewer problems.	❍	❍	❍	❍	❍	❍
It's probably a good thing that certain groups are at the top and other groups are at the bottom.	❍	❍	❍	❍	❍	❍
Inferior groups should stay in their place.	❍	❍	❍	❍	❍	❍
Sometimes other groups must be kept in their place.	❍	❍	❍	❍	❍	❍
It would be good if groups could be equal.	❍	❍	❍	❍	❍	❍

Group equality should be our idea.	❍	❍	❍	❍	❍	❍
All groups should be given an equal chance at life.	❍	❍	❍	❍	❍	❍
We should do what we can to equalize conditions for different groups.	❍	❍	❍	❍	❍	❍
Increased social equality is beneficial to society.	❍	❍	❍	❍	❍	❍
We would have fewer problems if we treated people more equally.	❍	❍	❍	❍	❍	❍
We should strive to make incomes as equal as possible.	❍	❍	❍	❍	❍	❍
No group should dominate society.	❍	❍	❍	❍	❍	❍

What is your sex?

❍ Male

❍ Female

What grade are you currently in?

❍ 5th

❍ 6th

❍ 7th

❍ 8th

How would you classify yourself?

- ❍ American Indian/Native American
- ❍ Asian
- ❍ Black/African American
- ❍ Hispanic/Latino
- ❍ White/Caucasian
- ❍ Pacific Islander
- ❍ Other _____

Which of the following do you consider yourself?

- ❍ Christian
- ❍ Muslim
- ❍ Jewish
- ❍ Roman Catholic
- ❍ Latter Day Saints or Mormon
- ❍ Buddhist
- ❍ Hindu
- ❍ Agnostic (you are not sure if there is a God)
- ❍ Atheist (you believe there is no God)
- ❍ Spiritual, but not committed to a particular faith
- ❍ Don't give religious things much thought
- ❍ Other _____

Appendix B

Student Climate Change Beliefs and Content Knowledge Correlation Tables

Table B1

Initial Pairwise Correlation Results on Targeted Beliefs and Content Questions/Categories from the Climate Change Pre-Intervention Student Survey

	1	2	3	4	5	6	7	8	9	10	11
1. Global Warming (GW) Belief	--										
2. Confidence that GW is not happening	-0.57***	--									
3. Think Scientists Believe in GW	-0.06	-0.42***	--								
4. GW Severity	0.06	-0.24*	0.17	--							
5. Worry about GW	-0.08	0.34**	-0.03	-0.19	--						
6. Have heard about GW	-0.03	0.25*	0.01	-0.16	-0.07	--					
7. Avg. perception of lack of information	-0.25*	0.45***	-0.00	-0.15	0.33**	0.16	--				
8. Knowledge of GW mitigation strategies	0.24*	-0.29**	-0.05	-0.01	-0.17	-0.10	-0.35***	--			
9. Total Climate Change Knowledge	0.31**	-0.39***	-0.05	-0.06	-0.21*	-0.17	-0.33**	0.82***	--		
10. Amount of time thought about GW	-0.01	0.37***	-0.07	-0.02	0.27*	0.08	0.38***	-0.30**	-0.31**	--	
11. How important is GW	0.01	0.31**	-0.29*	-0.14	0.47***	-0.05	0.23*	-0.17	-0.15	0.49***	--

Note. $*p < .05$. $**p < .01$. $***p < .001$

Table B2

Post-Intervention Pairwise Correlation Results on Targeted Beliefs and Content Questions/Categories from the Climate Change Student Survey

	1	2	3	4	5	6	7	8	9	10	11
1. Global Warming (GW) Belief	--										
2. Confidence that GW is not happening	-0.55***	--									
3. Think Scientists Believe in GW	-0.09	-0.29*	--								
4. GW Severity	0.12	-0.23*	0.04	--							
5. Worry about GW	0.11	0.23*	-0.17	0.03	--						
6. Have heard about GW	-0.09	0.23*	0.05	-0.17	0.08	--					
7. Avg. perception of lack of information	-0.21*	0.46***	-0.03	-0.11	0.21*	0.22*	--				
8. Knowledge of GW mitigation strategies	0.18	-0.25*	0.02	-0.00	-0.007	-0.23*	-0.32**	--			
9. Total Climate Change Knowledge	0.22*	-0.40***	0.06	0.10	-0.13	-0.25*	-0.49***	0.79***	--		
10. Amount of time thought about GW	-0.30**	0.44***	-0.14	-0.13	0.26*	0.18	0.39***	-0.37***	-0.41***	--	
11. How important is GW	-0.15	0.28**	-0.10	-0.02	0.35***	0.07	0.24*	-0.13	-0.15	0.44***	--

Note. *$p < .05$. **$p < .01$. ***$p < .001$

Appendix C

Parents-Climate Change Knowledge, Beliefs, and Worldview Survey

My FIRST Name is:

My LAST Name is:

Today's DATE is: (MM/DD/YYYY)

My Student's First and Last Name is: (Only provide names of students who are participating in the STEM Career Club in the middle school. You may list multiple children's names here.)

_____

My student's school is:

- ❍ Taylor Middle School
- ❍ Butler Middle School
- ❍ Clark Middle School
- ❍ Gulf Middle School

In 5 words or less, what words/terms first come to your mind when you hear the term "Climate Change?"

1. Recently, you may have noticed that global warming has been getting some attention in the news. Global warming refers to the idea that the world's average temperature has been increasing over the past 150 years, may be increasing more in the future, and that the world's climate may change as a result. What do you think? Do you think that global warming is happening?

- ❍ Yes
- ❍ No
- ❍ Don't Know

1a. How sure are you that global warming is happening?

- ❍ Extremely Sure
- ❍ Very Sure
- ❍ Somewhat sure
- ❍ Not at all sure

1b. How sure are you that global warming is not happening?

- ❍ Extremely sure
- ❍ Very sure
- ❍ Somewhat sure
- ❍ Not at all sure

2. Assuming global warming is happening, do you think it is...

- ❍ Caused mostly by human activities
- ❍ Caused by both human activities and natural changes
- ❍ Caused mostly by natural changes in the environment
- ❍ None of the above because global warming isn't happening
- ❍ Other
- ❍ Don't know

3. Which comes closer to your own view?

- ❍ Most scientists think global warming is happening
- ❍ Most scientists think global warming is not happening
- ❍ There is a lot of disagreement among scientists about whether or not global warming is happening
- ❍ Don't know enough to say

4. How worried are you about global warming?

- ❍ Very worried
- ❍ Somewhat worried
- ❍ Not very worried
- ❍ Not at all worried

5. Personally, how well informed do you feel about...

	Very well informed	Fairly well informed	Not very well informed	Not at all informed
How the Earth's "climate system" works	❍	❍	❍	❍
The different causes of global warming	❍	❍	❍	❍
The different consequences of global warming	❍	❍	❍	❍
Ways in which we can reduce global warming	❍	❍	❍	❍

6. Have you ever heard of the "greenhouse effect"?

- ❍ Yes
- ❍ No

6a. The “greenhouse effect” refers to:

- ❍ Gases in the atmosphere that trap heat
- ❍ The Earth's protective ozone layer
- ❍ Pollution that causes acid rain
- ❍ How plants grow
- ❍ Don't know

7. Which of the following gases in the atmosphere are good at trapping heat from the Earth's surface? (Mark all that apply.)

- ❑ Carbon dioxide
- ❑ Methane
- ❑ Water vapor
- ❑ Hydrogen
- ❑ Oxygen
- ❑ Don't know

8. Are each of the following statements definitely true, probably true, probably false, definitely false, or you do not know?

	Definitely true	Probably true	Probably false	Definitely false	Don't know
Weather often changes from year to year.	❍	❍	❍	❍	❍
Climate means the average weather conditions in a region.	❍	❍	❍	❍	❍
Climate often changes from year to year.	❍	❍	❍	❍	❍
Weather means the average climate conditions in a region.	❍	❍	❍	❍	❍
Climate and weather mean pretty much the same thing.	❍	❍	❍	❍	❍

9. Are each of the following statements definitely true, probably true, probably false, definitely false, or you do not know?

	Definitely true	Probably True	Probably false	Definitely false	Don't know
In the past, the Earth's climate always shifted gradually between warm and cold periods.	❍	❍	❍	❍	❍
Climate changes have played an important role in the advance or collapse of some past human civilizations.	❍	❍	❍	❍	❍
The Earth's climate is warmer now than it has ever been before.	❍	❍	❍	❍	❍
In the past, rising levels of carbon dioxide in the atmosphere have caused global temperatures to increase.	❍	❍	❍	❍	❍
In the past, rising global temperatures have caused carbon dioxide levels in the atmosphere to increase.	❍	❍	❍	❍	❍
Compared to the climate of the past million years, the last 10,000 have been unusually warm and stable.	❍	❍	❍	❍	❍
The Earth's climate has been pretty much the same for millions of years.	❍	❍	❍	❍	❍
The Earth's climate is colder now than it has ever been before.	❍	❍	❍	❍	❍

10. The average temperature of the Earth's surface is currently about 58 degrees Fahrenheit (oF). What do you think the average temperature of the Earth's surface was during the last ice age?

11. Which of the following are "fossil fuels"?

	Yes	No	Don't know
Coal	❍	❍	❍
Oil	❍	❍	❍
Natural gas	❍	❍	❍
Wood	❍	❍	❍
Hydrogen	❍	❍	❍
Solar energy	❍	❍	❍

12. The energy in fossil fuels originally came from:

	Definitely true	Probably True	Probably false	Definitely false	Don't know
The fossilized remains of dinosaurs	❍	❍	❍	❍	❍
Photosynthesis by plants over millions of years	❍	❍	❍	❍	❍
The sun	❍	❍	❍	❍	❍
Uranium in the Earth	❍	❍	❍	❍	❍

13. What gas is produced by the burning of fossil fuels?

❍ Oxygen
❍ Hydrogen
❍ Helium
❍ Carbon dioxide
❍ Don't know

14. Which of the following countries emits the largest total amount of carbon dioxide?

- ❍ United States
- ❍ China
- ❍ India
- ❍ Germany
- ❍ Japan
- ❍ Don't know

15. Which of the following countries emits the most carbon dioxide per person?

- ❍ United States
- ❍ China
- ❍ India
- ❍ Germany
- ❍ Japan
- ❍ Don't know

16. How much does each of the following contribute to global warming?

	A lot	Some	A little	Not at all	Don't know
Cars and trucks	❍	❍	❍	❍	❍
Burning of fossil fuels for heat and electricity	❍	❍	❍	❍	❍
Deforestation	❍	❍	❍	❍	❍
The hole in the ozone layer	❍	❍	❍	❍	❍
Toxic wastes	❍	❍	❍	❍	❍
Aerosol spray cans	❍	❍	❍	❍	❍
Nuclear power plants	❍	❍	❍	❍	❍
Volcanic eruptions	❍	❍	❍	❍	❍
The sun	❍	❍	❍	❍	❍
Acid rain	❍	❍	❍	❍	❍
The space program	❍	❍	❍	❍	❍
Cows	❍	❍	❍	❍	❍

16a. Of the following, which one do you think contributes most to global warming?

- ❍ Burning of fossil fuels for heat and electricity
- ❍ Cars and trucks
- ❍ The hole in the ozone layer
- ❍ Deforestation
- ❍ Toxic wastes
- ❍ The sun
- ❍ Nuclear power plants
- ❍ Volcanic eruptions
- ❍ Cows
- ❍ Aerosol spray cans
- ❍ The space program
- ❍ Acid rain

17. Are each of the following statements definitely true, probably true, probably false, definitely false, or do you not know?

	Definitely true	Probably True	Probably false	Definitely false	Don't know
Global warming will cause some places to get wetter, while others will get drier.	❍	❍	❍	❍	❍
The decade from 2000-2009 was warmer than any other decade since 1850.	❍	❍	❍	❍	❍
Scientists can't predict the weather more than a few days in advance – they can't possibly predict the climate of the future.	❍	❍	❍	❍	❍
Scientists' computer models are too unreliable to predict the climate of the future.	❍	❍	❍	❍	❍
The Earth's climate has changed naturally in the past, therefore humans are not the cause of global warming.	❍	❍	❍	❍	❍
Global warming will cause temperatures to increase by roughly the same amount in all countries.	❍	❍	❍	❍	❍
Any recent global warming is caused by the sun.	❍	❍	❍	❍	❍
The record snowstorms this winter in the eastern United States prove that global warming is not happening.	❍	❍	❍	❍	❍
The Earth is actually cooling, not warming.	❍	❍	❍	❍	❍
Global warming is happening, but will be more beneficial than harmful.	❍	❍	❍	❍	❍

18. Which of the following statements is correct?

- ❍ All of the glaciers on Earth are melting away
- ❍ Most of the glaciers on Earth are melting away
- ❍ Some of the glaciers on Earth are melting away
- ❍ None of the glaciers on Earth are melting away
- ❍ Don't know

18a. Over the past 100 years, has the speed of glacier melting increased, decreased or stayed the same?

- ❍ Increased
- ❍ Stayed the same
- ❍ Decreased

19. If no additional actions are taken to reduce global warming, how much do you think global sea levels will rise by the year 2100?

- ❍ 10-12 feet
- ❍ 3-4 feet
- ❍ 6-9 inches
- ❍ Zero
- ❍ Don't know

20. How much do you think each of the following actions would reduce global warming if they were done worldwide?

	A lot	Some	A little	Not at all	Don't know
Switching from fossil fuels to renewable energy (wind, solar, geothermal)	❍	❍	❍	❍	❍
Planting trees	❍	❍	❍	❍	❍
Reducing tropical deforestation	❍	❍	❍	❍	❍
Reducing toxic waste (nuclear, chemical)	❍	❍	❍	❍	❍
Switching from gasoline to electric cars	❍	❍	❍	❍	❍
Driving less	❍	❍	❍	❍	❍
Increasing public transportation	❍	❍	❍	❍	❍
Switching from regular (incandescent) to compact fluorescent light bulbs	❍	❍	❍	❍	❍
Insulating buildings	❍	❍	❍	❍	❍
Switching from fossil fuels to nuclear power	❍	❍	❍	❍	❍
Banning aerosol spray cans	❍	❍	❍	❍	❍
Stop punching holes in the ozone layer with rockets	❍	❍	❍	❍	❍
Placing a large tax on all fossil fuels	❍	❍	❍	❍	❍
Having at most 2 children per family	❍	❍	❍	❍	❍
Fertilizing the ocean to make algae grow faster	❍	❍	❍	❍	❍
Stop eating beef	❍	❍	❍	❍	❍
Using airplanes to scatter dusts high in the atmosphere	❍	❍	❍	❍	❍

20a. Of the following actions, which one do you think would reduce global warming the most?

- ❍ Switching from fossil fuels to renewable energy (wind, solar, geothermal)
- ❍ Planting trees
- ❍ Reducing tropical deforestation
- ❍ Reducing toxic waste (nuclear, chemical)
- ❍ Switching from gasoline to electric cars
- ❍ Driving less
- ❍ Increasing public transportation
- ❍ Switching from regular (incandescent) to compact fluorescent light bulbs
- ❍ Insulating buildings
- ❍ Switching from fossil fuels to nuclear power
- ❍ Banning aerosol spray cans
- ❍ Stop punching holes in the ozone layer with rockets
- ❍ Placing a large tax on all fossil fuels
- ❍ Having at most 2 children per family
- ❍ Fertilizing the ocean to make algae grow faster
- ❍ Stop eating beef
- ❍ Using airplanes to scatter dusts high in the atmosphere

21. How much had you thought about global warming before today?

- ❍ A lot
- ❍ Some
- ❍ A little
- ❍ Not at all

22. How important is the issue of global warming to you personally?

- ❍ Extremely important
- ❍ Very important
- ❍ Somewhat important
- ❍ Not too important
- ❍ Not at all important

23. On some issues people feel that they have all the information they need in order to form a firm opinion, while on other issues they would like more information before making up their mind. For global warming, where would you place yourself?

- ❍ I need a lot more information
- ❍ I need some more information
- ❍ I need a little more information
- ❍ I do not need any more information

People in our society often disagree about how far to let individuals go in making decisions for themselves and issues of equality and discrimination. How strongly do you agree or disagree with each of these statements?

	Strongly Disagree	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree
The government interferes far too much in our everyday lives.	❍	❍	❍	❍	❍	❍
Our society would be better off if the distribution of wealth was more equal.	❍	❍	❍	❍	❍	❍
It's not the government's business to try to protect people from themselves.	❍	❍	❍	❍	❍	❍
Discrimination against minorities is still a very serious problem in our society.	❍	❍	❍	❍	❍	❍
The government should do more to advance society's goals, even if that means limiting the freedom and choices of individuals.	❍	❍	❍	❍	❍	❍
Society as a whole has become too soft and feminine.	❍	❍	❍	❍	❍	❍
The government should stop telling people how to live their lives.	❍	❍	❍	❍	❍	❍
It seems like blacks, women, homosexuals and other groups don't want equal rights, they want special rights just for them.	❍	❍	❍	❍	❍	❍
Government should put limits on the choices individuals can make so they don't get in the way of what is good for society.	❍	❍	❍	❍	❍	❍
We have gone too far in pushing equal rights in this country.	❍	❍	❍	❍	❍	❍

Sometimes government needs to make laws that keep people from hurting themselves.	❍	❍	❍	❍	❍	❍
We need to dramatically reduce inequalities between the rich and the poor, whites and people of color, and men and women.	❍	❍	❍	❍	❍	❍

What is your sex?

❍ Male

❍ Female

What is your age

❍ 18-29

❍ 30-47

❍ 48-66

❍ 67+

❍

What is your highest level of education achieved?

❍ Less than high school

❍ High school graduate

❍ Some college/technical school

❍ College graduate

❍ Post graduate/Advanced degree

What is your yearly household income?

❍ less than $25K

❍ $25K - $50K

❍ $51K - $75K

❍ $76K - $100K

❍ $101K - $175K

❍ $176K or more

How would you classify yourself?

- ❍ American Indian/Native American
- ❍ Asian
- ❍ Black/African American
- ❍ Hispanic/Latino
- ❍ White/Caucasian
- ❍ Pacific Islander
- ❍ Other _____

Which of the following do you consider yourself?

- ❍ Christian
- ❍ Muslim
- ❍ Jewish
- ❍ Roman Catholic
- ❍ Latter Day Saints or Mormon
- ❍ Buddhist
- ❍ Hindu
- ❍ Agnostic (you are not sure if there is a God)
- ❍ Atheist (you believe there is no God)
- ❍ Spiritual, but not committed to a particular faith
- ❍ Don't give religious things much thought
- ❍ Other _____

Appendix D

At-home Intervention Instructions and Questions

Thank you for choosing to become involved as a family to learn about climate globally, nationally, and locally! Please follow the instructions below and return materials to your student's school. Enjoy!

Materials Checklist

Materials you can keep:

This Instruction Sheet

Question Sheets (unless you wrote additional responses on this)

(2) Individual Soft Drinks

Microwave Popcorn Pack

Materials you will need to return to your school after completion (approximately one week after receiving materials):

- ☐ The labeled bag you received your materials in
- ☐ Audio Recorder in its box
- ☐ *Years of Living Dangerously* DVD (60 min)
- ☐ *Exploring Climate Change* DVD (22 min)

Directions

1. Choose whether you want to watch the two videos via the provided DVDs OR from You Tube (Years of living Dangerously: https://youtu.be/brvhCnYvxQQ) and (Exploring Climate Change. They are the same two videos that you have been provided in your bag.
2. Grab your soft drinks from the fridge and pop your popcorn for movie night!
3. Prior to watching each of the two videos, please TURN ON THE AUDIO RECORDER PROVIDED. There is an on/off switch on the left side of the recorder. Once ON, you only need to hit the RED RECORD button in the middle of the recorder. The recording time will begin moving on the screen and the red light will come on at the top right of the recorder. Please sit close to your family members and try to keep the audio recorder within 2-3 feet of all family members involved.
4. Next, please talk through the pre-video questions prior to watching each video.
5. PLEASE LEAVE THE AUDIO RECORDER ON THROUGHOUT THE PRE-VIDEO QUESTIONS, WHILE THE ENTIRE VIDEO PLAYS, AND THROUGH THE POST-VIDEO QUESTIONS….I would love to hear your thoughts about the video as it plays!
6. Finally, please talk through the post-video questions after watching each video.
7. If you are not watching both videos back to back, you can hit the stop button on the recorder and turn it off. Please remember to turn it back on and hit the record button when you come back to watch the second video! Follow the same instructions with both videos…just be sure to keep the recorder recording through all of the pre questions, while the video is playing, and the post-video question discussion.
8. As long as the audio recorder is recording, you do not need to write the answers to the questions down on paper. If you have technical difficulties, you could write your answers down as a last resort. If you do any of the optional extension activities, please discuss on the audio recorder as well.
9. Please return the indicated materials above with your student to the STEM Career Club teacher at the school who is listed on the outside of the materials bag within about one week of receiving the materials.

Looking at Global and National Effects of Climate Change
Video 1: *Years of Living Dangerously*- Episode 1: Dry Season

Families: **BEFORE you watch the movie please discuss the following questions with each other and respond as completely as you can!*

1. Have you heard the term "climate change?"

2. Where have you heard about climate change?

3. How do you know what to believe is true or what is false when you get information?

4. How do you determine whether or not a source is credible (is a source that you can trust)?

5. Are you aware of anything happening **around the world** (ex. other states, countries, and continents) that is contributing to climate change? How do you think these actions contributing to climate change?

6. Do you think **your actions** can impact our climate and environment? Can you list any examples?

Families: **DURING the movie, please note any parts of the movie you found interesting, confusing, or surprising. When you finish the movie (or you can pause the movie as you're watching) please discuss these points.*

Families: **AFTER you watch the movie please discuss the following questions with each other and respond as completely as you can!*

7. Did this video make you think about climate change any differently than you did before watching the video? How?

8. Do you think understanding Syria's water war important? Why or why not?

9. The video mentioned deforestation's impact on wildlife. How do you feel about this?

10. Religious leaders, politicians, and scientists often express their views and understanding about climate change differently. Do you think all of these perspectives should be taken into account? Why or why not?

11. If a friend asked you what the main purpose of the film was, what would you tell them?

12. Describe anything you or your family would change or do differently after watching this film.

Looking at National and Local Effects of Climate Change
<u>Video 2</u>: *Exploring Climate Change*

Families: **BEFORE you watch the segment please discuss the following questions with each other and respond as completely as you can!*

1. Do you know of anything **in your community** (ex. neighbors, school, and businesses) that affects climate? If so, how are these actions contributing to climate change?

2. Is there anything that you currently do that positively impacts our environment? If so, what?

3. What do you think the term "carbon footprint" means? What kinds of things do you think affect your "carbon footprint?"

Families: **DURING the segment, please note any parts of the movie you found interesting, confusing, or surprising. When you finish the segment (or you can pause the segment as you're watching) please discuss these points.*

Families: **AFTER you watch the segment discuss the following questions with each other and respond as completely as you can!*

4. Did this locally made video segment make you think about climate change any differently than you did before watching the video? How?

5. Was there any evidence presented in the segment that supports the idea that the climate is changing? Please list any evidence you can remember.

6. Was there any evidence presented in the segment that support the idea that the climate is NOT changing? Please list any evidence you can remember.

7. Can you or your family do things that impact climate? If so, what? If not, why not?

For even more information and ways you can connect positively with the environment, check out these resources:

Nature's Notebook: This link directs you to a citizen science project where you can collect and enter real data about seasonal changes in plants and animals in your area. The documentation of seasonal changes can help determine the effects of climate change around the world over time.
https://www.usanpn.org/natures_notebook
US EPA: A Student's Guide to Global Climate Change: This site provides students more information to help explain climate change impacts and provides ways for students to be part of the solution.
http://epa.gov/climatechange/kids/index.html
US EPA: Climate Change: This site can be used by both students and parents. It provides information specifically for the Southeastern United States as well as basic scientific information and action plans to reduce greenhouse gas emissions and reduce carbon footprints.
http://www.epa.gov/climatechange/
US Energy Information Administration-North Carolina: This is a really interesting website that allows the viewer to determine the types, locations, and specific information of renewable and non-renewable energy plants in their own counties. There are also interesting facts concerning energy consumption and use in North Carolina as compared to other states in the country.
http://www.eia.gov/state/?sid=nc
Global Footprint Network- Footprint Calculator: There are many carbon footprinting calculators available online. This site is one of many; however, it is fairly simple and easy to follow. It allows you to see how your actions impact the environment and how your actions compare to people worldwide.
http://www.footprintnetwork.org/en/index.php/GFN/page/calculators/

**If you have gone to any of the websites above for further information or to become involved, I would love to know what you think.*
Example questions to answer: What are a few things that you learned that you did not know prior to visiting the site? Did you discover any new ways you want to get involved to positively impact our environment for the future? Which sites did you like the best? Why?

Appendix E

Semi-Structured Interview Questions for Family Interviews

1. What are your names?
2. What is your relationship?
3. Had either of you heard about climate change prior to the STEM club activities this semester?
4. What had you heard about climate change?
5. Do you believe that our climate is changing?
6. Are you concerned about climate change? Why or why not?
7. What was your involvement in the climate change activities this semester?
   (*To student:* How many/which club meetings did you attend?)
   (*To parent:* Did you participate in any of the activities at the parent meetings? Did you and your student complete the at home intervention activities?)
8. What kinds of things have you learned that you didn't know about climate change prior to your involvement in STEM Career Club activities this semester?
9. Have you begun to think about local or global climate change any differently since participating in the climate change interventions? Can you explain your response a little further?
10. Have you changed any of your behaviors to be more environmentally conscious? If so, how have you changed your behavior? If not, why have you not changed your behavior in response to global climate change?
11. Do you plan on making any long-term changes in the future to help mitigate or slow down your personal or community impacts on our changing climate? Can you please explain your response?
12. Do you feel as if there are any barriers for you or your family that hinder you from making positive changes for your environment in regards to climate change? If so, what are these barriers?

Appendix F

Participant Provided Demographic Data of Students and Parents Participating in the At-Home Intervention and/or Interviews

Table F1

Provided Demographic Data for Student and Parent Participants for the At-Home Intervention and/or Interviews

Family Pseudonyms	**Family Members for At-Home Intervention**	**Hours Engaged**	**Level of Engagement At-Home**	**Race/ Ethnicity**	**Gender**	**Worldview**	**Grade/Age**	**Religion**	**SES (only on parent survey)**	**Level of Education (only on parent survey)**
Kenneth (son)	INTERVIEW ONLY	6	0	Ca	M	No Response	6th Grade	No Response	--	--
Sarah (mom)	INTERVIEW ONLY	0	0	Ca	F	IE	Age 30-47	Christian	< 25K	Some college
T.J. (son)	Mother & Son	8	2	AA	M	No Response	8th Grade	Spiritual (no specific faith)	--	--
Rita (mom)	Mother & Son	4	2	AA	F	No Response	Age30-47	Christian/ Baptist	< 25K	No Response
Maggie (daughter)	Mother, Daughter, & Son	8	2	Ca	F	No Response	7th Grade	Catholic	--	--
Susan (mom)	Mother, Daughter, & Son	3	2	Ca	F	IE	Age 30-47	Agnostic	76-100K	College Graduate
Carmen (daughter)	Mother, Daughter, & Sons (2)	8	1	AA	F	IE	6th Grade	Muslim	--	--
Tanya (daughter)	Mother, Father, & Daughter	6	2	AA	F	C--	6th Grade	Christian	--	--
Shania (daughter).	Mother & Daughter	8	2	AA	F	No Response	6th Grade	No Response	--	--
Jaleen (son)	Mother & Son	6	2	AA	M	IH	7th Grade	Atheist	--	--
James (son)	Father, Sons (2), & Daughter		1	AA	M	--E	6th Grade	Christian	--	--

Table F1 Continued

Family Pseudonyms	Family Members for At-Home Intervention	Hours Engaged	Level of Engagement At-Home	Race/ Ethnicity	Gender	Worldview	Grade/Age	Religion	SES (only on parent survey)	Level of Education (only on parent survey)
Jarett (son)	Father, Sons (2), & Daughter	2 (video only)	1	NA+AA	M	C--	5th Grade	Christian	--	--
Jerry (father)	Father, Sons (2), & Daughter	2	1	AA	F	IE	Age 30-47	Christian	25-50K	College Graduate
Becky (daughter)	Sister & Brother	8	1	Ca	F	IE	6th Grade	Christian	--	--
Joseph (son)	Mother & Son	6	2	H+AA	M	IE	6th Grade	Christian	--	--
Shannon (daughter)	Mother, Daughter, & Son	4	2	Ca	F	No Response	6th Grade	No Response	--	--
Melissa (mom)	Mother, Daughter, & Son	3	2	Ca	F	CE	Age 30-47	Christian	51-75K	High School Graduate
Christopher (son)	INTERVIEW ONLY	6	0	Ca	M	No Response	7th Grade	No Response	--	--
Monique (daughter)	Mother & Daughter	6	1	AA	F	No Response	7th Grade	No Response	--	--
Janelle (mom)	Mother & Daughter	2	1	AA	F	No Response	No Response	No Response	No Respons e	Some College
Kimberly (daughter)	INTERVIEW ONLY	6	0	AA+NA+ Ca	F	IE	6th Grade	Don't give religious things much thought	--	--
Jackie (mom)	INTERVIEW ONLY	1	0	Ca	F	CE	Age 30-47	Roman Catholic	25-50K	Some College
Matthew (nephew)	Aunt & Nephew	8	1	AA	M	0H	6th Grade	Christian	--	--
Kira (aunt)	Aunt & Nephew	?	1	AA	F	IE	Age 18-29	Christian	25-50K	Some college

Table F2 Continued

Family Pseudonyms	Family Members for At-Home Intervention	Hours Engaged	Level of Engagement At-Home	Race/ Ethnicity	Gender	Worldview	Grade/Age	Religion	SES (only on parent survey)	Level of Education (only on parent survey)
Jillian (daughter)	Mother, Daughter, & Cousin	4	1	AA	F	No Response	7th Grade	Don't give religious things much thought	--	--
Linda (mom)	Mother, Daughter, & Cousin	2	1	AA	F	IE	Age 48-66	Christian	< 25K	High School Graduate
Kylie (daughter)	Mother, Daughter, Son, Grandmother, & Grandfather	6	2	Ca	F	IE	6th Grade	Christian	--	--
A'isha (daughter)	INTERVIEW ONLY	6	0	AA	F	--E	6th Grade	Christian	--	--
Shana (daughter)	Mother & Daughters (2)	?	2	AA	F	No Response	6th Grade	No Response	--	--
Teila (daughter)	Mother & Daughters (2)	4	2	AA	F	No Response	7th Grade	Christian	--	--
Lucas (son)	Mother & Son	6	1	AA	M	IE	8th Grade	Christian	--	--
Sharron (mom)	Mother & Son	2	1	AA	F	IE	Age 30-47	Christian	25-50K	Some college
Gerry (son)	Father & Son	6	1	NA	M	IE	7th Grade	Christian	--	--
Kyle (dad)	Father & Son	2	1	NA	M	IH	Age 48-66	Christian	76-100K	College Graduate

Note. AA = African American; Ca = Caucasian; H = Hispanic; NA = Native American; M = Male; F = Female; I = Individualistic; E = Egalitarian; C = Communitarian; H = Hierarchical; I0 = Individualist + (neither egalitarian nor hierarchical); -- = No response given; Some students and parents chose not to provide survey or demographic data.